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Reactor Division

HISTORY OF THE AEC SODIUM COMPONENTS
DEVELOPMENT PROGRAM

RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

Volume III

Edited by H. W. Savage

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DECEMBER 1966

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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CONTENTS

PageVolume I

Foreword	iii
Introduction	1
Sodium Components Development Working Group	2
Sodium Components Development Program Contractor Selection Board	8
Subcommittees	10
Summary of Development Programs	11
Effects of Sodium on Containment Materials	12
Mass Transfer in Sodium Systems (GE)	12
Mechanical Properties of Materials in Sodium (MSAR)	16
Measurement of Impurities in Sodium	18
Electrochemical Meter for Continuous Measurement of Oxygen in Sodium (UNC)	18
Determination of Oxygen in Sodium at Concentrations Below 10 ppm (BMI)	21
Measurement of Oxygen in Sodium Below 10 ppm (UNC)	23
Techniques for Measurement of Impurities in Sodium (MSAR)	25
Sodium Technology Loop (Resistivity Meter) (APDA)	27
Hydrogen Detector (AI)	34
Sodium Equipment	37
Flow Controllers (Valve Tests) (AI, WE, CR, OI)	37
Ultrasonic Under-Sodium Scanner (APDA)	40
Analysis of the Sodium Cold Trap of the Enrico Fermi Reactor (WET)	43
Conceptual Design of Large Sodium Pump Test Facility (WET)	45
Heat Exchangers for Steam Generation	47
Sodium-Heated Steam-Generator Summary (APDA)	47
Study of Optimum Steam Conditions and Cycles for Large Sodium-Cooled Nuclear Power Plants (APDA)	48
Intermediate Heat Exchanger and Steam Generator (LCO) ..	49
Preliminary Design for Steam Generator and Inter- mediate Heat Exchanger (BLH)	60
Fabrication and Testing of Steam Generator (BLH)	61
Analysis and Evaluation of Performance Data on the ALCO Steam Generator and Intermediate Heat Ex- changer (BLH)	63
Sodium Components Test Installation Design Study (APDA)	64
Sodium Components Test Installation (AI)	65
Modular Steam Generators (AI)	67
Shell-Side Heat Transfer Studies (AI)	69

Second Steam Generator (B&W)	72
Small-Leak Sodium-Water Reaction Test Program (APDA) ...	74
Operation Experience	75
Compilation of Operating Experience for Enrico Fermi Fast Reactor (APDA)	75
Appendix A. AEC Sodium Components Development Program — Ob- jectives, Organization, and Procedures	79
Appendix B. Minutes of Sodium Components Development Program Working Group	91
Initial Meeting	93
Meeting No. 1	97
Meeting No. 2	101
Meeting No. 3	104
Meeting No. 4	106
Meeting No. 5	107
Meeting No. 6	112
Meeting No. 7	116
Meeting No. 8	118
Meeting No. 9	121
Meeting No. 10	123
Meeting No. 11	125
Meeting No. 12	128
Meeting No. 13	134
Meeting No. 14	139
Meeting No. 15	144
Meeting No. 16	155
Meeting No. 17	160
Meeting No. 18	166
Meeting No. 19	176
Meeting No. 20	182
Meeting No. 21	193
Meeting No. 22	204
Meeting No. 23	213
Meeting No. 24	224
Meeting No. 25	239
Meeting No. 26	249
Meeting No. 27	256
Meeting No. 28	269
Meeting No. 29	282
Meeting No. 30	291
Meeting No. 31	304
Meeting No. 32	333
Meeting No. 33	338
Meeting No. 34	348
Meeting No. 35	356
Meeting No. 36	363
Meeting No. 37	366
Meeting No. 38	386

Volume II

Appendix C. Reports of Subcommittee Meetings	393
Reports of Subcommittee on Shell-Side Heat	
Transfer	395
Report of Meeting on April 7-8, 1960	397
Report of Meeting on May 26-27, 1960	401
Report to SCDP Chairman, June 13, 1961	406
Report of Meeting on July 27-28, 1961	409
Report to SCDP Chairman, September 29, 1961 ...	416
Report of Subcommittee on Once-Through Steam	
Generator	419
Report of GR Meeting, May 9, 1960	421
Reports of Subcommittee on Mechanical Proper-	
ties of Materials	423
Report of Meeting on May 24-25, 1960	425
Report of Meeting on February 15, 1961	435
Report of Meeting on January 9, 1962	438
Report of Meeting on November 29-30, 1962	450
Report of Meeting on February 4-5, 1964	463
Report of Meeting on August 19-20, 1964	471
Report of Meeting on February 23-24, 1965	479
Report of Subcommittee on Carbon Analysis	487
Report of Meeting on March 20, 1962	489
Reports of Subcommittee on Sodium Mass Transfer	
Program	495
Report of Meeting on January 19-21, 1961	497
Report of Meeting on October 2-4, 1961	514
Report of Meeting on November 30-December 1,	
1961	539
Report of Meeting on September 26-28, 1962	567
Report of Meeting on February 11-15, 1964	590
Report of Subcommittee on Sodium Components	
Test Installation Design Review	627
Report of Meeting on September 18, 1961	629
Reports of Subcommittee on Steam Generator	
Testing	633
Functions of Ad Hoc Committee on Steam	
Generator Testing	635
Report of Meeting on November 13-15, 1963	637
Report of Meeting on December 18, 1963	642
Report of Meeting on December 19-20, 1963	646
Status Report on Steam Generators as of	
January 16, 1964	651
Report of Meeting on March 11, 1964	660
Report of Meeting on March 12-13, 1964	663
Summary of Steam Generator Program as of	
June 11, 1964	668
Report of Meeting on August 12, 1964 Regard-	
ing B&W Full-Size Generator	673

Report of Meeting on October 13-14, 1964 Regarding SCTI and Modular Generators	682
Status Report of Steam Generators Program as of March 1965	688
Minutes of Meeting on June 18, 1965 Regarding B&W Steam Generator Design Review	694
Long-Range Planning Report NYO-10725, January 1964	699
Reports of Subcommittee on Analytical Procedures for Determining Impurities in Sodium	717
Report of Meeting on February 18-19, 1964	719
Report of Meeting on April 17, 1964	725
Report of Meeting on June 30, 1964	727
Report of Meeting on October 15-16, 1964	731
Report of Meeting on February 24, 1965	736
Reports of Meetings on Mass Transfer Program Review	757
Report of Meeting on February 24, 1964	759
Report of Meeting on March 2, 1964	763
Task Force Report	765
Appendix D. AEC Invitations to Bid and Specifications	771
Steam Generator	773
Design Study for Sodium Components Test Installations	793
Operation of Sodium Components Test Facility	801
Flow Controller	807
Analysis of Sodium for Low-Level Oxide Content	815
Mass Transfer of Materials in Sodium	821
Physical Properties of Materials in Sodium	829
Shell-Side Heat Transfer	837
Meter for Continuous Indication of Sodium Oxide Content in Sodium	845
Hydrogen Detector for Sodium Systems	851
Appendix E. Questionnaires Sent to Contractors and Replies	859
Form Letter Requesting Information from Con- tractors and Copy of Questionnaire	861
Atomics International	865
Shell Side Heat Transfer	867
Hydrogen Detector Development	869
Sodium Components Test Installation	870
Modular Steam Generator	874
Atomic Power Development Associates	879
Sodium Heated Steam Generator Summary	881
Study of Optimum Steam Conditions and Cycles for Large Sodium-Cooled Nuclear Power Plants	881
Small Leak Sodium-Water Reaction Test Program	883
APDA Sodium Technology Loop	886
Ultrasonic Scanner	891

Compilation of Fermi Operating Experience	892
Sodium Boiler Development Contract	895
Sodium Components Test Facility	898
The Babcock and Wilcox Company	901
Sodium-Heated Steam Generator Program	903
Baldwin-Lima-Hamilton Corporation	909
Sodium Heated Steam Generator and Inter- mediate Exchanger Preliminary Design Study ...	911
ALCO/BLH Sodium Heated Steam Generator Re- search and Development Contract Including Fabrication and Testing of Components	914
Analysis and Evaluation of Performance Data on ALCO Steam Generator and Intermediate Heat Exchanger	921
Battelle Memorial Institute	923
Determination of Oxygen in Sodium at Con- centrations Below 10 ppm	925
United Nuclear Corporation	927
Measurement of Oxygen in Sodium Below 10 ppm ..	930
Electrochemical Meter for Continuous Measurement of Oxygen in Sodium	933
Westinghouse Electric Corporation	939
Design of Large Sodium Pump Test Facility	941
Examination of Contents of Fermi Reactor Cold Trap	947

Volume III

Appendix F. Questionnaires Sent to Members and Alternates and Replies	953
Form Letter and SCDP History Questionnaire	955
Alphabetical List of Individuals to Whom Questionnaires Were Sent	957
Replies to Questionnaire Arranged Alphabetically by Name of Individual	959
Appendix G. Monthly Coordination Reports	1009
January 1962	1011
February 1962	1019
March 1962	1025
April 1962	1034
May 1962	1040
June 1962	1047
July 1962	1055
August 1962	1063
September 1962	1071
October 1962	1079
November 1962	1088
December 1962	1099
January 1963	1109

February 1963	1118
March 1963	1127
April 1963	1134
May 1963	1147
June 1963	1158
July 1963	1170
August 1963	1182
September 1963	1191
October 1963	1201
November 1963	1211
December 1963	1219
January 1964	1226
February 1964	1233
March 1964	1241
April 1964	1249
May 1964	1256
June 1964	1264
July 1964	1272
August 1964	1280
September 1964	1290
October 1964	1299
November 1964	1309
December 1964	1319
January 1965	1330
February 1965	1340
March 1965	1349
April 1965	1357
May 1965	1364
June 1965	1374
July 1965	1384
August 1965	1395
September 1965	1405
October 1965	1416

APPENDIX F

QUESTIONNAIRES SENT TO MEMBERS AND ALTERNATES AND REPLIES

OAK RIDGE NATIONAL LABORATORY

OPERATED BY

UNION CARBIDE NUCLEAR COMPANY

POST OFFICE BOX Y
OAK RIDGE, TENNESSEE

March 29, 1965

At the request of Glen Wensch, I am preparing a history of the Sodium Components Development Program from its inception. The period covered will probably be January 30, 1957 to July 1, 1965.

The records indicate that you participated as a member, alternate, or special attendee of the Working Group and its subcommittees. In order to achieve agreement on who did what and when, would you please search your memory and files for the information requested in the enclosure.

I would very much appreciate receiving this information as soon as convenient, since I have promised a preliminary draft of the history by July 1.

Sincerely yours,

H. Wesley Savage
H. Wesley Savage

HWS:sj

Enclosure

SCDP HISTORY QUESTIONNAIRE

- (a) Name
- (b) Organizational affiliations during period when active with SCDP
- (c) Titles of your positions during period when active with SCDP
- (d) Present organizational affiliation and address
- (e) Present position
- (f) Undergraduate and graduate degrees, institutions, and dates
- (g) Present basic profession
- (h) Professional specialties predominant in your SCDP work
- (i) Beginning and ending dates as member, alternate, or special attendee (designate which) for SCDP Working Group or Committee
 - 1. If you were an alternate or special attendee, list meetings attended
 - 2. List Working Group technical assignments and dates where known
 - 3. If an AEC member, list specific contracts administered, giving contract title, number, contractor, beginning and ending dates
- (j) Beginning and ending dates as member or alternate (designate which) for SCDP subgroups or subcommittees--list individually
 - 1. List subgroup technical assignments and dates where known
 - 2. List subgroup meetings attended, locations, and dates
 - 3. List specialties with respect to subgroup activities
- (k) At the time of your starting date (should agree with (i) or (j) above), state (1) your years of technical experience, and (2) your years of alkali metal experience
- (l) List technical documents (proposals, reports, etc.,--but not general correspondence) to or for the SCDP Working Group or subgroups prepared by you or for which you were responsible, with dates, and document identification symbol if known
- (m) Provide additional remarks in the form of brief, terse explanations or as additional comments pertinent to SCDP, its history, and evolution.

PLEASE NOTE:

Please provide this information to me as soon as possible and piecemeal if that will expedite its receipt by me.

I expect you will be able to answer virtually immediately all questions except (i-2), (i-3), (j-1), (j-2), (l), and (m).

H. Wesley Savage

3/29/65

Alphabetical List of Individuals To Whom Questionnaires Were Sent

	<u>Organization</u>	<u>Replies Received</u>
W. F. Anderson	AI (Consultant)	X
R. E. Aronstein	AEC & AI	X
John A. Bailey	AEC-SAN	X
R. Bane	ANL	X
C. E. Barrett	NASA	
J. H. DeVan	ORNL	
R. W. Dickinson	AI	X
Joseph Dissler	AEC-NY	X
Robert Duffy	AEC-SAN	
O. E. Dwyer	BNL	
D. A. Gardiner	ORNL	X
R. J. Gariboldi	AEC-CH	X
Kurt Goldmann	UNC	X
G. C. Gower	AEC-CH	X
R. E. Harris		
T. P. Heckman	AEC-CH	
K. C. Hoffman	BNL	X
J. P. Holliday	AEC-SAN	
Irwin E. Jackson	AEC-WASH	
Ralph J. Jones	AEC-WASH	X
J. F. Kaufman	AEC	
L. Kelman	ANL	
C. J. Klamut	BNL	X
K. Kuczen	ANL	
R. W. Lockhart	GE	✓
R. E. MacPherson	ORNL	X
W. B. McDonald	ORNL	
J. M. McKee	UNC	X
J. J. Morabito	APDA	X
A. E. Mravca	AEC	X
T. A. Nemzek	AEC-CH	X
L. Newman	BNL	X
C. A. Pursel	AEC-CH	
J. J. Purcell	AEC-CH	X
C. W. Richards	AEC	
A. Romano	BNL	
H. W. Savage	ORNL	X
W. R. Simmons	ANL	
F. A. Smith	ANL & AEC	X
George Stern	UNC	X
T. Trocki	GE	X
G. R. Waterbury	LASL	X
G. W. Wensch	AEC-WASH	
J. C. White	ORNL	X
L. E. Whinery	LASL	
Jules Wise	AEC	X
W. R. Wykoff	LASL	

REPLIES TO QUESTIONNAIRE ARRANGED ALPHABETICALLY
BY NAME OF INDIVIDUAL

Attachment to
65AT-2583

SCDP HISTORY QUESTIONNAIRE ANSWER SHEET

April 14, 1965

- (a) William F. Anderson
- (b) Atomics International
- (c) Research Specialist
- (d) San Fernando Valley State College, Northridge, Calif.
Atomics International, Canoga Park, Calif. (part time)
- (e) San Fernando Valley State College - Assistant Professor, Engineering
Atomics International - Specialist
- (f) B.S. - Civil Engineering 1948 Lafayette College
B.S. - Electrical Engr. 1948 Lafayette College
M.S. - Civil Engineering 1954 Calif. Inst. Tech.
- (g) Engineering Teaching and Practice
- (h) Stress Analysis and Mechanical Properties of Materials
- (i) None
- (j) Sub-committee on Materials of Sodium Components Working Group
 - (1) Assignment - Review effort at MSAR on Mechanical Properties of Materials in Sodium
 - (2) Four review visits to MSAR were attended --
 - May 24, 25, 1960
 - Feb. 15, 1961
 - Jan. 9, 1962
 - Nov. 29, 30, 1962
 - (3) Thermal Stress Analysis
Mechanical Properties of Materials (Low Cycle Fatigue)
- (k) at May 25, 1960
 - (1) Years of Technical Experience
Approx. 15
 - (2) Years of Alkali Metal Experience
Approx. 5

SCDP HISTORY QUESTIONNAIRE ANSWER SHEET (Continued)Attachment to
65AT-2583April 14, 1965
Page 2

(1) Reports

Participated in preparation of four review reports, one following each review visit. No document numbers available.

- (m) I also prepared an analysis of the proposed thermal shock test apparatus at MSAR and presented the results of this analysis to a meeting of the Sodium Components Working Group in Chicago following one of the sub-committee meetings, in January 1962, I believe.

SCDP HISTORY

- (a) Robert E. Aronstein
- (b) AEC - Chicago Operations Office
- (c) Reactor Engineer
- (d) Atomics International
P.O. Box 309
Canoga Park, California
- (e) Specialist - Applications Engineering
- (f) BSME, California State Polytechnic College
San Luis Obispo, California
- (g) Mechanical Engineering - nuclear power
- (h) Program Administration and Sodium Technology
- (i) December 1960 to February 1962 - Member Technical Assignments

AEC Chairman of Shell Side Heat Transfer,
Sodium Components Test Installation and
Sodium Mass Transfer Subcommittees - 6/61 to 2/62

AEC Assignments - Technical Program Responsibility

Heat Exchanger and Steam Generator, Contract
AT(11-1)-666, Alco Products - 12/60 to 2/62

Sodium Components Test Installation, Contract
AT(11-1)-GEN-8, Atomics International - 2/61 to 2/62

Shell Side Heat Transfer, Contract AT(11-1)-GEN-8,
Atomics International - 9/60 to 2/62

Mass Transfer in Sodium, Contract AT(04-3)-189 #15,
General Electric - 6/61 to 2/62

- (j) AEC Chairman Shell Side Heat Transfer Subcommittee
6/61 to 2/62

Meetings - 7/27 and 28, 1961 at Atomics International
Canoga Park, California

10/3/61 at General Electric, San Jose, California

AEC Chairman Sodium Components Test Installation
Subcommittee - 5/61 to 2/62

Meetings - No recollection

AEC Chairman Sodium Mass Transfer Subcommittee -
6/61 to 2/62

Meetings - 10/2 and 3, 1961 at General Electric,
San Jose, California

11/30 and 12/1, 1961 at Chicago Operations Office,
Argonne, Ill.

(k) 6 years technical experience
3 years sodium technology

(l) Report #2 on GE Sodium Mass Transfer Program, Nov.22,1961

Report #3 on GE Sodium Mass Transfer Program, March 13,1962

(m) I was secretary for Meeting #25, May 1961 at Lincoln, Neb.

UNITED STATES
ATOMIC ENERGY COMMISSION
SAN FRANCISCO OPERATIONS OFFICE

2111 BANCROFT WAY
BERKELEY
CALIFORNIA 94704

RD:JAB

Mr. H. Wesley Savage
Building 9201-3
Post Office Box Y
Union Carbide Nuclear Corporation
Oak Ridge, Tennessee

Dear Mr. Savage:

Listed below is the information requested in your March 29, 1965, letter. As my association with the Sodium Components Working Group has been somewhat informal, you may choose not to include me in this listing.

- (a) John A. Bailey
- (b) AEC/SAN
- (c) Chief, Reactor Projects Branch
- (d) U. S. Atomic Energy Commission
San Francisco Operations Office
2111 Bancroft Way
Berkeley, California 94704
- (e) Chief, Reactor Projects Branch
- (f) B.M.E. - RPI (1950)
M.M.E. - RPI (1951)
- (g) Mechanical Engineering
- (h) Mechanical Engineering
- (i) 1. Alternate member Sodium Components Information Group on
April 14-15, 1964, in Hollywood.

Secretary, Sodium Components Working Group on March 3, 1965.
- 2. N.A.
- 3. Projects and Project Engineers: P.A. 10 (W. R. Gee);
P.A. 15 (J. P. Duffy); and SEFOR (J.P. Holliday)

H. Wesley Savage

- 2 -

(j) N.A.

(k) 1. 13 years

2. None

(l) N.A.

(m) N.A.

Sincerely yours,

John A. Bailey, Chief
Reactor Projects Branch

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

April 6, 1965

In reply refer—

65AT-2365

Mr. H. W. Savage
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Dear Wes:

In response to your questionnaire dated 29 March, the following information is submitted:

- a. Robert W. Dickinson
- b. Atomics International Division, NAA
- c. Chief Project Engineer, SGR program; Director, Sodium Reactors Department
- d. Atomics International, P. O. Box 309, Canoga Park, California
- e. Assistant to Executive Vice President
- f. B.A., University of California 1941
M.S., USN Post Graduate School 1948
S.M., Mass. Inst. of Tech. 1953
- g. Engineering Administrator
- h. Mechanical engineering, metallurgy
- i. Member Working Group, February 1958 (inception) to April 1963 (dissolution of industrial participation)
 1. Regular member
 2. Unknown at this time; will research files
 3. Not applicable
- j. Not known at this time; do not remember any
- k. As of February 1958
 1. 16 years
 2. 5 years
- l. None directly; participated in AI proposals on:
 1. Mass transfer (went to GE)
 2. Shell side heat transfer
 3. SCTI

P.O. Box 309, Canoga Park, California

Cable Address: ATOMICS

Mr. H. W. Savage
Oak Ridge, Tenn.

-2-

April 6, 1965
65AT-2365

- m. SCDP provided forum for coordination of diverse, previously only casually related liquid metals development programs. Served to fix "standards" when none were available, and demonstrated requirements for test and test facilities. These were probably its most important contributions; with the increasing body of technical knowledge and personnel which became available, largely as a result of its early efforts, dissolution of the SCDP working group as such became desirable, as its guidance functions were no longer necessary. Sufficient highly qualified personnel in the customers' organizations became available so that the ever-present risk of inadvertent conflict of interest could be eliminated with less impact on the technical program.

Sort of miss the old gang, though! It was both pleasant and exciting.

Sincerely,

R. W. Dickinson
Assistant to the
Executive Vice President
Atomics International Division

Answers to SCDP History Questionnaire

- (a) Joseph J. Dissler
- (b) USAEC, New York Operations Office, Reactor Development Division
- (c) Senior Project Engineer
- (d) Same as (b). 376 Hudson Street, New York, New York 10014
- (e) Same as (c)
- (f) Bachelor of Mechanical Engineering - City College of New York - 1/54
M.S. Mechanical Engineering - Rensselaer Polytechnic Institute - 1/61
- (g) Nuclear Engineering
- (h) Heat transfer and hydraulics - liquid metal cooled fast reactors
- (i) Beginning date as member of SCDP Working Group - February 12, 1965
 - 1. Not applicable
 - 2. None
 - 3. Senior Project Engineer for contracts under J. Wise's cognizance
- (j) Beginning date as member and Chairman of Sodium Impurities Standing Committee - February 12, 1965
 - 1. Not applicable
 - 2. February 24, 1965 meeting of the Sodium Impurities Standing Committee at the New York Operations Office, N. Y.
 - 3. Liquid metal heat transfer and hydraulics
- (k) 1. Years of technical experience as of starting date of SCDP membership - 11 years
 - 2. Alkali liquid metal experience - 8 years
- (l) Proposed Program for Development of Analytical Procedures for Sodium Contaminants, transmitted by memo, Dissler to Wensch, dated March 1, 1965, (Symbol R:JW:SCDP).
- (m) No comments or remarks to offer

SCDP HISTORY QUESTIONNAIRE

- (a) Donald A. Gardiner
- (b) Statistics Section, Mathematics Division, Oak Ridge National Laboratory
- (c) Statistician
- (d) Same as (b) above, P.O. Box Y, Oak Ridge, Tennessee, 37831
- (e) Statistician
- (f) B.S. University of Buffalo, 1943
M.B.A. University of Buffalo, 1948
Ph.D. North Carolina State College, 1956
- (g) Statistician
- (h) Design of experiments; Statistical analysis
- (i) 1. Special attendee (consultant) with Ad Hoc Committee
Nov. 15, 1961 San Jose, California
Nov. 29, 1961 Chicago, Illinois
Sept. 25, 1962 San Jose, California
Feb. 10, 1964 San Jose, California
2. ?
3. ---
- (j) See (i) above
- (k) 1. 5 years
2. None
- (l) None
- (m) I have been impressed by the serious effort put forth by my colleagues on the Ad Hoc Committee to implement the program by intelligent use of the scientific method.

UNITED STATES
 ATOMIC ENERGY COMMISSION
 CHICAGO OPERATIONS OFFICE
 9800 SOUTH CASS AVENUE
 ARGONNE, ILLINOIS 60439

August 5, 1965

Mr. H. Wesley Savage
 Oak Ridge National Laboratory
 P. O. Box Y
 Oak Ridge, Tennessee

Dear Wes:

Sorry not to have sent this information to you sooner, but my activity and relationship to the Sodium Components Development Program Working Group's history is nil. At most I am a recent student. But the data for your questionnaire is as follows:

- (a) Richard J. Gariboldi
- (b) U. S. Atomic Energy Commission
Chicago Operations Office
- (c) Engineer (reactor)
- (d) U. S. Atomic Energy Commission
Chicago Operations Office
- (e) Engineer (reactor)
- (f) BSME, Marquette University, 1951
- (g) Mechanical engineer
- (h) Machine design, heat transfer, fluid flow, reactor core and reactor plant design
- (i) (1) Alternate - New York, June 10, 1964
San Francisco, February 3, 1965
Chicago, June 16, 1965
- (2) None
- (3) None

Mr. H. Wesley Savage

- 2 -

August 5, 1965

(j) None

(k) (1) Eighteen years

(2) One year

(1) COO-279, "An Evaluation of Four Design Studies of a
1000 MWe Ceramic Fueled Fast Breeder Reactor"

Fast Reactor Program Newsletters, Nos. 1-7 and 10

Sincerely yours,

Richard J. Gariboldi
Reactor Engineering Division

SCDP HISTORY QUESTIONNAIRE
FOR KURT GOLDMANN

a) Name?

Kurt Goldmann

b) Organizational affiliations during period when active with SCDP?

Nuclear Development Corporation of American, merged into United Nuclear Corporation

c) Titles of your positions during period when active with SCDP?

SDR Chief Project Engineer

Consulting Engineer

Manager, Heat Transfer Section

Manager, Engineering Development Department

d) Present organizational affiliation and address?

United Nuclear Corporation, Development Division,
5 New Street, White Plains, New York

e) Present position?

Manager, MCR Primary Systems Department

f) Undergraduate and graduate degrees, institutions, and dates?

Penn State, BSME, 1942

MIT, MSME, 1946

g) Present basic profession?

Engineering

h) Professional specialties predominant in your SCDP work?

Mechanical Engineering

- i) Beginning and ending dates as member. List Working Group technical assignments and dates where known?

Member of the SCDP Working Group from February 27, 1958. Attended all meetings through October 11, 1962. Was advised of the discontinuance of the Working Group by letter from T. A. Nemzek dated April 22, 1963.

My principal contributions as a member of the Working Group consisted of assisting in defining the areas which required sodium component development, preparing worksopes for specific programs, reviewing technical portions of proposals, reviewing and evaluating the progress of work by the contractors. In addition to these normal duties as a participating member, I contributed the following:

Preparation of a program scope for the design, construction and operation of a full scale sodium component test facility built around the 30 MW heater from KAPL (Aug. & Sept. 1958).

Inspected the 30 MW sodium heater at KAPL in August 1958 and again in storage at Tonowanda in January 1959.

Attended NASA-AEC Liquid Metal Corrosion Meeting at BNL on December 14th and 15th and reported on the meeting to the Working Group on January 10-12, 1962.

Participated in review of requirements for sodium-cooled ATR loops at AEC-COO on March 5th and 6th, 1962.

Reviewed and commented on various reports, outlines, etc.

- j) Beginning and ending dates as member for SCDP subgroups or subcommittees.

- 1) List subgroup technical assignments and dates where known.

Appointed to Subcommittee on Shell Side Heat Transfer on March 10, 1960.

Appointed coordinator of Materials Properties Subcommittee on April 28, 1960.

- 2) List subgroup meetings attended, locations, and dates.

My files are incomplete on the Shell Side Subcommittee meetings. Since you were the coordinator, I trust that you have all of the required information.

The Materials Properties Subcommittee met on May 24th and 25th, 1960; February 15, 1961 and January 9, 1962. All 3 meetings took place at a hotel in Pittsburgh and at MSA Research Corp., Callery, Pennsylvania. In addition to the authors of the reports listed below, T. Heckman of the Chicago Operations Office represented the AEC at all 3 meetings.

- 3) List specialties with respect to subgroup activities.

Heat transfer and engineering requirements for materials used in sodium system components.

- k) At the time of your starting date, state (1) your years of technical experience, and (2) your years of alkali metal experience.

16 years of technical experience; 8 years of alkali metal experience.

- l) List technical documents to or for the SCDP Working Group or subgroups prepared by you or for which you were responsible, with dates, and document identification symbol if known.

I trust that you will cover all reports issued by the Working Group and the Shell Side Heat Transfer Subcommittee. The following reports were issued by the Materials Subcommittee:

- A) Report on Sodium Component Materials Program by W. F. Anderson, A.I., J. H. DeVan, ORNL, G. Stern, NDA and K. Goldmann, NDA(Coordinator) submitted to SCDP Working Group, June 10, 1960.
- B) Letter from K. Goldmann, Subcommittee Coordinator, to T. A. Nemzek dated February 28, 1961, reference DEVE-347, and

- C) Third Review Report on Sodium Component Materials Program by W. F. Anderson, A.I., J. H. DeVan, ORNL, G. Stern, NDA and K. Goldmann, NDA (Technical Coordinator) submitted to SCDP Working Group, February 15, 1962.

For your convenience, I am enclosing a copy of each of these documents.

- m) Provide additional remarks in the form of brief, terse explanations or as additional comments pertinent to SCDP, its history, and evolution.

The Working Group performed a most valuable function of guiding the Sodium Component Development Program. As representatives of the reactor industry and laboratories, all members were keenly interested in bringing reliable and economic sodium system components into being. While each member was connected with a different type of reactor, the needs for components external to the reactor were nearly identical.

SCDP HISTORY QUESTIONNAIRE

- (a) Name
George C. Gower
- (b) Organizational affiliations during period when active with SCDP
U. S. Atomic Energy Commission, Chicago Operations Office
9800 South Cass Avenue, Argonne, Illinois
- (c) Titles of your positions during period when active with SCDP
Reactor Engineer - and member of the Standing Committee for Steam
Generator Testing
- (d) Present organizational affiliation and address
U. S. Atomic Energy Commission, Chicago Operations Office
9800 South Cass Avenue, Argonne, Illinois
- (e) Present position
Same as (c) above
- (f) Undergraduate and graduate degrees, institutions, and dates
University of Utah - BS degree ME in 1959
Graduate work in control systems and semiconductor electronics -
University of California - Extension Division 1961-62
- (g) Present basic profession
Mechanical engineer
- (h) Professional specialties predominant in your SCDP work
Design, fabrication and operation of experimental (R&D) sodium loops.
Design, fabrication and testing of sodium components.
Mechanical design review of proposed and existing liquid metal cooled
heat transfer equipment and supporting R&D projects.
Preparation and presentation of the technical aspects associated with
the above.
- (i) Beginning and ending dates
August 1963 to March 1965
Member, Standing Committee for Steam Generator Testing

Meetings attended: (SCDP)

January 16-17	1964	(HQ)
April 14-15-16	1964	(AI)
June 11-12	1964	(NY)
November 16-17	1964	(CH)
March 3-4	1965	(SAN)

Contracts:

		<u>Started</u>
(AI)	AT(11-1)-GEN-8 (Only SCDP)	May/48
(BLH)	AT(11-1)-1213	Nov/62
(B&W)	AT(11-1)-1280	Apr/63
(UNC)	not available at this time	Apr/65

All above contracts are still in existence.

(j) Beginning and ending datesMeetings of the Standing Committee for Steam Generator Testing:

<u>Meetings attended:</u>	<u>at</u>
November 19, 1963	AI
December 18, 1963	BLH
December 19-20, 1963	B&W
March 11, 1964	Santa Monica, California
March 12-13, 1964	AI
October 13-14, 1964	AI
March 23-24, 1965	AI

Specialties with respect to committee activities:

As an AEC committee member at the above meetings, participation was in the capacity of cognizant engineer on the contracts listed in (i) above with the specific interests listed under (h) above.

(k) Experience

- (1) Years of technical experience - 4 years
- (2) Years of alkali metal experience - 4 years

(l) Technical Documents

- (1) Assisted in the rewrite of the "Black Book".
- (2) Assisted in the preparation of seven Standing Committee reports and numerous briefing documents.

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, L. I., N. Y.
TEL. YAPHANK 4-6262

REFER

April 7, 1965

Mr. H. W. Savage
Oak Ridge National Laboratory
Post Office Box Y
Oak Ridge, Tennessee

Dear Mr. Savage:

Following is the information that you requested of me in your SCDP History Questionnaire:

- a. Kenneth C. Hoffman
- b. Nuclear Engineering Division, Brookhaven National Laboratory.
- c. Project Engineer
- d. Brookhaven National Laboratory, Upton, L.I., New York
- e. Associate Engineer
- f. Bachelor of Mechanical Engineering, New York University, June 1954.
- g. Engineer
- h. Heat transfer and component development
- i. No meetings attended
- j. Attended following meetings of Steam Generator Subcommittee as a committee member:
 1. November 13, 14, 15, 1963 - Meeting at AI to review SCTI program and Modular Steam Generator concept.

Mr. H. W. Savage

-2-

April 7, 1965

2. March 12, 13, 1964 - Meeting at AI to review SCTI and MSG.

3. August 12, 1964 - Meeting at AEC Headquarters to discuss B. & W. Steam Generator design.

k. As of November 1963, nine years of technical experience and seven years of alkali metal experience.

l. Participated in preparation of Steam Generator Subcommittee reports.

m. No comments.

Very truly yours,

Kenneth C. Hoffman

KCH:jk

Mr. Kenneth C. Hoffman
Brookhaven National Laboratory
81 Cornell Avenue
Upton, New York 11973

ANSWERS TO SCDP HISTORY QUESTIONNAIRE

- (a) Ralph H. Jones
- (b)
 - 1. Atomic Power Development Associates
 - 2. Atomics International
 - 3. U. S. Atomic Energy Commission
- (c)
 - 1. Operations Division Head
 - 2. Senior Technical Specialist
 - 3. Senior Reactor Engineer
- (d) USAEC Headquarters, Washington, D. C.
- (e) Senior Reactor Engineer, Liquid Metal Cooled Reactors Branch,
Division of Reactor Development and Technology
- (f) Electrical Engineer, RPI, 1936
- (g) Engineer
- (h) Liquid metal components and reactor systems
- (i)
 - 1. Special attendee March 21, 1962 meeting at "H" Street, Wash., D. C.
 - AI alternate October 10-11, 1962 meeting at ORNL.
 - Secretary January 1962 to date.
 - Acting Chairman April 17-18, 1964 meeting at Los Angeles.
 - 2. Presentation to Ad Hoc Steam Generator Committee on "Sodium-
Water Reactions in Steam Generators" at Los Angeles March 11, 1964.
- (k)
 - 1. 26 years
 - 2. 9 years

April 5, 1965

SCDP History Questionnaire

- (a) Carl J. Klamut
- (b) Brookhaven National Laboratory
- (c) Metallurgist
- (d) Brookhaven National Laboratory
Upton, New York
- (e) Metallurgist
- (f) BSME, N.Y.U., 1951
- (g) Metallurgy
- (h) Liquid Metal Corrosion
- (i) Alternate (for O. E. Dwyer)
re: G. E. Mass Transfer Program Committee Meeting
Feb. 24, 1964, Chicago, Ill.
- (j) Member - Subcommittee for the Investigation of the Physical
Properties of Materials in High Temperature Sodium. Attended
meetings held at MSA, Callery, Pa. on: Feb. 4-5, 1964,
Aug. 19-20, 1964, Mar. 23-24, 1965.
- (k) Technical - 13 years
Liquid Metal - 12 years; Alkali Metals - 5 years
- (l) Contributed to Subcommittee Reports #4, #5, #6 relative to
MSA "Physical Properties of Material in Sodium Program".

(1) SCDP HISTORY QUESTIONNAIRE

- (a) Name - Robert W. Lockhart
- (b) Organizational affiliations during period when active with SCDP-
General Electric Company, Atomic Power Equipment Department, 2151 S. 1st Street, San Jose, California
- (c) Titles of your positions during period when active with SCDP-
Development Program Engineer
- (d) Present organizational affiliation and address -
General Electric Company, Atomic Products Operation, 175 Curtner Avenue,
(Same place, different address) San Jose, California
- (e) Present position -
Consulting Engineer - Sodium Reactor Systems
- (f) Undergraduate and graduate degrees, institutions, and dates -

BSME-1943	University of California, Berkeley
MSME-1945	University of California, Berkeley
Degree of Mechanical Engineer - 1946	University of California, Berkeley
- (g) Present basic profession -
Nuclear Reactor and Liquid Metal Technology (see (h) below)
- (h) Professional specialties predominant in your SCDP work-
Heat transfer-Fluid Flow-Thermal stress analyses; Sodium Steam Generator Design; Material exposure in sodium, and Liquid Metal System Operation
- (i) Beginning and ending dates as member, alternate, or special attendee (designate which) for SCDP Working Group or Committee -
Attended August, 1958 SCDP Sodium heat Exchanger and Steam Generator Contractor Information Meeting at Germantown as alternate working group member for Mr. Tom Trocki. (I presented a requested paper on Sodium Steam Generator Operating Experience at this meeting.) I was a SCDP Working Group Member from the following meeting (9/12/58) until the industrial members were excused in the fall of 1963. Also see the last paragraph of (j).
- (j) Beginning and ending dates as member or alternate (designate which) for SCDP subgroups or subcommittees--List individually -
Coordinator of a subgroup to investigate the analysis of carbon in sodium. One meeting March 20, 1962 in Washington, D.C. 1960-1963 (Final report

GEAP 4602 "Results of the USAEC Round-Robin Analysis for Carbon Impurity in Sodium").

Member of subgroup coordinated by Fred Smith to discuss the Griscom-Russell Intermediate Heat Exchanger Steam Generator work. The only meeting was held at GR in May, 1960 at Masillon, Ohio.

Member of the subgroup coordinated by J. Morabito, APDA, to review the SCTI at Atomics International in Canoga Park. One meeting was held in 1962.

Attended five SCDP Working Group Ad Hoc Review Group Meetings as contractor (GE) representative (Project Engineer). GE personnel did not attend Review group's closed discussions. (1961-1964).

I also attended two meetings of the SCDP Working Group Sodium Impurity Subgroup coordinated by Mr. Jules Wise, AEC-NY, in New York City, February, 1964, and Hollywood, California April 13 and 15, 1964. I was invited as a special attendee to maintain continuity of the Working Groups sodium impurity activities.

- (k) At the time of your starting date, state (1) your years of technical experience, and (2) your years of alkali metal experience-
 - (1) 15 years of technical experience;
 - (2) 12 years of alkali metal experience in the fall of 1958.
- (l) List technical documents to or for the SCDP Working Group of subgroups prepared by you or for which you were responsible, with dates, and document identification symbol if known -
 - (a) GEAP 4602 - Results of the USAEC Round Robin Analysis for Carbon Impurity in Sodium by R.W. Lockhart et al, March, 1964.
 - (b) Contributed section on model steam generators to a report coordinated by C.A. Pursel, AEC-CH, "Sodium Heated Steam Generator Summary", TID 18072, September, 1962.
 - (c) Sodium Mass Transfer Project reports.
- (m) Provide additional remarks in the form of brief, terse explanations or as additional comments pertinent to SCDP, its history, and evolution - None.

SCDP History Questionnaire

- a) Robert E. MacPherson, Jr.
- b) Oak Ridge National Laboratory
- c) Engineer
- d) Oak Ridge National Laboratory
Building 9201-3
P. O. Box Y
Oak Ridge, Tennessee
- e) Engineer
- f) B.S. Chemistry, Allegheny College, 1943
B.S. Chemical Engineering, University of Pittsburgh, 1948
ORSORT, 1959
- g) Chemical Engineering
- h) Liquid Metals Technology
Component Test Procedures
Heat Transfer
- i) Alternate - 1961 to present
 - 1. Atomics International, 9/10/61
Ad Hoc Review of Alco Test Program

AEC Headquarters, Germantown, 8/12-13/63
Review of B&W Steam Generator Design

Argonne National Laboratory, 11/16-17/64
Working group meeting
 - 2. None
 - 3. Not applicable
- j) Subcommittee member - 1963 - present
 - 1. None
 - 2. Ad Hoc Committee on Steam Generator Testing

Atomics International, Los Angeles, 11/13-15/63
Baldwin-Lima-Hamilton, Philadelphia, 12/18/63
Babcock and Wilcox, Cleveland, 12/19-20/63
Atomics International, Los Angeles, 3/12-13/64

Atomics International, Los Angeles, 10/13-14/64
Atomics International, Los Angeles, 3/23/24/65

- 3. Same as (h), above.
- k)
 - 1. 17 years technical experience
 - 2. 10 years liquid metals experience
- l) None
- m) -

UNITED NUCLEAR
C O R P O R A T I O N
DEVELOPMENT DIVISION

SCDP History Questionnaire

- a. John M. McKee
- b. Nuclear Development Corporation of America (NDA), later changed to United Nuclear Corporation.
- c. Engineering Advisor, Materials Department
- d. United Nuclear Corporation
5 New Street
White Plains, New York 10601
- e. Same as c.
- f. B.S. in Electrochemical Engineering, MIT, 1940
M.S. in Metallurgy, NYU, 1953
- g. Metallurgist
- h. Liquid metal corrosion, metallurgy of sodium coolant system materials.
- i. Attended one meeting of the SCDP working group to report on development of the Electrochemical Monitor for Oxygen in Sodium at NDA. Believe this was at San Jose, California on October 4, 1961.
- j. Participated in periodic reviews of progress on two SCDP contracts:
 - 1. Mass transfer of steel by sodium at 1200°F, General Electric Co., APED, San Jose, California.
 - 1st Review, January 19 & 20, 1961, San Jose, Cal.
 - 2nd Review, October 2, 3 & 4, 1961, San Jose, Cal.
 - 3rd Review, November 30 & December 1, 1961, COO, USAEC, Argonne, Illinois
 - 4th Review, September 26, 27 & 28, 1962, San Jose, Cal.
 - 5th Review, February 11-15, 1964, San Jose, Cal.
 - 2. Properties of Materials in Sodium, Mine Safety Appliance Research Corporation, Callery, Pa.
 - 4th Review, November 29, 1962, Callery, Pa.
 - 5th Review, February 4 & 5, 1963, Callery, Pa.

UNITED NUCLEAR
C O R P O R A T I O N
DEVELOPMENT DIVISION

Page 2

6th Review, August 19 & 20, 1964, Callery, Pa.
7th Review, March 23 & 24, 1965, Callery, Pa.

See Item h for professional specialties involved.

- k. As of January, 1961, I had 19 years of technical experience and 8 years of alkali metal experience.
- l. I participated as a coauthor in writing review reports on the meetings cataloged under Item j.
 - 1. Report on GE Sodium Mass Transfer Program, January 21, 1961
 - 2. Report #2 on GE Sodium Mass Transfer Program, November 22, 1961
 - 3. Report #3 on GE Sodium Mass Transfer Program, March 13, 1962
 - 4. Ad Hoc Committee Report (#4) on Review of Experimental Investigation of Mass Transfer in 1200°F Sodium Systems, December 12, 1962
 - 5. Ad Hoc Committee Report (#5) on Review of Experimental Investigation of Mass Transfer in 1200°F Sodium Systems, April 1, 1964
 - 6. Reports of the subcommittee for the Investigation of the Mechanical Properties of Materials in High Temperature Sodium performed by MSA Research Corp.:

Review Report No. 4, January 25, 1963
Review Report No. 5, March 4, 1964
Review Report No. 6, November 4, 1964
Review Report No. 7, June 14, 1965
- m. The review group meetings have been characterized by intensive discussion and writing sessions continuing far into the night. The mass transfer review group has spent 12 days at San Jose, California and has never yet found time to spend an evening in San Francisco. This must be a record of some sort.

ANSWERS TO SCDP HISTORY QUESTIONNAIRE

- (a) J. J. Morabito
- (b) Atomic Power Development Associates, Inc.
- (c) Head of Liquid Metal and Steam Systems Section
Head of Design Division
- (d) Atomic Power Development Associates, Inc.
1911 First Street
Detroit, Michigan 48226
- (e) Fermi Project Engineer
- (f) B.M.E., Pratt Institute, 1950
- (g) Engineering
- (h) Heat Exchanger, Heat Transfer, Economics and Sodium Chemistry
- (i) February 27, 1958 to end (member)
- (j) 1. SCTI (subgroup) Nov. 1958 - June 1963
Steam Generator Subgroup - May 1961 - September 1962
Shell Side Heat Transfer Subgroup - January 1961 - October 1961
Steam Cycle Subgroup
- (k) February 1958 (1) 8 years, (2) 4 years

SCDP HISTORY QUESTIONNAIRE

- a. Andrew E. Mravca
- b. U. S. Atomic Energy Commission, Chicago Operations Office,
Argonne, Illinois
- c. Project Coordinator, Fast Reactor Test Facility (FARET) and
Zero Power Plutonium Reactor (ZPPR)
- d. U. S. Atomic Energy Commission
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439
- e. Project Coordinator
- f. Illinois Institute of Technology, B.S. Mechanical Engineering,
graduated January 1957.

International Institute of Science & Engineering, February 1957-
November 1957.

Illinois Institute of Technology, graduate work in Mechanical
Engineering, September 1959 - January 1963, evening program.

St. Procopious College, management program, presently attending.

- g. Reactor engineering
- h. Mechanical engineering
- i. August 1963 to March 1965
Chairman, Steam Generator Ad Hoc Committee

Meetings (information) SCDP:

August 20-21, 1963 at AI
January 16-17, 1964 at Washington, D. C.
April 17-18, 1964 at AI

Contracts AT(11-1)-GEN-8, BLH AT(11-1)-1213 and B&W AT(11-1)-1280

- j. Steam Generator Ad Hoc Committee meetings:
November 19, 1963 at AI
December 18, 1963 at BLH
December 19-20, 1963 at B&W
March 11, 1964 at Santa Monica
March 12-13, 1964 at AI
October 13-14, 1964 at AI

- k. 8 years technical experience
2 years alkali metal experience

- 1. Steam Generator Test Program, Ad Hoc Committee Reports

- Report No. 1, dated November 19, 1963
 - Report No. 2, dated December 23, 1963
 - Report No. 3, dated December 23, 1963
 - Report No. 4, dated March 23, 1964
 - Report No. 5, undated, for March 12-13, 1964 meeting
 - Report No. 6, dated November 25, 1964

- Sodium Component Working Group meetings

- Report No. 1, dated January 16-17, 1964
 - Report No. 2, dated June 11-12, 1964
 - Report No. 3, dated March 3-4, 1965

Charter, memo Mravca to Wensch, dated September 26, 1963

- m. No comment.

SCDP HISTORY QUESTIONNAIRE

- (a) Leonard Newman
- (b) Brookhaven National Laboratory
- (c) Head, Analytical Chemistry Group of the Nuclear Engineering Department
- (d) Brookhaven National Laboratory
% Hot Laboratory
Upton, Long Island, New York
- (e) Same as (c)
- (f) B.S. - Polytechnic Institute of Brooklyn, 1952
Ph.D. - Massachusetts Institute of Technology, 1956
- (g) Chemist
- (h) Analytical Chemist
- (i) Not applicable
- (j) Member of The Standing Committee for Sodium Impurities of The Sodium Components Development Program Working Group, from February 1964 to present.

Meetings -

a. New York Operations Office	Feb. 24, 1965
b. APDA, Detroit	Oct. 15, 1964
c. Argonne National Laboratory	June 30, 1964
d. Hollywood, California	April 17, 1964
e. New York Operations Office	Feb. 18, 1964

- (k) (1) 8 years, (2) 3 years
- (l) None
- (m) None

UNITED STATES
ATOMIC ENERGY COMMISSION
CHICAGO OPERATIONS OFFICE
9800 SOUTH CASS AVENUE
ARGONNE, ILLINOIS 60439

June 23, 1965

Mr. H. Wesley Savage
Oak Ridge National Laboratory
P. O. Box Y
Oak Ridge, Tennessee 37831

Dear Mr. Savage:

Please refer to your letters of March 29, 1965, April 1, 1965, and April 22, 1965, regarding information for the history of the Sodium Components Development Program.

The following is in response to the SCDP History Questionnaire which was enclosed in your March 29, 1965, letter.

- a. John J. Purcell
- b. AEC-CH
- c. Reactor Engineer
- d. AEC-CH
- e. Reactor Engineer
- f. BS Mechanical Engineering; graduate of International School of Nuclear Science and Engineering.
- g. Engineer
- h. Sodium Component
- i. Attended the following Working Group Meetings:

January 16 and 17, 1964	-	Washington
April 14 and 15, 1964	-	Hollywood
November 16 and 17, 1964	-	Chicago
March 3 and 4, 1965	-	San Francisco
June 18, 1965	-	Chicago
- j. Attended the following Standing Committee Meetings:

Meeting No. 5 February 4 and 5, 1964	at MSAR
Meeting No. 6 August 19 and 20, 1964	at MSAR
Meeting No. 7 March 23 and 24, 1965	at MSAR

Mr. H. Wesley Savage

- 2 -

June 23, 1965

k. As of September, 1963, when I was assigned to the committee, I had eight years engineering experience, three years in the field of sodium cooled reactors.

l. Not applicable

m. Not applicable

Your letter of April 1, 1965, requested information regarding the Standing Committee on Mechanical Properties of Materials in Sodium. The following is a list of meetings and reports. Our records show that you have received a copy of all these reports:

Meeting No. 1 held May 25, 1960 - reported June 10, 1960.
Meeting No. 2 held February 15, 1961 - reported February 28, 1961.
Meeting No. 3 held January 9, 1962 - reported February 15, 1962.
Meeting No. 4 held November 29, 1962 - reported January 25, 1963.
Meeting No. 5 held February 4 and 5, 1964 - reported March 4, 1964.
Meeting No. 6 held August 19 and 20, 1964.

Your letters of April 22, 1965, state that questionnaires were sent to Atomic Power Development Associates, Battelle Memorial Institute and Mine Safety Research Corporation. We could not add any information to that to be provided by these contractors. If the information provided by these contractors is not adequate, please let us know.

Sincerely yours,

John J. Purcell

SCDP History Questionnaire

- a. H, Wesley Savage
- b. Oak Ridge National Laboratory
- c. Head, Engineering Development Department, Reactor Division
- d. Oak Ridge National Laboratory, P. O. Box Y, Oak Ridge, Tennessee 38730
- e. same as (c)
- f. B. S. in ME, Tufts College, 1935
- g. Mechanical Engineering
- h. Experimental engineering, corrosion and mass transfer,
shell side heat transfer, contractor performance evaluations,
sodium technology
- i. Member - August 5, 1958 to present
 - 1. Technical coordinator - SMT program, 1960 to present
 - 2. Shell side heat transfer subcommittee
 - 3. Task force on 2 new GE loops
 - 4. History of SCDP - June 1964 to present
- j. to be supplied
- k. as of August 1958 - 23 years technical experience
- 8 years liquid metal experience
- l. (to be supplied)

SCDP QUESTIONNAIRE(a) NAME:

Fred A. Smith

(b) ORGANIZATIONAL AFFILIATION DURING PERIOD WHEN ACTIVE WITH SCDP:

ANL-1958-1960, AEC-COO-1960-1963, ANL-1963 - present

(c) TITLES OF YOUR POSITION DURING PERIOD WHEN ACTIVE WITH SCDP:

ANL-1958-1960 Associate Physicist

AEC-COO-1960-1963 Branch Chief, Sodium Reactors

ANL-1963 - present Associate Nuclear Engineer

(d) PRESENT ORGANIZATIONAL AFFILIATION AND ADDRESS:

Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60440

(e) PRESENT POSITION:

Associate Nuclear Engineer

(f) UNDERGRADUATE AND GRADUATE DEGREES, INSTITUTION, AND DATE:

B. S., Physics and Mathematics Roanoke College, 1943

(g) PRESENT BASIC PROFESSION:

Physicist; Nuclear Engineer

(h) PROFESSIONAL SPECIALTIES PREDOMINANT IN YOUR SCDP WORK:

Sodium system components, design and operation

(i) BEGINNING AND ENDING DATES AS MEMBER, ALTERNATE, OR SPECIAL ATTENDEE (DESIGNATE WHICH) FOR SCDP WORKING GROUP OR COMMITTEE:

Jan. 30, 1957, Sodium Heat Exchanger Meeting, member
Apr. 25, 1958, Technical Consultant, Sodium Components,
Selection Board

1. IF YOU WERE AN ALTERNATE, A SPECIAL ATTENDEE, LIST MEETINGS ATTENDED:

Not applicable

2. LIST WORKING GROUP TECHNICAL ASSIGNMENTS AND DATES WHERE KNOWN:

Feb. 27, 28, 1958 Functional Spec. for S. G. & H. X. -
Part of a group effort.

SCDP QUESTIONNAIRE

-2-

Aug 5, 1958 "Current Sodium Component Development Tests at ANL", F. Smith & W. Simmons presented at Information Meeting, AEC Germantown, for potential industrial sodium component manufacturers.

Nov. 15, 1958 "Sodium Frosting Research", a memo from E. Smith to T. A. Nemzek suggested a work scope for Sodium Frosting research: no action taken because of priority of other activities.

Nov. 26, 1958 "Sodium Components Test Facility", F. Smith to T. A. Nemzek, memo, presenting functional specifications for a building to test large sodium components.

May 26, 27, 1958 Presentation by F. Smith for Working Group in "Sodium Frosting", "Purification", and "Sodium Sampling".

3. IF AN AEC MEMBER, LIST SPECIFIC CONTRACTS ADMINISTERED, GIVING CONTRACT TITLE, NUMBER, BEGINNING AND ENDING DATES:

A.E.C. - R.E.D. Personnel were not contract administrators. Contract administration at C.O.O. is a function of the Contracts Division. However, while at C.O.O., I assisted the Contract Administrators with technical matters for the following subject contracts:

Test Facility:	A.1.
O ₂ Meter:	BMI, & UNC
Mars Transfer:	GE (also Carbon Round Robin)
Mech. Properties:	MSA
Steam Generator II:	B&W
Blake Meter:	APDA

The time span of my work associated with above tasks was from 1960-1963 where as Branch Chief, Sodium Reactor, I was responsible for technical direction of Sodium Components Program.

(k) AT THE TIME OF YOUR STARTING DATE, STATE (1) YOUR YEARS OF TECHNICAL EXPERIENCE, AND (2) YOUR YEARS OF ALKALI METAL EXPERIENCE:

Years of technical experience as of 1958 were from 1943-1958 or 15 years.

Years of alkali metal experience as of 1958 were from 1947-1958 at ANL or 11 years.

(1) LIST TECHNICAL DOCUMENTS (PROPOSALS, ETC.) TO OR FOR SCDP WORKING GROUP PREPARED BY YOU OR FOR WHICH YOU WERE RESPONSIBLE, WITH DATES, ETC.

See item 1, 2 above.

SCDP QUESTIONNAIRE

-3-

In addition, I prepared the initial work scope (with T. P. Heckman and R. E. Harris) for the 2nd Steam Generator Contract.

I was responsible for planning and editing the document TID-3029 "Sodium Heated Steam Generator Summary", Sept. 19, 1962, which was conceived as an necessary adjunct to the 2nd Steam Generator Study.

(m) PROVIDE ADDITIONAL IN THE FORM OF BRIEF, TERSE EXPLANATION OR AS COMMENTS PERTINENT TO SCDP, ITS HISTORY AND EVOLUTION.

The need for the SCDP was correctly identified by Dr. G. W. Wensch USAEC, when he called together the first Sodium Heat Exchanger Meeting on January 30, 1957.

As a consequence of that meeting, it was evident that the USN was not going to support further sodium heated steam generator development under the Sea Wolf Program. The civilian sodium power development programs of EBR II, FERMI, AND HNPF were limited to about 950°F steam generation. There was a need for a separate non-nuclear test program (like the Navy Alplause Test Program) to develop an industrial design basis for steam generation of advance temperature and pressure of the units associated with reactor projects current in 1958.

At a follow up of the January 30, 1957 ad hoc Working Group meeting, the following general objection was developed which acted as a guide for subsequent action of the AEC. These objectives were and are:

OBJECTIVES AND PURPOSE OF SODIUM COMPONENTS WORKING GROUP

1. To assist in the development of improved and more reliable, at less cost, components for sodium and other liquid metal systems through:
 - a. Recommending components for development and establishing priority of effort.
 - b. Critically analyzing and reviewing designs of components submitted.
 - c. Suggesting, reviewing and commenting on proposed development programs for specific components.
 - d. Suggesting tests to be carried out on components and the place where these tests should be conducted.
 - e. Suggesting functional specifications and such other specifications as warranted for components to be developed.
2. To coordinate supplementary development programs on components which are under way at contractor sites.
3. To serve as a general technical advisory group to the AEC in the area of liquid metal system components.

-4-

The AEC-Sodium Components Working Group added members from both Industry and the National Laboratories. The Working Group acted at all times as a technical advisory group with both the AEC and the industrial advisers acting in a manner as to preclude a conflict of interest within the Working Group.

The principal component which this group focused attention was a sodium heated steam generator development program. Because of the working knowledge of Working Group Members, other development programs were considered by the AEC as needing additional technical support to gain a 1200°F temperature capability. Specific areas studied were the mechanical properties of several available structural materials in 1200°F Na.; a mass transfer program used the same structural materials with several dynamic duplex material loops logging over 15,000 hours at temperatures from 850°F to 1300°F. In addition were studied a number of different methods of oxygen analysis, a continuous monitor of oxygen in sodium, a 10" flow control device was successfully tested, and a hydrogen detector was developed and tested.

The principal accomplishment of the AEC and the SCDP has been to provide a Steam Generator Test Facility at Atomic International which is designed to have a 35 MWT heat input capability. This non-nuclear facility is nearly operable and one Steam Generator is ready for test; two other types of steam generators are in the design and construction stage. A paramount feature of the test facilities is the ability to test Steam Generators and other engineering components without the conservative regard which is required for a nuclear facility.

Some operational shake-down will be required of this unique and specialized complex test stand. Operation of the facility and tests of steam operation of different designs can be a large factor in providing an adequate design basis for the components for subsequent nuclear plants. This facility will, therefore, provide a means of realistically reducing the unit cost of future units.

The time span to conduct the variety of tasks briefly described above has been well within the time span of the completion and initial power operation of EBR II, FERMI, and HNPFF. One can conclude, therefore, that the AEC-DRD has shown commendable and consistent good judgement in the difficult task of establishing priorities for events in both the reactor projects and the non nuclear SCDP.

Since both FARET and SEFOR are to be built without steam generation, the SCDP is the only mechanism by which experience can be gained with high performance sodium heated steam generators.

The SCDP has spanned a period of time from 1958 to the present with changes in both AEC and non AEC personnel. The past years, as well as the future evolution of economic sodium heated steam generators is a parody of Edison's statement that genius is 99% perspiration.

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DEVELOPMENT DIVISION

5 NEW STREET
WHITE PLAINS, NEW YORK 10601
WHITE PLAINS 8-5800

In Reply Refer
To: MTL-4610

April 27, 1965

Mr. H. Wesley Savage
Oak Ridge National Laboratory
Post Office Box Y
Oak Ridge, Tennessee

Re: Your letter and questionnaire of March 29, 1965

Dear Wes:

I shall attempt to answer your SCDP history questionnaire as completely as my records permit.

- a. George Stern
- b. Nuclear Development Corporation of America (NDA)
United Nuclear Corporation (United Nuclear Corporation
resulted from a merger of NDA with several other
organizations. The period covered is approximately
May 1960 to February 1962.)
- c. Manager, Materials Department (NDA)
Manager, Materials Research Department (UNC)
- d. United Nuclear Corporation (UNC), 5 New Street,
White Plains, New York, 10601
- e. Manager, Materials Research Department (UNC)
- f. B.Ch.E., College of the City of New York, 1937
M.S. in Metallurgical and Chemical Engineering,
University of Michigan, 1939
- g. Metallurgist

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C O R P O R A T I O N
DEVELOPMENT DIVISION

MTL-4610
Page 2

- h. Metallurgy-Physical Metallurgy, Materials Testing, Metallography and Liquid Metal Technology.
- i. I was not a member or alternate of the SCDP working group or committee. However, I was a special attendee to several of their meetings at which time I reported on the work our company was doing on the Electrochemical Monitor for Oxygen in Sodium. I definitely attended a meeting at Lincoln, Nebraska and a meeting at Palo Alto on August 20-21, 1963.
- j. My records are not complete in regard to this subject. It would be well to check with COO, since a member of their staff attended each meeting held and undoubtedly kept complete records. The following dates all apply to my membership in the SCDP subcommittee concerned with the MSA work on liquid metal:

May 24-25, 1960 - Pittsburgh
February 15, 1961 - Pittsburgh
January 9, 1960 - Pittsburgh

The broad technical assignment was to critically review the MSA contract.

- k. As of May 24, 1960, I had 21 years of technical experience since receiving my M.S. degree at the University of Michigan. As of May 1960, I had 3 years of experience with alkali metals.
- l. The subcommittee working on the MSA contract issued reports on June 10, 1960 and on February 15, 1962. These reports will be more precisely referenced in the response of K. Goldmann of United Nuclear.
- m. It is my opinion that the subcommittee appointed by the SCDP to work on the MSA contract performed a valuable function:
 - 1. It clarified and defined the work scope of the contractor. The contractor's initially proposed work scope was not responsive to the needs of the SCDP.
 - 2. It exerted a strong influence on the contractor to hire metallurgical consultants and metallurgists which were missing from his staff.

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MTL-4610
Page 3

3. It reviewed progress of the work to assure that meaningful and significant results were obtained.

Sincerely yours,

George Stern,
Manager
Materials Research Department

GS/mbs

cc: K. Goldmann
M. M. Shapiro
Jules Wise - NYOO

SCDP HISTORY QUESTIONNAIRE

- (a) T. Trocki
- (b) General Electric Company, Atomic Power Equipment Department
- (c) Specialist, Nuclear Technology, Advance Engineering
- (d) Same
- (e) Manager, Core and Fuel Design Unit, Engineering Section
- (f) BSME, University of Pittsburgh
- (g) Mechanical - nuclear engineering
- (h) Mechanical engineering, chemical engineering
- (i) Member SCDP - Early 1958 to December 1958
- (j) Not applicable
- (k) 17 years technical experience - 6 years liquid metal experience
- (l) None

- (a) Glenn R. Waterbury
- (b) Los Alamos Scientific Laboratory, University of California
- (c) Assistant Group Leader, Chemical and Instrumental Analysis Group
- (d) Los Alamos Scientific Laboratory
Box 1663, Los Alamos, New Mexico, 87544
- (e) Same as (c) above.
- (f) BS, Chemistry, Colorado State University, 1944
PhD, Physical Chemistry, Iowa State University, 1952
- (g) Chemistry (analytical)
- (h) Analytical chemistry of the alkali metals
- (j) 1. Subcommittee on Sodium Impurities of the AEC Sodium Components Development Working Group. (The name was changed recently to Standing Committee for Sodium Impurities)
Acting member: February 18, 1964 to October 15, 1964; Member: October 15, 1964 to date
2. Meetings of this subcommittee attended:
February 18 and 19, 1964, New York Operations Office, Atomic Energy Commission; April 17, 1964, Hollywood, California;
June 30, 1964, Argonne National Laboratory, Le Mont, Illinois;
October 15 and 16, 1964, Detroit, Michigan;
February 24, 1965, New York Operations Office, AEC, New York
3. Analytical chemistry of alkali metals, especially sodium
- (k) 1. 18 years
2. 5 years
- (l) Assisted in formulating reports of the subcommittee (see report of Jules Wise or Joseph Dissler, subcommittee chairmen, who were the authors of these reports)

INTRA-LABORATORY CORRESPONDENCE**OAK RIDGE NATIONAL LABORATORY**

April 5, 1965

To: H. W. Savage

Re: SCDP History Questionnaire

- a. J. C. White
- b. Oak Ridge National Laboratory
- c. Assistant Director, Analytical Chemistry Division
- d. Oak Ridge National Laboratory, P. O. Box X, Oak Ridge, Tenn. 37831
- e. Same as (c).
- f. B. S. - Indiana University - 1943
M. S. - Ohio State University - 1948
Ph.D. - Ohio State University - 1950
- g. Chemist
- h. Direct research and development of analytical methods for molten salts, alkali metals, radio- and nuclear chemistry.
- i. None.
- j. Member, Subcommittee for Methods of Analysis - 1963 to present.
 - 1. -
 - 2. April 14-16, 1964, Hollywood, California.
(Moderated panel discussion on Methods of Analysis).
October 15,16, 1964, Detroit, Michigan.
February 24,25, 1965, New York, New York.
 - 3. -
- k. (1) 15 years technical experience
(2) 15 years of alkali metal experience.
- l. None.
- m. None.

J. C. White

ez

UNITED STATES
ATOMIC ENERGY COMMISSION
NEW YORK OPERATIONS OFFICE
376 HUDSON STREET
NEW YORK 14 NEW YORK

TELEPHONE NO
YUKON 9-1000

REFER TO

R:JW:SCDP:1.1

April 21, 1965

Mr. H. Wesley Savage
Oak Ridge National Laboratory
P. O. Box Y
Oak Ridge, Tennessee

SUBJECT: SODIUM COMPONENTS DEVELOPMENT PROGRAM HISTORY

Dear Mr. Savage:

In reply to the request in your March 29 and April 1 letters, I am furnishing you below the information you asked for your use in preparing the SCDP history. I have limited my reply for specific applicability to the SCDP. The alphabetical designations through (m) correspond to those in your March 29 letter.

- (a) Jules Wise
- (b) U.S. Atomic Energy Commission (New York Operations Office)
- (c) Project Engineer and Senior Project Engineer
- (d) U.S. Atomic Energy Commission, New York Operations Office,
376 Hudson Street, New York, N. Y. 10014 (Telephone:
212 YU 9-1000)
- (e) See (c)
- (f) College of the City of New York B Ch E 1938
University of Michigan MS 1939
- (g) Nuclear engineering
- (h) Project engineering, sodium impurities, sodium reactor
components, sodium reactors
- (i)&(j)
Membership in SCDP

SCDP Working Group	Member	April 1963 - Feb. 1965
Standing Committee for	Chairman	Jan. 1964 - Feb. 1965
Sodium Impurities	Member	Feb. 1965 - Present

Mr. H. Wesley Savage

-2-

April 21, 1965

Meetings Attended

Working Group: 5/13-14/63; 8/20-21/63; 1/16-17/64;
4/15-16/64; 6/11-12/64; 11/16-17/64

Location information should be in your records.

Standing Committee: 2/18-19/64; 4/17/64; 6/30/64;
10/15-16/64; 2/24/65

Minutes attached show locations and give more information.

AEC (NY) SCDP Contracts Information

See my letter to you dated April 13, 1965.

- (k) Technical experience: Since 1939
- Alkali metal experience: Since 1960
- (1) i - Long Range Sodium Components Development Program
 - See my letter to you dated April 13, 1965.
 - ii - Program for Development of Analytical Procedures for Sodium Contaminants Analysis (Memorandum from J. J. Dissler to G. W. Wensch, R:JW:SCDP, dated March 1, 1965) (Copy attached)
- (m) Standing Committee for Sodium Impurities Membership
 - i - Chairmanship transferred from T. Heckman (CHO) to J. Wise (NYO) January 1964
 - ii - Membership at that time
 - R. Bane (ANL), D.T. Eggen (AI), R.W. Lockhart (GE), C.F. Metz (IASL), L. Newman (BNL), J.C. White (ORNL), J. Wise (NYO)
 - iii - Membership change about March 1964-F. A. Smith (ANL) added.
 - iv - Membership change about January 1964-D. T. Eggen (AI) and R.W. Lockhart (GE) left the committee
 - v - Membership change October 1964
 - G.R. Waterbury (IASL) replaced C.F. Metz (IASL)
 - vi - Membership change about December 1964
 - A. Romano (BNL) added
 - vii - Change January 1965
 - J.J. Dissler (NYO) replaced J. Wise (NYO) as Chairman.
 - J. Wise retained membership.

Sincerely yours,

Jules Wise, Project Engineer
Reactor Development Division

Enclosures:

As stated above

APPENDIX G
MONTHLY COORDINATION REPORTS

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JANUARY 1962

I. A.

<u>Current Projects</u>	<u>Contractors, Address, Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
1. Heat Exchanger & Steam Generator	Alco Products, Inc. Schenectady 5, N.Y. L. E. Phillips	AT(11-1)-666	CH
2. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
3. Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
4. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
5. Flow Controllers	Westinghouse Electric Corp., Atomic Power Dept., P. O. Box 355, Pittsburgh 30, Pa. J. P. Thorel	AT(11-1)-681	CH
6. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
7. (SAN) Mass Transfer	General Electric Co. Atomic Power Equip- ment Dept., P. O. Box 254, San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
8. (NYOO) Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N.Y. H. Steinmetz	AT(30-1)-2877	NYOO
9. (NYOO) Consulting	United Nuclear Corp. 5 New Street White Plains, N.Y. K. Goldmann	AT(30-1)-2834	NYOO
10. Low Level Oxide Analysis (Blake Meter)	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. A. P. Donnell	AT(11-1)-865 #3	CH

<u>Current Projects</u>	<u>Contractors, Address, Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
11. Consulting	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. J. J. Morabito	AT(11-1)-865 #1	CH

B. STATUS REPORT FOR SODIUM COMPONENTS DEVELOPMENT PROGRAM

1. OBJECTIVE

The objective of the Sodium Components Development Program is closely related to the known problems associated with the existing sodium cooled reactors and the assumption that improved sodium cooled reactors are needed. The existing sodium cooled reactor plants represent an investment of well over \$200,000,000. They also represent a potential of supplying various power needs that are both unique and competitive with existing sources of power. The specific objective of the program is to develop within industry a competence for the manufacture of reliable and economic non-nuclear components common to all types of sodium cooled reactors for civilian power application.

Sodium as a reactor coolant in comparison to other coolants shows several potential advantages, such as: (a) low initial cost of the coolant, (b) ability to reach high temperatures at low pressure, (c) low neutron cross sections, (d) low melting point, (e) high boiling point, (f) large heat transfer coefficient, (g) compatible with conventional materials at temperatures up to 1200°F, (h) thermal stability, and (i) radiation stability.

These known properties aim naturally to the improvement of the existing reactors by raising the temperature, the heat flux, and other performance specifications, thereby resulting in more economical power generation. To support proposed advanced reactor designs, the technology of sodium and the technology of the containing materials must be advanced.

Industry has been and will be invited to assist the sodium cooled reactor program by research and development of component parts that make up the "conventional" part of a power plant.

2. HISTORY

The Sodium Components Development Program was initiated by the Division of Reactor Development in the Fall of 1957 as a Headquarters activity. Following a series of information meetings between industry and the AEC, the first contracts were let in June 1958 for studies of heat exchangers and steam generators. In October 1958, the direction and administration of the program was transferred to the Chicago Operations Office (CH). Other contracts were then initiated by CH in 1958 and 1959. The original (and continued) goal of the program was to develop within industry the competence for manufacturing reliable and economic components for use in connection with the

existing and with advanced sodium cooled nuclear reactor central station power plants. The original target was to have components capable of using 1200°F sodium from the reactor and delivering 1050°F steam at 2200 psi to the turbine, available by 1963.

3. COMPLETED PROJECTS

a. Seawolf Examination

The results of an examination in 1959 of the reactor system are contained in an unclassified report, NDA 2114-2, titled "Radioactive Mass Transfer, Sodium Activation, and Component Examination in the Seawolf Power Plant." Classified data from the same investigation are included in NDA 2114-1. The examinations revealed no deleterious effects to a degree that would question the use of sodium as a coolant in civilian power reactors. The problem of separating sodium from H₂O, however, will require improved designs of steam generators and superheaters.

b. Low Level Oxide Analysis

The results of the BMI study are included in the topical report, BMI-1538, titled "Determination of Oxygen in Sodium at Concentrations Below 10 ppm." This study surveyed all of the methods that had even a slight possibility of working. The more probable methods were investigated in the laboratory without success. The wet chemical method that was developed by other investigators was referenced but was not worked on. UNC-NDA proposed refinements to the wet chemical method which is reported in NDA 2154-6, "Experimental Determination of Contaminants in Sodium."

c. Hydrogen Detection in Sodium

The feasibility studies performed by AI were satisfactory; the work was therefore extended to include the development of a continuous detection device. A topical report by AI summarizing this work is NAA-SR-6986. The method selected by AI as most practical was the diffusion of H₂ through a Ni membrane for the separation of H₂ from sodium, followed by the detection of H₂ by a mass spectrometer. The same materials and instruments were incorporated into an integral instrument for power plant use.

d. Flow Controllers

The 12-inch controller development by Westinghouse Electric Corporation has been terminated following the failure of the ball bearings during the 1000°F gas test. Disposition of this component is under study with the intent to simplify the mechanical linkage and subject to high temperature, flowing sodium tests. A similar design study by Crane Company was terminated after a survey and preliminary design of a flow controller was submitted to the AEC. A third investigation of the same problem by Ohio Injector Company was considered successful and is reported in NAA-SR-TDR-6081.

4. STATUS OF ALL CURRENT PROJECTS

a. Test Facility

The test facility has been considered the means by which the major components of the Sodium Components Development Program will be

proven out. The objectives of the program are to assist all sodium cooled nuclear power projects by providing, through industry, the capability to produce components that will have:

- (1) Greater operating reliability
- (2) Higher thermal performance
- (3) Lower capital and operating costs
- (4) Wider system applicability

To assure the program that such a facility would provide the services considered essential to the attainment of these objectives, proposals were invited and reviewed, and a contract awarded to the Atomic Power Development Associates, Inc. (APDA) for the performance of a design study.

Following the study, the existing prospective facilities were canvassed, and portions of the Atomics International (AI) installation at Santa Susana were selected for modification to serve as the sodium test facility. AI initiated the design and equipment lists during November 1960.

The present schedule for the test facility is co-ordinated with the fabrication of a 30 MW IHX (intermediate heat exchanger) and a 30 MW steam generator to allow startup and testing in the fall of 1962.

b. Intermediate Heat Exchanger and Steam Generator

Following three independent studies of new concepts during FY 1958, the study contract with Alco Products, Inc. was extended to include R&D, detail design, and fabrication of one 30 MW IHX and one 30 MW steam generator. Alco Products, Inc. was authorized during February 1961 to initiate detail shop drawings and to issue material purchase orders for the IHX.

The schedule for these two units includes delivery of the IHX to AI by September 1962 and delivery of the steam generator by November 1962.

c. Flow Controllers

The 10-inch controller fabricated by the Ohio Injector Company was delivered to AI and has been subjected to flow and thermal shock tests. These tests indicated the need for minor corrections which are being made by AI. Results of the tests are reported in document NAA-SR-TDR-6081.

d. Low Level Oxide Analysis

Results were reported in NDA 2154-6, "Experimental Determination of Contaminants in Sodium," August 30, 1961. Because of the limited prospects for the BMI approach, a proposal by the Nuclear Development Associates, Division of United Nuclear Corporation (NDA) to investigate wet chemical methods to solve the identical problems was accepted. This work was continued at UNC in FY 1961 and completed early in FY 1962. This work is to be extended to refine the technique within the limits of available funds.

e. Continuous Oxygen Concentration Meter

Whereas the contracts with BMI and NDA were for establishing absolute techniques, or standards, for measuring oxygen, additional investigations are needed for the development of monitoring devices to show relative effects or changes in the sodium of an operating plant.

An instrument developed by Dr. Blake of the U.K. appears to have the capabilities for performing this task. The work of testing and evaluating an actual meter was assigned to APDA where a test rig has been assembled. UNC is also working on a continuous monitoring device which was considered a logical continuation of their effort on oxide analysis and is reported in "Development of a Continuous Meter for Oxygen in Sodium," UNC-5000, dated January 15, 1962.

f. Mass Transfer Studies

A better understanding of the behavior of materials of construction for sodium cooled systems in the 1200°F range is considered essential. GE was awarded a contract and has constructed six dynamic loops for the investigation of the mass transfer phenomena as related to: types of material, temperature, temperature differential, velocity, oxygen content, possible other contaminants, and time.

Although measurable effects, much greater than originally anticipated, have been noted in the first runs, these effects are still not cause for alarm. Also, the first runs were intentionally made with oxide concentrations much higher than would be normally permitted in an operating plant. The data collected from the first series of loop experiments are being subjected to statistical analysis in the attempt to establish a mathematical model to explain the mass transfer phenomena. To adequately understand the effects of all of the variables that appear to contribute to the corrosion, additional test equipment such as different geometrical configurations is presently needed.

g. Physical Properties of Materials

Other properties of the materials of construction for sodium cooled systems in the 1200°F range that are considered essential are: creep, tensile strength, fatigue strength, and resistance to thermal fatigue. A contract was awarded to the Mine Safety Appliance Research Corporation (MSA) to investigate these physical properties for representative ferritic and austenitic steels under various sodium environments.

This project was delayed to allow for an extended critical review by specialists in this type of work. The review resulted in several changes in the procedures of running the tests. The loops are now in the detail design, procurement, and fabrication stage. Actual testing is estimated to start during the third quarter of FY 1962. Thermal shock tests originally contemplated have been deferred indefinitely.

5. STATUS OF ANTICIPATED ADDITIONAL PROJECTS

Steam Generators

Exclusive of the reactor core, the one single component that is most important to the reliable and economical operation of a sodium cooled

power plant is the steam generator. Therefore, the emphasis to any additional work will be directed to exploring new or improved ways of designing steam generators.

A scope of work has been prepared for a study which would define the optimum conditions for a second generation steam generator. Operating conditions as a function of cost would be determined so that in soliciting new steam generator design proposals, the proposers can be given limits within which to propose. It is expected that a second generation steam generator would be contracted for after completion of the study. This unit would be tested in the SCTI following completion of tests on the Alco unit.

Appendices:

A - Schedule, Sodium Components Test Installation

II. MEETINGS

Jan. 9, 1962	Subgroup and MSAR, Physical Properties of Materials, Callery, Pennsylvania.
Jan. 10, 11 & 12	Working Group, Including Alco and AI, Argonne, Illinois.
Jan. 23, 1962	AEC, Alco, and Superior Tube, Norristown, Pennsylvania.

III. CH CORRESPONDENCE AND PROGRESS REPORTS

Jan. 3, 1962	Memo, F. A. Smith, CH, to C. W. Richards, CPAO, re "Fission Product Release from Large Sodium Fires."
Jan. 3, 1962	Letter, L. E. Phillips, Alco, to T. A. Nemzek, CH, and Working Group transmitting progress report dated Dec. 13, 1961, plus Revised Functional Specifications for 30 MW IHX and Steam Generator.
Jan. 4, 1962	Letter, T. A. Nemzek, CH, to R. W. Dickinson, AI, inviting D. Casey, R. Cygan, and Bill Anderson to Working Group meeting January 10, 11 & 12, 1962.
Jan. 4, 1962	Letter, A. P. Donnell, APDA, to Fred C Mattmueller, CH, re status of the equipment for testing a Blake meter.
Jan. 5, 1962	Memo, T. A. Nemzek, CH, to Joel V. Levy, CPAO re testing of first tube bundle, Shell Side Heat Transfer.
Jan. 5, 1962	GE Progress Letter No. 30 on "Mass Transfer Investigation in Liquid Metal Systems."
Jan. 5, 1962	Letter, Kurt Goldmann, UNC, to J. D. Hart, NYOO, UNC Monthly Letter No. 4 re consulting services under Contract AT(30-1)-2834.

Jan. 9, 1962 Letter, Professor B. E. Short, University of Texas, to T. A. Nemzek, CH, re financial support for heat transfer studies by doctoral students.

Jan. 9, 1962 Memo, T. P. Heckman to File, Trip Report of January 9, 1962, to MSAR with Materials Subgroup of the Sodium Components Development Program Working Group.

Jan. 12, 1962 Letter, W. R. Wykoff, LASL, to Working Group, K-3 Monthly Progress Report K-3-449 on Steam Generator Test Loop Examination.

Jan. 15, 1962 NAA-SR-5732, "Detection Device for Hydrogen in Sodium."

Jan. 15, 1962 Letter, H. Steinmetz, UNC, to J. Wise, NYOO, Monthly Progress Report No. 4 on development of a continuous oxygen in sodium meter.

Jan. 16, 1962 MSAR Corporation Progress Report No. 16 on "Effect of 1200 F Sodium on Austenitic and Ferritic Steels."

Jan. 16, 1962 Letter, L. E. Phillips, Alco, to T. A. Nemzek, CH, re a meeting among AEC, Alco, Superior Tube, and Allegheny Ludlum concerning bimetallic tubes for steam generators.

Jan. 17, 1962 Letter, F. C. Mattmueller, CH, to J. H. Driscoll, WEC, re shipping of sodium flow controller to AI.

Jan. 18, 1962 Memo, T. A. Nemzek, CH, to J. V. Levy, CPAO, transmitting "Revised Functional Specifications for 30 MW IHX and Steam Generator" in reply to TWX from Levy requesting same.

Jan. 19, 1962 Letter, T. A. Nemzek, CH, to Professor B. E. Short, University of Texas, advising on where to submit a proposal for doing heat transfer studies.

Jan. 22, 1962 TWX, T. A. Nemzek, CH, to R. H. Ball, SAN, concurring in need for two additional mass transfer investigation loops.

Jan. 22, 1962 Memo, T. A. Nemzek, CH, to File, "Summary of Recommendations by Sodium Components Development Working Group - January 10, 11, and 12, 1962."

Jan. 24, 1962 Letter, T. P. Heckman, CH, to J. F. O'Sullivan, Tracerlab, thanking for inquiry re hydrogen detection and referring to AI report NAA-SR-6986.

Jan. 25, 1962 Letter, T. A. Nemzek, CH, to Kurt Goldmann, UNC; G. Stern, UNC; W. F. Anderson, AI; J. H. DeVan, ORNL, with copies to J. R. Menke, UNC; S. Siegel, AI; and A. M. Weinberg, ORNL, expressing thanks for serving on Materials Subgroup of the Sodium Components Development Program.

Jan. 25, 1962 Letter, J. M. McKee, UNC, to H. W. Savage, ORNL; to D. I. Sinizer, AI, re AI's report on mass transfer in pump loop at AEC-NASA meeting.

Jan. 30, 1962 Memo, F. A. Smith, CH, to C. A. Pursel, CH, Subject: "Trip Report: Superior Tube Company, January 23, 1962 - Companies Represented: Allegheny Ludlum, Superior Tube Company, Alco Products, Inc., USAEC."

Jan. 31, 1962 Letter, W. A. Glaeser, BMI, to S. G. Nordlinger, Chief, Reactor Components Development Branch, DRD, re direction from Working Group of Sodium Components Development Program on problem of surface sticking between mated parts submerged in sodium for long periods.

Jan. 31, 1962 Letter, T. A. Nemzek, CH, to R. W. Lockhart, GE, re visit of two MSA scientists and T. P. Heckman to GE on February 7, 1962.

Jan. 31, 1962 Memo, T. A. Nemzek, CH, to R. E. Harris, DRD, re "Minutes of Sodium Components Development Program Meeting No. 26."

Modification No. 5 to AT(11-1)-666 with Alco Products, Inc., heat exchangers and steam generators.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
FEBRUARY 1962

I. Listing of Current Projects

<u>Current Projects</u>	Contractors, Address, <u>Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger & Steam Generator	Alco Products, Inc. Schenectady 5, N. Y. L. E. Phillips	AT(11-1)-666	CH
b. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
c. Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
d. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e. Flow Controllers	Westinghouse Electric Corp., Atomic Power Dept., P. O. Box 355, Pittsburgh 30, Pa. J. P. Thorel	AT(11-1)-681	CH
f. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g. Mass Transfer	General Electric Co. Atomic Power Equip- ment Dept., P. O. Box 254, San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
h. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYOO
i. Consulting	United Nuclear Corp. 5 New Street White Plains, N. Y. K. Goldmann	AT(30-1)-2834	NYOO
j. Low Level Oxide Analysis (Blake Meter)	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. A. P. Donnell	AT(11-1)-865 #3	CH

<u>Current Projects</u>	<u>Contractors, Address, Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
k. Consulting	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. J. J. Morabito	AT(11-1)-865 #1	CH

II. Status of All Current Projects

- a. Intermediate Heat Exchanger & Steam Generator - Alco Products, Inc.
Contract AT(11-1)-666

The schedule for the 30 MW Intermediate Heat Exchanger and the 30 MW Steam Generator, designed and fabricated by Alco Products, Inc. to be used in conjunction with the Sodium Components Test Installation, includes the delivery of IHX to AI by September 1962 and delivery of the Steam Generator by November 1962.

- b. Test Facility - Atomics International - AT(11-1)-8

Construction on the SCTI continued during February. Heater erection is now 70% complete. Purchasing instructions have been issued for the following: control panel, small sodium valves, and a 10 MW sodium cooler. Purchase orders have been placed for the sodium heater burners, furnace preheater coils, and the boiler feed pump speed control. A method has been developed whereby sodium flow in the furnace section can be continued even though the burners have flamed out. A new design of a mixing tee for the sodium system has been conceived which will incorporate the low pressure drop requirements. Design work has been completed on the next construction package which will be the foundations for the condensate pump, sodium tanks, feedwater heaters, and deaerator.

- c. Valve Test - Atomics International - AT(11-1)-8

The Ohio Injector Corporation flow controller has completed 226 of the 500 scheduled thermal shocks in the high temperature range (1200°F to 1025°F) without being damaged.

- d. Physical Properties of Materials - MSA - AT(11-1)-765

MSA Research Corporation continued to investigate the physical properties of representative ferritic and austenitic steels under various sodium environments. Fatigue testing of a 316 stainless steel specimen at 1200°F in air on a 26" mandrel was discontinued after 212,750 cycles. The two loops for fatigue, creep, and stress testing are undergoing testing operations and revisions. New specimens have been received for these tests. The University of Michigan and MSAR have signed the contract for creep, stress, and tensile tests in air and helium, but it has not been approved by the AEC.

Work on the thermal shock tests has been halted because of contemplated AEC revision of the program.

e. Mass Transfer - General Electric Company - AT(04-3)-189 #15

GE's mass transfer activities during January consisted of the operation and modification of the six dynamic test loops, the analysis of the steel and sodium samples from the loops, and the evaluation of the existing corrosion data by multiple regression methods. The fourth run in Loop 2 (316 SS - $2\frac{1}{4}$ Cr-1 Mo) was completed after 2800 hours, and steel and sodium samples were withdrawn for analysis. Sodium and steel samples were also removed from Loop 4 (316 SS - 5 Cr) after 1400 hours of operation of run 4. Significant flow fouling was experienced in Loop 6 (5 Cr) and a 30% flow decrease was observed.

f. Continuous Oxide Meter - United Nuclear Corporation - AT(30-1)-2877

Experiments to demonstrate the feasibility of an electrochemical approach to meter oxide concentration were continued. The test apparatus consisted of a nickel-nickel oxide electrode and the zirconia-calcia electrolyte. Modifications were made to eliminate the drift in the readings and to shorten the response time.

Test results at two temperatures gave readings considerably lower than predicted theoretically. This could be due to errors in the assumptions that (1) the oxide activity is proportional to the oxide concentration and (2) equilibrium was attained in the cold trap which regulates oxide concentration.

A zirconia tube failed after 20 hours at 1190°F but can be used for hundreds of hours at 900°F.

g. Consulting - United Nuclear Corporation - AT(30-1)-2834

A summary report was prepared on the Materials Subcommittee meeting held at MSAR on January 9. K. Goldmann attended the Working Group meeting held at AEC-CH on January 10-12 and also reviewed monthly reports from contractors on the projects under the Sodium Components Development Program. J. McKee helped prepare a summary report of the last meeting of the Mass Transfer subcommittee.

h. Sodium Resistivity Meter Test Loop - Atomic Power Development Associates, Inc. - AT(11-1)-865 #3

The Sodium Resistivity Loop at APDA has been designed for testing the UKAEA Blake Meter. The status of the loop is such that it should be ready to fill with sodium on February 28, 1962. The support structure has been completed, and the control panel and panel-end wiring have proceeded as far as they can go. Shop welding assembly of pipe, tanks, and valves is proceeding satisfactorily, and field welding was scheduled to begin on February 19.

Loop Characteristics:

(1) A large capacity (1000 pounds of sodium) to allow easy contaminant management. Loop is constructed of 4 inch diameter stainless steel pipe. Flow can be regulated from 10 gpm to 400 gpm.

(2) A sodium hold-up tank of 30 gallons which is 25% of system capacity and which can be adjusted and sampled readily.

(3) High operating temperature to permit high soluble contamination of the sodium. Loop can be operated for a short period at 1200°F and continuously at 1000°F.

III. Other Activities

- a. Third Review Report on Sodium Components Materials Program (Anderson, AI; DeVan, ORNL; Stern, UNC; Goldmann, UNC) - February 15, 1962

A meeting was held by the Materials Subcommittee at MSAR on January 9 to review the Physical Properties of Material work. Certain modifications in the test program were recommended. These changes involved the details of specifying stress conditions and do not alter the basic objectives of the program. No changes in the over-all number of tests, equipment design, or allotted contractual periods should be required by the modifications.

It was recommended that the specimens be investigated immediately for variability. Rupture and creep rate tests should be taken over a range of nine loads instead of the previously suggested two different loads. The fatigue tests should be modified from three specimens at each of two stress levels to two specimens at each of three stress levels. Creep and creep rupture tests of 2 $\frac{1}{4}$ Cr - 1 Mo steel at 1100°F in air should be dropped from the program. Tensile specimens of both original material and material exposed to sodium should be tested at room temperature as well as high temperatures. Since MSAR's present thermal shock system would require modification to perform the required tests, inclusion of this test in the present physical properties program is a subject to be reviewed by the Working Group.

- b. Results of First Round-Robin Analysis for Carbon in Sodium by R. W. Lockhart, GE, dated February 23, 1962

The first round-robin analysis for carbon in sodium to demonstrate the ability of various laboratories to reliably analyze carbon impurity in sodium has been completed. AI had supplied a set of three samples to each of the following companies: AI, duPont, ANL, Ethyl, GE, UNC. The results of these analyses have now been analyzed.

There was considerable spread in the data as reported by the different laboratories. No pattern was evident between the different laboratories who agreed at one concentration level but not at others. Many of the analysts felt that the carbon was not uniformly distributed in the sodium when the samples were prepared. It was not possible, therefore, to critically evaluate the different analytical procedures used by the participating laboratories.

It was recommended that a second round-robin analysis be initiated. However, this should be preceded by a determination of a recommended procedure to prepare, sample, and ship the samples with the intent of achieving uniformly distributed carbon in the sodium. Each laboratory should analyze the samples using the same procedure as in the first round-robin analysis. Data should also be included concerning the analysis of blanks and standard samples.

IV. Meetings

February 7, 1962 AEC-CH with GE at San Jose, California, regarding Carbon Analysis in Sodium

February 7, 1962 MSAR representatives met with GE representatives at San Jose, California, to co-ordinate the procedures and data of the respective contracts under the Sodium Components Development Program.

February 8, 1962 AEC-CH with AEC-SAN regarding the GE contract on Mass Transfer in Sodium.

February 23, 1962 Alco Products, Inc., AI, AEC-CPAO, and AEC-CH at Canoga Park, California, to co-ordinate technical data and schedules of the respective contracts under the Sodium Components Development Program.

V. CH Correspondence and Progress Reports

February 1, 1962 Memo, C. A. Pursel, CH, to D. J. Casey, CH, re AI's revised estimate for FY 1962 for the SCTI.

February 1, 1962 Letter, T. A. Nemzek, CH, to Working Group, invitation to Sodium Components Development Program review and Working Group meetings in Washington on March 21 and 22, 1962.

February 2, 1962 Letter, R. Cygan, AI, to T. A. Nemzek, CH, enclosing January Progress Report on SCTI.

February 2, 1962 Memo, T. A. Nemzek, CH, to J. V. Levy, CPAO, re status of SCTI.

February 2, 1962 Memo, J. V. Levy, CPAO, to DRD and CH, Weekly Report on AI Projects.

February 5, 1962 Letter, T. A. Nemzek, CH, to R. C. Werner, MSAR, enclosing GE Progress Letter No. 30 on Mass Transfer.

February 5, 1962 Memo, T. A. Nemzek, CH, to J. V. Levy, CPAO, re control panels and instrumentation for SCTI.

February 6, 1962 Memo, T. A. Nemzek, CH, to J. V. Levy, CPAO, re co-ordination meeting among Alco, AI, and the AEC on February 23.

February 6, 1962 Letter, F. C. Mattmueller, CH, to W. D. Leggett, Alco, re co-ordination meeting among Alco, AI, and the AEC.

February 7, 1962 Letter, K. Goldmann, UNC, to J. D. Hart, NYOO, Letter Report on Contract AT(30-1)-2834 for Month of January 1962.

February 7, 1962 Memo, K. A. Dunbar, CH, to F. K. Pittman, DRD, re administration of Sodium Components Development Program.

February 8, 1962 Memo, J. V. Levy, CPAO, to DRD and CH, Weekly Report on AI Projects.

February 9, 1962 GE Progress Letter No. 31 on Mass Transfer, Contract AT(04-3)-189 #15.

February 9, 1962 Memo, J. P. Lagowski, CH, to T. P. Heckman, CH, re economic incentive for elimination of secondary loop.

February 12, 1962 Letter, F. C. Mattmueller, CH, to R. C. Werner, MSAR, re recommendations of SCDP subgroup meeting of January 9, 1962.

February 13, 1962 Letter, T. A. Nemzek, CH, to Working Group, enclosing minutes of 27th SCDP meeting of January 10, 11, and 12, 1962.

February 13, 1962 MSAR Progress Report No. 17 covering January 1962, Contract AT(11-1)-765 Mod. 1.

February 14, 1962 Memo, W. D. Smith, CPAO, to T. A. Nemzek, CH, re control panels and instrumentation for SCTI.

February 15, 1962 Memo, J. V. Levy, CPAO, to DRD and CH, Weekly Report on AI Projects.

February 16, 1962 Letter, H. Steinmetz, UNC, to J. Wise, NYO, Monthly Progress Report No. 5, Contract AT(30-1)-2877.

February 16, 1962 Letter, C. A. Pursel, CH, to L. E. Phillips, Alco, requesting copy of APAE-41, Vol. III.

February 16, 1962 Memo, T. A. Nemzek, CH, to G. W. Wensch, DRD, enclosing APAE-41, Vol. III, "Intermediate Heat Exchanger and Steam Generator Concept Studies."

February 16, 1962 Letter, R. H. Jones, APDA, to F. C. Mattmueller, CH, enclosing report on Resistivity Loop, Contract AT(11-1)-865 #3.

February 19, 1962 Letter, T. A. Nemzek, CH, to Working Group, enclosing "SCDP Project Co-ordination Report, January 1962."

February 19, 1962 Letter, K. Goldmann, UNC, to T. A. Nemzek, CH, enclosing Third Review Report on Materials Program by the Materials Subcommittee.

February 21, 1962 Letter, L. E. Phillips, Alco, to C. A. Pursel, CH, enclosing copy of APAE-41, Vol. III.

February 21, 1962 Memo, J. V. Levy, CPAO, to DRD and CH, Weekly Report on AI Projects.

February 23, 1962 Letter, R. W. Lockhart, GE, to T. A. Nemzek, CH, enclosing "Results of the First Round-Robin Analysis for Carbon in Sodium."

Appendix A - Current Cost Status

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
MARCH 1962

I. Listing of Current Projects

<u>Current Projects</u>	<u>Contractors, Address, Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger & Steam Generator	Alco Products, Inc. Schenectady 5, N. Y. L. E. Phillips	AT(11-1)-666	CH
b. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
c. Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
d. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e. Flow Controllers	Westinghouse Electric Corp., Atomic Power Dept., P. O. Box 355, Pittsburgh 30, Pa. J. P. Thorel	AT(11-1)-681	CH
f. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g. Mass Transfer	General Electric Co. Atomic Power Equip- ment Dept., P. O. Box 254, San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
h. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYOO
i. Consulting	United Nuclear Corp. 5 New Street White Plains, N. Y. K. Goldmann	AT(30-1)-2834	NYOO
j. Low Level Oxide Analysis (Blake Meter)	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. A. P. Donnell	AT(11-1)-865 #3	CH

<u>Current Projects</u>	Contractors, Address, <u>Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
k. Consulting	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. J. J. Morabito	AT(11-1)-865 #1	CH

II. Status of All Current Projects

a. Intermediate Heat Exchanger and Steam Generator - Alco Products, Inc.

Fabrication on the 30 MW Intermediate Heat Exchanger is continuing. The fact that nozzles are not available is preventing further work being done on shells. Assembly is scheduled to begin in June with testing being done in September and delivery in October.

A delivery schedule for the steam generator cannot be estimated until a firm delivery date has been set for the composite tubing. The original experimental order of tubing from Superior Tube Company was rejected because of difficulties with the Inconel surface. These difficulties will be corrected by a change in heat treatment. Until a composite tubing order has been approved by the AEC and placed with Superior, a new schedule estimate will not be made.

b. Test Facility - Atomics International

Construction on the SCTI continued during February. Erection of the sodium heater is 75% complete. Flame observation windows will be added in several places along the front burner wall to permit adequate visual coverage of the five gas burners as recommended by Peabody Engineering (burner manufacturer), Bailey Meter Company (control supplier), and Hartford Steam Boiler Insurance Company. The HNPF free surface pump can be adapted for use in the SCTI secondary sodium system by rewinding the drive motor for higher speed and horsepower.

Design work continued on the SCTI. Evaluation of the use of bellows expansion joints in the sodium piping was continued. Using the analogue model, primary sodium system transient response was checked out, and preliminary analysis of test results indicates stable system operation for all required transients. Additional analogue work will include a more refined representation of the IHX and also transient testing of the steam generator using the combined primary and secondary sodium systems without an IHX.

c. Valve Test - Atomics International

The second half of the thermal shock program consisted of 500 thermal shock cycles at 35°F/sec for five seconds from 1200°F to 1025°F inlet sodium temperature. The 500 cycles were completed without valve binding which indicated that the valve bore distortion which had occurred in the first-half of the shock test program was caused by relief of strains due to welding and not by thermal shock. Detailed dimensional measurements to be made of the valve bore and valve gate will verify this statement.

d. Shell Side Heat Transfer - Atomics International

AEC-CPAO authorized AI during March to proceed with the testing of the first tube bundle of the Shell Side Heat Transfer Studies.

The piping system for the loop is completed, including a 1.2 MW electrical heater and a 1 MW cooler. A minor amount of installation and checkout work will be required before the loop can be loaded with sodium.

e. Blake Meter Test - Atomic Power Development Associates, Inc.

The test loop with the Blake meter installed was operated for a two-week shakedown period. Preliminary data taken during a two-day test operation indicated a significant temperature effect. The meter and the preliminary data are being analyzed to determine if the temperature effects can be compensated by the meter.

f. Mass Transfer - General Electric Company

On November 30 and December 1, 1961, the Ad Hoc Review Group for Sodium Mass Transfer Studies met at the Chicago Operations Office to discuss the Sodium Mass Transfer Program at the General Electric Company. The objectives of this third Ad Hoc Review were to review progress since their October meeting and to recommend future effort for the program to the AEC and the Working Group. The Review Group consisted of R. E. Aronstein, AEC-CH (Chairman); H. W. Savage, ORNL (Technical Co-ordinator); J. H. DeVan, ORNL; J. M. McKee, UNC; J. J. Morabito, APDA; and D. I. Sinizer, AI.

The Review Group recommendations were:

- (1) The program should proceed according to the five-run fractional replicate statistical plan developed during the meeting to determine the effect of the primary variables: T_{max} , oxygen contamination, and delta T.
- (2) GE should recommend a program to determine the effects on mass transfer of other variables.
- (3) The loop flow fouling material which has been observed in the cold leg should continue to be investigated thoroughly for composition and for potential thermal and flow problems in a large loop.
- (4) GE should complete the analysis of the radioactive tab runs and make recommendations regarding continued application of radio tracer techniques.
- (5) An interim report should be prepared by GE to report the results of the program to date.
- (6) Close co-ordination should be maintained by the AEC between the GE Mass Transfer and the MSAR Materials Program to assure that the effects on physical properties of metallurgical changes observed in the GE work are evaluated in the MSAR program.

g. Physical Properties of Materials - MSA Research Corporation

During the report period a set of 18-inch radius mandrels were being purchased for the fatigue study of stainless steel and $2\frac{1}{4}$ Cr-1 Mo steel

in air and helium. Three Cr-Mo specimens have been tested in air at 1100°F using a 3.125 inch radius mandrel. Both loops for the fatigue, creep and stress tests in sodium have been revised and both are scheduled for testing some time in March. The creep, stress and tensile tests in air and helium are being conducted by the University of Michigan. Some tests have been made and the data are given in this report. Testing procedures are also given. The changes in the technical scope as suggested by the AEC are reported.

h. Continuous Oxide Meter - United Nuclear Corporation

The test apparatus for demonstrating the feasibility of the electrochemical oxygen monitor has demonstrated a response to varying oxygen content in the sodium. Recent data have shown a rapid and direct correlation between cold trap temperatures and the millivolt response of the meter.

i. Consulting - United Nuclear Corporation

Preparations were made for the Sodium Components meeting in Washington. Progress reports from contractors and documents from AEC-CH relating to projects under the Sodium Components Development Program were reviewed and commented upon.

j. Flow Controller - Westinghouse Electric Corporation

All engineering and fabrication work has been terminated. Negotiations concerning the shipment and costs of the components are continuing.

III. Meetings

March 20, 1962	AEC-CH with the Carbon Analysis in Sodium Ad Hoc Committee in Washington, D. C.
March 20, 1962	AEC-CH with the Working Group in Washington, D. C.
March 21, 1962	AEC Sodium Components Development Program Washington Headquarters Review with the Contractors
March 22, 1962	AEC with the Working Group to Review the Sodium Components Development Program
March 22, 1962	AEC Headquarters with AEC-CH Review of the Sodium Components Development Program

IV. Reports

GE Progress Letter No. 32, "Mass Transfer Investigation in Liquid Metal Systems," February 1 through February 28, 1962, dated March 9, 1962.

MSA Progress Report No. 18, "Effect of 1200 F Sodium on Austenitic and Ferritic Steels," February 1962, dated March 13, 1962.

Atomics International, "Testing of OIC Flow Controller."

AI Progress Letter No. 12, "Sodium Components Test Installation," March 1, 1962, through March 31, 1962.

Project Status and Cost Report for "Investigation of Mass Transfer in Liquid Metals" for the month of February 1962.

Progress Report, Sodium Components Design Program Contract AT(11-1)-666, dated February 28, 1962, "Fabrication of 30 MW Intermediate Heat Exchanger and Steam Generator."

Volume I APAE-112, "Thermal and Mechanical Final Design of 30 Megawatt Heat Exchanger and Steam Generator for Sodium Cooled Reactor System."

Volume II APAE-112, "Chemical and Stress Analysis of 30 Megawatt Heat Exchanger and Steam Generator for Sodium Cooled Reactor System."

V. CH Correspondence

- March 1, 1962 Letter, F. Smith to Messrs. M. Soenen and J. Herpin, CEN-EURATOM, Groupe D'Exploitation Du Reacteur Br 2, Et De Ses Installations Connexes, Mol - (Belgique), answering questions relating to oxygen in sodium and the buildup of Na 22 in radioactive systems.
- March 1, 1962 Memo, J. V. Levy to K. A. Dunbar, Subject: "Sodium Components Test Installation - Request for Modification of Directive No. CP-61-8," enclosing a breakdown of the operating costs - actual and estimated - for the fiscal years 1961, 1962, and 1963.
- March 1, 1962 Letter, R. Cygan (AI) to T. A. Nemzek, transmitting SCTI Monthly Progress Report for February 1962.
- March 2, 1962 Memo, F. K. Pittman to K. A. Dunbar, Subject: "Sodium Reactors: Sodium Pumps, ASCR Project 4454," concurring in CH's recommendation that work scope for FY 1962 under ASCR project be changed to permit completion of tests already started on the helical rotor pump.
- March 5, 1962 Memo, T. A. Nemzek to J. V. Levy, Subject: "Shell Side Heat Transfer Program," requesting determination of the feasibility of transferring funds to operate the Shell Side Heat Transfer Test from funds available for the Test Facility.
- March 6, 1962 Letter, F. C. Mattmueller to Admiral W. D. Leggett (Alco), Subject: "Request for Reports - Contract AT(11-1)-666."
- March 6, 1962 Letter, Justin Karp (UNC) to J. Wise (NYOO), enclosing financial reports on contracts AT(30-1)-2830, 2832, 2834, and 2877 for the month of January 1962.
- March 6, 1962 TWX AEC-130, C. W. Richards to F. Smith, regarding a meeting of contractors to discuss sodium sampling techniques and analysis for carbon.
- March 6, 1962 Letter, T. A. Nemzek to Messrs. Dickinson (AI), Goldmann (UNC), and Simmons (ANL), regarding meeting of carbon analysis Ad Hoc Review Group to be held in Washington on March 20, 1962; Working Group meeting March 20; Sodium Components Development Program Review on March 21 and 22.

Progress reports from MSA and GE for the month of January 1962 were transmitted. Agenda for the Analysis for Carbon in Sodium Meeting was furnished.

- March 6, 1962 Letter, T. A. Nemzek to Messrs. Barrett (NASA), Harris (DRD), Savage (ORNL), and Wykoff (LASL), regarding above meetings and information.
- March 6, 1962 Letter, T. A. Nemzek to J. J. Morabito (APDA), regarding above meetings and information.
- March 6, 1962 Letter, T. A. Nemzek to R. W. Lockhart (GE), regarding above meetings and information.
- March 7, 1962 Letter, R. W. Dickinson (AI) to T. A. Nemzek, commenting on SCDP Project Co-ordination Report for January 1962.
- March 7, 1962 Memo, T. A. Nemzek to J. V. Levy, Subject: "Sodium Pumps, ASCR Project 4454," concurring in CPAO's recommendation for a change in work scope for deferment of development of a linear induction pump; tests on the helical rotor pump which have already started should be completed.
- March 7, 1962 Letter, T. A. Nemzek to R. L. Hudson (Ethyl Corporation), forwarding report entitled "Results of the First Round-Robin Analysis for Carbon in Sodium" prepared by R. W. Lockhart (GE).
- March 8, 1962 Letter, T. A. Nemzek to Dr. Robert C. Werner (MSA), forwarding report entitled "Results of the First Round-Robin Analysis for Carbon in Sodium" prepared by R. W. Lockhart (GE).
- March 8, 1962 Letter, T. A. Nemzek to Penn Lindsay (E.I. duPont de Nemours Company), forwarding report entitled "Results of the First Round-Robin Analysis for Carbon in Sodium" prepared by R. W. Lockhart (GE).
- March 8, 1962 Letter, A. P. Pollman to D. E. Rivinius (AI), authorizing AI to incur costs on the SCTI in accordance with estimated expenditures for FY 1962.
- March 8, 1962 Letter, Kurt Goldmann to John D. Hart (NYOO), furnishing UNC's sixth monthly letter report on Contract AT(30-1)-2834.
- March 8, 1962 Letter, T. A. Nemzek to H. W. Savage (ORNL), regarding corrections to minutes of Working Group Meeting No. 27; minutes for subgroup review of the GE Mass Transfer work; meetings to be held in Washington on March 20, 21, and 22; AI to be prepared to answer questions concerning the Shell Side Heat Transfer work.
- March 9, 1962 Memo, J. T. Harris to J. P. Jewett, Subject: "Purchase Approval of SCTI Instrumentation."
- March 12, 1962 Letter, F. C. Mattmueller to A. P. Donnell (APDA), regarding representation on Carbon Analysis Ad Hoc Review Group by E. C. Kovacic.

March 12, 1962 Letter, R. W. Lockhart (GE) to T. A. Nemzek, Subject: "Sodium Components Development Program Working Group - Appraisal and Comments."

March 12, 1962 Letter, Fred C. Mattmueller to Admiral W. D. Leggett (Alco), regarding clarification of communications between Alco and AI.

March 12, 1962 Memo, T. A. Nemzek to J. V. Levy, Subject: "Communications between AI and Alco."

March 12, 1962 Letter, D. E. Rivinius (AI) to J. V. Levy, 62AT1880, Subject: "Initiation of Design for Installation of Alco Steam Generator and IHX in the SCTI."

March 12, 1962 Memo to File, Thru C. A. Pursel from F. A. Smith, Subject: "Notes on Telephone Call, R. Harris to F. Smith, March 9, 1962," regarding contract with the University of Michigan to do creep tests for MSA.

March 12, 1962 Memo, K. A. Dunbar to F. K. Pittman and J. A. Derry (DRD and Division of Construction and Supply, HQ), transmitting copies of Sodium Components Development Program Project Co-ordination Report for the month of February 1962.

March 13, 1962 Letter, R. E. Aronstein as Chairman, Mass Transfer Ad Hoc Review Group, to T. A. Nemzek, stating Review Group recommendations and transmitting Report No. 3.

March 14, 1962 Memo, C. W. Richards to T. P. Heckman, Subject: "Sodium Components Development Program Review - March 21-22, 1962," enclosing AI program summaries for meeting in Washington.

March 15, 1962 Memo, K. A. Dunbar to F. K. Pittman, Subject: "Reorientation of the Atomics International Advanced Sodium Cooled Reactor Program and Participation in the Program by Empire State Atomic Development Associates," regarding suspension of the Shell Side Heat Transfer work.

March 15, 1962 Letter, J. V. Levy to D. E. Rivinius (AI), Subject: "Sodium Pumps, ASCR Project 4454," giving approval to change the work scope of ASCR Project 4454 by deferring development of an annular linear induction pump in order that testing of the helical rotor pump may be completed in FY 1962.

March 19, 1962 Letter, T. A. Nemzek to Dr. A. V. Grosse (Research Institute of Temple University), regarding possible proposal of extending Dr. Grosse's Isotopic Method to AEC requirements for measuring carbon and oxygen content in the low ppm range (1-10) of the primary sodium coolant.

March 19, 1962 Letter, F. J. Holt (E. I. duPont de Nemours Company) to T. A. Nemzek, acknowledging receipt of carbon analysis report enclosed with letter dated March 8, 1962.

March 20, 1962 Memo, J. V. Levy to T. A. Nemzek, authorizing AI to proceed with the testing of the first tube bundle for the Shell Side Heat Transfer Studies; required funds are available from existing FY 1962 funds; AI requested to submit a revised schedule for the test since program will probably extend into FY 1963.

March 20, 1962 Letter, J. V. Levy to D. E. Rivinius (AI), authorizing AI to proceed with the testing of the first tube bundle for the Shell Side Heat Transfer Studies Program.

March 21, 1962 Letter, J. V. Levy to R. W. Dickinson (AI), Subject: "Communications between AI and Alco."

March 22, 1962 Directive Authorization CP-61-8 Modification No. 1 for "Design, Procurement, and Construction of a Sodium Components Test Installation at AI, Santa Susana, California."

March 22, 1962 Letter, R. L. Campbell (MSA) to A. Fremling, Subject: "Financial Information on Contract No. AT(11-1)-765," requesting additional funds to continue beyond April 30, 1962.

March 27, 1962 Memo, F. A. Smith to T. L. Walker, Subject: "Alco Inquiry 42,207, February 28, 1962, Purchase Order 8-42207-5."

March 28, 1962 Letter, T. A. Nemzek to Working Group Members, transmitting BMI, GE, MSA, Alco, and AI reports.

March 28, 1962 Memo to File, Thru T. A. Nemzek from F. A. Smith, Subject: "MSA Requirement for Additional Funds."

March 28, 1962 Memo to File, Thru L. A. Redecke from A. Fremling, Subject: "Trip Report on Sodium Components Development Review Meetings on March 21 and March 22."

March 28, 1962 Letter, F. C. Mattmueller to J. H. Driscoll (Westinghouse), Subject: "Contract No. AT(11-1)-681," concerning the shipment of the sodium flow control valve components to AI and the settlement and close out of this agreement.

March 29, 1962 TWX, F. C. Mattmueller to C. H. Staub (MSA), Modification No. 4 to Contract AT(11-1)-765 being processed for extension of work through July 15, 1962.

March 30, 1962 Letter, Fred C. Mattmueller to Admiral W. D. Leggett, Jr. (Alco), Subject: "Contract AT(11-1)-666," approving purchase order to Superior Tube Company for bimetallic tubing.

March 30, 1962 Memo, F. C. Mattmueller to J. B. Lee, Subject: "Contract No. AT(11-1)-765, MSA Research Corporation," requesting modification of contract to provide extension of term through July 15, 1962, and increase in funds.

March 30, 1962 Memo, A. P. Pollman to T. A. Nemzek, Subject: "Initiation of Design for Installation of Alco Steam Generator and IHX in SCTI," requesting concurrence with AI's request with funds available in ASCR Project 4461.

March 30, 1962 Letter, F. A. Smith to N. A. Nielsen (E. I. duPont de Nemours Company), requesting arrangements necessary to use a film titled "Stress Corrosion Cracking" for the next Sodium Components Development Program Working Group meeting.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
APRIL 1962

I. Listing of Current Projects

<u>Current Projects</u>	<u>Contractors, Address, Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger & Steam Generator	Alco Products, Inc. Schenectady 5, N. Y. L. E. Phillips	AT(11-1)-666	CH
b. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
c. Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
d. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e. Flow Controllers	Westinghouse Electric Corp., Atomic Power Dept., P. O. Box 355, Pittsburgh 30, Pa. J. P. Thorel	AT(11-1)-681	CH
f. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g. Mass Transfer	General Electric Co. Atomic Power Equip- ment Dept., P. O. Box 254, San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
h. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYOO
i. Consulting	United Nuclear Corp. 5 New Street White Plains, N. Y. K. Goldmann	AT(30-1)-2834	NYOO

<u>Current Projects</u>	Contractors, Address, <u>Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
j. Low Level Oxide Analysis (Blake Meter)	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. E. H. Jones	AT(11-1)-865 #3	CH
k. Consulting	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. J. J. Morabito	AT(11-1)-865 #1	CH

II. Status of All Current Projects

a. Intermediate Heat Exchanger and Steam Generator - Alco Products, Inc.

Work on the 30 MW IHX is continuing at the Dunkirk plant. Design, analysis, and procurement for the steam generator is continuing but with several uncertainties. The Alco Products, Inc. made the decision to withdraw from the nuclear and heat exchanger business to concentrate on their other products. The engineering staff and the shop personnel will be held together for the completion of the two Sodium Components Development Program units if at all possible.

Development of the bimetallic tubing among Alco, Superior Tube, and Allegheny Ludlum continued with encouraging results.

b. Test Facility - Atomics International

Erection of the sodium heater is over 85% complete. The new gas burner throat tiles and mounting rings were received and are being installed. The 18-year old surplus steam condenser is being adapted to the system which includes: reducing the surface by one-half, repacking the tubes, and installing an adapter to the inlet steam flange.

The complete gas and flame control system for the sodium heater has been finished.

A new method of adapting the HNPF free surface sodium pump for use in the SCTI is being investigated since the manufacturer of the Dynamatic coupling has stated that modifying the driving rotor for the intended motor speed is impossible.

c. Flow Controller - Westinghouse Electric Corporation

In accordance with instructions furnished to Westinghouse by AEC-CH, Westinghouse shipped all valve components including production tooling to AI. Copies of design, test, and maintenance documents were delivered to CH and were, in turn, distributed by CH to members of the Working Group and contractor administrators of the Sodium Components Development Program.

d. Physical Properties of Materials - MSA Research Corporation

A summary of the fatigue test results to date was tabulated and photographs of eight stainless specimens and three Cr-Mo specimens were presented. The nineteen photographs show before and after conditions of the entire specimen plus enlargements of selected areas.

Some difficulties have been experienced with the bellows of the plugging valve and also the sodium level affecting the dial gage reading. These problems are being corrected.

No stainless steel specimens have been tested in Loop No. 1 during the report time. The system was charged and operated at temperature. A decision was made to temporarily delay testing to evaluate the performance of the test machines and Loop No. 2 before committing specimens for testing.

e. Mass Transfer Investigations - General Electric Company

Activities were directed toward operation of the test loops, analysis of the steel and sodium samples, and evaluation of corrosion data by multiple regression methods. Computer work has been completed for the multiple regression analysis of corrosion data from all test runs completed prior to December 31, 1961. Evaluation of these analyses is proceeding as well as preparation of a topical report, GEAP-3726, describing the work.

The ferritic steel samples prepared since January 1962 have been machined from pipe stock and all surfaces ground for uniformity. The data shown in AR 5-3-1 are the first test results available for new ferritic steel samples, and the observed corrosion data indicate an unexplained departure from the previously consistent trend of weight gain in the cold leg.

f. Oxygen Monitor - United Nuclear Corporation

The voltage of the electrochemical oxygen monitor at 540°F was measured in a series of experiments as a function of cold trap temperature. The voltage was found to change with cold trap temperature in a reproducible manner and the results are consistent with theory. Equipment for sampling sodium for chemical analysis from the test apparatus was designed and partly built. A quarterly progress report was written.

g. Resistivity Loop - Atomic Power Development Associates, Inc.

Shakedown testing of the resistivity loop was completed and a number of minor changes in the loop instrumentation and controls were made. The loop operation was made continuous, using three shifts per day for five days each week.

The initial tests were to determine the anomalies of the resistivity meter to variables other than sodium oxide content. The preliminary results of these tests to date indicate a sensitivity to temperature when the sodium temperature is other than 525 to 590°F. Preparations are being made to check the effects of step changes of temperature, flow, and supply voltage to the meter readings.

III. Meetings

April 13, 1962 AEC-CH with Alco Products, Inc. at Argonne, Illinois.

April 19, 1962 AEC-CH with Baldwin-Lima-Hamilton (formerly Griscom Russell).

IV. Reports

GE Progress Letter No. 33, "Mass Transfer Investigation in Liquid Metal Systems, March 1 through March 31, 1962," dated April 6, 1962.

MSA Progress Report No. 19, "Effect of 1200 F Sodium on Austenitic and Ferritic Steels, March 1962," dated April 18, 1962.

UNC-5010, "Development of a Continuous Meter for Oxygen in Sodium," quarterly progress report for December 1, 1961, to February 28, 1962, dated April 15, 1962.

AI Progress Letter No. 12 on Sodium Components Test Installation for March 1962.

APDA Status Report on Resistivity Loop as of April 1, 1962 - Contract AT(11-1)-865.3, dated April 4, 1962.

UNC Monthly Progress Report No. 7, Contract AT(30-1)-2877, March 1962, dated April 26, 1962.

CPAO Weekly Report on Atomics International Projects, dated April 26, 1962.

Project Status and Cost Report for "Investigation of Mass Transfer in Liquid Metals" for the month of March 1962.

V. Correspondence

April 2, 1962 Letter, R. Cygan (AI) to T. A. Nemzek, Subject: "Sodium Components Test Installation Monthly Progress, March 1962."

April 3, 1962 Memo, C. A. Pursel to F. C. Mattmueller, authorizing extension of contract with MSA and additional funds.

April 4, 1962 Memo, K. A. Dunbar to J. C. Clarke (NYOO), Subject: "Sodium Components, Supercritical Reactor, and Fast Reactor Development Programs, FY 63-64 Program Review."

April 4, 1962 Letter, T. A. Nemzek to L. E. Phillips (Alco), transmitting GE report on "Mass Transfer Investigation in Liquid Metal Systems."

April 4, 1962 Letter, E. H. Jones (APDA) to F. C. Mattmueller, re "Status Report on Resistivity Loop as of April 1, 1962 - Contract AT(11-1)-865.3."

April 6, 1962 Memo, T. A. Nemzek to J. V. Levy, Subject: "Initiation of Design for Installation of Alco Steam Generator and IHX in SCTI."

April 9, 1962 Memo, F. C. Mattmueller to Official Contract File, Subject: "Justification for Modification No. 4 to Contract No. AT(11-1)-765 with MSA Research Corporation."

April 9, 1962 Letter, F. C. Mattmueller to C. H. Staub (MSA), Subject: "Contract No. AT(11-1)-765, Modification No. 4."

April 9, 1962 Letter, Robert L. Campbell (MSA) to A. Fremling, Subject: "Contract AT(11-1)-765, Monthly Financial Report."

April 10, 1962 Memo, T. A. Nemzek to Those Listed Below, Subject: "Meeting to Discuss Continued Fabrication of IHX and Steam Generator, Contract AT(11-1)-666."

April 11, 1962 Memo, K. A. Dunbar to A. L. Tackman (Office of Personnel, HQ), Subject: "Extension of Advisory Boards."

April 11, 1962 Memo, J. B. Lee to N. D. Naiden (General Counsel, HQ), Subject: "Sodium Components Working Groups."

April 11, 1962 Memo, J. DeKany to C. W. Richards (CPAO), Subject: "Underrun of SCTI Operating Costs for FY 62."

April 11, 1962 Letter, M. R. Cox (WEC) to F. C. Mattmueller, stating that sodium flow control valve components have been shipped to AI (Contract AT(11-1)-681.

April 12, 1962 Memo, T. A. Nemzek to J. V. Levy, Subject: "SCTI - AI Inspection during Alco Fabrication."

April 16, 1962 TWX AEC 175, C. A. Pursel to J. Wise, NYOO, regarding program review at UNC April 25 to discuss Fast Reactor Safety, Sodium Components Continuous Oxygen Analysis, and Proposed RUC-UC Fast Reactor Study.

April 18, 1962 Letter, F. C. Mattmueller to W. D. Leggett (Alco), regarding placing two test plate weld samples in the inlet or outlet regions of the intermediate heat exchanger now being fabricated.

April 18, 1962 Letter, F. C. Mattmueller to W. D. Leggett (Alco), recommending extension of strain gauge application to include verification of stress computations of the steam generator at the temperature and pressure environment to be achieved in the AI Test Facility.

April 19, 1962 Letter, J. J. L. Simpson (UNC) to C. A. Pursel, transmitting UNC-5010 - Quarterly Progress Report for Period December 1, 1961, to February 28, 1962, "Development of a Continuous Meter for Oxygen in Sodium."

April 19, 1962 Memo, Neil D. Naiden (General Counsel, HQ) to J. B. Lee, Subject: "Sodium Components Working Groups."

April 24, 1962 Memo, K. A. Dunbar to F. K. Pittman and John A. Derry (HQ), Subject: "Sodium Components Development Program Project Co-ordination Report, March 1962."

April 26, 1962 Memo, C. A. Pursel to Carl Backlund (SAN), Subject: "Sodium Components Development Program Mass Transfer, GE Contract AT(04-3)-189 #15," verifying the amounts of funds available for FY 1963.

April 27, 1962 Letter, T. A. Nemzek to Working Group Members, transmitting project co-ordination report for March 1962, minutes for meetings held March 21 and 22, 1962, MSA progress report, and GE progress report.

April 23, 1962 Letter, F. C. Mattmueller to M. R. Cox (WEC), regarding shipment of sodium flow control valve components to AI, also authorizing payment in the amount of \$20,339.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
MAY 1962

I. Listing of Current Projects

<u>Current Projects</u>	<u>Contractors, Address, Person In Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger & Steam Generator	Alco Products, Inc. Schenectady 5, N. Y. L. E. Phillips	AT(11-1)-666	CH
b. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
c. Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
d. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
f. Mass Transfer	General Electric Co. Atomic Power Equip- ment Dept., P. O. Box 254, San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
g. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYOC
h. Consulting	United Nuclear Corp. 5 New Street White Plains, N. Y. K. Goldmann	AT(30-1)-2834	NYOO
i. Low Level Oxide Analysis (Blake Meter)	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. E. H. Jones	AT(11-1)-865 #3	CH
j. Consulting	APDA 1911 First Street Detroit 26, Mich. J. J. Morabito	AT(11-1)-865 #1	CH

II. Status of All Current Projects

a. Intermediate Heat Exchanger and Steam Generator - Alco Products, Inc.

Fabrication of the IHX and welding development for the steam generator continued with minor delays in the schedules. The schedule for the steam generator was still contingent upon satisfactory tube rounds from Allegheny-Ludlum. Negotiations continued among AEC, Alco, and third parties for completion of the steam generator contract following Alco's decision to withdraw from the nuclear and thermal products industry.

b. Test Facility - Atomics International

AI will furnish a high temperature strain gage assembly to be installed in the Alco IHX. Sodium heater gas burners have been installed. Four of the seven flame view ports have been installed.

Deaerating heater, both feedwater heaters, condensate booster pump, and the boiler feed pump have been set in place.

The use of heated compressed air at 100 psi and 600°F in pipe tracers appears feasible for sodium pipe preheating in the SCTI.

Piping details in the vicinity of major sodium heat transfer equipment have been worked out and final location of the IHX, steam generator, primary and secondary pumps has been established. The P&I diagrams, detail drawings, and calculations for the steam and treated water piping have been made and are being checked.

c. Physical Properties of Materials - MSA Research Corporation

All of the test machines were in operation. Plots of the stress to rupture data for the Cr-Mo and stainless steel as well as plots for the fatigue tests of the Cr-Mo and stainless steel specimens are included in Report No. 20 dated May 16, 1962. The data given is inconclusive at this time; however, certain indications of uniformity and consistency are apparent. The results of all the tests performed in this period are presented in tabular form.

d. Mass Transfer Investigations - General Electric Company

Both steel and sodium samples were withdrawn and submitted for analysis from loop No. 1 after 1405 hours of run 1-3.

The first steel samples were removed from loop No. 2 at 1426 hours of a scheduled test run of 5000 hours.

A new stainless steel pump cell of modified design to improve the head characteristics was procured for loop No. 4. The analysis for samples from run 1-2 and run 2-4 contains observed gamma count data determined on the 256 channel analyzer. The results indicate that (1) activity decreases with distance around the loop downstream from the foil source, (2) Fe-59 activity on the metal coupons is too low to be measured, and (3) activity varies with sample weight change, i.e., the highest activity values correspond to the largest weight gains and the lowest activity values to the largest weight losses.

e. Oxygen Monitor - United Nuclear Corporation

Preliminary measurements were made on the effect of temperature variations upon the electrochemical oxygen monitor in the temperature range of 500-560°F with the cold trap temperature kept constant for a set of measurements. In this series of measurements, the cold trap temperatures ranged from 380 to 440°F. The temperature coefficient values were not consistent and ranged from -.41 to -.62 millivolts/°F. These measurements will be repeated.

The response of the electrochemical cell to oxygen concentration was rechecked and the first results were anomalous. The erratic values were attributed to a cold finger in the base of the cold trap. The cold trap will be redesigned to remove ambiguities as to the effective cold trap temperature.

f. Resistivity Loop - Atomic Power Development Associates, Inc.

The program to determine the variables, other than sodium contamination, which affect the resistivity meter continued and included the transient variation of supply voltage and the step changes in sodium flow. The supply voltage effect can be adjusted to a negligible value within the instrument. The flow effect is not fully understood at this time and the problem is being investigated. The oxide tests were conducted over a range of plugging temperatures of 240° to 500°F. Preliminary results indicate a considerable spread in the reading of the resistivity meter; therefore, additional runs are being made to improve on the repeatability of the values and to establish calibration curves.

g. Shell Side Heat Transfer Studies - Atomics International

A schedule was established for testing Basic Unit No. 12 as follows:

- (1) Flow studies using water.
- (2) Installation of the unit in test section.
- (3) Loop shakedown tests.
- (4) Operational tests - assuming three replications of each experimental point.

The specific operating conditions will be those given in detail in the report "Discussion of Basic Unit Designs for Shell Side Heat Transfer Studies," 794-41-276, March 31, 1961. The total flow rates will range from 90 gpm to 422 gpm with a maximum sodium temperature of 900°F. The particular basic units to be tested subsequently depend on whether or not a decision is made to study only units with pure parallel or pure cross flow characteristics.

III. Meetings

May 10, 1962 Hyman Kirtchik, Consulting Chemist Project Manager, Flight Propulsion Lab Department, General Electric Company, visited CH to discuss alkali metal chemical analysis for carbon.

May 15, 1962 F. A. Smith and F. C. Mattnueller visited Alco Products, Inc., Dunkirk, New York.

May 17-18, 1962 Kurt Goldmann participated in a Heat Transfer Symposium at the Brookhaven National Laboratory.

May 22, 1962 Alco Products, Inc. visited AI at CPAO regarding the steam generator test program.

May 22-25, 1962 T. P. Heckman attended the 11th Annual AEC Corrosion Symposium at the Brookhaven National Laboratory.

May 29, 1962 Alco Products, Inc. and Baldwin-Lima-Hamilton visited CH regarding the steam generator contract.

IV. Reports

Letter Report from United Nuclear Corporation, May 25, 1962, "Contract (30-1)-2877, Monthly Progress Report No. 8, April 1962."

Progress Letter No. 13, for reporting period April 1 through April 30, 1962, "Sodium Components Test Installation."

APAE-112, Volume IV, dated May 15, 1962, "Operation and Maintenance Procedures for 30 Megawatt Heat Exchanger and Steam Generator for Sodium Cooled Reactor System."

Alco Products, Inc. Progress Report, Contract AT(11-1)-666, for the period ending April 30, 1962, "Sodium Components Design Program."

BMI Report for April 1962, "Friction and Wear of Sliding Surfaces in Sodium Environments."

Progress Report No. 20, dated May 16, 1962, for the month of April 1962, "Effect of 1200 F Sodium on Austenitic and Ferritic Steels."

Progress Letter No. 34, dated May 6, 1962, for reporting period April 1 through April 30, 1962, "Mass Transfer Investigation in Liquid Metal Systems."

V. Correspondence

May 1, 1962 Letter, T. A. Nemzek to W. R. Wykoff (LASL), regarding report K-3-458 titled "2000 Kilowatt Sodium Test Facility."

May 3, 1962 Letter, T. A. Nemzek to Working Group Members, transmitting Westinghouse documents and APDA status report on resistivity loop.

May 4, 1962 TWX, T. A. Nemzek to C. W. Richards (CPAO), concerning C. E. Peterson accompanying Micro-Dot welding engineering on Alco visit.

May 4, 1962 Memo, C. A. Pursel to J. T. Harris, Subject: "Alco Steam Generator, Procurement for Contract AT(11-1)-666."

May 8, 1962 Letter, C. B. Graham (A-C) to T. A. Nemzek, re proposal from Allis-Chalmers on "3-Phase R&D Program for Coating and Testing Graphite for Resistance to Liquid Sodium."

May 9, 1962 Memo, T. A. Nemzek to J. V. Levy, Subject: "Future Plans for Utilizing the Damaged Westinghouse Electric Corporation 12-Inch Sodium Flow Controller."

May 10, 1962 Memo, G. W. Wensch to T. A. Nemzek, Subject: "Comments on Sodium Components Development Program Project Co-ordination Report - March 1962."

May 11, 1962 Letter, Wayne H. Jens (APDA) to F. A. Smith, re problems associated with carbon in sodium.

May 15, 1962 Memo, T. P. Heckman to F. A. Smith, Subject: "Alco Products, Inc. Steam Generator Status."

May 16, 1962 Letter, F. A. Smith to N. A. Nielsen (E.I. DuPont De Nemours & Co., Inc.), requesting film entitled "Stress Corrosion Cracking."

May 16, 1962 Memo, K. A. Dunbar to F. K. Pittman, Subject: "Sodium Components: New Project Proposals for FY 1963 by Atomics International," which included "Effect of Heat Transfer on Corrosion" and "Evaluation of Components for Sodium Service."

May 17, 1962 Letter, F. A. Smith to Dr. Wayne H. Jens (APDA), considering the use of C-14 as a means to make economical, routine, and hopefully precise measurement of total carbon contained in sodium.

May 17, 1962 Memo, T. A. Nemzek to C. A. Pursel, Subject: "May 8, 1962, Ltr Proposal from A-C to Nemzek - 3 Phase R&D Program for Coating and Testing Graphite for Resistance to Liquid Sodium."

May 18, 1962 Memo, C. A. Pursel to Fred C. Mattmueller, Subject:
May 10, 1962 "Completed Sodium Components Development Program Contracts."

May 18, 1962 Letter, T. A. Nemzek to Working Group Members, scheduling 29th meeting of the Working Group at Lewis Research Center, NASA, Cleveland, Ohio, June 5 and 6, 1962.

May 18, 1962 Memo, K. A. Dunbar to F. K. Pittman and J. A. Derry (HQ), Subject: "Sodium Components Development Program Project Co-ordination Report, April 1962."

May 18, 1962 Memo, T. A. Nemzek to G. W. Wensch, Subject: "Sodium Components Development Program Co-ordination Report, March 1962," regarding comments and questions on subject report.

May 21, 1962 Memo to File, Thru: C. A. Pursel, from F. A. Smith, Subject: "Trip Report: Status of Alco Steam Generator and IHX, May 16, 1962."

May 21, 1962 Letter, Fred C. Mattmueller to Admiral W. D. Leggett, Jr. (Alco Products), Subject: "Contract No. AT(11-1)-666," re C. E. Peterson, AI, being the inspector to follow critical areas remaining in completion of work under subject contract.

May 21, 1962 Letter, R. W. Lockhart (GE) to R. W. Dickinson (AI), re progress letter on work that AI is doing on carbon analysis in sodium.

May 22, 1962 Memo, C. A. Pursel to T. A. Nemzek, Subject: "Comments on the A-C Proposal to Perform R&D on Plasma Deposited Coatings for Graphite."

May 23, 1962 Letter, S. Kallmann (Ledoux & Co.) to T. P. Heckman, regarding carbon analysis in sodium and offering to participate in the next round robin.

May 24, 1962 Memo, F. K. Pittman to K. A. Dunbar, Subject: "Application of PERT Technique to Sodium Components Test Installation Project at AI."

May 24, 1962 Letter, F. A. Smith to H. Kirtchik (GE), concerning submission of unsolicited proposals to ANL and CH on oxygen in sodium.

May 25, 1962 Memo, K. A. Dunbar to E. C. Shute (SAN), Subject: "Contract AT(04-3)-189 #15, Mass Transfer," requesting GE to complete 189 form.

May 25, 1962 Memo, K. A. Dunbar to J. C. Clarke (NYOO), Subject: "Contract No. AT(30-1)-2877 - Continuous Oxide Meter," requesting UNC to complete 189 form.

May 28, 1962 USAEC CH Announcement 39, "Establishment of Contractor Selection Board" to recommend the selection of a contractor to design and fabricate a prototype sodium to water steam generator as a part of the Sodium Components Development Program.

May 29, 1962 Letter, F. C. Mattmueller to C. H. Staub (MSA), requesting MSA to complete 189 form on their Contract AT(11-1)-765.

May 29, 1962 Memo, T. A. Nemzek to J. V. Levy, Subject: "Application of PERT System to Sodium Components Test Installation Project," requesting AI to adopt the PERT system of scheduling for project control, also to forward to CH by July 1, 1962, two copies of over-all schedule together with all pertinent backup work sheets.

May 29, 1962 Letter, T. A. Nemzek to Working Group Members, forwarding documents and reports from Alco, BMI, GE, and MSA.

May 31, 1962 TWX, F. C. Mattmueller to W. D. Leggett, Jr. (Alco), requesting progress report on Contract AT(11-1)-666.

Supplement to Correspondence Listing

May 1, 1962 Letter, R. Cygan (AI) to L. E. Phillips (Alco),
furnishing answers to Alco questions on P&I Diagram
7593-44861. (AI letter 62AT3245)

May 7, 1962 Letter, L. E. Phillips (Alco) to R. Cygan (AI),
concerning review of AI preliminary drawings
E-303-356-S13 and SK-4-18-62 covering the proposed
method of supporting and guiding the intermediate
heat exchanger and steam generator. Reference
AI letter 62AT3246, Contract AT(11-1)-666.

Undated Letter, R. Cygan (AI) to L. E. Phillips (Alco),
62AT3246, transmitting preliminary drawings showing
the proposed schemes for supporting the IHX and
steam generator in the SCTI.

May 7, 1962 Letter 62AT2202, R. W. Dickinson (AI) to J. V. Levy,
Subject: "Shell Side Heat Transfer Program," re
planned schedule for testing Basic Unit No. 12.

May 9, 1962 Memo, A. P. Pollman (CPAO) to T. A. Nemzek, Subject:
"Shell Side Heat Transfer Studies," enclosing AI
letter 62AT2202 which submits a revised schedule for
the testing of the first tube bundle.

May 15, 1962 Letter 62AT3656, R. W. Dickinson (AI) to T. A. Nemzek,
concerning the status of studies on the mechanical
behavior of structural materials in sodium.

May 18, 1962 Memo to File from F. C. Mattmueller, Subject: "Trip
Report - Visit to Alco Products Dunkirk Facilities -
May 17, 1962."

May 24, 1962 TWX, W. D. Stephenson (PNRO) to F. Mattmueller, re
Navy work at Dunkirk and delivery schedules.

Supplement to Report Listing

Letter Report for Month of April 1962, Contract AT(30-1)-2834, United
Nuclear Corporation, "Consulting."

Letter, R. H. Jones (APDA) to F. C. Mattmueller, May 4, 1962, "Status
Report on Resistivity Loop as of May 1, 1962 - Contract AT(11-1)-865.3."

Letter, J. Karp (UNC) to J. Wise (NYOO), May 25, 1962, transmitting
financial reports on Contracts AT(30-1)-2830, 2832, 2834, and 2877 for
the month of April 1962.

Project Status and Cost Report for month of April 1962, "Investigation of
Mass Transfer in Liquid Metals."

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JUNE 1962

I. Listing of Current Projects

	<u>Current Projects</u>	<u>Contractors, Address, Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
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c.	Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
d.	Shell Side	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e.	Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
f.	Mass Transfer	General Electric Co. Atomic Power Equip- ment Dept., P. O. Box 254, San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
g.	Continuous	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYOO
h.	Consulting	United Nuclear Corp. K. Goldman	AT(30-1)-2834	NYOO
i.	Low Level Oxide Analysis (Blake Meter)	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Michigan E. H. Jones	AT(11-1)-865 #3	CH

	<u>Current Projects</u>	Contractors, Address, <u>Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
j.	Consulting	APDA 1911 First Street Detroit 26, Mich. J. J. Morabito	AT(11-1)-865 #1	CH

II. Status

a. IHX and Steam Generator - Alco Products, Inc.

50% of all tube sheet drilled holes for the IHX were checked for surface roughness. On 10% of the holes from the unit, a spiral from drilling was observed. The spiral will be removed before the tube bundle is inserted. Alco and Atomics International (AI) reached tentative agreement on the testing of the IHX and steam generator. Fabrication of the steam generator and operation of the test loop is being turned over to Baldwin-Lima-Hamilton.

b. Test Facility - Atomics International

Erection of the sodium heater is practically complete. The boiler feedwater pump has been leveled and grouted in place. Both feedwater heaters, together with the deaerating heater, have been installed. Initial mechanization of Alco steam generator model has been done and is being checked out. Structural design for steam and sodium equipment supports have been completed and sent out for bids. 10 inch stainless sodium pipe and fittings have been ordered. Bids have been received for the installation of steam, feedwater, and cooling water piping systems. The sodium pump is being modified to adapt it to the secondary sodium system conditions. The blower and associated drive motor and magnetic coupling for the main sodium cooler have been specified. The steam power system and auxiliaries package have been released for purchase.

c. Physical Properties of Materials - MSA Research Corporation

All of the test machines were in operation. Plots of the stress to rupture data for the Cr-Mo and stainless steel, as well as plots for the fatigue tests of the Cr-Mo and stainless steel specimens, are included in Report #21, dated June 11, 1962. The preliminary results of all the tests performed by the end of this report period are reported in tabular form.

d. Mass Transfer Investigations - General Electric Company

Steel and sodium samples were withdrawn and submitted for analysis from loop #3 at the end of run 3-7, loop #5 after 1400 hours of run 5-3, and loop #6 after 694 hours of run 6-3.

Activities were directed toward the completion of three topical reports: operation of the test loops, analysis of the steel and sodium samples, and evaluation of "HC" type corrosion data by multiple regression methods.

The following reports were prepared and are in the process of final editing, reproduction, and review:

GEAP 3725-SMT	I - Test Loop Design
GEAP 3726-SMT	II - Screening Test Data and Analysis
	Vol. 1 - Mass Transfer Results
	Vol. 2 - Metallurgy
	Vol. 3 - Corrosion Sample Data
GEAP 4006-SMT	III - Application of Liquid NH_3 as a Sodium Leaching Agent

e. Oxygen Monitor - United Nuclear Corporation

Experiments were made with the electrochemical oxygen monitor consisting of liquid sodium, a 3.5 W/O CaO stabilized zirconia tube and a Cu-Cu₂O reference electrode in the temperature range 550-900°F. These experiments show that at temperatures above 750°F an electrochemical monitor based on these materials does not function properly. The cell gave a good response at 650°F, a somewhat low response at 750°F, and a very small response at 900°F. After the 900°F experiment, the cell temperature was reduced to 550°F and its response was found to be low.

One explanation for these observations is that above 750°F the zirconia reacts with the sodium to form an oxygen deficient surface layer.

f. Resistivity Loop - Atomic Power Development Associates, Inc.

Oxide run #3 was completed with the results confirming the previous data. All three runs were combined and shown. The plugging indicator valves still show a tendency to deviate from a straight line below 300°F plugging temperature.

Oxide run #4 was an attempt to establish the absolute relationship between resistivity and oxide content. Oxygen gas was mixed with carrier argon and injected into the sodium through a micrometallic filter. Periodic plugging and instrument troubles rendered these tests useless; however, further tests will be attempted.

The Gas Entrainment Test was started with argon gas injected into the suction of the mechanical pump. Preliminary results are shown for gas injection rates up to 800 cubic centimeters per minute.

g. Shell Side Heat Transfer Studies - Atomics International

Construction of the test loop was completed to the extent that experimental operations may be conducted for which the maximum power demands do not exceed 1200 kw. Maximum power demands for basic unit 12 are about 840 kw. Fabrication of basic unit 12 was completed and the exchanger was fitted with pilot tube parts for use in the tube side water flow distribution tests. The unit was installed in an existing hydraulic loop and flow tests were started. Calibration runs in the LCTL of the permanent magnet flow meters was completed, as was miscellaneous instrument check-out, calibrations, and some overhaul. Flow studies, using both dye and bubble techniques, and analytical studies relative to the influence of non-uniform tube side flow distribution on overall heat transfer, and the influence of various boundary conditions on liquid metal tube flow heat transfer coefficients, were conducted.

III Meetings

June 5-6 Working Group Meeting No. 29 at NASA Lewis Research Center, Cleveland, Ohio

June 7,8,18,19,20,28 - Contract Selection Board for a Sodium Heated Steam Generator

June 28-29 AEC, Alco, AI, and BLH Meeting in Schenectady, New York, to review the IHX and SG Test Program

IV Reports for SCDP Co-ordination Report

MSA Research Corporation Progress Report 21 for May 1962, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated June 11, 1962.

General Electric Company Progress Letter 35 for May 1962, "Mass Transfer Investigation in Liquid Metal Systems", dated June 6, 1962

Alco Products Progress Report, "Sodium Components Design Program, Contract AT(11-1)-666", dated April 30, 1962.

General Electric Company Project Status and Cost Report for May 1962, "Investigation of Mass Transfer in Liquid Metals".

AI Progress Letter 14, "Sodium Components Test Installation", for May 1962.

BMI Report on "Friction and Wear of Sliding Surfaces in Sodium Environments", for May 1962.

AI Progress Letter 8, "Shell Side Heat Transfer Studies", for April and May, dated June 1, 1962.

APDA "Status Report on Resistivity Loop as of June 1, 1962 - Contract AT(11-1)-865.3", dated June 4, 1962.

GEAP-4006, "Sodium Mass Transfer: III The Application of Liquid Ammonia as a Sodium Leaching Agent".

Alco Products APAE-112, Volume III, "Material and Welding Specifications for 30 Megawatt Heat Exchanger and Steam Generator for Sodium Cooled Reactor System".

UNC Letter Report for Month of May 1962, Contract AT(30-1)-2834, "Consulting".

UNC Monthly Progress Report 9 for May 1962, Contract AT(30-1)-2877, "Continuous Oxide Meter",

UNC Monthly Financial Reports for Contracts AT(30-1)-2834, "Consulting", and AT(30-1)-2877, "Continuous Oxide Meter".

V

CH Correspondence for SCDP Report

June 1, 1962	Letter, R. W. Lockhart (GE) to T. A. Nemzek, Subject: "Sodium Components Development Program Working Group - First AD Hoc review of the Carbon Impurity Analysis Program", with Report No. 1 from the Carbon Analysis Ad Hoc Review Group.
June 1, 1962	Letter, R. W. Lockhart (GE) to T. A. Nemzek, Subject: "Sodium Components Development Program Working Group - Carbon Analysis".
June 1, 1962	Memo to File from F. C. Mattmueller, Subject: "Telephone Conversation with L. Phillips, Alco Products", regarding preliminary estimates of cost to complete the steam generator.
June 1, 1962	Letter 62-AT-4095, R. Cygan (AI) to T. A. Nemzek, Subject: "Co-ordination Meeting between Alco and AI", held May 22-23, 1962, on IHX and steam generator work.
June 4, 1962	Memo, A. G. Fremling to L. A. Redecke, Subject: "Meeting with Alco and Baldwin-Lima-Hamilton", held May 29, 1962, discussing progress of Alco to find possible successor companies to take over steam generator fabrication.
June 6, 1962	Letter 62-AT-4061, R. W. Dickinson (AI) to S. G. Mordlinger (DRD), pertaining to work at BMI on friction and wear of rubbing surfaces in liquid sodium.
June 6, 1962	Letter, S. Saxon (NYOO) to J. M. Findlay (Liquid Metals, Inc., Westford, Mass.), pertaining to the contract awarded to UNC for the development of a continuous meter for oxygen in sodium.

- June 7, 1962 Letter, W. D. Leggett (Alco) to F. C. Mattmueller, regarding C. E. Peterson's assignment to act as inspector at Dunkirk Plant to follow fabrication of IHX; Alco is transferring Mr. Mackowski from Schenectady office to Dunkirk to act as liaison engineer.
- June 11, 1962 Memo, F. A. Smith to File, THRU C. A. Pursel, Subject: "Phone Call: Alco Products, June 11, 1962", regarding a meeting June 14-15 at Dunkirk between Alco and BLH; proposed meeting in Philadelphia among Superior, AI, Alco and AEC re purchase order with Allegheny-Ludlum for six duplex tubes.
- June 12, 1962 Letter, F. A. Smith to R. W. Dickinson (AI), thanking AI for the IOL concerning rupture disks on the steam generator; also, furnishing information on the possibility of acquiring Alco test rig for corrosion-heat flux studies.
- June 12, 1962 Memo to File from R. E. Harris (DRD), Subject: "APDA Request for Use Charge for Loop Testing U.K. Resistivity Meter - Telephone Call from Alex Fremling, CH, 6-11-62."
- June 12, 1962 Letter, J. R. Birle (GE) to W. H. Brummett (SAN), Subject: "Contract AT(04-3)-189, P.A. No. 15, Sodium Mass Transfer Investigations", regarding continuation of the subject program through FY 1963.
- June 12, 1962 TWX, F. C. Mattmueller to A. P. Donnell, (APDA), funds added to Contract AT(11-1)-865 PA #3, to cover six months use charge on 4" sodium loop.
- June 12, 1962 Letter, R. D. Seifert (Alco) to F. C. Mattmueller, regarding preparation of proposal for turning over fabrication of the steam generator from Alco to BLH.
- June 12, 1962 Letter, T. A. Nemzek to R. Cygan (AI), requesting SCTI monthly progress transmittal letter be addressed to J. V. Levy, with a carbon copy to T. A. Nemzek.
- June 13, 1962 Memo, R. E. Harris (DRD) to U. M. Staebler, Subject: "Trip Report - June 5-8, Trip to Cleveland Ohio, and Chicago, Illinois".
- June 13, 1962 Memo, A. G. Fremling to F. C. Mattmueller, Subject: "Contract AT(11-1)-666, Alco Products, Inc.," stating that Alco was advised by telephone that the Commission prefers to have test rig work transferred to successor contractor rather than having it completed by Alco, and that proposal should be based upon this fact; advising Alco should prepare a proposal offering alternate approaches to the problem, one estimating the cost associated with transferring the work to BLH and the other for maintaining the work at Alco.

June 13, 1962 Letter, T. A. Nemzek to C. A. Barrett (NASA), thanking NASA for the interesting and instructive meeting held at the Lewis Research Center, June 5-6, 1962.

June 14, 1962 Memo, K. A. Dunbar to F. K. Pittman and J. A. Derry, transmitting Sodium Components Development Program Project Co-ordination Report, May 1962.

June 15, 1962 Memo, F. K. Pittman to K. A. Dunbar, Subject: "Report on Alco IHX and Steam Generator", requesting summary report covering results of negotiations with Alco and plan of action for expeditiously completing the steam generator and IHX.

June 18, 1962 Letter, L. E. Phillips (Alco) to F. C. Mattmueller, enclosing progress report on Contract AT(11-1)-666, dated April 30, 1962.

June 18, 1962 Letter, L. E. Phillips (Alco) to C. E. Peterson (AI), Subject: "Intermediate Heat Exchanger for Sodium Cooled Reactor - Contract AT(11-1)-666", stating that 50% of all tube sheet drilled holes were checked for surface roughness with Profilometer at Dunkirk.

June 19, 1962 Letter, W. S. Mott (UNC) to J. D. Hart (NYOO), "Contract AT(30-1)-2834, Sodium Consulting Proposal UNC-D-62046",

June 21, 1962 Letter, W. S. Mott (UNC) to NYOO, Subject: "Extension of Contract AT(30-1)-2877, Development of Meter for Continuous Determination of Oxygen in Sodium Proposal UNC-D-62043",

June 22, 1962 Memo, K. A. Dunbar to E. C. Shute, Subject: "Contract AT(04-3)-189, P.A. No. 15, Sodium Mass Transfer Investigation", regarding authorization to continue the subject project agreement.

June 25, 1962 Memo to File from F. C. Mattmueller, Subject: "Telephone Conversation with Phil Otten, Baldwin-Lima-Hamilton", regarding costs to be incurred by respective parties as a result of the transfer and reassembly of the test loop to BLH.

June 26, 1962 TWX, F. C. Mattmueller to P. S. Otten (BLH), re preparation of Contract for completion of steam generator presently contracted for with Alco Products under Contract AT(11-1)-666; arrangements being made to transfer test loop now located in Alco Schenectady facilities for completion of test program by BLH.

June 26, 1962 TWX, K. A. Dunbar to J. V. Vinciguerra (HQ), re preliminary agreements reached with representatives

of Alco and BLH, concerning disposition of work remaining under Contract AT(11-1)-666, related to Sodium Components Program.

- June 27, 1962 Letter, W. D. Leggett (Aclo) to F. C. Mattmueller, re Alco assuming the cost of disassembling, packaging and shipping the high pressure, high temperature test loop from Schenectady Laboratory to the BLH plant in Philadelphia.
- June 29, 1962 Memo, F. C. Mattmueller to J. B. Lee, Subject: "Contract AT(11-1)-765, MSA Research Corporation", requesting appropriate modification to subject contract for extension and increase in funds.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JULY 1962

I. Listing of Current Projects

	<u>Current Projects</u>	<u>Contractors, Address, Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a.	Heat Exchanger & Steam Generator	Alco Products, Inc. Schenectady 5, N.Y. L. E. Phillips	AT(11-1)-666	CH
*				
b.	Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
c.	Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
d.	Shell Side	Atomics International	AT(11-1)-8	CPAO
e.	Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
f.	Mass Transfer	General Electric Co. Atomic Power Equip- ment Dept., P. O. Box 254, San Jose 12, Calif.	AT(04-3)-189 #14	SAN
g.	Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N.Y. H. Steinmetz	AT(30-1)-2877	NYOO
h.	Consulting	United Nuclear Corp. K. Goldmann	AT(30-1)-2834	NYOO
i.	Low Level Oxide Analysis (Blake Meter)	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
j.	Consulting	APDA J. J. Morabito	AT(11-1)-865 #1	CH
k.	Boiling Sodium Heat Transfer	Univ. of Wisconsin Madison 5, Wisc. M. W. Carbon	AT(11-1)-1070	CH

* See next page

	<u>Current Project</u>	<u>Person in Charge</u>	<u>Contract No.</u>	<u>Administrator</u>
1.	Liquid Metal Heat Transfer	Brookhaven National Laboratory Upton, N. Y. D. E. Dwyer		NYOO
*	Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. P. S. Otten	AT(11-1)-1213	CH

II. Status

a. IHX and Steam Generator - Alco Products, Inc.

IHX

The drawings are complete and all material is available in the Dunkirk shop. The tubes have been bent into sine waves and hydrostatically pressure tested. The fabrication schedule has slipped in some areas, but shipment by the end of November 1962 appears feasible.

Steam Generator

The drawings are complete and all material is on hand at the Dunkirk shop except the composite tubing. The pilot order for tubing passed the Vidigage of starting tube rounds for bond evaluation, flattening and flaring tests, one hundred per cent dye penetrant inspection of outside surface and sections of the inside surface, tensile properties, helium leak check, and numerous microspecimens. Difficulty was encountered in the ultrasonic testing due to a high continuous background. This may be related to a heavy band of carbide precipitate of the stainless steel side of the interface. Improvements in the ultrasonic testing and in an alternate to this method are being investigated. Fabrications of this unit will be transferred to Baldwin-Lima-Hamilton (BLH). The best possible shipment date, based on Alco schedule, appears to be May 1963.

Test Program

Alco held a meeting with Atomics International (AI) in May and June 1962, to formulate the test program for the complete steady state and for the transient operation of these units. Completion of this work is anticipated by mid-August 1962. BLH will participate in future meetings to finalize the test program formulation.

b. Test Facility - Atomics International (AI)

Design

The sodium and inert gas piping design package is ready for bidding. Design work remaining consists of the sodium system preheating and steam generator safety system.

Procurement

A cost and schedule for addition of a 35 MW sodium-to-air cooler was prepared for submission to the AEC.

Construction

Installation of the startup thermocouples for the sodium heater is in progress. Equipment platforms in building 356 are 80% completed. Work has started on steam, feedwater, and cooling-water piping systems.

c. Physical Properties of Materials - MSA Research Corporation (MSAR)

All of the test machines were in operation. Plots of the stress to rupture data for the Cr-Mo and for the stainless steel specimens, tested up to this report, are included in the report. The results of some of the tests are preliminary and are reported in tabular form. Procedures to analyze the steel specimens and the sodium were discussed. Considerable attention has been given to the carbon concentration since the future program calls for a series of tests in 1200°F sodium saturated with carbon. Substitution of pure oxygen for the Van Slyke solution in the carbon analysis technique is continuing and the requirement for pure oxygen appears to be less demanding.

The data and general information are now beginning to accumulate in quantity and MSAR will point out and discuss those trends and areas that appear to be significant in future reports.

d. Mass Transfer Investigation - General Electric Company (GE)

Activities during June were directed toward the completion of the topical reports listed in last month's report, operation of the test loops, analysis of the steel and sodium samples, and evaluation of "HC" type corrosion data by multiple regression methods.

Steel and sodium samples were withdrawn from the 316SS-2-1/4 Cr loop (#2) after 2805 hours (second sample period) of run 2-5 operation and from the 316SS-5Cr loop (#4) after 698 hours of run 4-5 operation. These samples were analyzed.

Spectrographic analysis and X-ray diffraction data for the filter samples showed the following results:

Light grey material	primarily Na ₂ CO ₃ with α Fe trace
Dark grey material	primarily crystallized α Fe with unidentified minor phase
Dark brown particles	primarily γ Fe with traces of α Fe and Na ₂ CO ₃
Blue white material	Na ₂ CO ₃ major phase, trace of α Fe plus some weak unidentified lines
Green crystals	not identified
White material	evidence of CaCO ₃ weaker lines unidentified
Opaque crystals	diffraction pattern unsatisfactory for identification
Black material	primarily γ Fe with some α Fe

e. Resistivity Loop - Atomic Power Development Associates (APDA)

Gas entrainment tests were run using argon, helium and xenon gases. Again, there was found to be no evidence of residual retention of the gas in the sodium for any of the three gases tested. Since xenon may be of immediate interest, the resistivity charts are included in the APDA progress report. The gas entrainment tests were completed on June 18, 1962.

Preparation of the system for the carbon program involved discharging the contaminants of the stainless steel mesh cold trap into the system and removal of these by the zirconium hot trap. The stainless steel mesh unit can now be used as a hot trap to determine the effectiveness of the stainless steel mesh for removal of carbon.

Twelve 1/4" x 12" spectrographic graphite electrodes were caged and introduced into the surge tank on June 27, 1962.

f. Shell Side Heat Transfer - Atomics International (AI)

The tube side water flow distribution studies of Basic Unit 12 were completed. An informal report NAA-SR-MEMO-7348, "Tube Side Flow Distribution Effects on Heat Exchanger Performance," describes the results of the analysis. The test loop was readied for sodium operations with the exception of the heat exchanger. A detailed plan was formulated for conducting shakedown and operational runs. Professor Short has conducted further flow distribution studies of baffled exchangers using a bubble technique and has comprehensively recorded the results on film.

g. Boiling Liquid Metal Heat Transfer - University of Wisconsin

Work has proceeded on fabricating two new heating elements for the boiling apparatus. The first element has a stainless steel sheath and will be welded directly to the Haynes 25 container. The second element has a molybdenum sheath, and this design incorporates a mechanical seal.

Installation of the new heating element sheaths necessitated opening the vessel. The sodium was removed, the vessel cleaned with alcohol, and new sodium will be inserted after the sheaths are installed.

h. Liquid Metal Heat Transfer - Brookhaven National Laboratory (BNL)

Project 9 - Correlate Heat Transfer Coefficients for In-line Turbulent Flow of Mercury Through Unbaffled Rod Bundles

This project was inactive during this report period.

Project 10 - Heat Transfer Studies with NaK

This loop, with a test section of 19 heated 1/2" OD rods spaced on an equilateral triangular grid with a P/D ratio of 1.750, was placed in operation about five months ago. Data for heat transfer coefficients for turbulent in-line flow of NaK through unbaffled rod bundles were plotted.

Project 13 - Boiling Potassium

Layout for the loop is continuing. All four EM pumps have been tested and are currently in transit. Material for the condenser vessel has been received and is being fabricated. Analytical studies have progressed on boiling two-phase flow with flow regimes of the following characteristics

- a. bubble flow
- b. slug flow
- c. annular flow
- d. fog flow

Project 15

In this project, surface temperatures, velocity, and temperature profiles will be measured for flow of mercury through concentric annuli, with heat transfer from the inner wall. The plan is to modify the present mercury loop to incorporate an annulus test section.

1. Oxygen Monitor - United Nuclear Corporation (UNC)

The test apparatus was modified so that four different electrochemical cells could be tested simultaneously, also so that the response time of the cells to cold trap temperature changes would be improved.

Tests were continued with the multiple cell head. The results were more variable than experienced in the past. Contributing factors to this variability are: voltage drift of the cells, difficulties in operating the thermal convection loop, and the increased time required for the sodium in the test section to reach a uniform oxygen concentration in equilibrium with the cold trap. Apparently, the major problem lies in obtaining a cell whose voltage is stable over long periods of time.

Various reference electrodes, as well as various ceramics, will be tested in the near future with the aim of obtaining a cell with superior voltage stability.

III. Meetings in July

- July 1 Working Group Meeting at CH to compile data on existing sodium heated steam generators.
- July 19 Unsolicited visit to AEC-CH by Combustion Engineering Company to present their current design studies on sodium heated steam generators.
- July 26 Meeting at CH among AEC, ANL, Alco, Superior Tube, SWRI, BLH, regarding nondestructive testing and fabrication of duplex tubing for sodium-steam generator application.

IV. Reports for SCDP Co-ordination Report

Alco Products Progress Report, "Sodium Components Design Program, Contract AT(11-1)-666," dated June 29, 1962.

AI Progress Letter 15, "Sodium Components Test Installation," for June 1962.

University of Wisconsin Progress Report No. 11, "Boiling Liquid Metals Heat Transfer," dated June 1, 1962.

University of Wisconsin Progress Report No. 12, "Boiling Liquid Metals Heat Transfer," dated July 1, 1962.

AI Progress Letter 9, "Shell Side Heat Transfer Studies," dated July 3, 1962.

UNC Letter Report for June 1962, Contract AT(30-1)-2834, "Consulting."

GE Progress Letter, "Mass Transfer Investigation in Liquid Metal Systems," dated July 6, 1962.

UNC Monthly Financial Report for Contracts AT(30-1)-2834, AT(30-1)-2832, AT(30-1)-2877, and AT(30-1)-3023.

GE Progress Status and Cost Report for June 1962, "Investigation of Mass Transfer in Liquid Metals."

Brookhaven National Laboratory Summaries of the results of R/D for the months of May and June, dated July 23, 1962.

APDA Report, "Status Report on Resistivity Loop as of July 1, 1962, Contract AT(11-1)-865.3," dated July 2, 1962.

MSAR 62-77 Progress Report 22, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated July 16, 1962.

UNC-5028 Report, "Development of a Continuous Meter for Oxygen in Sodium,"

V. CH Correspondence for SCDP Report for July 1962

July 3	Letter, F. C. Mattmueller to W. D. Leggett, Jr., "Proposal for transfer of certain existing contractual responsibilities of Alco Products to Baldwin-Lima-Hamilton."
July 3	Memo, F. C. Mattmueller to J. B. Lee, "Proposed New Contract with BLH and Contract Modification for Alco Products, Inc., Contract AT(11-1)-666."
July 3	Letter, R. H. Jones to F. C. Mattmueller, regarding Mr. Jones leaving APDA to join AI.
July 5	Memo, T. A. Nemzek to J. V. Levy, "Second Round-Robin Carbon Analysis under the SCDP," regarding sodium samples distributed to six participants.
July 10	Letter, T. A. Nemzek to Working Group, Minutes of Twenty-ninth SCDP Meeting held in Cleveland, Ohio, June 5 and 6, 1962, and documents and reports for their information.
July 10	Memo to File from F. A. Smith, "Alco Steam Generator - Trip Report," regarding meeting held at Alco June 28-29, 1962, to review SCTI program.
July 10	Letter, F. C. Mattmueller to L. E. Phillips, requesting that Mr. P. S. Otten be provided with all technical reports issued by Alco during the remainder of the contract period.
July 10	Memo, T. A. Nemzek to J. V. Levy, "AI Inspection Assistance at Dunkirk, New York - Contract AT(11-1)-666," requesting that Mr. Peterson be advised that Mr. Mackowski is to be assigned as liaison engineer between Alco, Schenectady, and Alco, Dunkirk.
July 11	Memo, T. A. Nemzek to J. V. Levy, "SCTI-BLH Co-ordination, Reports, Modified Croloy," requesting AI to exchange information with BLH.
July 11	Memo to File, F. A. Smith, "SCTI - Phone Conversation - AI-CH CPAO," regarding discussion of technical questions raised by review of SCTI steam piping, between F. Smith, CH, J. DeKaney, CPAO, and R. Cygan, AI.
July 11	Letter, F. C. Mattmueller to C. H. Staub, "Contract AT(11-1)-765 - Modification No. 5," regarding the extension of the contract through August 31, 1962, and providing additional funds.
July 11	Letter, T. A. Nemzek to J. Morabito, transmitting a requested document.
July 11	Letter, F. C. Mattmueller to P. S. Otten, BLH, request for technical information, plans, schedules, etc.

July 12 Memo, K. A. Dunbar to J. C. Clarke, "Additional Effort on the Absolute Technique for the Determination of Oxygen in Sodium," requesting UNC to prepare definite, concise work scope to establish a "laboratory standard."

July 12 Memo, F. A. Smith to File, "Phone Conversation - Alco Products Steam Generator Tube Procurement Information - July 10, 1962," discussion regarding meeting to discuss problems of tube procurement.

July 12 Memo, T. A. Nemzek to G. W. Wensch, "Alco Report APAE-41, Volumes I, II, and III - IHX Steam Generator Designs," above volumes sent.

July 16 Memo, F. A. Smith to File, "Phone Call - Alco Products, Inc., July 16, 1962," regarding proposed meeting to be held in CH.

July 17 Letter, F. C. Mattmueller to A. P. Donnell, regarding J. Morabito editing the Sodium Heated Steam Generator Performance Study.

July 18 Memo, J. J. King to C. A. Pursel, "Contract AT(04-3)-189 PA #15, Mass Transfer," copy of Form 189 received.

July 20 Memo, G. W. Wensch to File, regarding DRD's concern in CH's decision to waive ultrasonic inspection of bimetallic tubing for use in Alco steam generator.

July 25 Letter, T. A. Nemzek to participants in second round of analysis (SCDP), enclosing new procedures and copy of result of first round robin.

July 27 Memo, K. A. Dunbar to F. K. Pittman, "Ultrasonic Inspection for Procurement of Bimetallic Tubes - Alco Steam Generator," regarding the amendment of specifications for the procurement of bimetallic tubing for the Alco steam generator.

July 30 Letter, F. A. Smith to C. H. Staub, request for "Status Report" on work to date under contract AT(11-1)-765.

July 30 Memo, K. A. Dunbar to F. K. Pittman, "Application of PERT Technique to Sodium Components Test Installation at AI," regarding procedures which will be used to apply the PERT technique to SCTI.

July 30 TWX, A. P. Pollman to T. A. Nemzek, AI advised they would like finished tubes, good ingot, and data available for utilization of 4S 8 material at Alco.

CURRENT COST STATUS
SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
BUDGET ACTIVITY NO. 04-01-04-20

<u>Project Title</u>	<u>Contractor & Proj. No.</u>	<u>Contract No.</u>	<u>Current Month</u> ⁽¹⁾	<u>Current FY 1962 Cost</u>
a. Heat Exchanger & Steam Gen.	Alco Prod. Inc.	AT(11-1)-666	91,516 ⁽²⁾	424,660
b. Test Facility	AI 4461	AT(11-1)-8	46,800	844,513
c. Valve Test	AI 4466	AT(11-1)-8	- 0 -	13,266
d. Shell Side Heat Transfer	AI 4468	AT(11-1)-8	12,507	223,316
e. Flow Con- trollers	WEC	AT(11-1)-681	- 0 -	20,339
f. Physical Properties	MSA	AT(11-1)-765	10,308 ⁽²⁾	243,282
g. (SAN) Mass Transfer	GE	AT(04-3)-189 #15	29,206	429,876
h. (NYOO) Continuous Oxide Meter	UNC	AT(30-1)-2877	10,014	79,945
i. (NYOO) Consulting	UNC	AT(30-1)-2834	1,326	15,308
j. Low Level Oxide Analysis (Blake Meter)	APDA	AT(11-1)-865 #3	704 ⁽²⁾	11,286
k. Consulting	APDA	AT(11-1)-865 #1	3,694 ⁽²⁾	13,694

(1) Steps have been taken to improve current monthly cost estimate reporting.

(2) Cost last reported, May 1962.

Appendix "A"

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
AUGUST 1962

I. Listing of Current Projects

	<u>Current Projects</u>	Contractors, Address, <u>Person in Charge</u>	<u>Contract No.</u>	<u>Contractor Administrator</u>
a.	Heat Exchanger & Steam Generator	Alco Products, Inc. Schenectady, 5, N.Y. L. E. Phillips	AT(11-1)-666	CH
b.	Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. P. S. Otten	AT(11-1)-1213	CH
c.	Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
d.	Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e.	Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
f.	Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g.	Mass Transfer	General Electric Co. Atomic Power Equip- ment Dept., P. O. Box 254, San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
h.	Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYOO
i.	Consulting	United Nuclear Corp. K. Goldmann	AT(30-1)-2834	NYOO
j.	Low Level Oxide Analysis (Blake Meter)	Atomic Power Dev. Associates, Inc. 1911 First Street Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
k.	Consulting	Atomic Power Dev. Associates, Inc. J. J. Morabito	AT(11-1)-865 #1	CH

	<u>Current Projects</u>	Contractors, Address, <u>Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
l.	Boiling Sodium Heat Transfer	Univ. of Wisconsin Madison 5, Wisc. M. W. Carbon	AT(11-1)-1070	CH
m.	Liquid Metal Heat Transfer	Brookhaven National Laboratory Upton, N. Y. D. E. Dwyer		NYOO

II. Status

a. IHX and Steam Generator - Alco Products, Inc.

IHX

Machining and assembly of the IHX continued with only minor difficulties and delays. The strain gauges intended for the IHX, internally located at tube sheet to shell joint, were damaged during the assembly process and were removed. Alco Products, Inc. and Atomics International (AI) are deleting the provision for new strain gauges. Meanwhile, baffles and thermocouples were installed.

Steam Generator

The shell was ready for shipment. The upper and lower tube sheets have been overlayed; however, machining of the overlay is required. The upper and lower heads were overlayed on the inner surface of the hemisphere, and the nozzle openings were bored. The lower shroud was fabricated and one section of the upper shroud was ready for dye checking.

Test Program

A final draft of the Alco Test Program Report was prepared for review at a joint meeting among AEC, AI, and Alco.

b. Test Facility - Atomics International - (AI)

Installation of equipment platforms has been completed. Some additional structure will be added to accommodate the pipe hangers.

Work on the steam system is limited to foundations for the water and chemical treatment system. Excavation is completed, form work and reinforcing is 50% complete, and 25% of the concrete has been poured.

Certain additions and changes to the steam power systems and auxiliary drawings, as requested by the water treatment consultant, are being made. Analog studies of the feedwater control indicated the need for some modifications in the control loops. Tentative modifications have been made in the design and are presently being set up on the analog for check-out.

Analysis of the IHX support structure has been completed, and the results indicate that the vessel should be clamped at the support plane.

c. Physical Properties of Materials - MSA Research Corporation (MSAR)

Test data of the stainless steel and the Cr-Mo specimens subjected to stress rupture, creep, tensile, and fatigue tests in different environments are beginning to accumulate. The results have been listed in tabular form and plotted on graphs; however, curves through the plotted points have not been attempted.

Samples of the sodium were removed from the loops once a week and analyzed for carbon content. Attempts to interpret the data to determine the effects of cold trapping on the carbon concentration are inconclusive. There may be too many other factors influencing the carbon solubility that make these particular loops poor testing grounds for this particular phenomenon.

Photographs of all specimens have been taken before and after each test. Photomicrographs have been taken of representative specimens and will be examined by Dr. Freeman of the University of Michigan.

d. Mass Transfer Investigations - General Electric Company (GE)

Activities were directed toward the completion of the topical reports, operation of the test loops, analysis of the specimens and sodium samples, and evaluation of the data.

The first end-of-run data for all 316 SS loops, run 1-3, was reported in detail. The corrosion rates, when compared with values from previous run 1-2, appear:

- (1) Two to three times lower for samples of C1, C2, and H3 outlet
- (2) considerably lower for the in-pipe samples which were exposed in both 1-2 and 1-3 runs

The first end-of-run data was reported for all 2-1/4 Cr loops #5. A review of the available results indicates:

- (1) a decrease in corrosion rate with time for H3 and H3R samples
- (2) both weight gain and weight loss for the cold leg samples, whereas the previous 700 and 1400 hour data indicates weight loss only.
- (3) the magnitude of the corrosion rates for samples from C1 and C3 to be considerably lower than the 700 and 1400 hour sample data
- (4) C3 in-pipe sample corrosion rates of $< 1.0 \text{ mg/dm}^2\text{-mo}$ for previously exposed samples and +18. for the new sample

e. Resistivity Loop - Atomic Power Development Associates (APDA)

The objective of the carbon tests in the resistivity loop was to determine whether:

- (1) the resistivity meter has the required sensitivity and signal stability to indicate carbon contamination at levels tolerable in plant operation
- (2) the resistivity meter, operating in conjunction with a plugging meter, can be made to discriminate between oxygen contamination and carbon contamination

Carbon was introduced into the loop by means of twelve 1/4" high purity graphite rods immersed in the sodium at 750°F.

It is concluded that within the experienced parameters of the carbon test, the resistivity loop cold trap is not effective as a hot trap and cannot be used to control the carbon level in the loop for the purpose of calibrating the resistivity meter.

It is proposed to conclude the current carbon test by correlating resistivity readings with laboratory analyses of sodium samples taken over an appropriate range of carbon values.

f. Shell Side Heat Transfer - Atomics International (AI)

The first test unit, Basic Unit 12, was installed in the test section and loop checkout was started. The system was filled with sodium which was circulated for about 20 hours. Problems associated with the main sodium pump required removal of the pump from the loop. An existing large helical rotor electromagnetic pump unit that has very recently been tested and demonstrated to have an infinitely variable capacity up to flows well beyond the project requirement is being installed in the loop.

Professor Short's studies indicate that the experimental design for basic unit tests employing only models for which $\alpha = 0^\circ$ and 90° should be carried out. Two primary reasons for reaching the above conclusion are:

- (1) the water model studies of baffled heat exchangers indicate that for the bundle geometries which appear to be attractive for sodium applications, knowledge of sodium heat transfer characteristics in tube bundles for pure parallel and pure cross flow alone, when coupled with the shell side flow distribution analyses, should provide the best information (for the same number of basic unit tests) for predicting shell side heat transfer performances.
- (2) the water model studies of simulated basic units with $\alpha \neq 0^\circ, 90^\circ$, indicate that bundle end walls (tube sheets) affect the shell side flow distribution sufficiently that the sodium heat transfer results obtained with bundles of reasonable size could not be accepted without reservation as being characteristic of either conditions for infinitely long tubes or conditions that actually exist in baffled exchangers. If at the end of the program as presently planned, i. e., after the verification unit tests, it appears desirable to test basic units having $\alpha \neq 0^\circ, 90^\circ$, we may then try to solve the problem of controlling shell side flow in a manner to give "pure" heat transfer conditions. The means for such control are not apparent at this time.

g. Boiling Liquid Metal Heat Transfer - University of Wisconsin

Work has proceeded on installation of a new stainless steel heating element and on preparing the apparatus for another test run. Vacuum troubles have been encountered but will be remedied soon.

Work has also proceeded on the fabrication of a new Haynes 25 boiling test section and is essentially complete.

h. Oxygen Monitor - United Nuclear Corporation (UNC)

The report on this project dealing with work performed through July 31, 1962, was written (UNC-5032). Two new test loops were completed and testing of electrochemical cells was started with these loops.

The original test apparatus was used to test simultaneously four different electrochemical cells for response to changes in oxygen content, temperature coefficient, and voltage stability. The data obtained indicated that the voltage response to changes in oxygen content is independent of the nature of the reference electrode. However, the type of reference electrode used determines the temperature coefficient and the voltage stability of the cell. Only in the case of the copper-copper oxide power electrodes were the results fairly consistent and in agreement with theory.

III. Meetings in August

- August 7 AEC with APDA in Detroit, Michigan, to review the Resistivity Meter Project.
- August 8 AEC with MSAR in Callery, Pennsylvania, to review the Physical Properties of Materials Project.
- August 21-22 AEC with AI and Alco in Canoga Park, California, to review the final drafts of the IHX and Steam Generator Test Program.

IV. Reports for SCDP Co-ordination Report

AI Progress Letter No. 10, "Shell Side Heat Transfer Studies," dated August 13, 1962.

BMI Monthly Progress Report, Section A, dated August 21, 1962.

GE Project Status and Cost Reports on Project Agreement 15, dated August 9, 1962.

GE Progress Status and Cost Report for July 1962, "Investigation of Mass Transfer in Liquid Metals."

GE Progress Letter, "Mass Transfer Investigation in Liquid Metal Systems," dated August 3, 1962.

APDA Report, "Summary Report - July 1962 - Contract AT(11-1)-865, Project 3."

MSAR Progress Report No. 23, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels."

UNC Letter Report for July 1962, Contract AT(30-1)-2834, dated August 13, 1962.

UNC Monthly Progress Report No. 10 for June, Contract AT(30-1)-2877, dated August 6, 1962.

UNC Monthly Progress Report No. 11 for July, Contract AT(30-1)-2877, dated August 21, 1962.

UNC 5028 Quarterly Progress Report for the Period March 1962 to May 1962, "Development of a Continuous Meter for Oxygen in Sodium."

USAEC Cost Report on Plant and Equipment Changes in Progress, Period ending June 30, 1962.

Supplemental Agreement between The University of Michigan and MSA Research Corporation, effective July 11, 1962.

UNC-5032 Final Report for the Period September 1, 1961, to July 31, 1962, "Development of a Continuous Meter for Oxygen in Sodium," dated August 24, 1962.

V. Correspondence for August 1962

August 1	Memo, T. A. Nemzek, CH, to A. P. Pollman, CPAO, "Air-Cooled Heat Dump for SCTI," regarding preliminary cost estimate, time schedule, and layout for air-cooled heat exchanger.
August 1	TWX, F. C. Mattmueller, CH, to W. D. Leggett, Alco, "Contract AT(11-1)-666," authorization to ship steam generator components to BLH.
August 2	Letter, L. E. Phillips, Alco, to F. A. Smith, CH, copy of the informal report giving results of the strain gauge installation attempt.
August 6	Letter, F. A. Smith, CH, to J. H. Wright, WEC, sending copy of the 1958 invitation to industry for proposal to develop a sodium heated steam generator.
August 7	Letter, R. Cygan, AI, to L. E. Phillips, Alco, with a summary, "Test Program Transients," which is in line with the Commission's request to review the program from the "user" standpoint.
August 7	Letter, A. P. Donnell, APDA, to F. C. Mattmueller, CH, confirmation of J. Morabito's agreement to review comments and edit the report entitled, "Sodium Heated Steam Generator Performance Summary."
August 10	Letter, L. E. Phillips, Alco, to F. A. Smith, CH, regarding test program meeting at Atomics International, August 21-22, 1962.
August 10	Letter, S. G. Nordlinger, DRD, to R. W. Dickinson, AI, regarding basic mechanisms of wear and lubrication of various metals sliding in liquid sodium.
August 14	Memo, F. A. Smith, CH, to C. A. Pursel, CH, "Trip Report - Carbon Analysis in Sodium - Resistivity Loop - Fast Reactor Safety Studies," discussion of three above subjects in Detroit, Michigan, August 7, 1962.
August 14	Memo, T. P. Heckman, CH, to C. A. Pursel, CH, "Trip Report - Review of the Status of the Physical Properties in Sodium at MSA Research, Callery, Pennsylvania, and Discussion on Sodium Chemistry," discussion with Dr. Werner and J. W. Mausteller, August 8, 1962.
August 15	TWX, F. C. Mattmueller, CH, to L. E. Phillips, Alco, approval given for issuance of purchase order to Superior Tube Company for bimetallic tubing.

August 16 Letter, R. L. Campbell, MSAR, to F. C. Mattmueller, CH, submission of updated MSAR Schedule 189.

August 16 Memo, C. A. Pursel, CH, to F. C. Mattmueller, CH, "Modification Number 6 - Contract AT(11-1)-765 - MSA Research Corporation," regarding the extension of the contract through September 30, 1962.

August 16 Memo, K. A. Dunbar, CH, to F. K. Pittman, DRD, "Ultrasonic Inspection Amendment for Procurement of Bimetallic Tubes - Alco Steam Generator," copy of consultant's report forwarded.

August 16 Letter, F. C. Mattmueller, CH, to W. D. Leggett, Alco, five unsigned copies enclosed of Modification No. 6 - Contract AT(11-1)-666.

August 16 TWX, F. C. Mattmueller, CH, to L. E. Phillips, Alco, authorization to ship demineralizer DA44-B-17 and deoxygenerator 326-011-121 to BLH along with other loop components.

August 16 Memo, F. C. Mattmueller, CH, to J. B. Lee, CH, "Contract No. AT(11-1)-765, MSA Research Corporation," requesting appropriate modification to subject cost-reimbursement contract.

August 17 Memo, F. A. Smith, CH, to C. A. Pursel, CH, "Westinghouse Electric Corporation (WEC)-DRD-CH-NY00 Meeting - August 10, 1962, Headquarters," regarding AEC postoperational assistance program for Fermi.

August 17 TWX, O. L. Thompson, CPAO, to T. F. Thulstrup, CH, July 1962, Sodium Components Projects Costs.

August 17 Memo, A. P. Pollman, CPAO, to T. A. Nemzek, CH, "Utilization of 4S8 Material at Alco," regarding where and how above material should be shipped.

August 15 Letter, C. H. Staub, MSAR, to F. C. Mattmueller, CH, acknowledging letter of request for Status Report on work to date under Contract AT(11-1)-765.

August 21 Letter, C. A. Pursel, CH, to J. H. Wright, WEC, enclosures and invitation to participate in second round of analysis of carbon in sodium mailed.

August 21 Memo, C. A. Pursel, CH, to F. C. Mattmueller, CH, "Justification for Cost of Metallurgical Test and UT Strip for Bimetallic Tube - Alco Products, Inc.," recommendation that charge for additional tests be accepted.

August 21 Memo, F. C. Mattmueller, CH, to C. A. Pursel, CH, "Contract AT(11-1)-1070, with The University of Wisconsin," transmittal of documents submitted in accordance with requirements covering subject contract.

August 27 Letter, A. P. Pollman, CPAO, to R. W. Dickinson, AI, "Transfer of Metals from Alco Products, Inc. - Contract AT(11-1)-666 to Atomics International," request for no-cost purchase order in favor of Alco for 4S8 material on ASCR Project 4435.

August 29 TWX, K. A. Dunbar, CH, to F. K. Pittman, DRD, regarding no sodium components being surplus at this time.

August 29 Letter, F. J. Walcavich, CH, to P. S. Otten, BLH, "Contract AT(11-1)-1213," information that responsibility for administration of above contract being assigned to F. C. Mattmueller, CH, and future correspondence should be addressed to him.

August 31 TWX, K. A. Dunbar, CH, to J. V. Levy, CPAO, authorization to expend \$350,000 of FY 1962 operating funds for SCTI.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
SEPTEMBER 1962

I. Listing of Current Projects

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contractor Administrator</u>
a. Heat Exchanger & Steam Generator	Alco Products, Inc. Schenectady 5, N.Y. L. E. Phillips	AT(11-1)-666	CH
b. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
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d. Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
f. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pennsylvania R. C. Werner	AT(11-1)-765	CH
g. Mass Transfer	General Electric Co. Atomic Power Equipment Department, P. O. Box 254, San Jose 12, California R. W. Lockhart	AT(04-3)-189 #15	SAN
h. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYOO
i. Low Level Oxide Analysis (Blake Meter)	Atomic Power Develop- ment Associates, Inc. 1911 First Street Detroit 26, Michigan J. Cameron	AT(11-1)-865 #3	CH

II. Status

a. IHX and Steam Generator

IHX - Alco Products, Inc.

Shop work on the shell is complete and is ready to receive the tube bundle except for minor construction details. The upper tube sheet is in the

machine shop with only the making of a radius on all tube holes still needed. The tube bundle is being fit with its full length heat shields and will then be inserted into the shell. Upper and lower channel heads are in the process of final machining and will be attached to the tube sheets. After the shell and bundle are mated, the upper tube sheet will be put in place and two girth seams in the shell will be welded and X-rayed. The next step will then be the tube-end welding.

Steam Generator - Alco Products, Inc.

The second shipment of rough parts of the steam generator assembly was sent to Baldwin-Lima-Hamilton (BLH) on September 5, 1962. The balance of parts was scheduled for shipment during the following week.

The welding development of the tube-to-tube sheet welds of the composite tubes to the Inconel overlaid tube sheet is being reviewed. The weld configuration which had been subjected to thermal shock tests developed some cracking. A new weld configuration appears to have considerable promise and Alco expects to have a formal weld procedure completed by the end of October.

Steam Generator - Baldwin-Lima-Hamilton (BLH)

The BLH Corporation was awarded an AEC contract to complete certain portions of the steam generator work under the AEC-Alco Product contract. These portions included the completion of manufacturing and assembly of the steam generator and the erection and operation of the Alco test loop.

BLH was represented at a meeting in August among AEC, AI, Alco, and BLH to resolve the final test program as proposed by Alco to be performed in the Sodium Components Test Installation (SCTI) at Santa Susanna, California. This meeting determined the final editing of the Alco Report APAE-122, "Test Program for 30 MW Prototype Sodium IHX and Steam Generator."

All material is on hand at either BLH or Alco with the exception of the tubing. The purchase order for the tubing was placed by Alco with Superior Tube Company with the delivery promise of February 1963.

The engineering drawings are complete; however, changes may be necessary for the location of the rupture disk nozzle and for instrumentation.

The agreement was made that the tubing will be bent into sine wave configuration and hydrotested at BLH with arrangements yet to be made for the use of the Alco dies and bending equipment.

A firm delivery date for the steam generator has not been established by BLH, but will be set in the near future, dependent upon the delivery of satisfactory tubing.

b. Test Facility - Atomix International (AI)

Construction

Installation of the fuel gas piping and control system for the sodium heater is 80% completed.

The treated water storage tank and pumps have been installed together with the high pressure flash tank and the condenser cooling water piping is 70% completed.

Installation of instrument air piping and cable trays from instrument lines and thermocouples is under way with 15% completion.

Modification of steam condenser water boxes was completed and the units installed.

Design

Analogue computer work on the steam generator-feedwater control system has been completed and indicates that the extremely flexible system utilized for this installation is fully justified.

Procurement

A contract for installation of the sodium and inert gas system piping is now in effect. Delays in the delivery of several important items by suppliers is delaying the completion of this work.

The supplier of the sodium preheater and the sodium cooler has moved the delivery of both these items to about the first of February.

c. Physical Properties of Materials - MSA

The operation of loop 1 was continuous except for three interruptions caused by failure of the electrical leads to immersion heaters and of a temperature controller. These interruptions resulted in 20°F drops for 30 minutes in one pot, 3 hours in another, and four hours in a third pot.

Stainless Steel

A total of seven stainless steel specimens have been tested to failure in fatigue and with the completion of the helium and air tests curves can be drawn showing the relative effects of cyclic strain ranges in different test environments.

The sixth and final stress rupture of stainless steel in air was still in progress. The results of these rupture tests conducted in sodium and air are in close agreement and are plotted with the drawing of curves through the test points planned for the next report.

The present data for stainless steel creep tests indicate that creep rates in sodium may run three to four times higher than in air; however, any final conclusions are withheld until all the data have been processed and carefully studied.

Cr-Mo

The results of all the Cr-Mo fatigue tests are plotted and the data to date show good agreement in triplicate specimens with the exception of the last helium tests and indicate to date that the specimens tested in sodium and helium are closely grouped and the specimens tested in air show more rapid failures. The last helium tests under short time cyclic strain are erratic and inconsistent with

previous tests. The two specimens which failed in the shortest number of cycles showed signs of oxidation and will be repeated.

Two exposed stress rupture specimens were tested in sodium at 16,500 psi and 14,000 psi stresses with failures in 20 and 72 hours respectively. These tests when compared to unexposed specimens at the same stress levels indicate that sodium had a definite effect on the stress rupture properties; however, conclusions will be withheld until the data has been processed and carefully studied.

The creep rates of the Cr-Mo specimens in sodium are much higher than in air. Since this difference is so great, an extra 8,000 psi specimen has been started.

Analysis of the Sodium

A sample of the sodium from each loop is taken each week and analyzed with the results indicating wide fluctuation for certain constituents such as Ni and C. Attempts to analyze the data to determine the effects of cold trapping on the carbon concentration are inconclusive. However, studies and method of improving techniques are still being carried out in a separate test rig and it is hoped that some conclusions will be obtained during this phase of the program.

Metallurgical Examination

Photographs of all specimens have been taken before and after each test. Photomicrographs have been taken of representative specimens. All photographs and data are submitted to Dr. Freeman, University of Michigan, for his examination and comments.

d. Mass Transfer Investigations - General Electric Company (GE)

Steel and sodium samples were withdrawn and submitted for analysis from the 316 loop #1 after 700 hours of run 1-4 operation, from the 316-2 $\frac{1}{4}$ Cr loop #3 after 1400 hours of run 3-8 operation, and from the 2 $\frac{1}{4}$ Cr loop #5 after 717 hours of run 5-4 operation.

During this period the Material Analysis Company (MAC) of Palo Alto, California, provided electron-probe microanalysis of one 316 SS corrosion sample that was exposed in the 316 SS - 2 $\frac{1}{4}$ Cr loop #3 for 2800 hours at 1200°F. The metallographic section indicates a 0.2 mil ferritic layer similar to many of those that have been observed during the operation of this project. The MAC provided continuous traverses for Fe, Ni, and Cr over a distance of 100 microns perpendicular and parallel to the surface. Some of these traverses were thus located in the dark-etching zone that appears just below the ferritic layer. Point count traverses were also made for the same three components in two locations normal to the surface and to a depth of about 30 microns. Steps of 1 micron were used with a probe diameter of 1 micron. The results indicate no change in metallic composition in the dark-etched zone and that there was severe bulk diffusion to a depth of approximately 5 microns for Ni and 10 microns for Cr. There was a significant depletion of both of these materials in the last 5 microns. The extreme surface phase of the layer was reported to be 86.1% Fe, 3.3% Ni, and 5.4% Cr, while the bulk of the sample was reported to have 63.0% Fe, 12.9% Ni, and 19.6% Cr. Additional samples will be submitted for micro-probe analysis to determine whether

this layer becomes thicker as a function of test condition parameters and to determine the slope of this steep decomposition gradient in order to provide an improved corrosion model.

Exchange of sodium samples from a GE Mass Transfer Loop and a MSAR, Physical Properties of Materials Loop was arranged primarily for the purpose of making a comparison of the analysis of carbon impurity in the sodium used in the two USAEC projects. GE will ship a standard 20 cc sample of sodium withdrawn at about 700°F from loop #2 and contained in a pyrex glass.

e. Resistivity Loop - Atomic Power Development Associates (APDA)

The results of the carbon contamination experiments, which terminated on August 8th, were inconclusive. The results of analyses on sodium samples taken from the surge tank on July 24 at maximum contamination, as well as during subsequent cold trapping and filtering operations through August 8th were tabulated. The concentration of both elemental carbon (C) and carbonate (CO_3) is reported as ppm of carbon. Samples were filtered through a 5-micron micrometallic frit placed into the tip of the sample thief for the purpose of segregating solid particles of carbon entrained in the sodium loop.

Carbonate determinations were rational and consistent with solubility. An examination of deposits on the filter frit showed them to be 90% carbonate and 10% metallic particles of 10-micron size. Carbon determinations were erratic, indicating that the solid-phase carbon passing through the frit was not homogeneously distributed in the sodium. Until the problems of two-phase contamination are resolved, calibration of the meter will not be possible.

The final report on this project is scheduled for completion on October 15.

f. Continuous Oxide Meter - United Nuclear Corporation (UNC)

A topical report covering this work from September 1961 to July 1962 was issued as UNC-5032 "Development of a Continuous Meter for Oxygen in Sodium."

Measurements were continued on the voltage stability and the response to changes in oxygen content of various electrochemical cells. An increase of 5 millivolts corresponds to a change in oxygen content from 16.5 ppm to 13.4 ppm. Examination of the results shows that the cells with the $\text{Cu-Cu}_2\text{O}$ powder reference electrode and the $\text{Na-Na}_2\text{O}$ reference electrode had good voltage stability. The response of these cells to changes in oxygen content (as measured by cold trap temperature) was also checked and the results reported. The agreement between the calculated voltage changes and the experimental values is generally in good agreement.

Voltage stability is necessary before the electrochemical device can function as a reliable and sensitive oxygen monitor. Therefore, different methods for preparing these electrochemical cells are being tried with the aim of developing cells with reproducible and stable voltages.

III. Meetings

September 11	AEC with Alco Products, Inc., Dunkirk, New York, to review the status of the IHX
September 12	AEC with Alco and Baldwin-Lima-Hamilton to discuss the turnover of portions of the Alco contract to BLH
September 19-20	AEC pre-proposal meeting and presentation for industry on a second sodium heated steam generator
September 26	AEC with AI in Canoga Park, California, to review status of carbon in sodium specimens
September 27-28	AEC and Ad Hoc Group with General Electric, San Jose, California, to review status of mass transfer investigations.

IV. Reports for SCDP Co-ordination Report

AI Progress Letter #18, Sodium Components Test Installation, September 1 through September 30, 1962.

AI Surveillance Status and Acceptance Report on the Alco IHX and Steam Generator dated September 28, 1962.

APAE-122, "Test Program for 30 MW Prototype Sodium Intermediate Heat Exchanger and Steam Generator," Alco Products, Inc., dated September 14, 1962.

APDA Progress Report, August 1 to September 15, 1962, Contract AT(11-1)-865, Project Agreement 3, Resistivity Loop.

BLH Progress Report, "Fabrication of 30 MW Steam Generator and Related Work," dated September 28, 1962.

GE Progress Letter #38, "Mass Transfer Investigations in Liquid Metal Systems," August 1, 1962, to August 31, 1962, dated September 4, 1962.

MSAR-62-109, Progress Report No. 24, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated September 17, 1962.

UNC Letter Report No. 12, dated September 12, 1962, Contract AT(30-1)-2877, "Continuous Meter for Oxygen in Sodium."

UNC-5032, "Development of a Continuous Meter for Oxygen in Sodium for the period September 1, 1961, to July 31, 1962.

Sodium Heated Steam Generator Summary, AEC-APDA Contract AT(11-1)-865, Task 1, dated September 19, 1962.

V. Correspondence

Contract AT(11-1)-1213, between Baldwin-Lima-Hamilton Corporation and the USAEC, entered into August 29, 1962.

Modification No. 6 Supplemental Agreement Contract AT(11-1)-666, between Alco Products, Inc., and the USAEC, entered into August 29, 1962.

- September 6 Ltr 62AT6532, R. Cygan (AI) to T. A. Nemzek, Subject: "Alco 30 MW Steam Generator," requesting design method used by Alco and the corresponding steam generator shell rating for the short-time pressure rise caused by the sodium-water reaction in the event of tube failure at the water end of the unit.
- September 10 Ltr, A. P. Pollman (CPAO) to J. F. Trevillyan (AI), Subject: "Sodium Components Test Installation," authorizing expenditure from available FY 1963 operating funds.
- Ltr, to Ad Hoc members, GE Mass Transfer Program, stating meeting will be held at San Jose, California, September 26, 27, and 28, to assist in making a technical review of the program.
- September 11 Memo, K. A. Dunbar to Messrs. Pittman and Derry (DRD), transmitting Sodium Components Development Program Project Co-ordination Report for July 1962.
- Memo, A. P. Pollman (CPAO) to C. A. Pursel, CH, Subject: "Alco IHX," enclosing a copy of C. E. Peterson's report of his last inspection trip to Alco to observe the fabrication effort on the IHX for the SCTI testing program.
- September 12 Ltr, T. A. Nemzek to Working Group Members, transmitting BMI, GE, and MSA progress reports
- September 13 TWX, F. C. Mattmueller to W. D. Leggett (Alco), approving P. O. 8-42207-S.
- Memo, C. A. Pursel to F. C. Mattmueller, Subject: "MSA - Effect of Sodium on Materials - Contract No. AT(11-1)-765," authorizing extension of contract through June 3, 1963.
- September 14 Ltr 62AT6755, R. Cygan (AI) to T. A. Nemzek, Subject: "Damage Factors for Alco Test Units"
- Memo, F. C. Mattmueller to J. B. Lee, Subject: "Contract No. AT(11-1)-765, MSA Research Corporation," requesting modification to subject contract to extend contract and increase funds.
- Ltr 62AT6756, R. Cygan (AI) to T. A. Nemzek, Subject: "SCTI Test Program Co-ordination Meeting," held August 21 and 22 which discussed room temperature strain gage measurement of steam generator and the transient testing of the units.
- Ltr, R. W. Lockhart (GE) to W. H. Brummett, Jr., (SAN) Subject: "Status of Carbon Analysis Work Associated with the Sodium Mass Transfer Project and Request for Contracting Officer's Approval of Support for this Work"
- September 14 Memo, F. A. Smith to C. A. Pursel, Subject: "Trip Report - Alco Products - IHX Status at Dunkirk, New York, and Transfer of Information, Alco-BLH, CH, at Schenectady, New York"

September 17 Memo, T. A. Nemzek to J. V. Levy, Subject: "Alco Steam Generator - Sodium H₂O Pressure Rise in Event of the Failure at Water End"

Ltr, F. C. Mattmueller to W. D. Leggett (Alco), referencing AI letter 62AT6532 and stating that AI had been requested to make a separate set of assumptions on the mode of maximum creditable failure of the Alco unit and to perform a set of calculations as to the short time pressure rise based on the assumptions made by AI.

Memo, W. J. Stanley, CH Finance Division, to Those Listed Below, Subject: "Assignment of Accounting Liaison Responsibility for CH Sodium Components Development Contracts"

Ltr 62AT6780, R. W. Dickinson (AI) to J. V. Levy, Subject: "Lifting Lugs for Alco IHX"

Memo, T. A. Nemzek to J. V. Levy, Subject: "Shell Side Heat Transfer - Fabrication and Test of Two Additional Tube Bundles"

Memo, L. A. Redecke to F. C. Mattmueller, Subject: "Visit to Dunkirk and Schenectady Regarding Contract No. AT(11-1)-666"

September 21 Ltr, T. A. Nemzek to Working Group Members, stating next meeting of the Group will be October 10 and 11 and furnishing agenda.

September 28 Memo, R. C. Vogel (ANL) to F. Smith, Subject: "APDA's Proposal to Study 'The Effect of the Form or Species of Carbon and the Effect of Oxygen Contamination on the Carburization of Stainless Steel in Liquid Sodium'"

September 5 TWX F. C. Mattmueller to L. E. Phillips (Alco), requesting preparation of 100 copies of report entitled "Steam Generator-IHX Test Program" and furnishing proposed distribution.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
OCTOBER 1962

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N.Y. L. E. Phillips	AT(11-1)-666	CH
b. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
d. Valve Test	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
f. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g. Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
h. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N.Y. H. Steinmetz	AT(30-1)-2877	NYOO
i. Low Level Oxide Analysis (Blake Meter)	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH

II. STATUS

a. IHX and Steam Generator

IHX - Alco Products, Inc.

The girth weld of the tube sheet to the shell has been made. The subsequent inspection of the weld and of the radiographs revealed that the welding was performed at excessively high temperatures, resulting in the formation of droplets of over 3/16-inch diameter on the ID surface. This condition will not satisfy the requirements for allowing the vessel to receive a New York code stamp.

The problem regarding the use of the IHX in the existing condition as opposed to attempting the necessary repairs to meet code specifications is being evaluated by Alco, the AEC, and independent contractors.

Steam Generator - Baldwin-Lima-Hamilton Corporation

A meeting held with the manufacturing personnel established a satisfactory procedure whereby BLH will use the Alco drawings during the manufacture of the steam generator. A detailed BLH process sheet will be issued for each component and component assembly. The Quality Control Department will also issue instructions in order that the necessary permanent records of each component and component assembly are obtained.

A visitation was held October 24 at the Alco-Dunkirk facility. Representatives of BLH Manufacturing, Welding, Quality Control, and Engineering Departments were present. The purpose of the trip was to review the transfer of the steam generator manufacture from Alco to BLH and to determine if the necessary records, procedures, etc., are in BLH's possession.

The sine wave tube bending equipment and dies have been received at BLH.

Atomics International (AI) has officially requested the relocation of the rupture disc nozzle and a change in the design and position of the lifting lugs. The exact design of the lifting lugs will be supplied by AI at a later date. They will be similar to those used on the intermediate heat exchanger. Alco Products, Inc. will make the necessary drawing changes for the nozzle relocation at this time.

High Temperature High Pressure Test Loop - Baldwin-Lima-Hamilton Corporation

The erection of the test tower is progressing satisfactorily. At the present time, a crane is being installed at the top of the tower. This crane will be used during the remainder of the installation and the subsequent testing. Trial startup by December 3 is forecast as a result of preliminary planning.

b. Sodium Components Test Installation - Atomics International

Construction

Installation of the fuel gas piping and control valves is 95% complete. This system will be finished when one more gas valve is delivered during November. Work completion on steam power system is as follows:

All cooling water piping between condenser and cooling tower installed, all condensate lines in place, heater drains installed, low pressure steam lines up to the third pressure reducing valve, and the demineralizer piping installed. Spooling of the high pressure steam piping is under way at a pipe fabricating shop. The primary and secondary sodium expansion tanks have been set in place. Installation of cable trays and instrument air piping is 30% complete.

Design

Preheating systems for all large diameter sodium pipe (above 3-inch size) have been designed. Design of the two rupture disc effluent containment tanks and associated support systems in conjunction with the Alco steam generator is under way. A comprehensive report covering all the analogue studies done for this project is being written.

Procurement

The first shipment of reworked stainless steel fittings has been received by the piping fabricator and spooling of the large sodium piping will start. The first section of the control panel has been delivered.

c. Physical Properties of Materials - MSA Research Corporation

The two sodium loops for testing Type 316 stainless steel and $2\frac{1}{2}$ Cr-1 Mo steel specimens are still in operation with the majority of the tests in "as is" sodium having been completed. In Loop No. 1 (stainless steel specimens) only the pre-exposed stress rupture specimens remain in progress. Loop No. 2 (Cr-Mo specimens) has an extra creep specimen and a long time stress rupture test still in progress. Completion of the tests in progress will finish the first test series in which pre-exposed and unexposed Type 316 stainless and $2\frac{1}{2}$ Cr-1 Mo steel specimens were tested in 1200°F and 1100°F sodium respectively under stress-to-rupture, creep, and fatigue conditions. Also in this series are stress-to-rupture, creep, tensile, and fatigue tests in air and helium at their respective temperatures of 1100°F and 1200°F. These tests are still in progress and all but the fatigue tests are being conducted at the University of Michigan.

The results are of a preliminary nature at this time, but the sodium and air stress-to-rupture tests with 316 stainless steel specimens

show excellent agreement indicating no noticeable effect of sodium. The creep tests of 316 stainless steel specimens resulted in higher creep rates in sodium than in air which may indicate the shape of the creep curve to be different in sodium than in air. The fatigue tests are not complete but preliminary results indicate Type 316 stainless steel has a longer fatigue life in helium and sodium than in air, especially under lower cyclic strain (longer test periods).

The Cr-Mo stress rupture results show a slight difference between the air and sodium tests with indications that sodium might be expected to shorten the stress rupture life of $2\frac{1}{2}$ Cr-1 Mo steel at these high temperatures. Higher creep rates were also experienced in sodium than in air, indicating the possibility of different shaped creep curves in sodium than in air. The fatigue tests show no difference between sodium and helium tests but both show longer fatigue life than tests in air.

Completion of additional tests and further metallurgical studies will permit more specific conclusions.

d. Mass Transfer Investigations - General Electric Company

Activities were directed toward the completion of the last of five topical reports, operation of the test loops, analysis of the steel and sodium samples, and evaluation of the corrosion and metallographic data.

Steel and sodium samples were withdrawn and submitted for analysis from the 316 stainless steel loop (No. 1) after 1400 hours of run 1-4 operation, from the 316 stainless steel 5Cr loop (No. 4) at the end of run 4-5 operation, and from the $2\frac{1}{2}$ Cr loop (No. 5) after 1400 hours of run 5-4 operation.

The fourth Ad Hoc technical review of this project was made on September 26, 27, and 28 by T. P. Heckman, CH, Chairman; J. Holliday, SAN; H. W. Savage, ORNL; J. H. DeVan, ORNL; D. Gardiner, ORNL; J. M. McKee, UNC; and D. I. Sinizer, AI. Comments and recommendations from this review will be issued by the Chicago Operations Office as soon as possible. During this meeting, a considerable amount of attention was focused on the change in surface composition and gross carbon content of the corrosion samples. Many helpful comments on data interpretation were expressed by the reviewers. The proposed five-run fractional replicate test program should be completed on four of the loops in about one year, the 5 Cr loop will require about another year to complete, and the second 316 stainless steel $2\frac{1}{2}$ Cr loop (No. 2) should continue to be operated under special test conditions, such as long-term tests and different geometrical conditions. After the initial five-run screening tests are completed, special tests should be run to increase the information on new variables including the effect of geometry and carbon content.

Analysis of Samples

The 700-hour analysis reports for samples from the 316 stainless steel, the 2½ Cr, and the 5 Cr loops show expected trends. Previous runs have indicated that the first sample period data should be used with extreme caution due to initial (seasoning) effects. It is interesting to note, however, that measurable corrosion rates were observed on the low temperature, low oxide run on Loop No. 1. The slightly negative weight change on the C3 outlet sample is so close to zero that there is no significance. The observation of a carbon case in the 2½ Cr sample from C1 (AR 5-4-1) was noted and followed as more data from this run become available. The weight gain data from H2 and H3R locations in the 5 Cr loop hot-cold run were surprising. This preliminary H-C data confirm a downstream effect that will be analyzed after additional data are collected.

All of the AR data are preliminary (or as observed) since they are issued as promptly as possible. While some of the corrosion rates may appear large, it is convenient to know that a corrosion rate of 100 mg/dm²/mo for material with the density of steel is equivalent to 0.6 mil/yr.

e. Shell Side Heat Transfer - Atomics International

The helical rotor EM pump installation was completed.

A large capacity cold trap and associated instrumentation have been added to the test loop.

The main sodium cooler developed leaks and was replaced by a lower capacity (1 MW) unit.

Test loop operations began with concentration on (1) cleaning the sodium by cold trapping and (2) pump performance studies to ensure flow stability at all desired experimental conditions.

Tube and shell side plenums for Basic Units 2 and 8 have been redesigned to provide better flow distribution.

Two new analytical approaches have been used (one at Atomics International and the other by Professor Short at the University of Texas) to predict the influence of number of tube rows on shell side flow distortion for units having $\alpha \neq 0$ or 90. The calculated results were in reasonable agreement with experimental results obtained by Professor Short. These analyses provide a basis for determining basic unit heat exchanger size required to minimize shell side flow edge effects for units having $\alpha \neq 0$ or 90.

f. Oxygen in Sodium Monitor - United Nuclear Corporation

The design of a pumped sodium loop was started. This loop will have provisions for testing a number of electrochemical devices simultaneously and be capable of independent control of oxygen content, temperature, and flow rates. The loop will be

characterized by a range of flow velocities from 0 to 5 gallons per minute, will have 1/2-inch diameter piping, and will operate at temperatures from 500 to 1000°F.

Measurements were made of the response of the electrochemical cells to changes in cell temperature and oxygen content of the sodium of three electrochemical cells with Cu-Cu₂O powder reference electrodes. The results are erratic, particularly for the temperature range of 500 to 550°F. In agreement with theory, the observed voltage changes are small. (An increase of 5 millivolts corresponds to a change in oxygen content from 16.5 ppm to 13.4 ppm.) The quite small effect of temperature upon cell voltage is probably overshadowed by the instability in cell voltage for these three cells.

The observed effects of temperature variation and change in oxygen content with a Na-Na₂O reference electrode were in fair agreement with theory. Considerable difficulty was encountered in the experiments with the Na-Na₂O reference electrodes.

It is planned to redesign the electrochemical cell to a more rugged and convenient form. This will involve a metal to ceramic seal for which the ceramic will most likely be based on zirconia or thorium. In addition, experimental work on the development of metal to zirconia seals was started in the UNC laboratory.

III. MEETINGS

October 10-11	Thirtieth meeting of the Working Group of the Sodium Components Development Program at the Oak Ridge National Laboratory.
October 12	AEC with ORNL on the general subject of sodium chemistry with emphasis on carbon in sodium.

IV. REPORTS

AI Surveillance Status and Acceptance Report - AT(11-1)-666 - SCTI Steam Generator and Intermediate Heat Exchanger

AI Progress Report on Shell Side Heat Transfer Studies, dated October 22, 1962.

APDA Summary Report - August 1 to September 15, 1962, AT(11-1)-865, PA #3, Resistivity Loop.

BLH Progress Report on Sodium Components Design Program, AT(11-1)-1213, dated October 4, 1962.

BLH Weekly Progress Report on Steam Generator Contract AT(11-1)-1213, dated October 16, 1962.

BLH Weekly Progress Report on Steam Generator Contract AT(11-1)-1213, dated October 23, 1962.

GE Progress Letter No. 39, Mass Transfer Investigation in Liquid Metal Systems, dated October 5, 1962.

GE Project Status and Cost Report on PA #15, Mass Transfer, dated October 8, 1962.

MSA Progress Report No. 25, Effect of 1200°F Sodium on Austenitic and Ferritic Steels, dated October 19, 1962.

UNC Monthly Progress Report No. 13 for September, AT(30-1)-2877, Continuous Oxide Meter, dated October 19, 1962.

V. CORRESPONDENCE

- October 1 Nemzek to Levy, asking CPAO to ask AI to propose a cost estimate and technical justification of the need for additional data on damage factors related to the Alco steam generator and intermediate heat exchanger.

- October 1 Nemzek to Cope (OROO), regarding Sodium Components Development Program Working Group meeting at ORNL October 10 and 11, 1962.

- October 1 Dunbar to Pittman and Derry, transmitting copies of the monthly project co-ordination report for August 1962.

- October 2 Mattmueller to Otten (BLH), asking BLH to transmit an informal weekly report in accordance with AT(11-1)-1213.

- October 3 Richards (CPAO) to Smith, transmitting copies of AI letter 62AT8672 which provides the information Smith desired on the capabilities of the SCTI with and without the proposed heat dump.

- October 3 Mattmueller to Staub (MSA), transmitting copies of AT(11-1)-765 Modification No. 7 for review and comment.

- October 3 TWX, Mattmueller to Leggett (Alco), stating sine wave bending of steam generator tubes supplied by Superior will be performed by BLH.

- October 3 TWX, Mattmueller to Otten (BLH), stating sine wave bending of steam generator tubes will be performed by BLH under AT(11-1)-1213.

- October 3 Heckman to Pursel, "Trip Report - Second Round Carbon in Sodium Analysis Samples - General Sodium Chemistry," September 24-25, 1962.

- October 3 Heckman to Pursel, "Trip Report - Ad Hoc Committee of the Sodium Components Development Program - Review of

Mass Transfer Work - General Electric Company,"
Contract (04-3)-189, PA #15.

- October 4 TWX, Mattmueller to Seifert, asking for estimate of feasibility and costs associated with improved positioning of the upper lifting lugs for the intermediate heat exchanger.
- October 9 Mattmueller to Lee, asking OC to prepare supplements to AT(11-1)-1213 with BLH and AT(11-1)-666 with Alco to provide additional information as stated in the memorandum.
- October 9 Dunbar to Pittman, transmitting a revised "Sodium Components Test Installation PERT Network," dated July 16, 1962.
- October 9 TWX, Mattmueller to Seifert, authorizing Alco to position lugs in accordance with our TWX dated October 4, using funding available under AT(11-1)-666 to cover \$2500 estimated costs.
- October 12 Draggett (Alco) to Mattmueller, stating that Superior Tube Company has asked that certain modifications be made to the terms and conditions (PD-183) attached to Alco's purchase order 8-42207-5.
- October 16 Nemzek to Working Group, transmitting pertinent reports.
- October 23 Nemzek to Hughey (SAN), regarding distribution of reports under AT(04-3)-189, PA #15.
- October 24 Mattmueller to Leggett (Alco), transmitting copies of AT(11-1)-666, Modification No. 7, for review and comment by Alco.
- October 24 Mattmueller to Staub (MSA), stating tests to be performed October 1, 1962, through June 30, 1962, on Contract AT(11-1)-765.
- October 24 Mattmueller to Otten (BLH), transmitting copies of Contract AT(11-1)-1213, Modification No. 1, for review and comments.
- October 25 Wensch to Smith, regarding sodium reactors AI proposal to test magnet drive capability.
- October 25 Mattmueller to File, recording telephone conversation with Otten (BLH) concerning some correspondence on Contract AT(11-1)-1213.
- October 26 Fremling to Redecke, regarding Contract AT(11-1)-666, Alco Products, intermediate heat exchanger.

October 29 Nemzek to Levy, asking CPAO to request AI to make the stated changes and modifications to the original instructions regarding second round carbon in sodium analysis specimens.

October 29 Karp (UNC) to Wise (NYOO), transmitting copies of financial report for the month of September 1962.

October 29 Mattingly to Working Group, transmitting copies of pertinent reports.

October 30 Heckman to Pursel, trip report on ORNL trip made October 10, 11, and 12.

October 30 Mattmueller to Staub (MSA), asking for 35 additional copies of Progress Report No. 25.

October 30 Mattmueller to Leggett (Alco), stating comments on modifications to terms and conditions of Form PD-183 requested by Superior Tube Company

October 31 Mattmueller to Leggett (Alco), asking for data and calculations which pertain to work done in connection with Contract AT(11-1)-666.

October 31 Nemzek to Levy, asking CPAO to advise AI of our plans to ask AI staff to assist us in determining the suitability of the Alco Intermediate Heat Exchanger (IHX) to be used in the SCTI.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
NOVEMBER 1962

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N.Y. L. E. Phillips	AT(11-1)-666	CH
b. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
d. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
e. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
f. Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
g. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N.Y. H. Steinmetz	AT(30-1)-2877	NYOO
h. Resistivity Meter (Blake Meter)	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH

II. STATUS

a. IHX and Steam Generator - Alcoa Products Inc. and Baldwin-Lima-Hamilton Corporation

Sodium-to-Sodium Intermediate Heat Exchanger

Trouble has been experienced at Alcoa-Dunkirk in deciding on acceptability of the closure welds between the shell and the tube sheets. At this time, this problem is still under advisement. In view of this, the delivery of this unit by the end of December appears to be a possibility at this time.

Steam Generator

(1) Outstanding Material

In addition to the tubing which is expected in February 1963, Alcoa will transfer the upper and lower tube sheets, upper and lower heads, manway covers, thermocouples, and nozzle shields to BLH. It was reported that all of this material is ready for delivery with the exception of the lower head.

(2) Engineering

Alcoa has received the request from AI for the change in location of the rupture disc nozzle in the shell. This change is now being made. Also, AI requests a change in the design of the lifting lugs. The redesign of these lugs will be supplied by AI at a later date and will be similar to those furnished on the intermediate heat exchanger.

(3) Fabrication

The tubes will be formed into the sine wave configuration at BLH. The dies and necessary bending equipment are now in the BLH facility.

The BLH manufacturing personnel have agreed to use the Alcoa drawings as is for the manufacture of this unit. Detailed process sheets will be issued for each component and component assembly instead of using the Alcoa travelers. It is felt that this method would create less confusion in the shop. The first process sheets are ready for distribution.

Alcoa has obtained permission for the use of Stoddard Solvent (Atlantic 52) during the hydrotest in place of methyl alcohol on the intermediate heat exchanger. This change has been requested because of safety reasons. Alcoa will save the testing fluid and ship it to BLH for use during the hydrotest of the steam generator.

A meeting was held at Alcoa-Dunkirk on October 24, 1962, regarding the method of transfer and type of information that will be transferred from Alcoa to BLH. Messrs. Clark

and Ascenzi reviewed the weld procedures and also discussed the problems which had arisen during the manufacture of the intermediate heat exchanger at Alco. The remainder of the personnel discussed in general the manufacturing, tooling, and possible assembly problems which would arise.

Alco is transferring to BLH the baffle drill jig, lead pins, and alignment pins that were used during the manufacture of the intermediate heat exchanger.

(4) Delivery

As yet, no firm delivery date has been established by the Production Control Department. The receipt of the tube will still be the controlling factor.

The Critical Path Flow Chart is being finalized. As soon as it is completed, the AEC will be supplied copies of this document.

Welding Development

Alco has completed all the welding development for the tube-to-tube sheet weld. A tube sheet is now being machined which will have approximately 100 tube holes which will be used for the welding consistency test. Also, it will be necessary to have the thermal shock test run on the completed tube joint before this program can be considered as complete.

High Temperature High Pressure Test Loop

The external portion of the tower has been erected, including the installation of a traveling crane which is mounted on the top of the tower. The piping is being checked out for leaks prior to its installation in the tower. Bids have been received for the rectifiers which will supply power for the test loop. These are being evaluated prior to final purchase recommendations.

New Steam Generator

Proposals were received November 26, 1962, from six industrial firms in response to the AEC-CH invitation regarding new and improved sodium heated steam generators.

b. Sodium Components Test Installation - Atomics International

Construction

Completion of the fuel gas piping is still being delayed by lack of one gas control valve from Bailey Meter. Inability to obtain all necessary materials is delaying delivery of the high pressure steam piping spools and the desuperheater assembly. The remaining work (excluding the above two items) on the steam power system covers

only the water treatment chemical feed lines and the plastic pipe for treated water supply.

Installation of sodium piping support structure is under way, together with supporting structure for IHX. Continued delay in spooling of sodium piping has been caused by procurement problems with large sodium piping fittings as described below under procurement.

Design

Preheating systems for all vessels and sodium piping have design 90% completed. Design of the two rupture disc effluent containment tanks has been completed. Although the two tanks are similar, differences in design are necessary to accommodate the varying steam generator nozzle movements at opposite ends of the unit. Design of the electrical power system covering panelboard to equipment tie-in for all motors and heaters has been completed. Analogue study report is 80% complete.

Procurement

Shipment of balance (80%) of stainless steel fittings for sodium piping was finally received at the piping fabricator's plant on November 25. Inert gas system bottle manifolds and receiver tanks were received during the past month, together with the second section of the control panel.

c. Shell Side Heat Transfer - Atomics International

Shakedown runs of the shell side heat transfer loop were completed, and low power runs were initiated on Basic Unit 12. Subsequent recurrent problems with the cooler and with the heaters have impeded progress. The 1200 KW electric heater failed during test run No. 17, and the immersion heater will be repaired or replaced.

d. Physical Properties of Materials - MSA Research Corporation

The status of the investigation of materials in sodium at temperatures up to 1200°F was reviewed November 29, 1962, at a meeting among MSAR, Professor Freeman of the University of Michigan, and a Sodium Components Development Program Ad Hoc Group.

The data reported in MSAR-62-126, MSAR-62-142, and current unreported data were reviewed and summarized as follows:

Purpose and Scope

The project was initiated for the purpose of determining the effects of reactor grade sodium and normally anticipated contaminants upon representative types of structural steels of interest for the construction of sodium systems. Type 316 stainless steel was selected as representative of the austenitic steels, and 2½ Cr-1 Mo was

selected as representative of the ferritic steels. The maximum temperatures selected were 1200°F for the austenitic and 1100°F for the ferritic. The contaminants to be intentionally introduced into the sodium after the reactor grade sodium tests were completed would be oxygen, carbon, and nitrogen. The types of tests selected for revealing any possible effects of the environments upon the materials were tensile, creep, stress-to-rupture, and fatigue. In addition to these physical tests, appropriate chemical analysis and metallurgical examinations were designated for assisting in the interpretation of the physical properties.

The two loops are fabricated of Type 316 stainless steel with Type 315 specimens tested in loop No. 1 and with 2½ Cr-1 Mo specimens tested in loop No. 2. The first series of tests, designated Test 1 in loop No. 1 and Test 2 in loop No. 2, are nearly complete with the preliminary results as follows:

Fatigue Tests

The plots of the data for both materials show little difference between helium and sodium environments; however, there is a decided difference for the plot of the air tests with failures occurring considerably sooner in air.

Creep Tests

The shapes of the curves for both materials in helium, air, and sodium are similar with a displacement of the creep rate ordinate that indicates a higher rate in sodium. This difference in the rate curve may be attributed to a difference in the testing equipment used for sodium as that used for the gas atmosphere, plus normal variations that will exist between heats of material. An improvement in creep testing equipment for an opaque environment is needed.

Tensile Tests

The nonstressed, pre-exposed to sodium specimens are awaiting tensile testing at the University of Michigan.

Stress-to-Rupture Tests

The results of the tests of 316 specimens in air and sodium are in such close agreement that a single stress-rupture curve is justified.

For the 2½ Cr-1 Mo specimens, the pre-exposed specimens fail considerably sooner; however, the three separate plots for the different environments are converging for longer time tests.

Future Program

Upon completion of Tests 1 and 2, minor modifications will be made to the loops to improve the performance of the test equipment and hopefully the accuracy of test data.

The next test in loop No. 1 (Test 3) will be a repeat of Test 1 except that the sodium will be saturated with carbon as a contaminant.

The next test in loop No. 2 (Test 4) will be a repeat of Test 2 except that the sodium will be contaminated with oxygen maintained at a level of 300 ppm.

e. Mass Transfer Investigations - General Electric Company

Steel and sodium samples were withdrawn and submitted for analysis from the 316 stainless steel loop (No. 1) after 1400 hours of operation, from the 316 stainless steel 2½ Cr loop (No. 2) after 5600 hours of the continuing operation, from the 316 stainless steel 2½ Cr loop (No. 3) after 2800 hours of the continuing operation, and from the 5 Cr loop (No. 6) after 1400 hours of hot/cold operation.

Wet chemical analysis of a sodium sample taken at the same time as the exchange sample sent to MSAR indicates that it contains 10 ppm elemental carbon, 87 ppm "carbonate" carbon (or a total of 97 ppm C), 0.6 ppm Fe, > 0.11 ppm Ni, 0.15 ppm Cr, and 117 ppm K. These samples (#2-5-5) were removed from the 316 stainless steel 2½ Cr mass transfer loop (No. 2) after 4494 hours of run 5 and/or after 12,196 hours of loop operation. All of this time, the loop has been operated at 1200°F maximum temperature, 500°F delta T, and cold trapped to 300°F plugging temperature.

Analysis of Samples

The 1400-hour analysis reports for samples removed from the 316 stainless steel and the 2½ Cr loops, in general, show expected trends. It is interesting to note that the 1400-hour stainless sample in the H1 (900°F) position continues to indicate a weight gain. The corrosion rate in the H3 (1100°F) and C1 (1000°F) holders is about a factor of 10 less than during run 1-2 when these holders were 100°F higher in temperature. The corrosion rate during the 1400-hour period in the 2½ Cr loop was less in both the hot and cold legs than during the initial 700 hours. The recent data show that the H1 (1000°F) sample has gained weight. Comparing this data with run 5-2 (500°F instead of the present 250°F delta T), the hot leg (same temperatures) has about the same observed corrosion rate while the slope of corrosion rate versus 1/T has reversed, i.e., in this run the C1 samples have gained more weight than the C3 samples in the cold leg.

Corrosion data from the 316 stainless steel 5 Cr loop operated under Type IV run conditions (of 1200°F, 250 delta T and 305°F T_s) showed a continual decrease in corrosion rate with time. The H1 samples gained weight and show a very limited velocity effect. Comparing the recent data with run 4-2 data (250°F versus 500°F delta T and all sample holders at the same temperature except Ce), there has been a large decrease in apparent corrosion rates.

The apparent conclusion is that ΔT is an important variable in corrosion rate data. Possibly loop seasoning has also affected the results.

f. Continuous Oxide Meter - United Nuclear Corporation

The design of the pumped sodium loop was 90% complete as of November 1. Procurement of materials for the pumped loop was initiated.

Electrochemical cells with thoria - 15 w/c yttria electrolyte and Cu-Cu₂O reference electrodes were tested. The cell voltage responded with changes in oxygen content at test temperatures of 750 - 900°F. Zirconia electrolytes reacted with sodium at temperatures in this range, and the cell voltage drifted considerably with time. The thoria electrolyte tubes were very fragile, and no further work is planned with thoria tube electrolytes. The possibility of obtaining flame sprayed thoria electrolyte will be investigated.

Further measurements of the response of the electrochemical cells to changes in the oxygen content of the sodium and the cell temperature were made. The observed temperature coefficients are relatively small, and these data are not as reproducible, nor in as good agreement with theory, as data that have been obtained on other electrochemical cells of the same composition. Further experiments will be made in which the method of preparing the electrochemical cell and the nature of the reference electrode will be varied. The aim of these experiments will be an electrochemical cell of improved voltage stability and reproducibility.

Zirconia to Kovar seals have been made by metallizing the zirconia with molybdenum - manganese powder and then brazing with manganese - nickel or with copper. None of the seals were leak tight when tested with the helium mass spectrometer. Efforts to obtain zirconia to metal seals that are leak tight and resistant to sodium will be continued.

g. Resistivity Meter - Atomic Power Development Associates, Inc.

A topical report, APDA-149, "Evaluation of the Blake Sodium Resistivity Meter," was issued covering the exploratory operations performed in the APDA test loop. A summary of the results is as follows:

The Rhometer (sodium) temperature compensator was successfully operated in the 400-600°F range, holding the signal constant over $\pm 10^\circ\text{F}$ temperature excursions. Deviations of $\pm 50^\circ\text{F}$ from set-point produced a meter error of plus 0.1% R, equivalent to a 10 ppm change in oxygen content or 0.25 ppm error per degree deviation beyond the $\pm 10^\circ\text{F}$ stable range. The effect of temperature transients beyond the $\pm 50^\circ\text{F}$ range was more pronounced. No compensator adjustment was provided above the 600°F set-point, and the range was not explored below 400°F.

A deviation of 10 volts from the designed input of 240 volts produced a meter error of $\pm 0.01\%$ R, equivalent to a 1 ppm change in oxygen content. Voltage excursions beyond the 230-250 volt range generated irrational signals. The effect of supply voltage variation was circumvented by installing a voltage regulator and by adjusting to design voltage immediately before each meter reading.

A linear relation was observed in the 6.5- to 8.5- gpm range, and the meter was zeroed in at 7.5 gpm. Flow deviation from 7.5 to 8.5 gpm produced a meter error of 0.015% R, equivalent to a 1.5 ppm change in oxygen content. During operations, the flow rate was confined to the 7- to 8- gpm range, partly because of the nonlinear character of the flow effect beyond this range and partly to avoid the more severe effects of temperature changes implicit in any flow transient.

Gas entrainment produced a readily definable pattern on the recorder chart. For the purpose of gaging meter response time to gas entrainment and to produce a more definitive signal pattern, a special high-speed recorder was employed for the gas entrainment runs. Argon was detectable at a flow of 200 cc per minute STP, or 0.0528 gpm, amounting to 2.5 parts in 10^4 by volume in the 200 gpm sodium loop. Correcting for temperature and pressure, volumetric sensitivity was established at 4.6 parts in 10^4 or 460 ppm. Recorder strip patterns at higher injection rates were more intense; however, no attempt was made at quantitative interpretation of these strip patterns. Meter response in the geometry of the loop lagged behind gas injection startup by approximately one minute and behind gas injection cutoff by the same length of time. No residual signal was observed after gas runs, and there was no distinction between the signal pattern of helium, argon, and xenon gas.

Calibration of the Rhometer for oxygen contamination was successful within the 10-80 ppm range as determined by plugging meter runs. The cold trap equilibrium temperatures confirmed plugging meter data in the lower section of this range with a divergence of 5 ppm at the 30 ppm level. Below 10 ppm, plugging meter readings were more widely scattered, and the central values in this scatter area showed a drift from the expected curve (values extrapolated from 10-80 ppm operating range).

Because of the 600°F upper limit imposed by the Rhometer temperature compensator, oxygen would not dissolve readily above the 80 ppm level, and steady state was not realized. Each oxide increment to the loop caused an initial perturbation of the Rhometer signal not unlike a gas entrainment pattern. Signal blips of lesser magnitude have also been observed on release of plugging meter deposits, and it was concluded that this signal pattern indicated the entrainment of solid Na_2O particles which are slow to dissolve at the limited loop temperature. A pattern of signal blips persisted for hours after each oxide increment.

Carbon contamination by direct solution at 750°F was detectable by the Rhometer; however, quantitative interpretation was not attempted for several reasons. At 150°F above the upper limit of the temperature compensator, the Rhometer signal showed a wide scatter. Moreover, laboratory determinations of carbon content were even less reliable. This was later explained by the presence of unfilterable, submicron carbon particles in irregular distribution. It is noted, however, that carbonates were successfully filtered with a 5-micron stainless steel frit and consistent determinations were obtained for dissolved carbonates.

Another problem was encountered in attempting a controlled ramp-down on the carbon contamination by means of a stainless steel hot trap. At 1200°F, the Type 304 stainless steel mesh gave up some surface impurity which temporarily promoted the Rhometer signal, but on restoration to the 750°F loop temperature of the carbon test run it was found that no significant carburization had occurred. The carbon content of the sodium in the loop was later reduced by conventional cold trapping and filtering through a 10-micron stainless steel frit.

One other anomaly was observed during the carbon test runs, that of long-term drift under high contamination exposure. When the Rhometer was zeroed in on Monday mornings after a week-end on automatic control, a slight drop was always observed in signal intensity.

III. MEETINGS

November 19-21	AEC-CH, DRD, with APDA in Detroit, Michigan, to review the resistivity meter loop status and discuss future work.
November 27	AEC-CH and NYOO with UNC at White Plains, New York, regarding electrochemical cells for the detection of specific contaminants in sodium.
November 28	AEC-CH with NYOO in New York City, regarding liquid metal projects.
November 29	AEC-CH, MSAR, Professor Freeman of the University of Michigan, and the Ad Hoc Group in Gallery, Pennsylvania, reviewing the status of the physical properties of materials in sodium.
November 30	AEC-CH with Ad Hoc Group in Pittsburgh, Pennsylvania, evaluating the physical properties of materials in sodium project.

IV. REPORTS

APDA 149, "Evaluation of the Blake Sodium Resistivity Meter," dated October 15, 1962.

GE Progress Letter No. 40, "Mass Transfer Investigation in Liquid Metal Systems, October 1, 1962 through October 31, 1962," dated November 2, 1962.

MSAR 62-142, Progress Report No. 26, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated November 14, 1962.

UNC Monthly Progress Report No. 14, "Continuous Oxide Meter," dated November 23, 1962.

V. CORRESPONDENCE

November 6	Multiple address letter to Working Group, transmitting copies of minutes of meeting No. 30 of the Working Group and copies of monthly project report.
	Letter, Mattmueller to Abderhalden, re relocation of the rupture disc nozzle in order to accommodate the containment vessel in the SCTI pit.
November 7	Memo to Those Listed from Dunbar, transmitting copies of monthly project report to HQ (September).
	Memo to File from Mattmueller, re extension of due date for proposals from A-C, BLH, and Westinghouse (re steam generator).
November 8	Letter, Seifert to Mattmueller, stating there are no notebooks or engineering data containing information on Alco's IHX which have not been sent to CH or BLH.
November 13	Modification No. 7 to AT(11-1)-666, Alco Products, Inc.
	Modification No. 1 to AT(11-1)-1213, Baldwin-Lima-Hamilton Corporation.
November 14	Memo to Those Listed from Dunbar, transmitting copies of monthly project report to HQ (October).
	BLH weekly report on steam generator contract for week ending November 10, 1962.
	Letter, Barrett to Heckman, comments on minutes of meeting No. 30 of SCDP Working Group.
	Letter, Savage to Nemzek, comments on minutes of meeting No. 30 of SCDP Working Group.
November 15	Letter, Staub to Mattmueller, re modification to physical properties of materials test loops, Contract AT(11-1)-765.

Letter, Mattmueller to Donnell, re Contract AT(11-1)-865, PA #3, to extend the evaluation of the Blake Meter.

Memo, Nemzek to Levy, re proposal to test magnetic drive coupling from Westinghouse Electric Corporation 12" flow controller.

November 16

Letter, Nemzek to Werner, MSA, confirming arrangements for an Ad Hoc Group to review the investigation of materials being performed under Contract AT(11-1)-765.

November 16

Letter, Nemzek to Those Listed, re Ad Hoc Group review of the investigation of materials being performed under Contract AT(11-1)-765 by MSA.

November 19

TT, Wensch to Nemzek, putting Destordeur (EURATOM) on the distribution list for copies of SCDP monthly status report.

Modification No. 4 to extend subcontract with University of Michigan under prime Contract AT(11-1)-765 with MSA.

November 23

Memo, Heckman to File, re IHX status at Alco Products, Inc.

November 28

Memo, Smith to File, re Alco IHX inspection status by P. Peterson.

BLH weekly letter on steam generator contract for week ending November 24.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
DECEMBER 1962

I. LISTING OF CURRENT PROJECTS

	<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a.	Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N.Y. L. E. Phillips	AT(11-1)-666	CH
b.	Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c.	New Steam Generator	Undesignated		CH
d.	Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
e.	Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
f.	Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g.	Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
h.	Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N.Y. H. Steinmetz	AT(30-1)-2877	NYOO
i.	Resistivity Meter (Blake Meter)	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH

II. STATUS

a. IHX and Steam Generator - Alco Products, Inc.

The IHX was inspected and given a code stamp by an eastern insurance company. The AI inspector signed and attached AI shipping

tag No. 14095 to the vessel with the Alco shipping receipts. The IHX was shipped during the last week of December 1962 in a covered truck trailer and is expected to arrive at the California destination during the second week of January 1963.

Five boxes of extra copies of reports, masters of the reports, and other information related to the steam generator were shipped by Alco to BLH. In addition, a roll of original drawings, sketches, and layouts pertaining to the Alco contract for both the IHX and the steam generator was shipped to BLH.

There are three additional areas of work being completed in the Alco Schenectady Laboratory as follows:

- (1) Stainless-to-stainless tube-to-tube sheet welding. This program is complete and the report is being written.
- (2) Bimetallic tube-to-tube sheet welding. Qualification runs are being started. The report will be finalized after this work is completed.
- (3) Thermal shock test. This work continued through the month of December.

It is Alco's intent to incorporate these three areas of work into one final report which will be distributed in accordance with the AEC distribution list. Additional copies and masters will be sent to BLH.

With the shipment of this material, with the exception of the report mentioned above, Alco has submitted to BLH all original work and reports generated under the subject contract.

The contract term with Alco Products, Inc. was extended to June 30, 1963.

b. Steam Generator - Baldwin-Lima-Hamilton Corporation

Outstanding Material

The tubing is still expected to be delivered in February 1963. The upper and lower tube sheets have been shipped by Alco and are now in BLH plant.

Engineering

Alco has made the necessary drawing changes for the relocation of the rupture disc nozzle. These changes have been received and are now in the shop.

Fabrication

Fabrication has been started on the shell of the steam generator. Fabrication on remaining portions will begin after Quality Control has reviewed records supplied by Alco.

Alco obtained permission to use solvent (Atlantic 52) for the hydro test fluid in place of menthyl alcohol. In view of this, BLH has issued a purchase order to Alco for the transfer of this material to BLH after Alco has completed their tests and will then use the same material for the hydro test of the steam generator. The baffle drill jig lead pins and aluminum pins which were used by Alco for the manufacture of the intermediate heat exchanger have been received at BLH.

Delivery

A Critical Path Flow Chart is being finalized. From this chart an anticipated delivery date will be formulated.

c. New Steam Generator - Undesignated

The AEC Contractor Selection Board interviewed five industrial firms that had submitted proposals. The Board is evaluating the information presented.

d. Sodium Components Test Installation - Atomics InternationalConstruction

Fuel gas piping system has been completed. The high pressure steam piping spools have been installed. The desuperheater assembly has been shipped from Kentucky on December 21.

Installation of the IHX support structure together with sodium piping supports has been completed. Eleven sodium piping spools are at the site. Inert gas manifold stations and gas receiver tanks are in place and piped.

Design

Design of all preheating systems is complete. Design of steam generator pit piping is complete.

Procurement

Items received during the month: Sodium control valves, sodium flow-mixing tees, vapor traps, fan for sodium-to-air cooler, and third section of control panel.

e. Shell Side Heat Transfer - Atomics International

Approximately 50% of the runs planned for basic unit #12 were completed when difficulties with the heater and the cooler

required a shutdown for repairs. Test runs will be resumed by late January 1963.

The designs for unit #2 with a square array of tubes and cross flow and for unit #8 with a equalateral tube array and also cross flow are complete. Construction of a plastic model to be used by AI and by Professor Short of the University of Texas to visually determine the fluid flow pattern through the use of water and colored solutions is complete.

f. Physical Properties of Materials - MSA Research Corporation

Type 316 Stainless Steel Test Specimens

The operation of sodium loop 1 (ss specimens) was continuous during this report period and test conditions were maintained. The three stress-to-rupture tests of the 4000 hours pre-exposed specimens continued. These were being tested at loads of 24,000, 21,500, and 20,000 psi. The specimens at 24,000 and 21,500 psi ruptured during this report period. An additional specimen was installed and tests begun under a load of 27,500 psi which also ruptured.

Stainless Steel Fatigue Tests

All fatigue tests in air and sodium for Test 1 have been completed. Three tests in helium under intermediate strain conditions will complete the tests in helium. These will be started during the next report period.

The data show failures occur in air considerably sooner at low strain conditions and as the strain is increased the difference between air and sodium failures becomes insignificant. The final helium tests may show the helium specimens significantly outlasting both the sodium and air specimens at the intermediate and high strain conditions.

Stainless Steel Stress Rupture Tests

All unexposed stress-to-rupture tests in sodium have been completed. The pre-exposed tests, therefore, indicate either a tendency for more scatter or an increase in life over the unexposed specimens.

The results of the tests in air and sodium are in such close agreement that a single stress-rupture curve is justified.

Stainless Steel Creep Tests

The three tests of stainless steel in sodium were terminated after 4000 hours of testing. No additional data are available on the tests in air and helium at this time.

The creep rates for the air (helium) and sodium are obtained by two different methods which may help explain part of the differences in these rates. For lack of a better proven method in sodium, MSAR is using dial gages outside the test pot. This is obviously less direct than the method used by the University of Michigan in air and helium. Although the rates appear higher in sodium than in air, the stress to produce a rate of 0.1%/1000 hours is approximately 10% less in sodium than air which is within the variations caused by different heats.

Analytical Sampling of Loop 1 (Stainless Steel Specimens)

Oxygen

The oxygen level is controlled at an equivalent saturation temperature of 300°F. Periodical (a maximum of every three days) plugging indicator tests determine the oxygen level, and if this level exceeds 300°F, cold trapping is initiated until the level is 300°F or lower. In addition to the regular schedule, the cold trap is operated each time a test pot is put back on the line following the replacement of specimens. The oxygen level was brought within specifications in four hours, but as the tests progress the cleanup time has increased due to oxide buildup in the cold trap. At the present time the cleanup time has been extended to six hours. No difficulties are being experienced in maintaining an oxide level at 300°F or lower for two or three week periods without cold trapping if test pots are not put on the line during this period.

Analyses of Sodium in Loop 1

A sample of the sodium is removed from the instream expansion tank once a week. Titanium sample buckets are now being used to avoid contamination.

Carbon analyses are performed by an analytical technique described in Progress Report 25. Attempts to analyze the data to determine the effects of cold trapping on the carbon concentration are inconclusive. However, studies and methods of improving techniques are still being carried out in a separate test rig, and it is hoped that some conclusions will be obtained during this phase of the program.

Metallurgical Examination of Stainless Steel Specimens

Photographs of all specimens have been taken before and after each test. Photomicrographs have been taken of representative specimens. Metallurgical examinations are incomplete at this time but the results will be reported along with the over-all conclusions for Test 1 in a later report.

2½ Cr - 1 Mo Steel Test Specimens

The operation of Sodium Loop 2 continued and test conditions were maintained, although the main heater control instrument failed on two occasions. A 40-degree drop in the main heater outlet occurred until the instrument was turned to manual control. Even with this 40-degree drop, the temperature about the test specimens was maintained by the individual heaters. Operation of the plugging indicator valve became difficult during this report period. There was no indication of bellows failure and hot sodium circulated through the valve has not, at this date, solved this problem.

2½ Cr - 1 Mo Fatigue Tests

All fatigue tests in air and sodium for Test No. 2 have been completed. Three tests at the intermediate strain conditions, one at the low strain condition, and a check of an exposed specimen at the high strain condition will complete the helium tests. These will be started in the next report period.

2½ Cr - 1 Mo Stress-To-Rupture Tests

No additional data have been received on stress-to-rupture tests being conducted in air and helium.

A final unexposed specimen is still under test and is not expected to fail before Test No. 2 is ended. All pre-exposed tests are complete.

The difference between the unexposed sodium and air tests is considered too great to be due to scatter. Two separate stress-rupture curves indicate a noticeable effect on the specimens tested in sodium. The results of the pre-exposed tests clearly indicate a weakening of specimens, due either to long time exposure to temperature, sodium, or a combination of both.

Selected specimens are being analyzed for carbon to determine if decarbonization has taken place.

2½ Cr - 1 Mo Creep Tests

The three Cr-Mo steel specimens in sodium have been terminated, one after 1839 hours and two after 4000 hours. A fourth specimen loaded at 8000 psi, which is a duplicate specimen, is still in progress at 1930 hours. This specimen is now showing a creep rate between 0.5 and 0.6% per 1000 hours. Previous data indicated the creep rate to be too high to read a minimum rate, but this now appears to have been erratic data caused by liquid level variations which in turn were caused by cover-gas pressure variations. Scheduled changes to the cover-gas manifold system between tests should eliminate the problem.

No additional data are available on the tests being conducted in air and helium.

No explanation is available at this time for the higher creep rates and the apparently different shape of the creep curve in sodium than in air. The stress to produce a creep rate of 0.1%/10,000 hrs is in excess of 25% lower than that in air. This is a greater deviation than caused by heat variation.

Analytical Sampling of Loop 2 (Cr - Mo Test Specimens)

Oxygen

The analyses and control of the oxygen in Loop 2 are identical to Loop 1.

Analyses of Sodium in Loop 2

A sample of the sodium is removed from the instream expansion tank once a week. Titanium sample buckets are now being used to avoid contamination.

Carbon analyses are performed by an analytical technique described in Progress Report 25 for September 1962. No better conclusions are apparent at this time from this data on the effects of cold trapping than the data from Loop 1.

Metallurgical Examinations of 2½ Cr - 1 Mo Steel Specimens

Photomicrographic studies of representative specimens are continuing. The results of these photomicrographs and interpretations will be included in future reports.

Future Work

Future work as outlined in Progress Report 26 is continuing although the review of this work by the Ad Hoc Group of the AEC indicated a revision of Test No. 4. Test No. 4 will be specified as operation at a high oxide level rather than under saturated carbon conditions.

g. Mass Transfer - General Electric Company

Activities were directed toward the operation of the six test loops, analysis of the steel and sodium samples, and evaluation of the corrosion and metallographic data. Considerable project-wide effort this month has been devoted to the Carbon-Sodium-Oxygen-Steel system. There is considerable evidence that this is affecting the mass transfer data being collected.

The 5600-hour corrosion data for the 316 SS-2½ Cr loop (No. 2) and the 2800-hour data for the 316 SS-2½ Cr loop (No. 3) generally show similar trends, exhibiting lower corrosion rates for increasing exposure time in both the hot and cold leg regions. While

the hot leg weight losses in loop No. 2 are almost identical for the exposure period 0 to 2800 hours and 2800 to 5600 hours, the cold leg weight gains are from 2 to 3 times greater for the 2800 to 5600-hour period than for the 0 to 2800-hour. The chemical analyses for run 2-5 sodium samples are interesting, showing Ca and Cr concentrations decreasing rather rapidly initially, then levelling out; but exhibiting higher concentrations of Fe, K, Ni, and elemental C at the intermediate sampling periods (1400 and 2800 hours) than either initially or at the 4500-hour sample period. However, the concentrations of all of these elements appear to be on the decline.

The 2800-hour data from loop No. 3 show a weight gain for the H1 sample as well as all cold leg samples, a condition previously noted at the end of the 700-hour exposure period.

The 0-1400-hour data for the 5 Cr loop show weight gains at all sample holder locations, continuing the trend exhibited in the 700-hour run. The 1400-hour samples exhibited an interesting velocity and/or location effect with substantially higher weight gains at the high velocity positions as compared with those at the low velocity location.

h. Continuous Oxide Meter - United Nuclear Corporation

The framework for the pumped loop was completed. The cold trap and main heater sections of the loop were fabricated and installation of loop piping components was started.

More measurements were made of the response of the electrochemical cell to changes in the oxygen content of the sodium and the cell temperature. The results obtained with a Cu-Cu₂O reference electrode are not strictly reproducible. In particular, the variability of the temperature coefficient indicates that other reactions besides $2\text{Cu} + \text{O} = \text{Cu}_2\text{O} + 2\text{e}^-$ may be significant in the operation of the Cu-Cu₂O reference electrode. Various other reference electrodes such as the Ni-NiO, Fe-FeO, Sn-SnO, and MnO₂-Mn₂O₃ electrodes were tested. None of these were as good as the Cu-Cu₂O reference electrode. The method of preparing the reference electrode will be studied in detail in order to improve upon the performance of the electrochemical cell.

Zirconia to Kovar metal seals, using a copper braze, were prepared by a manufacturer (Ceramics International). These seals were found to be leak tight when tested with helium mass spectrometer. However, exposure to sodium for one week at 550-600°F caused the seals to develop leaks. A Zirconia to Kovar seal that was lightly nickel plated at the metal to ceramic joint behaved far better. After a similar exposure to liquid sodium, only slight leaks could be detected with a helium mass spectrometer leak detector. Work on Zirconia to Kovar seals will be continued for the purpose of constructing a rugged electrochemical cell.

i. Resistivity Meter (Blake) - Atomic Power Development Associates

Authorization was given by DRD to extend the contract for the continued evaluation and development of the Blake Meter.

III. MEETINGS

None

IV. REPORTS

AI Surveillance Status and Acceptance Report for the SCTI IHX and Steam Generator for December 1962.

BLH Progress Report on Contract AT(11-1)-1213 for week ending November 24, 1962.

GE Progress Letter No. 41, "Mass Transfer in Sodium," dated December 2, 1962.

MSA Progress Report No. 27 - November 1962, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated December 14, 1962.

SCDP Monthly Project Co-ordination Report - November 1962.

UNC Monthly Progress Report No. 15, "Continuous Oxide Meter," dated December 28, 1962.

V. CORRESPONDENCE

December 3	Memo to File from Smith, re phone call from Roy Seifert, Alco, on IHX status.
December 5	Memo, Heckman to Pursel, re Ad Hoc Group review of MSAR status on Contract AT(11-1)-765, November 29 and 30, 1962.
	Letter, Mattmueller to Staub, asking to be advised whether the stated approach is acceptable to MSAR re the modification of the 2 test loops utilized under Contract AT(11-1)-765.
December 6	Letter, Heckman to DeVan, transmitting Heckman's draft of the Ad Hoc Review Report to ORNL - Also thanking ORNL for their time and effort.
December 7	Memo to File from Smith, re phone call from Roy Seifert, Alco, on IHX code approval - December 5, 1962.
December 10	Letter, Lockhart to Heckman, transmitting 100 copies of letter to participants in the second round analysis, reminding them to submit complete analysis report -

Also asking Heckman to send copy of letter with each sample that is distributed for analysis.

December 12	Memo, Ball to Nemzek, re sodium mass transfer program, Contract 189, PA #15.
December 14	Letter, Mattingly to Working Group, transmitting report re SCDP.
December 17	Memo, Ball to Nemzek, re distribution of report under Contract 189, PA #15.
December 18	Memo to File from Smith, re IHX status at Alco Products, Inc. Letter, Mattingly to Working Group, transmitting copies of reports re SCDP.
December 19	Letter, Nemzek to Those Listed, reports current status of second round analysis for carbon in sodium work.
December 21	Letter, Staub to Mattmueller, re technical proposal for extending work under Contract AT(11-1)-765. Memo to File from Smith, re Blake Meter continuation discussion with G. Wensch, December 19, 1962, stating funds to conduct study are available in CH.
December 27	Note, Heckman to Smith, re phone call to P. Peterson who was on way to Dunkirk to see IHX shipped.
December 28	TT, Groesch to Smith, stating IHX will be shipped from Alco on December 29, 1962.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JANUARY 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N.Y. L. E. Phillips	AT(11-1)-666	CH
b. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c. New Steam Generator	Undesignated		CH
d. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
e. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
f. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g. Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
h. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N.Y. H. Steinmetz	AT(30-1)-2877	NYOO
i. Resistivity Meter (Blake Meter)	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
j. Second Round Carbon Analysis	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO

II. STATUS

a. IHX and Steam Generator - Alco Products, Inc.

Modification No. 8 to the contract was executed to extend the terms of the contract to June 30, 1963. This additional time will allow for the completion of the development work that is under way in the Alco Schenectady Laboratory on (1) stainless-to-stainless tube-to-tube sheet welding, (2) bimetallic tube-to-tube sheet welding, and (3) thermal shock tests. The procurement of the bimetallic tubing for the steam generator is also Alco's responsibility.

b. Steam Generator - Baldwin-Lima-Hamilton Corporation

The sodium inlet and outlet nozzles were fit to the shell and have been tack welded in place. The rupture disc nozzle was fit into the shell prior to actual tacking in position.

The last shipment of material was received from Alco Dunkirk including the upper and lower heads, two (2) manway covers, thermocouples, twenty (20) drums of "Atlantic 52" to be used for hydro test, jigs, and some small hardware components. A review was made to determine if all the material has actually been received from Alco with the exception of tubing.

The latest promise regarding the shipment of the tubing is still the middle of February for the first shipment.

High Pressure High Temperature Test Loop

Atomic Energy Commission's approval for the purchase of rectifiers and transformers for the power supply for the test loop has been received. The actual purchase orders are being placed with the vendors.

Baldwin-Lima-Hamilton is in the process of welding, assembly, and testing the hot section portion of the piping for installation in the holder frame.

c. New Steam Generator - Undesignated

The AEC Contract Selection Board continued with the evaluation of the proposals and information obtained from the industrial firms.

d. Sodium Components Test Installation - Atomics International

Construction

The desuperheater piping assembly was received and installed. However, the desuperheating nozzle assembly does not fit the assembly properly and must be repaired. The manufacturer has been requested to rework or recommend the approved methods for correcting this item.

The Alco IHX has been mounted in its support structure. The unit was received in excellent condition at the site with the same unit gas pressure (~4 psig) as was applied at the manufacturer's plant. The inert gas is being maintained on the unit.

Approximately twenty (20) sodium piping spools have been installed to date and installation of the sodium service system piping has been started.

Procurement

Three (3) additional sections of the control panel have been delivered and installed in the control room. Six (6) out of ten (10) sections of the control panel are now in place. Fabrication problems continue to delay completion of the preheater section for the 35 MW sodium heater and the 85 MW cooler for the primary sodium system. A technical co-ordination meeting was held at the manufacturer's plant during the month which has resolved the questions and problems for the present to assure that work on these two major equipment items proceeds as rapidly as possible. Present anticipated delivery of these items is the first part of May 1963.

e. Shell Side Heat Transfer - Atomics International

The new cooler has been welded in place, X-rayed, and insulated. The 2-inch diameter tubes in the new cooler should be free from oxide plugging which was the difficulty with the earlier unit.

The plastic models for use in studying the flow distribution on the shell side of an IHX were completed.

f. Physical Properties of Materials - MSA Research Corporation

Approval of the proposal submitted by MSAR for loop modifications has been received from AEC. Material has been ordered and modifications will be made before initiating Tests 3 and 4.

The operation of sodium Loop 1 (SS specimens) was continuous during this period and test conditions were maintained. The final stress-to-rupture test of a 4000-hour pre-exposed specimen under a load of 20,000 psi continued until the specimen failed on January 2, 1963, which completed the sodium phase of Test 1. The system was drained at that time. Modifications of the loop are to be made immediately and Test 3 will begin when revisions are complete.

Stainless Steel Fatigue Tests

All fatigue tests in air and sodium for Test 1 have been completed. Three tests in helium under intermediate strain conditions will complete the tests in helium. These tests have just been started and results will appear in the next report.

The data show failures occur in air considerably sooner at low strain conditions and as the strain is increased the difference between air and sodium failures becomes insignificant. The final helium tests may show the helium specimens significantly out-lasting both the sodium and air specimens at the intermediate and high strain conditions.

Stainless Steel Stress Rupture Tests

All the stress-to-rupture tests in sodium have been completed. The fourth and final pre-exposed specimen failed after 1869.7

hours which completed the sodium phase of Test 1. No additional data are available on the tests in air and helium. The data for the pre-exposed specimens in sodium have more scatter than that of the standard specimens and also indicate a slight increase in life over the standard specimens. The pre-exposed specimens tested in sodium indicate an increase in rupture strength of approximately 25% due either to long time exposure to temperature, sodium, or a combination of both.

Stainless Steel Creep Tests

The three tests of stainless steel in sodium have been terminated after 4000 hours of testing. No additional data are available on the tests in air and helium at this time.

Stainless Steel Tensile Tests

No additional tests have been run during the last report period.

Physical Property Study of 2½ Cr - 1 Mo Steel Test Specimens

The operation of sodium Loop 2 continued and test conditions were maintained although the main heater control instrument failed on one occasion. A 40-degree drop in the main heater outlet occurred until the instrument was turned to manual control. Even with this 40-degree drop, the temperature about the test specimens was maintained by the individual heaters. Operation of the plugging indicator valve again became difficult without signs of a bellows failure. This valve will be checked further prior to start of Test 4.

Operation of Loop 2 was suspended and the system drained since the 8000 psi duplicate creep test indicated an increasing rate after 2587 hours of testing. Also, the final standard stress-to-rupture specimen had been under test for 6623.8 hours and gave no indication of failure in the near future. Modifications of the loop are to be made immediately and Test 4 will begin when revisions are complete.

2½ Cr - 1 Mo Fatigue Tests

All fatigue tests in air and sodium for Test 2 have been completed. Three tests at the intermediate strain conditions, one at the low strain condition, and a check of an unexposed specimen at the high strain condition will complete the helium tests. These will be started upon completion of the stainless steel helium tests. The data show a decided difference between tests in air and sodium with failures occurring much sooner in air.

2½ Cr - 1 Mo Stress-to-Rupture Tests

All stress-to-rupture tests in sodium have been completed or terminated. The results of the pre-exposed specimen tests clearly indicate a weakening of specimens due either to long time exposure to temperature, sodium, or a combination of both. Selected specimens have been analyzed for carbon to determine if decarbonization has taken place.

2½ Cr - 1 Mo Creep Tests

Four Cr - Mo steel specimens in sodium have been terminated, one after 1839 hours (10,000 psi load), one after 2587 hours (duplicate 8000 psi load), and two after 4000 hours (6000 and 8000 psi loads). The duplicate specimen loaded at 8000 psi was terminated after reaching a minimum rate of 0.57% per 1000 hours which occurred in 900-1800 hours. This rate then began to increase indicating the specimen had gone through the secondary creep rate and that the rate would increase until the specimen failed.

Carbon Analysis

In view of variation of the carbon values obtained, particulate carbon may be an important consideration. An apparatus has been built to obtain filtered samples to reduce the possibility of particulate carbon pickup. A piece of 3/4-inch stainless steel pipe was fitted with a micrometallic filter on one end and a standard taper joint on the other. An O-ring seal and a pipe fitting are attached to the sample pipe. The O-ring will allow the stainless steel pipe to be lowered into the sodium melt. The joint will be fitted with the standard sampling apparatus. By means of a slight vacuum, sodium will be drawn through the micrometallic filter, then sampled by dipping into this filtered metal. Filtration in this manner should establish whether particulate carbon is the cause of present variations.

Metallurgical Examination of Stainless Steel Specimens

The 316 stainless steel microstructure remains substantially the same after 4000 hours of exposure in sodium at 1200°F. There is a very slight indication that an increase in the carbide precipitation is occurring in the grain boundaries, but certainly not to the extent expected under these conditions.

The fatigue specimens increased in weight on an average of 0.04% in slightly less than 300 hours of exposure in sodium. The stress rupture specimens increased in weight 0.02% during the 4000 hours exposure to sodium at 1200°F. The macrohardness of these specimens increased from B81-82 to B84-85 under these conditions.

Metallurgical Examination of 2½ Cr - 1 Mo Alloy Steel Specimens

The 2½ Cr - 1 Mo alloy steel microstructure remains substantially the same after 4000 hours exposure in sodium at 1100°F. There are very slight indications that some decarburization is occurring because the grain boundaries appear somewhat lighter.

g. Mass Transfer - General Electric Company

Activities were directed toward the operation of the six test loops, analysis of the steel and sodium samples, and evaluation of the corrosion and metallographic data. Continuing effort this month has been devoted to the Carbon-Sodium-Oxygen-Steel system and in particular in the area of carbon analysis of loop sodium samples.

Modification No. 6 to the contract has been executed extending authorized time and funding for this project. It is anticipated that about 85% of the fractional replicate test plan loop operation will be completed by the end of this fiscal year. At present, the per cent completion of the Five Run Fractional Replicate Test Plan is 61% and the expenditure of authorized funding is 84%.

Analysis of Samples

The 700-hour Analysis Report for the 316 SS-5 Cr loop shows expected corrosion rate trends and in a more consistent manner than was the case in run 4-5-1. As has been noted before, however, "seasoning" effects may make these corrosion rates quite different (usually higher) from those at subsequent exposures. The 2800-hour data for the 2½ Cr loop, in general, show the corrosion rates decreasing as a function of exposure time.

Carbon Analysis of Sodium Samples

About four samples of sodium have been removed from the test loops during each test run and have been submitted for chemical analysis. During the first year of operation, GFY 1961, no attempt was made to analyze the samples for carbon, but due to the fact that the steel corrosion samples indicated considerable changes in carbon, it appeared to be necessary to determine the amount of carbon in the sodium. During GFY 1962, "elemental" carbon was determined in 43 sodium samples by the Pepkowitz-Porter method (wet oxidation with Van Slyke solution). Preparation of the sodium samples prior to the wet oxidation consists of dissolving the sample in water and then acidifying the solution to a normal pH.

Early this fiscal year, the gas evolved during the acidification step also was analyzed for carbon. The results were reported as ppm "carbonate" carbon in the sodium. All of the samples analyzed by this method indicated a greater yield of carbon from the "carbonate" step than from the elemental carbon analysis. This month five analyses have been made of the gases evolved during the water solution step as well as the acidification and the wet oxidation stages. Again, significant quantities of carbon are apparent.

The amount of total carbon reported is from 27 to 6 times greater than the previously reported wet combustion or "elemental" analyses. Work is continuing to improve and simplify the analytical procedures and interpret these results. When more analyses become available, attempts will be made to correlate the three stage carbon analysis data as a function of loop material and operating history. All program sodium samples are being analyzed for carbon and will be reported. At present, there is a backlog of thirteen routine run samples and twenty-one special run samples. As the results become available, they will be reported in the appropriate Analysis Reports.

h. Continuous Oxide Meter - United Nuclear Corporation

Fabrication of major pumped loop components was continued. The main heater, cold traps, surge tank, sump tank and test sections were completed and mounted on the frame. Most of the interconnecting piping was prefabricated and is ready for installation.

Further assembly was postponed pending delivery of the liquid metal valves. Unforeseen delays in delivery of these valves have necessitated a postponement of the scheduled startup date for the loop. Every effort will be made to compensate for these delays.

The thermal convection loop, adapted for testing four cells simultaneously, was not operating properly. Apparently the cold trap was overloaded with oxide. This loop was dismantled and will be reassembled with a new cold trap.

More measurements were made of the response of the electrochemical cell to changes in oxygen content of the sodium and the cell temperature. The results obtained with a Cu-Cu₂O reference electrode are variable. No explanation can be offered at present for the lack of quantitative agreement between the theoretical and experimental voltage differences. In the light of our experience with the excessive contamination of the four test cell loop, perhaps contamination of the single cell loops is also introducing nonreproducible results. This will be checked.

Cells prepared by flame spraying zirconia onto metal substrate and cells involving metal to ceramic seals will be tested with the repaired loop. The effect of the particular method used to prepare the electrochemical cells, such as outgassing temperatures, upon cell stability will also be studied.

i. Resistivity Meter (Blake) - Atomic Power Development Associates

Contract negotiations continued with actual experimental work expected to start February 1, 1963.

j. Second Round Carbon Analysis - Atomics International

The sodium loop designed for the preparation of sodium samples to be used to compare various analytical techniques for the analysis of carbon in sodium was completed. Shakedown operation using stainless steel sample tubes was initiated. Preliminary results of the analysis of samples taken from different locations indicated that the carbon content of the sodium was homogeneous. The stainless steel specimen tubes will be replaced by nickel tubes and the first of three series of specimens will be taken in February 1963.

III. MEETINGS

January 7 AEC Contract Selection Board, for a new steam generator, met separately with representatives of five different industrial proposers.

IV. REPORTS

BLH Weekly Reports for weeks ending January 12, 19, and 26, 1963.

BLH Progress Report on Contract AT(11-1)-1213 for month ending December 31, 1962 - Sodium Components Design Program.

GE Monthly Report, "Mass Transfer Investigation in Liquid Metal Systems," December 1 through December 31, 1962.

MSA Progress Report No. 28 - December 1962, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated January 15, 1963.

UNC Monthly Progress Report No. 16 for December 1962 - Contract AT(30-1)-2877.

V. CORRESPONDENCE

- January 2 Letter, Mattmueller to Leggett, re Contract No. AT(11-1)-666 - Modification No. 8.
- January 3 Letter, Mattmueller to Staub, re Contract No. AT(11-1)-765, Modification No. 8.
- January 4 Letter, Mattmueller to Donnell, re Contract No. AT(11-1)-865, PA #3, informing APDA that CH is now making arrangements necessary to extend the subject contract.
- January 7 Letter, Nemzek to Those Listed, stating our appreciation for their participation as a member of a Mass Transfer Ad Hoc Group.
- January 8 Letter, Mattmueller to Staub, constituting a supplement to the program letter of October 24, 1962, covering work being performed by MSAR under Contract AT(11-1)-765.
- January 11 Memo, Richards to F. A. Smith, re Alco IHX transmitting reports on final inspection of SCTI IHX at Alco.

TT, Pittman to Dunbar, giving authorization to continue evaluation and development of Blake Meter and to transfer APDA funds as needed within availability.
- January 14 Memo, Mattingly to Working Group, transmitting reports relating to the SCDP.

Letter, Staub to Mattmueller, acknowledging receipt of our letter of 1/8/63 re procedures to be followed in Test 3 and 4 under Contract AT(11-1)-765.
- January 16 Letter, Mattmueller to Abderhalden, re Contract No. AT(11-1)-1213, checking on the weekly reports.

Memo to File from Smith, re phone call from P. Peterson, AI, pertaining to Alco IHX and its arrival at the AI test facility.
- January 17 Letter, Nemzek to Dickinson, AI, asking AI to add J. J. McCown, ANL, to list of participants to receive one specimen from each set of sodium samples of the Second Round Analysis for Carbon in Sodium.
- January 18 Letter, Mattmueller to Abderhalden re BLH Purchase Orders under Contract AT(11-1)-1213 - A. O. Smith Corporation and Westinghouse Electric.
- January 21 Memo, Mattmueller to J. Lee, re Contract No. AT(11-1)-865, PA #3, APDA, requesting an appropriate supplement to the subject cost-reimbursement contract.

- January 22 Letter, Abderhalden to Mattmueller, confirming a wire of 1/22/63, which gave accrued costs.
- Letter, Steffens to Mattmueller, transmitting organization chart.
- January 23 Memo, Richards to F. A. Smith, re sodium cooled and pre-heater purchase orders with BLH and AI's procurement difficulties with BLH.
- January 25 Memo, Nemzek to Levy, setting up a CH-AI-BLH technical information meeting on February 5, 1963, and transmitting agenda.
- Letter, Mattmueller to Abderhalden, re the CH-AI-BLH information meeting on February 5, 1963 (transmits agenda).
- January 29 Memo, Dunbar to Shute, re summary of the technical review of the sodium mass transfer project at GE in an Ad Hoc Committee Report dated December 12, 1962.
- Memo, Casey to Levy, re SCTI - request for Modification of Directive CP-61-8 Modification 8 to Contract AT(11-1)-765 - MSA Research Corporation.
- January 31 TT, Mattmueller to Wensch, Cost detail of APDA Project Agreements.
- January 29 Memo, Smith to File, re deviation from specification, 304 - 316 for Alco IHX.
- January 31 TT, Dunbar to Pittman, answering DRD questions concerning the Alco-BLH steam generator.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
FEBRUARY 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N. Y. L. E. Phillips	AT(11-1)-666	CH
b. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c. New Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
d. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. W. Dickinson	AT(11-1)-8	CPAO
e. Shell Side Heat Transfer	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO
f. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g. Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
h. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYOO
i. Resistivity Meter (Blake Meter)	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
j. Second Round Carbon Analysis	Atomics International R. W. Dickinson	AT(11-1)-8	CPAO

II. STATUS

a. IHX and Steam Generator - Alco Products, Inc.

The IHX arrived in satisfactory condition at Santa Susana, California, and installation into the SCTI was initiated by AI (see SCTI, AI).

The weld development of the duplex tube to the tube sheet for the steam generator continued. Small cracks were noted at the root of some of the welds in the thermal shock test assembly. These cracks are being sectioned and examined closely.

Fabrication of the duplex tubes by the Superior Tube Company was delayed. The testing of the first one-third of the tubes was scheduled for March 5, 1963.

b. Steam Generator - Baldwin-Lima-Hamilton Corporation

The tubing supplier indicated that approximately 175 tubes would be ready for ultrasonic testing and final inspection during the first week of March. The raw material for the remainder of the tubing has passed its initial test and was sent to the tubing manufacturer.

On February 5, 1963, a meeting was held at the AEC-CH to discuss the status and future schedule for the steam generator and for the test loop. The critical path flow chart was presented and the separate operations were reviewed. The need for sequential operations was pointed out; this results in an extended delivery date of the unit. Baldwin-Lima-Hamilton will try to improve on the forecasted operational times in the attempt to better the anticipated delivery date of November 15, 1963.

High Pressure High Temperature Test Loop

The buss bar network on the outside of the furnace has been removed and cleaned. All loose joints have been resoldered and refitted. All broken electrical insulators have been replaced and the buss bar network remounted and the pigtails installed. The internal brick work of the furnace is in the process of being cleaned prior to reassembly.

c. New Steam Generator - Babcock and Wilcox

The proposal submitted by Babcock and Wilcox for the design of a 1000 MWt unit, a 30 MWt prototype unit, and the fabrication of a 30 MWt prototype unit was selected for contract negotiation. Phase I, consisting of preliminary design and performance of associated research and development, will be initiated in FY 1963.

d. Sodium Components Test Installation - Atomics International

A contract was let to set the foundations for the preheater, cooler, and other system components in the SCTI. Operational plans are being rescheduled in line with the present construction schedule. Since shipment of the steam generator by BLH is estimated for November 1963, the system filling and startup are now scheduled

for mid-January 1964. Ten sodium piping spools (shop fabricated sections) were installed and the motor and speed control assembly for the 8.5 MW sodium cooler have been completed.

e. Shell Side Heat Transfer (SSHT) - Atomics International

Summary of Work from October 16, 1962, to February 20, 1963

- (1) The 1 MW cooler did not perform satisfactorily and was replaced by a 2.5 MW cooler.
- (2) The 1.2 MW sodium heater failed and was replaced by a 0.96 MW heater.
- (3) Approximately 30 test runs have been completed on Basic Unit 12.
- (4) Six clear plastic baffled heat exchanger models have been fabricated.

Tests on Basic Unit 12

Approximately 30 of the 75 test runs planned for Basic Unit 12 have been completed. These runs were limited to power levels below 300 KW. Tests have been performed with the hot fluid on both the shell and the tube sides. Heat balances have been within about 2% for the runs completed to date. Nine repetitions of one test run have been completed and the data are being reduced to allow determination of the standard deviation of the test runs. All data are being reduced using a data reduction computer program prepared for these shell side runs.

Baffled Heat Exchanger Models

Six basic models have been fabricated to study the flow velocities through baffled heat exchangers. These units are scale models of the 10 verification unit heat exchangers to be tested in the shell side program. The geometric variables embodied in these models are tube array (square and triangular), tube pitch to diameter ratio, baffle window opening, baffle spacing, and tube bundle to shell clearance. Six tube bundles were fabricated with removable baffles which can be spaced as desired on the bundles. These bundles are placed in one of three different shells to obtain the bundle clearance required. Water flow tests using dye injection (and perhaps particulate tracers) will be performed to determine fluid velocities in the bundle. These tests will serve as a guide in specifying the designs of the basic units and may also suggest elimination of some of the 10 verification units from the test program.

f. Physical Properties of Materials - MSA Research Corporation

Type 316 Stainless Steel Study

The operation of sodium Loop 1 (SS specimens) was suspended January 2, 1963, upon completion of the final test in the sodium phase of Test 1. At this time the loop was drained.

Fatigue Tests

The data show failures occur in air considerably sooner at low strain conditions and as the strain is increased (and time is shortened) the difference between air and sodium failures becomes insignificant. The final helium tests may show the helium specimens significantly outlasting both the sodium and air specimens at the intermediate and high strain conditions.

Stress to Rupture Tests

The results of the tests in air and sodium are in such close agreement that a single stress rupture curve is justified. The data for the pre-exposed specimens in sodium have more scatter than that of the standard specimens and also indicate a slight increase in life over the standard specimens. The pre-exposed specimens tested in sodium indicate an increase in rupture strength of approximately 25% due either to long time exposure to temperature, sodium, or a combination of both.

Creep Tests

Although the rates appear higher in sodium than in air, the stress to produce a rate of 0.1%/1000 hours is approximately 10% less in sodium than in air which is within the variations found between different heats.

2½ Cr - 1 Mo Study

The operation of sodium Loop 2 (2½ Cr - 1 Mo specimens) was suspended on December 28, 1962, upon completion of the sodium phase for Test 2 at which time the loop was drained.

Fatigue Tests

All fatigue tests in air and sodium for Test 2 have been completed. Three tests at the intermediate strain conditions, one at the low strain condition, and a check of an unexposed specimen at the high strain condition will complete the helium tests. These will be started upon completion of the stainless steel helium tests.

Stress to Rupture Tests

The difference between the sodium and air test is believed too great to be due to scatter. The results of the pre-exposed specimen tests clearly indicate a weakening of specimens due either to long time exposure to temperature, sodium, or a combination of both.

Selected specimens have been analyzed for carbon to determine if decarbonization has taken place.

Creep Tests

Here again the creep rates for air (helium) and sodium are obtained by two different methods which may help explain part of the differences in these rates. The differences in stresses to produce creep rates of 0.1%/1000 hours are greater than the expected deviation between different heats.

Analytical Results

Carbon Solubility and Solution Rates

Most of the work has been concentrated on this area during the past month. A number of areas must be clarified before loop operation at high carbon levels can be undertaken, including solution rates of carbon from a source such as carbon rod and the possibility of introduction of gross amounts of particulate carbon to the metal. Equipment had been constructed to determine solution rates of carbon rod and the carbon saturation value at 1200°F for sodium. A stainless steel vessel containing ten pounds of sodium which can be operated with or without cold trapping is being used for this study.

Dip samples have been taken in nickel buckets to determine the carbon content in the initial unfiltered sodium charge, during and after cold trapping, and after the insertion of carbon rods. Further testing is desirable before discussing trends and drawing conclusions. Thus far, no increase has been noted in the carbon level after addition of the carbon rod although additional data are needed before specific conclusions can be made.

Future Work

Mine Safety Appliance Research Corporation has completed the sodium and air phases of Tests 1 and 2. The fatigue test in helium at MSAR is continuing. The University of Michigan is continuing the creep, stress-rupture, and tensile tests in air and helium. Specimens of tests completed are being examined in preparation for a topical report covering Tests 1 and 2.

The scheduled work and proposed modifications of the two loops are continuing. Loop 2 is expected to be ready for operation during the next report period and Loop 1 shortly thereafter.

Examination and comparison of completed air and sodium tests are continuing in the belief the creep data can be better correlated. A method of measuring creep rates is being considered that may eliminate the use of dial gages and duplicate more closely the method used at the University of Michigan.

g. Mass Transfer - General Electric Company

Activities were directed toward the operation of the six test loops, analysis of the steel and sodium samples, and evaluation of the corrosion and metallographic data.

At present the per cent completion of the Five Run Fractional Replicate Test Plan is 64% and the expenditure of authorized funding is 87%.

Analysis of Samples

The 2800-hour Analysis Report for the 316 SS loop (#1), in general, shows expected corrosion rate trends as evidenced by hot leg sample weight losses and cold leg sample weight gains in approximate proportion to the exposure temperatures. There seems to be a downstream effect evident between H3-H3R. There was no consistent indication of "time-effect" (i.e., the tendency for the sample corrosion rates to decline with increasing exposure time).

The 1400-hour data for the 316-5 Cr loop (#4) show corrosion rates of the same order of magnitude as the earlier (700-hour) data. There is no clear evidence of "time-effect"; in fact, H1 and H3R samples, for no apparent reason, showed larger gains for this 1400-hour period than during the earlier period.

The 2800-hour data for the 5 Cr loop (#6) show unexpected behavior and no clear trend such as was evidenced by another very similar H-C run--4-4(3). The Loop 4 runs clearly displayed the downstream effect, i.e., that the corrosion rate is very high where the isothermal zone is established and tends to approach zero as the samples are located farther downstream. In run 6-4 there was little, if any, evidence of downstream since there was no initial high corrosion rate. There was also a surprising reversal of corrosion effect with weight gains in the hot leg and weight losses in the cold leg samples. The effect of the 2½ Cr sample, inadvertently installed in H2 during run 6-3, may explain to some extent the earlier (700 and 1400-hour) weight gains (due to increased carbon content) in both cold and hot legs, but it is difficult to see how this would have much bearing on the weight losses in the cold leg samples during the latter part of the run. In any event, the corrosion rates were low, being less than 0.06 mil/yr at most, and will probably be even lower when "carbon corrections" are made.

h. Continuous Oxide Meter - United Nuclear Corporation

Experiments with the electrochemical cells were continued and a quarterly progress report was issued.

Relatively little work was done on the pumped loop because of a delay in delivery of the liquid metal valves. The thermal convection loop, adapted for testing four cells simultaneously, was reassembled with a new cold trap and put into operation. Tests in all three thermal convection loops are continuing to find a method for preparing electrochemical cells of optimum reproducibility. Measurements on cell response to changes in oxygen content in the single cell loops agree with results reported earlier.

Experimental Results

Various electrochemical cells were tested for voltage stability and response to changes in cell temperature and oxygen content of the sodium. Cells with Cu-Cu₂O, Ni-NiO, Fe-FeO, Sn-SnO, Na-Na₂O, and MnO₂-Mn₂O₃ reference electrodes were tested. Of these, the cells with Cu²-Cu₂O reference electrodes gave the most reproducible results.

Electrochemical cells with thoria-15 w/o yttria electrolyte and Cu-Cu₂O reference electrodes were tested. The cell voltage responded to changes in oxygen content at test temperatures of 750 to 900°F, whereas zirconia electrolytes react with the sodium in this temperature range. However, the cell voltage of cells with thoria electrolytes drifted considerably with time. The thoria electrolyte tubes were also very fragile.

The results for the temperature coefficient are erratic, particularly for the temperature range of 500 to 550°F. In agreement with theory, the observed temperature coefficients, for a cell with a Cu-Cu₂O reference electrode, are small. (An increase of 5 millivolts corresponds to a change in oxygen content from 16.5 to 13.5 ppm at a cell temperature of 550°F.) The small effect of temperature upon cell voltage can be overshadowed by the instability of the cell voltage.

1. Second Round Carbon Analysis - Atomics International

The preparation of the first set of specimens of the Second Round Analysis for Carbon in Sodium was completed and specimens were shipped to all of the participants. Because of normal startup difficulties with the loop, these first specimens were possibly not within the intended specifications. An additional set of specimens, designated Set 1A, is therefore planned which will be cold trapped to 300°F to bring the oxygen content to an approximate level of 10 ppm. The carbon content of Set 1A will be at the "as purchased" level.

Preparations were proceeding for Sets 1A, 2, and 3 with the present plans to have Set 2 be high carbon and Set 3 have an intermediate carbon level.

III. MEETINGS

February 14	H. W. Savage, ORNL, visited AEC-CH to review the Mass Transfer Ad Hoc Review Report and the Physical Properties of Materials Ad Hoc Review Report.
February 18-19	T. P. Heckman, AEC-CH, visited AI to review the SCTI, SSHT, and Second Round Carbon in Sodium Specimen Preparation.
February 20	T. P. Heckman, AEC-CH, visited GE, San Jose, to review Mass Transfer Investigations and Second Round Carbon in Sodium data.
February 21	T. P. Heckman, AEC-CH, visited AEC-SAN regarding GE sodium activities.

IV. REPORTS

AI Monthly Progress Report for January 1963 on the Sodium Components Test Installation dated February 1, 1963.

AI Progress Report on Shell Side Heat Transfer Studies, Report No. 12, dated February 20, 1963.

AI Weekly Technical Progress Reports for the weeks ending February 6, 20, and 27, 1963.

BLH Progress Report on Contract AT(11-1)-1213 - Sodium Components Design Program - dated February 7, 1963.

BLH Weekly Report for the weeks ending February 2 and 23, 1963, dated February 12 and 26, 1963, respectively.

GE Project Status and Cost Report - "Irradiation of Mass Transfer in Liquid Metals," for January 1963, dated February 6, 1963.

GE Monthly Report on "Mass Transfer Investigation in Liquid Metal Systems," Report No. 43, February 8, 1963.

MSA Progress Report No. 29 - January 1963, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated February 15, 1963.

Westinghouse Sodium Pump Study Project - Monthly Cost Statement for the months of December and January, dated February 18, 1963.

V. CORRESPONDENCE

February 1	Letter, Levy to Trevillyan, re Sodium Components Test Installation, authorizing AI to proceed with the work utilizing FY 1962 funds.
February 4	Modification 8 to Contract No. AT(11-1)-666, Alco Products, Inc.
February 5	Memo, Fremling to Mattmueller, re meeting with AI and BLH to discuss progress on steam generator being fabricated under BLH Contract AT(11-1)-1213 and status of the SCTI facility at AI in which the steam generator will be tested.
February 7	Letter, Mattingly to Working Group, transmitting copies of reports related to SCDP.
February 11	Letter, Randall, Westinghouse, to Wise, NY, transmitting copies of the Monthly Progress Report for Sodium Pump Development and Test Facility Design.

Memo, Fremling to Mattmueller, re summary of current status of Alco Products work under Contract AT(11-1)-666. |
| February 12 | Letter, Mattmueller to Seifert, Alco, re problems concerning the warranty clause in the Superior Tube Company order and tubing material used in the IHX.

Memo, Mattmueller to Office of Counsel, regarding Supplement 3 to Project Agreement 3 of APDA Contract AT(11-1)-865 and justification for support. |
| February 13 | Letter, R. Cygan to Abderhalden, transmitting two copies of diagrams showing steam generator lug design and location of lug on steam generator shell. |

- February 13 Letter, J. DeVan and W. Savage to Nemzek, summary of the application of metallurgical data from the nuclear superheat materials program to the design and operation of a sodium-water steam generator.
- February 14 Letter, Mattmueller to Abderhalden, re current problems related to completion of the steam generator.
- February 15 Letter, Mattingly to Working Group, transmitting reports related to the SCDP.
- Letter, Nemzek to Anderson, AI; DeVan, ORNL; and McKee, UNC, thanking them for their participation as a member of a Physical Properties of Materials Ad Hoc Group of the SCDP during November 29 and 30, 1962.
- Memo, Nemzek to Levy, re BLH status related to the SCTI, asking Levy to inform R. Cygan of AI action to be taken because of difficulties in reaching successful welding technique to be used on steam generator tube-to-tube sheet joint.
- February 18 Memo, J. Wise to Harris, DRD, and Smith, CH, re Contract AT(30-1)-3123 - Sodium Pump Development and Test Facility Design - transmitting work program.
- February 19 Letter, Mattingly to Working Group, transmitting reports related to SCDP.
- February 21 TWX, Mattmueller to Abderhalden, asking to be advised if BLH plans to have a representative attend the testing of first one-third tubes at Superior Tube Company on March 5.
- February 25 Letter, Mattmueller to Seifert, Alco, concurring Alco's proposed approach to fulfilling BLH welding program material requirements.
- Letter, Steffens, BLH, to Mattmueller, re our request to have BLH submit 189's - BLH does not believe a 189 is necessary at this time.
- Letter, Seifert, Alco, to Mattmueller, re Contract AT(11-1)-666, transmitting copies of test reports for chrome material which was sent to AI.
- February 26 Letter, Abderhalden to Mattmueller, re Contract AT(11-1)-1213, transmitting copies of TWXs re shipping orders.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
MARCH 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N.Y. R. W. Bennett	AT(11-1)-666	CH
b. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c. New Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
d. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. Cygan	AT(11-1)-8	CPAO
e. Shell Side Heat Transfer	Atomics International J. S. McDonald	AT(11-1)-8	CPAO
f. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-8	CPAO
g. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
h. Resistivity Meter (Blake Meter)	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH

II. STATUS

a. IHX and Steam Generator - Alco Products, Inc.,

Intermediate Heat Exchanger Program

All engineering, manufacturing, and laboratory work relating to the IHX has been completed. A report covering the laboratory development program on the automatic welding of the stainless steel tube-to-tube sheets has been written. The shock test of the simulated welded tube-to-tube sheet has been completed, the data correlated and prepared as a rough draft report. Both of these reports will be integrated into a single final comprehensive report which will also include the tube welding development and the shock test relating to the steam generator program. Thus, this phase of the program is considered completed.

Steam Generator Program

Considerable cracking difficulty was encountered in the root pass of welds joining the bimetallic tube to the Inconel overlaid stainless steel tube sheet. This problem was finally solved by modification of the joint design and a change in the welding procedure to reduce the stress on the weld during its solidification. This joint modification has been incorporated in the final design and machining of tube sheets that have been sent to Baldwin-Lima-Hamilton from Dunkirk.

b. Steam Generator - Baldwin-Lima-Hamilton Corporation

The nozzle-to-shell welds still have some defects which will be repaired, and radiographic examination will be made following the weld completion.

Alco has resolved the "thin wall" conditions on the tubing at Superior Tube. The present minimum wall thickness of the tubing is 0.104 inch. Any tubes which do not meet this requirement will be acceptable if the wall thickness does not go below 0.100 inch and the stainless portion of the tube having a thickness of 0.072 inch minimum. Any tube which is being accepted in accordance with this criteria will be segregated and marked by Superior and the method of identification transmitted to Baldwin.

Weld Development at Alco

The welding consistency test was conducted as scheduled at Alco on March 26 with Baldwin-Lima-Hamilton representative in attendance. A report will be issued on this later.

High-Pressure High-Temperature Test Loop

The heat exchangers in the test loop have been welded to the tubing and the tests completed. The pressure gauge lines have been installed from the tower to the gauge board and have all been tested.

The mounting box for the rectifiers has been constructed and will be ready for installation upon receipt of the rectifier.

c. New Steam Generator - Babcock & Wilcox

The contract between the Commission and Babcock & Wilcox was signed, and work on Phase I consisting of preliminary design and performance of associated R&D was started March 20, 1963.

d. Sodium Components Test Installation - Atomics International

All the piping spools incorporating expansion bellows have been delivered to the SCTI from the piping fabricator. The startup (steam-feedwater system) steam boiler together with the gas-fired air heaters, for the preheating system, have been delivered. Except for the preheater and sodium cooler, both from Baldwin-Lima-Hamilton, this completes acquisition of outside purchased items. Two more sections of the control panel have been received so that eight of a total of ten required are now on hand.

e. Second Round Carbon Analysis - Atomics International

Circulation of the sodium and cold trapping operations continued in the loop being used to prepare sodium samples that will be intentionally contaminated with carbon. A supplementary set of sodium samples, designated set 1A, is being prepared with "as received" carbon level and 10 ppm oxide level. The two subsequent sets of samples will have carbon contents of 80 to 100 ppm and 20 to 40 ppm. These sets represent the range of carbon contamination levels which are of interest in sodium cooled reactors. Seventeen different laboratories have agreed to analyze a specimen from each set of samples and to report the data for the purpose of evaluating analytical techniques.

Tests to 1000°F have indicated a proprietary hard-chroming process can be used on joints of the specimen containers to prevent galling. This chrome process will be used as a substitute for the "Molykote" lubricating agent which was found to contain traces of carbon despite the supplier's certification to the contrary.

f. Physical Properties of Materials - MSA Research Corporation

Loop 1 modifications of the cover gas system and thermocouple arrangements have been nearly completed. A system to insure being able to saturate and maintain saturation of carbon is being designed and will be installed during the next report period. This consists of a pot with micrometallic filters to enclose a granular carbon source placed in a bypass stream. Valves are located such that this bypass may be isolated from the main stream and the carbon pot can be removed from the system without draining the main system. A valve will also be installed in the main stream in order that full system flow can be put through the carbon source. The bypass carbon source will be located after the main heater at the inlet to the test pots. A flow meter will also be installed on this bypass for monitoring flow rates.

Modifications have been completed on Loop 2, and operation will be initiated during the next report period. Upon receipt of foil material, samples will be made, inserted into pots and the shakedown run begun.

Carbon Solubility and Solution Rates

The study of carbon solution rates in sodium continued during the past month. Instrument malfunction has limited the amount of data which has been generated, but some conclusions can be drawn.

The vessel containing 10 pounds of sodium was heated to 1000°F, and samples for oxygen and carbon were extracted from the melt. Results suggest that the carbon level dropped from an average of 32 ppm to approximately 20 ppm in 36 days. Attempts were made to determine the effect of cold trapping on carbon levels but the data scatter and lack of sufficient data prevented drawing any conclusions on this phenomenon. The pressing need for determination of carbon solution rates in support of the program planned for Loop 1 prevented additional evaluation of cold trapping effects, but these effects will be determined later.

A spectrographically pure carbon rod 1/2 inch diameter by 4 inches long (6.48 inch²) was immersed in the sodium, and carbon concentration

was followed as a function of time. Initially no increase was observed in the carbon content of the sodium; in fact, a decrease to 10 ppm carbon was noted. However, these samples coincided with spectrometer malfunction, and the validity of these values cannot be established. Following instrument repair, an increase in carbon content of the sodium was observed. After 37 days, the carbon level had increased to 150 ppm at an average oxygen level of 100 ppm. Gratton's data indicate equilibrium solubility of carbon in sodium containing 240 ppm O_2 to be 170 ppm. These results suggest that the solution rate of carbon rod in sodium will be too low to assure saturation levels in the loop. A flow-through system containing granular graphite will be incorporated in the loop.

g. Resistivity Meter - Atomic Power Development Associates, Inc.

Work during the first month of operation under the recent contract extension included sodium cleanup, repair to the Rhometer temperature compensator, and an initial run with hydrogen gas injection to determine meter response. A newly-developed continuous hydrogen detector was installed in the cover gas system, and development was started on extension of the Rhometer temperature compensator range from 600°F to 1000°F.

Hydrogen Injection

Hydrogen injection was initiated on February 28, 1963, with the meter zeroed in at 422°F. Low-temperature injection was selected in order to take advantage of the lower dissociation pressure of sodium hydride. The formation of sodium hydride was further stimulated by throttling back on the pump discharge header to produce 20 psig in the loop at the injection probe. To prevent plugging, the probe was fed with argon at approximately 800 cc per minute immediately prior to and after hydrogen injection. Hydrogen was introduced in 1/4-ft³ increments over a 30-minute period. This quantity of gas would occupy approximately 3% of the volume in the 8-ft³ cover gas system if unreacted. Some 0.6% of hydrogen was found in the cover gas immediately after injection, indicating a 90% reaction. The reaction went to completion in 8 hours, resulting in a cover gas analysis of less than 100 ppm of hydrogen. The Rhometer indicated an increase of 0.02% resistivity, and the cold plugging temperature rose from 250°F to 370°F.

Because of the unexpected increase in the plugging temperature, it was decided to abandon injection at 422°F. Control samples were taken from the surge tank and loop temperature elevated to 570°F for further hydrogen injection.

Injection was then continued in 0.25 scf increments up to a cumulative total of 4 scf, and the Rhometer response time to gas injection was in the order of 30 seconds.

Hydrogen in the cover gas system increased abruptly during and after most of the gas injections. Hydrogen would then decrease from its maximum value at the rate of 2000 to 4000 ppm per hour after the injection, partly due to continued reaction and partly due to loss of hydrogen by purging.

Loop cleanup was attempted by elevating the operating temperature from 570°F at 100°F stages to 870°F and purging the cover gas periodically to favor dissociation of the NaH in solution. Sodium samples were taken for analysis at each temperature plateau in the temperature ramp.

The 90-hour high-temperature soak consumed some 300 scf of argon purge gas and reduced the NaH concentration by some 15-20% based on the assumption that there were equivalent NaH increments for each hydrogen injection and that the 0.48 % r value is valid. The results confirm statements in the literature to the effect that the presence of an argon cover gas will suppress the dissociation of NaH in sodium.

III. MEETINGS

- March 5 F. A. Smith (CH) visited Superior Tube Company to inspect the first production run of duplex tubes.
- March 6 F. A. Smith (CH) visited Baldwin-Lima-Hamilton to discuss the steam generator schedule and the test loop construction.

IV. REPORTS

- AI Cost Budget Report on Sodium Components Only for Fiscal Year 1963 through February 28, 1963.
- AI Sodium Components Test Installation Monthly Progress Report for February 1963 dated March 1, 1963.
- AI Surveillance Status and Acceptance Report for SCTI Steam Generator dated March 22, 1963.
- APDA Summary Report for March 1963 on Contract AT(11-1)-865, PA 3.
- BLH Weekly Report on Steam Generator Contract AT(11-1)-1213 - weeks ending March 9, March 16, and March 23, 1963.
- BLH Progress Report on the Sodium Components Design Program for February 1963 dated March 8, 1963.
- GE Project Status and Cost Report on Irradiation of Mass Transfer in Liquid Metals for March 1963.
- GE Progress Letter No. 44, Mass Transfer Investigation in Liquid Metal Systems, for February 1963 dated March 8, 1963.
- MSA Research Corporation Progress Report No. 30, Effect of 1200°F Sodium on Austenitic and Ferritic Steels, for February 1963 dated March 15, 1963.
- Westinghouse Monthly Progress Report No. 2, Sodium Pump Development and Test Facility Design for Period Ending February 28, 1963, dated March 1963.

V. CORRESPONDENCE

- March 4 Memo, F. C. Mattmueller (CH) to J. B. Lee (CH), asking OC to prepare a supplement to Contract AT(11-1)-765, MSA Research Corporation, establishing overhead rates for CY 1963.

Multiple address letter, T. A. Nemzek (CH) to participants of the Second Round of Carbon in Sodium Analysis, informing members that additional specimens for analysis will be made available.

- March 4 Memo, F. A. Smith (CH) to G. W. Wensch (HQ), discussing the reasons why AEC should ask ANL to design and fabricate an EBR-II type steam generator for test in the SCTI.
- Memo, T. A. Nemzek (CH) to J. V. Levy (CPAO), requesting AI to conduct additional work relating to second round carbon in sodium analysis specimens as a result of discussions with AI personnel which indicated a need for a few changes and several precautions.
- March 7 TWX, F. C. Mattmueller (CH) to R. D. Seifert (Alco), requesting Alco to make necessary arrangements to have Alco inspector witness inspection of tubing at Superior Tube Company.
- March 11 Memo, F. C. Mattmueller (CH) to G. W. Wensch (HQ), giving notification of contract execution for Contract AT(11-1)-865, PA 3, with APDA.
- TWX, R. D. Seifert (Alco) to F. C. Mattmueller (CH), stating Alco will require two men to witness inspection of tubing on March 13, 1963.
- March 12 Memo, F. A. Smith (CH) to C. A. Pursel (CH), trip report to Superior Tube Company on March 5 and to Baldwin-Lima-Hamilton on March 6.
- March 13 Letter, F. C. Mattmueller (CH) to C. H. Staub (MSA), asking for review and comments on Contract AT(11-1)-765, Modification No. 9.
- March 14 Letter, J. V. Levy (CPAO) to S. Siegel (AI), follow-up on CH's memo to Levy dated March 4 asking AI to conduct additional work on carbon in sodium analysis specimens.
- March 15 Memo, T. P. Heckman (CH) to C. A. Pursel (CH), trip report on February 18-21, 1963, to CPAO, AI, SAN, and GE.
- March 18 Memo, K. A. Dunbar to F. K. Pittman, re second steam generator project, asking for a review of cost information.
- March 19 Letter, R. D. Seifert (Alco) to J. B. Masters (Superior Tube Company) re the situation of several tubes below the minimum wall thickness of 0.104.
- March 20 Letter, M. W. Steffens (BLH) to F. C. Mattmueller (CH), re proposal addition to scope of work (this letter submits an introduction and description of the approach that would be followed to accomplish this work).
- March 20 Memo, T. A. Nemzek (CH) to J. V. Levy (CPAO), transmitting quality and fabrication reports concerned with the construction of the Alco IHX.

Letter, F. C. Mattmueller (CH) to P. B. Probert (B&W), stating his name was placed on distribution list for progress reports from GE and MSAR that relate to Contract AT(11-1)-1280.

March 21 Letter, G. Mattingly (CH) to SCDP Working Group, transmitting reports relating to SCDP R&D, for information and retention.

Letter, F. C. Mattmueller (CH) to R. C. Werner (MSAR), asking MSAR to put P. B. Probert on distribution list for reports concerning Contract AT(11-1)-1280.

March 25 TWX, F. C. Mattmueller (CH) to J. D. Stephen (B&W), re changes in proposed Contract AT(11-1)-1280.

March 29 Memo, F. C. Mattmueller (CH) to J. B. Lee (CH), asking Counsel to prepare an appropriate supplement to the subject cost-reimbursement contract, extending the term through December 31, 1963, without additional funds.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
APRIL 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N. Y. R. W. Bennett	AT(11-1)-666	CH
b. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
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e. Shell Side Heat Transfer	Atomics International J. S. McDonald	AT(11-1)-8	CPAO
f. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-8	CPAO
g. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
h. Resistivity Meter (Blake Meter)	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
i. Continuous Oxide Meter	United Nuclear Corp. 5 New St. White Plains, N. Y. H. Steinmetz	AT(11-1)-2877	NYO
j. Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
k. Sodium Cold Trap Studies	Westinghouse Electric Corp., Atomic Power Division P. O. Box 355 Pittsburgh 30, Pa. P. Cohen	AT(30-1)-3186	NYO
l. Sodium Pump Development Test Facility	Westinghouse Electric Corp. C. C. Randall	AT(30-1)-3123	NYO

II. STATUS

a. Steam Generator - Alco Products, Inc.

Development of the welding procedures for the welding of the bimetallic tubes into the tube sheet was completed. In order to assure adequate strength of the weld and integrity of the inner Inconel tube to the Inconel overlay on the tube sheet, a 15-pass weld was developed. A topical report covering the development and the procedures for the welding of the tubes into the steam generator is being prepared.

b. Steam Generator - Baldwin-Lima-Hamilton Corporation

Outstanding Material

The replacement piece of 1½" Schedule 80 Type 316 stainless steel pipe has been received at BLH, inspected, and is now being fabricated per drawing.

The necessary Type 316 material which was required for the redesigned lifting lugs has been received.

Two lots of approximately 179 total tubes have been inspected at the Superior Tube Company. Fifteen of these tubes have been temporarily rejected for surface indications either on the ID or OD surface. It is quite possible that surface dirt could be the cause for this rejection. These tubes will be salvaged if at all possible. The minimum wall thickness requirement is 0.104". Some of these tubes indicated a wall thickness slightly under this limit. Any tubes falling in this category will be segregated, dye marked for identification purposes, and the actual measurements of the respective tubes supplied to BLH. A record can be kept where these individual tubes are placed in the steam generator if accepted and used.

Atomics International has indicated that no satisfactory commercial strain gages are available on the open market which are satisfactory for 1200°F service. Atomics International has recommended a "flame-spray bonded gage." Baldwin-Lima-Hamilton will make the recommendation to the AEC regarding purchase and installation of the strain gages.

Fabrication

The weld joints for the rupture disc and inlet and outlet nozzles to the shell have all been completed and the X rays accepted. Assembling the 1" and the 1½" pipe nozzles to the shell is now in process.

Alco has given verbal agreement to the BLH proposal for reducing the clearance holes in the tube baffles immediately below the sine wave tube configuration.

The tube sheet drawing is being changed to incorporate the new tube joint configuration as required by the tube-to-tube sheet welding procedure.

High-Pressure High-Temperature Test Loop - Baldwin-Lima-Hamilton Corporation

The gage board is complete except for any electrical wiring or electrical gage controls which will be required. All the pressure lines to the board have been connected.

BLH continued with the assembly of the tube samples to the weld adapters. AI is preparing a 2½ Cr - 1 Mo modified sample.

Tubing has been located in Types 304 and 347 stainless steel which will be added to the test loop as additional tube samples.

The report for the water treatment evaluation and recommendations was planned for issuance the week of April 29th.

c. Second Steam Generator - Babcock & Wilcox

The contract was received on March 20, 1963, and was signed on April 3, 1963, covering work described briefly as follows:

Phase I

- (A) Preliminary design of 1000 MW sodium heated steam generators.
- (B) Supporting research and development work.
- (C) Preliminary design of 30 MWt prototype steam generator.

Phase II

- (A) Detail design of prototype steam generator.
- (B) Fabrication of prototype steam generator for installation and testing at SCTI, Santa Susana, California.
- (C) Final Design Report.

The steam generator, as it is now conceived, will have a capacity of 1000 MW in three units. This will allow a plant to operate at approximately two-thirds load with one sodium loop, including its steam generator, out of service for maintenance. The steam generators are designed to produce steam at 2400 psi, 1050°F with reheat to

1000°F. The boiler design being studied is an integral superheater design having the superheater and boiler surface in the same shell. At this stage in the study, the reheater will be located in a separate shell.

The superheater and boiler surface will be in the form of concentric helical coils which allow great flexibility in arrangement to have the optimum mass flow and pressure drop on both the sodium and water side. The boiler surface will be of Croloy 2½, and the superheater surface will be of Type 316 stainless steel.

Design Work

- (1) Work is proceeding on the optimization of the steam generator design. For these steam conditions, the over-all plant efficiency will be approximately 42.8%.
- (2) Calculations of heating surface are under way, and study drawings are being made to determine the best arrangement of the superheater and boiler tube bundles, and the best routing of the tubes from the tube bundles to the inlet and outlet tube sheets.
- (3) Work is proceeding on the Critical Path schedule. An arrow diagram has been completed for tasks included in Phase I of this contract. This schedule has been run on the computer to determine the critical path, and adjustments are being made to the schedule to give the least over-all time at reasonable cost.

Research and Development Program

The R&D Program consists of the following items:

- (1) Materials Program - Carbon transfer and effect on properties of materials.
- (2) Sodium-water reaction testing.
- (3) Procedure for welding tube to back side of tube sheet.
- (4) Effect on heat transfer and two-phase flow of coiling tubes.
- (5) Radiographic inspection of back side tube welds.

Work has begun on laying out the details of the programs and designing the test equipment on the above items with the exception of the sodium-water reaction testing. It is felt that this research program should be re-evaluated in light of the recent Fermi boiler failures.

d. Sodium Components Test Installation - Atomics International

Work started on the excavation and foundations for sodium and steam system equipment items and piping supports. The nozzle for the superheater carburetor was returned to the supplier for rework to conform to approved drawings.

Invitation-to-bid packages were sent out for the thermal insulation, air and steam preheating system, instrument air and miscellaneous

instrument hook-up work. This work will complete the major items of the SCTI. The installation of the steam generator is estimated for December 1963 and will be a separate work item.

e. Shell Side Heat Transfer - Atomics International

All experimental work on the shell side heat transfer has been stopped and the results of the completed tests are being prepared. Since there are no funds for this work in FY 1964, no further reports will be made until an AI topical is issued.

f. Second Round Carbon Analysis - Atomics International

Another set of sodium specimens, designated set 1A, was shipped on April 22, 1963, by rail express to all the laboratories participating in this program. These specimens are "as purchased" sodium which was cold trapped to an oxygen content of 10 ppm. Each specimen container was marked with an identifying code number. Three samples in this set were analyzed by AI to determine the level of carbon concentration in the sodium and to confirm the homogeneity of the samples.

Considerable effort was spent in developing a technique to prevent galling of the threaded tube fittings during sampling without introducing carbon contamination from lubricants applied to the threaded fittings into the specimen. The galling problem was solved by chrome plating the threaded portions of the fittings.

AI is proceeding with the preparation of set 2 which will contain added carbon. Forced circulation has been established through the "tea bag" section which contains reactor grade powdered graphite.

g. Physical Properties of Materials - MSA Research Corporation

(1) Type 316 Stainless Steel

The sodium phase of Test 1 has been completed and modifications have been made in preparation for Test 3. The bypass carbon pot as described in Progress Report 30 is being fabricated as material is received. This pot will be installed and shake-down runs started during the next report period.

Fatigue Tests

These curves include both plastic and elastic strain and, therefore, do not appear as straight line functions. The data show failures occur in air considerably sooner than in either helium or sodium which have similar life at low strain conditions, and as the strain is increased (and time decreased) the sodium and air failures occur much closer together.

Creep-to-Rupture Tests

The results of the tests in air, helium, and sodium are in such close agreement that a single creep-rupture curve is justified. The specimens exposed to sodium for 4000 hours and then tested in sodium have more scatter and a slight increase in life over original material tests.

Creep Tests

Further interpretation and discussion of results will be presented after further examination of tested specimens and completion of the creep tests in helium which are still in progress.

Tensile Tests

Tensile tests in air had been previously completed. Three exposed, unwashed specimens were tested at 1200°F in helium and six exposed specimens were tested at room temperature in helium. Three unexposed tests at room temperature will complete the 316 stainless steel tests in helium.

No significant change in either tensile strength or yield strength has been found.

(2) 2½ Cr - 1 Mo Steel

The sodium phase of Test 2 has been completed. Modifications have been completed and shakedown operations for Test 4 initiated.

In order to determine if creep data could be improved and if creep was occurring outside the gage length of the creep specimens, a dummy creep specimen identical to the actual test specimens, except the gage length was of such thickness to prevent creep, was installed in a creep test machine. A dial gage mounted directly from the test pot flange was added in addition to the one used during the Test 1 creep test. Comparison of these two locations for measuring creep rates and evaluation of creep outside of the gage length itself will be made.

Fatigue Tests

The results of all fatigue tests to date show a decided difference between tests in air and sodium with failures occurring much sooner in air.

Creep-to-Rupture Tests

All creep-rupture tests in sodium had been previously completed or terminated as had the creep-to-rupture tests in air.

The results of the 4000-hour sodium exposed tests in sodium clearly indicate a weakening of specimens due either to long time exposure to temperature, sodium, or a combination of both. The exposed specimen tests in helium also indicate this weakening.

Creep Tests

Further interpretation and discussion of results will be presented after a more detailed examination of tested specimens and completion of the creep tests in helium which are still in progress.

Tensile Tests

All tensile tests have been completed. The tensile strength of original material decreased 30% when tested in helium from that tested in air. The washed exposed tests in helium were 52% lower than the original material and the unwashed were 50% lower.

The yield strength also showed this decrease in strength. The original material test in helium was lowered 14% while the washed exposed test was lowered 39% and the unwashed tests were lowered 36%.

The somewhat erratic test results in general on the 2½ Cr - 1 Mo suggest that either exposure time or variation between specimens has been affecting test data and is being discussed further with Professor Freeman (University of Michigan).

(3) Metallurgical Results

Efforts associated with the metallurgical examination of stressed specimens have been increased. The major objective associated with this portion of the program is to correlate metallurgical changes occurring in specimens with strength data. Some of the effects that will be explored include:

- (a) Variations in grain size and orientation with changes in stress comparing air, helium and sodium exposed samples, as well as pre-exposed and stressed samples. Microhardness determinations will complement metallographic examinations.
- (b) Examination of the mode of fracture with increased stress with the environmental fluid as a parameter. Samples will be examined for internal damage at sites near the fracture face.
- (c) Changes of phases occurring in specimens as a result of exposure to the sodium environment, primarily with respect to carbon precipitation or depletion.
- (d) Comparison of corrosive attack of stressed versus unstressed specimens.
- (e) The presence of coatings.

Of all the test series performed, the fatigued specimens are presently the most complete in terms of mounted specimens. Comprehensive metallurgical examination of this series of tests was initiated.

The effects discussed above should not be regarded as conclusive since comprehensive metallurgical evaluation of fatigued specimens, and indeed all specimens, has only recently begun.

h. Resistivity Meter (Blake Meter) - Atomic Power Development Associates, Inc.

During the month of April, the operation of the loop was suspended in order to remove a defective heat exchanger in the loop plugging meter

assembly and to install a replacement cooler. The new plugging meter exchanger is a counter-current air-cooled unit, and the installation will incorporate the new plugging valve previously described. Analyses of sodium samples taken from the loop during the previous reporting period have not been completed, and no further conclusions can yet be drawn from the sodium hydride run data.

The loop has been maintained continuously at 570°F since the program was interrupted in order to avoid the delays which would be encountered in a cold startup at the conclusion of present maintenance. It is expected that operations will be resumed on May 1.

i. Continuous Oxide Meter - United Nuclear Corporation

Loop construction was completed in this period. Control consoles and instrumentation were installed. Wiring between the control consoles and loop, installation of thermocouples, insulation, leak testing and filling with sodium remain to be done. The completion of the loop had been delayed because of slow delivery of liquid metal valves.

Tests with the electrochemical cells showed anomalous results. A number of the electrochemical cells prepared gave considerably less than theoretical response (20-80% of theoretical) to changes in the oxygen level of the sodium. The cause of this is not known at this time.

Among the factors studied were the nature of the reference electrode, the calcia content of the zirconia electrolyte, the exact method of preparing the electrochemical cell, the loop in which the electrochemical cell was tested and the sodium flow rate. Reference electrodes studied included Cu-Cu₂O pellets, Ni-NiO pellets, and Cu-Cu₂O powder. Several different lots of zirconia containing 3.5, 4.0, and 7.5 weight per cent of calcia were tested.

j. Mass Transfer - General Electric Company

Activities were directed toward the operation of the six test loops, analysis of the steel and sodium samples, and evaluation of the corrosion and metallographic data. Continuing effort has been devoted to the carbon-sodium-oxygen-steel system and, in particular, in the area of carbon analysis of loop sodium samples. Three analysis reports show considerably higher sample weight changes upon returning to the higher oxygen level test condition.

During a flange repair on the 316 stainless steel loop (#1), a ½" schedule 40 pipe was broken in two. The metallurgical examination of the pipe that failed, some on the opposite side of the H3 sample holder and some about two feet downstream of the holder, is still being analyzed. Preliminary results indicated that there has been slight hardening (still Rockwell B scale) and a grain boundary change in the microstructure of the 316 stainless steel material during the 4000 hours at 1300°F with high oxygen, 7800 hours at 1200°F plus 2900 hours at 1100°F with low oxygen, and 750 hours at 1100°F with high oxygen. The examination also indicated some apparent loss of grains in longitudinal lines on

the ID of the pipe. Neighboring sections of the pipe that have not been exposed for as long a period or at 1300°F apparently are not as severely attacked. Details of these examinations will be reported as soon as they become available. The detailed metallurgical examination of the loops, after the 5-run fractional replicate test plan is completed, should provide long time exposure effects on all program materials.

The 700-hour corrosion data for the 316 stainless steel loop (#1) show expected trends, exhibiting the normal corrosion profile. The corrosion rates, however, are substantially greater for this Type V (high oxygen) run when compared with the comparable period during previous Types III and IV (low oxide) runs. Comparing the corrosion rates at the H3 and C3 position for each of the run conditions, the evidence points to the higher oxide in the present run as the cause of the greater corrosion, overshadowing the higher delta T in the Type III run, or the higher temperatures of the Type IV run.

The 5600-hour data for the 316 stainless steel - 2½ Cr loop (#3) in general show declining corrosion rates for increasing exposure time (continuing the normal corrosion profile). This trend is quite evident in the cold leg sample holders C2 and C3 which had "washed" samples. In all instances, the washed samples show higher corrosion rates for the initial (shorter) exposure period than for the longer period.

The 2800-hour data for the 316 stainless steel - 5 Cr loop (#4) are consistent with the expected normal corrosion profile. Again the corrosion rates of this Type V (high oxide) run when compared with the low oxide Type IV run, 4-5, show corrosion rates more than double the latter, countering the effect of the higher temperatures of run 4-5.

Except for the H3 position, the 1400-hour data for the 2½ Cr loop (#5) show no marked decrease in corrosion rates which one might have expected for this longer exposure period (i.e., normal corrosion profile shows decreasing corrosion with increasing time). As noted previously for runs 1-5 and 4-6, this higher oxide run is producing greater corrosion than former low oxide runs.

k. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Development of Sampling Techniques

Development of core drilling techniques for sampling of the sodium cold trap continued. Several coring tools were used to remove samples from a prototype containing demister mesh and filled with a pot metal whose melting temperature approximated that of sodium. In addition to the various coring tools employed, the temperature of the metal was varied from 70°F to -150°F to determine the optimum combination of cutting tool and metal temperature.

Review and Development of Analytical Techniques

A bibliography of current literature pertaining to techniques applicable to the sodium cold trap studies was prepared.

Close liaison was maintained with personnel working on the development of sampling techniques.

The recovery system of the Kjeldahl distillation for the determination of nitrogen was modified. Synthetic samples containing 10 to 20 micrograms of nitrogen were analyzed and were found accurate within 5% of the amount added.

The determination of carbide, carbonate, and elemental carbon is currently under investigation. Difficulties with the gas chromatograph necessitated the investigation of an alternate method for the determination of combined carbonate and elemental carbon utilizing the Leco Conductometric Carbon Analyzer. The limits of detection of this method are too high for the anticipated analyses.

The gas chromatograph is now operational and the original study is being continued. HMPA (hexamethylphosphoramide) which rapidly separates carbon dioxide, carbon monoxide, methane, and acetylene is utilized as the gas chromatographic absorbent. A Sargent integrating recorder has been added to the chromatograph to expedite data interpretation. Calibration will be completed on the carbon determination during the next period.

No effort was expended on optical emission spectrographic or metallographic techniques during this period.

1. Sodium Pump Development Test Facility - Westinghouse Electric Corporation

The topical report on the current status is behind schedule and was not issued during April as anticipated. Further editorial revision, inclusion of additional sections, and delay in completion of art work and reproduction have caused delay.

The collection of technical input information and the completion of the general scope and organization of the program to be recommended was completed. Information requested from Westinghouse Large Rotating Apparatus Section with regard to drives and speed control and from Westinghouse Central Research with respect to liquid metal bearing development and shaft seal problems was received.

An initial draft of the proposed development program was started. Completion of the draft is now scheduled for mid-May.

PERT dependency networks were reviewed and revised. Time and effort estimates will be completed for the network in the next month.

In anticipation of early approval of design criteria for the facility, discussions were held with a number of Architect-Engineers and the selection of a preferred A-E was made. A request for approval of this vendor was transmitted to NYOO for approval on April 18, 1963.

III. MEETINGS

April 3, 1963	MSAR representatives visited AEC-CH to discuss the status and future tests under Contract AT(11-1)-765.
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April 10, 1963 T. P. Heckman, CH, visited the EFR site to inspect the #1 steam generator bundle and discuss the tube failure problem.

April 25, 1963 F. A. Smith, CH, visited BLH to review status of steam generator contract.

IV. REPORTS

Alco Program Status Report - February 21 to April 1, 1963, dated April 1, 1963.

AI SCTI Monthly Progress Report for March 1963, dated April 1, 1963.

AI Surveillance Status and Acceptance Report - SCTI Steam Generator, dated April 27, 1963.

APDA Summary Report - April 1963 - Contract AT(11-1)-865, PA #3.

BLH Weekly Reports for Weeks Ending April 7, 13, 20, and 27, 1963.

BLH Monthly Progress Report for March 1963, dated April 4, 1963.

GE Monthly Progress Letter 45 for March, "Mass Transfer Investigations in Liquid Metal Systems," dated April 8, 1963.

MSA Technical Proposal 1510, "Revised Proposal on Investigation of the Physical Properties in High Temperature Sodium," Contract AT(11-1)-765, dated April 3, 1963.

MSAR 63-65, "Analytical Report on the Second Round Robin Carbon," dated April 26, 1963.

MSA Progress Report 31 for March, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," Contract AT(11-1)-765, dated April 12, 1963.

University of Wisconsin Progress Report 21 for March, "Boiling Liquid Metal Heat Transfer," dated April 5, 1963.

Westinghouse Monthly Progress Report 3 for March, "Sodium Pump Design and Test Facility Design," dated April 1963.

V. CORRESPONDENCE

April 2 CC memo, Dunbar to Pittman, re second steam generator project need of a long-term continuing research and development program.

Modification 2 to Contract AT(11-1)-1213 with BLH.

April 3 CC ltr, Mattmueller to Otten, asking for review and approval of Modification 2 to Contract AT(11-1)-1213.

CC ltr, Abderhalden to Mattmueller, re Contract AT(11-1)-1213, proposed addition to Scope of Work.

April 4 Memo, Levy to Nemzek, transmitting a copy of AI letter 63AT2099 which describes status of AI program to prepare carbon in sodium specimens for second round analysis.

- April 5 Memo, Nemzek to Levy, AI evaluation of tubing used in Alco heat exchanger.
- CC ltr, Walcavich to Skinkle, re Contract AT(11-1)-1280, stating corrected pages were inserted in the contract and the contract was executed.
- April 8 Ltr, Abderhalden to Mattmueller, program for high-pressure high-temperature loop, Contract AT(11-1)-1213.
- April 9 Modification 2 to Contract AT(11-1)-865 with APDA.
- April 11 Ltr, Staub to Mattmueller, requesting that MSA be put on the distribution list for classified scientific and technical reports.
- April 12 CC ltr, Mattmueller to Stephens, establishing administrative requirements and procedures as called for in Contract AT(11-1)-1280.
- April 15 Ltr, Seifert to Mattmueller, stating that Alco has completed the tube welding development program and that Alco tube welding gun is available for use by BLH.
- April 16 Modification 9 to Contract AT(11-1)-765 with MSA.
- April 17 Memo, Giambusso to Those Listed, setting up a meeting with HQ and contractors for the Sodium Components Development Program on May 13-14, 1963.
- Memo to File, F. Smith thru Pursel, re phone call BLH steam generator discussion with Peterson, AI.
- Ltr, Abderhalden to Seifert, stating as a result of tube failures at HNPF and Fermi the tube design of the steam generator should be modified slightly - asking for approval of change Contract AT(11-1)-1280.
- Ltr, Giambusso to Bradbury, LASL, asking for Wykoff's assistance in a new working group for SCDP, also would he be present at May 13-14 meeting at HQ.
- April 18 CC memo, Mattingly to R. C. Kelly, re request for standard distribution under Category C-44, Contract AT(11-1)-765, asking Kelly to place MSA on list.
- CC ltr, Mattmueller to Staub, stating Oak Ridge is being requested to place MSA on standard distribution list.
- April 22 Modification 2 to Contract AT(11-1)-1213 with BLH.
- April 23 Ltr, Mattmueller to Abderhalden, approving proposed method of operation and water chemistry control subject to the two stated items.
- Ltr, Reynolds, Foster Wheeler Corporation, to Mattmueller, stating that May 16 would be acceptable to discuss FW proposal for the sodium steam generator for the SCDP.

Ltrs to Donnell, APDA; Stephens, B&W; and Bennett, Alco; setting up a meeting with HQ and contractors for the SCDP May 13-14, 1963.

- April 24 Ltrs to Steffens, BLH, and Merry, MSA, setting up meeting with HQ and contractors for SCDP May 13-14, 1963.
- April 24 Memo, Nemzek to Levy, stating CH wrote to all of the CH contractors asking them to attend May 13-14, 1963, SCDP meeting.
- April 25 TT, Pittman to Dunbar, authorization to proceed with Phase I of the second SCDP steam generator, also a thorough review is desired before Phase II is authorized.
- Ltr, Cochran to Levy, re steam generator level indicator, asking CPAO to request BLH to furnish mounting brackets described by AI.
- April 26 Ltrs to Siegel, AI; Werner, MSA; Abderhalden, BLH; and Donnell, APDA; requesting them for co-operation by sending two copies of all future progress reports and topicals covering their work being performed under AEC contracts to O. E. Dwyer, BNL.
- April 29 Memo, Dunbar to Well, IA, thru Pittman, transmitting copies of the SCDP project co-ordination report and other additional progress reports by the SCDP contractors for HQ inspection and use.
- April 30 CC ltr, Mattmueller to Lilly, BLH, stating progress has been slow on the sodium-to-water steam generator fabrication, asking BLH to advise CH what steps BLH could take to expedite the performance of this work.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
MAY 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N. Y. R. W. Bennett	AT(11-1)-666	CH
b. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
d. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. Cygan	AT(11-1)-8	CPAO
e. Shell Side Heat Transfer	Atomics International J. S. McDonald	AT(11-1)-8	CPAO
f. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-8	CPAO
g. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
h. Resistivity Meter (Blake Meter) Loop	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
i. Continuous Oxide Meter	United Nuclear Corp. 5 New St. White Plains, N. Y. H. Steinmetz	AT(11-1)-2877	NYO
j. Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
k. Sodium Cold Trap Studies	Westinghouse Electric Corp., Atomic Power Division P. O. Box 355 Pittsburgh 30, Pa. P. Cohen	AT(30-1)-3186	NYO

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
1. Sodium Pump Development Test Facility	Westinghouse Electric Corp. C. C. Randall	AT(30-1)-3123	NYO

II. STATUS

a. Steam Generator - Alco Products, Inc.

The procedures for the fillet weld of 1/2" OD x .105" wall Inconel - type 316 stainless steel composite tubing to Inconel overlayed - type 316 stainless steel tube sheets utilizing a cold wire feed were modified and supplied to BLH. A final report on the welding procedure is expected in June.

b. Steam Generator - Baldwin-Lima-Hamilton Corporation

Outstanding Material

Sufficient quantity of bare welding rod (.030 diameter) has been received at BLH for use in the qualification of the tube-to-tube sheet welds. The production quantities of this weld wire are expected soon. BLH has received 228 production tubes from the Superior Tube Corporation. The final shipment of 80 or 82 tubes is expected to be made by June 10. This will complete the minimum tube requirements of 300 for this order.

Engineering

The tube sheet drawings showing the new weld joint preparation have been changed and the necessary information has been issued to the shop. The necessary tools to machine this special configuration have also been ordered and delivery has been promised week of June 17.

Fabrication

The fabrication of the shielding subassemblies has been completed prior to the final fitting and positioning into the shell subassembly. It has been decided that the baffles and the tube sheets will be drilled utilizing a tape control drill. This method of manufacture should insure uniformity of drilling and spacing of all tube holes.

As reported previously, it was necessary to add a straightening operation to the tube after it had been formed to the sine wave and radius configuration. This operation will consist of straightening the tubes so that both ends will be square with the tube sheets. The die which will be used for this operation has been completed but has not been tried out.

Welding Development

Alco has made the consistency weld check for the tube-to-tube sheet joint. A tube sheet with this joint has been subjected to thermal shock tests for a total of 50 cycles without any apparent indication of failure. They have furnished BLH with the welding procedure. A preliminary status report has been issued to the AEC by Alco in letter dated May 14, 1963, and the final report is expected to be completed by June 15.

In review, the high-temperature high-pressure test program will be in accordance with BLH letters to the AEC dated February 21, April 8, and

May 2, 1963, and the AEC letter to BLH dated April 23, 1963. Since we were unable to obtain 4% to 6% Cr-Ti stabilized ferritic steel tubing, this material was not added to the test loop. Baldwin-Lima-Hamilton Drawing 430-3-00020 of May 6, 1963, shows the flow diagram for the test loop.

High-Temperature High-Pressure Test Loop

The back portion of the furnace has been positioned in the test tower. The electrical wiring has been completed to the panel board through the main disconnect switch, transformer, rectifiers, and secondary cut-off switch. Wiring from the panel board to the back portion of the furnace has also been installed.

All of the tube samples have been welded to the adaptors. The tube samples have been placed in position on the holding rack which in turn will be installed in the upper portion of the tower.

The Cambridge Dissolved Oxygen Recorder has been transferred to the test site and is being checked out. The flame photometer is also being transferred to BLH. These instruments will be used to determine the water condition during the actual test run as per proposed program for high-pressure high-temperature test loop water conditioning which was submitted to the AEC by letter dated May 3, 1963.

c. Second Steam Generator - Babcock & Wilcox

Design of 1000 MW Steam Generator

In order to meet the over-all objective of developing economical, practical, large central station steam generators a change in the contract was requested, and granted, to increase the size of the boilers from 1000 MWt in three units to 1000 MWe in three units. For 1000 MWe the reactor would have to produce approximately 2333 MWt. Each boiler will handle 778 MWt.

This change will result in a somewhat lower estimated cost for the boilers for a 1000 MWe plant because three large boilers will cost less than nine small ones. There will be no change in the cost of the design work which is being undertaken under this contract.

Design work is proceeding. The over-all shell size of one boiler (778 MWt) will be approximately 12'6" ID and 70' high.

Work has begun on design of the reheaters. Three reheaters will be used for the 1000 MWe plant so that there will be one reheater per sodium loop as well as one boiler per sodium loop.

Critical Path Schedule

The schedule for preliminary design of the 1000 MWe steam generator and preliminary design of the 30 MWt prototype has been run on the Critical Path Method computer program. After some modifications to the schedule, the over-all time span has been reduced to approximately 1½ years. The schedule for the other phases of this contract, particularly the manufacturing of the prototype, will be added as soon as possible to make sure the delivery date of the prototype to SCTI will agree with the over-all scheduling of the test facility.

Research and Development

Work is proceeding on laying out the details of the various test programs which were approved under this contract with the exception of the sodium - water reaction test program. The tube failures at Enrico Fermi Station seem to indicate that rapid wear, overheating, and rapid corrosion can occur in conjunction with a tube failure. Babcock & Wilcox Company is assisting in the examination of tubes from the Fermi No. 1 Boiler--not under this contract--and results of this investigation will be used in formulating a revised R&D Program. This revised program on sodium - water reaction problems will be submitted in a new proposal.

d. Sodium Components Test Installation - Atomics International

Construction of the SCTI continued. The subcontract for the insulation and preheating package was submitted to the AEC for review and approval. The start of work under this subcontract is expected at the beginning of the new fiscal year.

e. Shell Side Heat Transfer - Atomics International

The shell side heat transfer loop was drained and all trace heating, except that for the pump throat, was turned off. The loop was then charged with nitrogen and provided with a continuous nitrogen supply.

f. Second Round Carbon Analysis - Atomics International

Early indications are that the "tea bag" method may be used successfully in elevating the carbon content of sodium samples. Analyses show that after five days of operation the carbon level increased from 12 to 30 ppm. Samples are being taken at 3-day intervals to provide useful information relative to the solubility of mold grade graphite in sodium.

g. Physical Properties of Materials - MSA Research Corporation

After some delay in receipt of material, the installation of the carbon bypass pot has been completed in Loop 1 (type 316 stainless steel specimen loop). Upon insulation and wiring of the heaters, shakedown operations will begin. Operation with foil and sheet specimens to determine the carburizing potential will follow the shakedown operation prior to start of Test 3.

Shakedown operation on Loop 2 (2½ Cr-1 Mo specimen loop) has been completed, and operation with foil and sheet specimens for determining the carburizing potential has been undertaken. These tests will be completed, final calibration of test machines made, and Test 4 initiated during the next report period.

Examination of specimens generated during Tests 1 and 2 will continue.

Type 316 Stainless Steel Test Specimens - Test 1

All tests at MSAR have been completed and tests at the University of Michigan in air and helium are being continued.

2½ Cr-1 Mo Steel Test Specimens - Test 2

All testing in sodium at MSAR has been completed. Fatigue tests in air have been completed. Fatigue tests in helium at MSAR and various testing in air and helium at the University of Michigan are continuing.

As described in Report MSAR 63-75, a dummy specimen with a heavy gage section was installed in a creep machine with a dial gage attached directly to the flange of the test pot in addition to the one used during Test 2. A typical test load was then applied and readings taken from the two locations as well as ambient temperature readings.

The readings obtained were averaged and plotted. From this data, the following conclusions can be made:

- (1) The creep in the measuring system outside the gage length is negligible.
- (2) The results of this test did not show cause to doubt the validity of the creep rates obtained during Tests 1 and 2.
- (3) Moving the dial gage will reduce the error obtained on loading and result is less general scatter.

The dial gage will be changed to the new location on all machines.

h. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

Work has progressed on the Rhometer temperature compensator to the point of successful operation at 900°F. Extension of this instrument's temperature compensation from 600°F was accomplished by a circuit modification. Two commercial, multiple-winding transformers, designated "A" and "B", were introduced to extend the incremental range of existing transformers. The new auxiliary transformers couple the voltage across the platinum temperature compensator resistance and the zero coefficient resistance into the signal summation loop of the original meter circuit. Compensation to 1000°F can be attained with only two ratio changes in transformers A and B or three set points in all, including the original circuit or "O" set point. The primary windings of transformers A and B actually remain in the circuit in "O" set position to avoid the effect of quadrature shift which would otherwise generate significant bias when changing to the advanced set positions.

A hydrogen detection device, modeled after a prototype developed by Atomic International in 1960, will be installed into the loop with appropriate flow control and temperature control to determine the range, sensitivity, and operating parameters of the instrument. This will be accomplished during the regular course of the Rhometer calibration for hydrogen contamination. If the hydrogen detector signal is definitive, it will serve to confirm Rhometer response to varying loop conditions.

i. Mass Transfer - General Electric Company

Activities were directed toward the operation of the six test loops, analysis of the steel and sodium samples, and evaluations of the corrosion and metallographic data. Both 316 stainless steel 2½ Cr loops have completed a total of more than 18,000 hours of operating time. Continuing effort has been devoted to the carbon-sodium-oxygen-steel system and in particular in the area of carbon analysis of steel samples.

Loop 1

The loop was down for routine sample changing at 1401 test hours. The oxide level showed some erratic behavior, increasing with time, and necessitating four downward adjustments during the month.

Loop 2

Operation at normal run 5 test conditions continued all month for this loop. No oxide adjustments were necessary.

Loop 3

The loop was down for routine sample changing at 743 hours and also to make flowmeter calibration checks. The oxide level during normal running appeared to be decreasing slowly, requiring adjustment upward. Only one downward adjustment was required after opening the loop for sample changing.

Loop 4

Operation was directed toward completion of pre-run flowmeter calibration and the normal seasoning operation. A leak at the cold trap inlet valve bellows on startup necessitated dumping the loop for repairs. The oxide level tended to increase during normal running, requiring several adjustments downward.

Loop 5

Operation at normal run 5 test conditions. The oxide level continued to show improvement requiring only four adjustments all month.

Loop 6

The loop was down for routine sample changing at 1405 test hours and to replace the H2 sampleholder flange which failed when startup was attempted. Oxide level continued to be erratic, requiring frequent adjustment both upward and downward.

Analysis of Samples

The 700-hour data for the 316 stainless steel 2½ Cr loop (No. 3) are interesting, showing corrosion (loss of weight) of both the hot and cold leg samples. For the sample at location C2 this loss was substantial for no apparent reason. Except for the high corrosion rate at C2, and the loss (instead of gain) in the cold leg, the corrosion rates are relatively low.

The 700-hour data for the 5 Cr loop (No. 6) show an expected corrosion profile, except for E3R which may be acting like the first cold leg sample with its lower-than-E3 temperature. These data for this high-oxygen run show an increase in weight changes when compared with the comparable exposure period in the previous low-oxygen run. The corrosion rates themselves, however, are somewhat lower than were noted for Loops 1, 4, and 5 for the higher oxygen condition.

j. Sodium Cold Trap Studies - Westinghouse Electric CorporationDevelopment of Sampling Techniques

Development of core drilling techniques for sampling of the sodium cold trap continued using the prototype trap containing demister mesh and filled with sodium. Motor driven hole saws made of 4130 carbon steel and carbolloy were tried at metal temperatures as low as -300°F using liquid nitrogen as the coolant. All corings were done in a specially designed dry box. The cores obtained at these low temperatures were malformed and consisted of twisted, compacted mesh in the weight ratio

of sodium to mesh of 1 instead of the loaded (original) ratio of 4 to 1. The sodium at -300°F was still plastic and examination of the mesh in the core showed it to be spiralled from the rotation of the coring tool. Lubrication of the hole saw with mineral oil did not improve the appearance of the core or lessen the spiralling of the mesh. Typical cores, drilled to a depth of 8", when removed from the drill, were less than 2" in length.

Review and Development of Analytical Techniques

A tentative analytical manual, WCAP-2310, was prepared for the chemical determination of sodium monoxide, carbonate, carbide, total carbon, nitrogen, and hydrogen in sodium.

Specific procedures for the determination of impurities in sodium by spectrographic methods and the identification of compounds by X-ray diffraction techniques are not included since no information as to the concentration levels of interest is known. The specialized techniques for these latter determinations have been selected and detailed procedures will be written after initial cores from the Enrico Cold Trap have been received. All work accomplished to date has been performed on synthetic samples and some minor modification in the selected analytical procedures may be necessary when the actual samples are received.

k. Sodium Pump Development and Test Facility Design - Westinghouse Electric Corporation

Work on revision of PERT network for the Pump Development Program continued during the month. At the end of the month, the dependency network had been revised and was ready for the addition of time and effort estimates.

The topical report on current status required further editorial revision, inclusion of additional sections, and art work. The draft will be submitted to the AEC for approval this month.

Work on the Pump Test Facility Design criteria was completed, including an artist's concept of the Facility, and submitted to the AEC for approval. Discussions were held with a number of Architect-Engineer firms and the selection of a preferred Architect-Engineer was made.

III. MEETINGS

May 9, 1963	A. G. Fremling, F. C. Mattmueller, and F. A. Smith, CH, attended meeting at Barberton, Ohio, with B&W to discuss various accounting and contract procedures and review the over-all project for the second sodium heated steam generator.
May 13-14, 1963	T. A. Nemzek, F. A. Smith, T. P. Heckman, and A. G. Fremling, CH, attended a SCDP Review Meeting in Washington, D. C.
May 20-24, 1963	T. P. Heckman visited headquarters and discussed status of the SCDP.
May 23, 1963	F. C. Mattmueller and F. A. Smith, CH, visited BLH to review the status of the steam generator and the high-pressure high-temperature steam test loop.
May 29, 1963	Babcock & Wilcox representatives visited AEC-CH and ANL to discuss $\text{Na-H}_2\text{O}$ reactions and a possible test program to verify these reactions.

IV. REPORTS

AI Progress Letter No. 25 for April dated May 1, 1963.

AI Surveillance and Acceptance Report for SCDP Steam Generator dated May 26, 1963.

BLH Weekly Report on Steam Generator Contractor for weeks ending May 11, 18, and 25, 1963.

B&W Weekly Progress Letter for the weeks ending May 3, 10, and 17, 1963, on Contract AT(11-1)-1280.

GE Monthly Progress Letter No. 46 for April, "Mass Transfer Investigations in Liquid Metal Systems," dated May 8, 1963.

GE Project Status and Cost Report for April, "Irradiation of Mass Transfer in Liquid Metals," May 1963.

MSA Progress Report No. 32 for April, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated May 10, 1963.

Westinghouse Monthly Cost Statement for April dated May 1963.

Westinghouse Monthly Progress Report No. 4, "Sodium Pump Development and Test Facility Design," May 1963.

V. CORRESPONDENCE

- May 1 Memo, Wensch to Pursel, suggesting ANL be requested to provide an analysis of the adequacy of the reduced tube thickness and assembly of all such tubes into the steam generator be held in abeyance until such an analysis has been completed.
- Memo, Levy to Nemzek, stating AI has prepared and shipped another set of sodium specimens to the various participants in the second round carbon analysis.
- Memo, Dunbar to Giambusso, stating we sent letters to contractors asking them to be present at the SCDP meeting in HQ May 13-14, 1963.
- Ltr, Menke (UNC) to Nemzek, stating UNC is always glad to assist in the SCDP Working Group meetings.
- May 2 CC ltr, Mattingly to Those Listed, transmitting reports for information re SCDP.
- Ltr, Otten to Mattmueller, transmitting procedure for controlling water chemistry in the program for high-pressure high-temperature test loop for review and comment.
- May 6 Memo, Smith to Pursel, re trip report on steam generator fabrication-review status of the work in progress at BLH.
- May 7 CC memo, Wensch to Wise, commenting on Monthly Progress Report No. 3, "Sodium Pump Study," Contract AT(30-1)-3123, Westinghouse.
- Memo, Levy to Nemzek, re AI evaluation of tubing used in Alco IHX.
- Info Copy TWX, CPAO to HQ, stating J. A. Leppare and D. F. Casey will represent AI at the SCDP meeting May 13-14, 1963.

Memo, Levy to Nemzek, transmitting letter in which AI requests BLH to furnish mounting brackets for the Alco steam generator liquid level indicator.

- May 8 CC memo, Mattmueller to J. Lee, requesting a modification to Contract AT(11-1)-1280 stating B&W is to design one of three identical steam generating systems for a 1000 MWe plant.

CC ltr, Mattmueller to Stephens, stating we are processing a contract modification for B&W to review and execute which will provide that B&W is to design one of three identical steam generating systems for a 1000 MWe plant.

Memo, Dunbar to Giambusso, transmitting names of all contractor representatives who will attend the May 13-14 SCDP meeting.

- May 9 CC ltr, Levy to Trevillyan, re operating funds for SCTI, increasing FY 1963 operating funds to amount not to exceed \$1,168,000.

- May 10 CC memo, Casey to Levy, commenting on SCTI bid package for thermal insulation, air and steam preheating system, instrument air, and miscellaneous instrument hook-up.

Cy ltr, Savage (ORNL) to Holliday (SAN), reporting visit to GE-SAN on April 22-24, 1963.

CC ltr, Mooradian (B&W) to Mattmueller, reporting costs incurred under Contract AT(11-1)-1280.

- May 15 CC TWX, Mattmueller to Abderhalden, authorizing BLH to furnish mounting brackets for the attachment of the source and detector units to the steam generator.

CC memo, Fremling to Mattmueller, summarizing the SCDP working review meeting held in HQ on May 13-14, 1963.

- May 17 Ltr, Seifert to Mattmueller, re costs for period ending June 15, 1963, under Contract AT(11-1)-666.

Memo, Pursel to Mattmueller, re work scope additions - APDA Contract AT(11-1)-865, PA #3, Blake Resistivity Meter.

CC TWX, Mattmueller to Abderhalden, concurring in B&W proceeding with loop shakedown test without awaiting for arrival of 2½ modified Croloy from AI.

CC ltr, Mooradian to Mattmueller, re a change in steam temperature. B&W sees no reason for making this change.

- May 20 CC memo, Mattmueller to J. Lee, Modification No. 4 to Contract AT(11-1)-865, PA #3, Sodium Resistivity Meter.

- May 20 CC memo, Spencer (CPAO) to Casey, answering questions raised by CH on SCTI bid package for thermal insulation, air and steam preheating system, instrument air, and miscellaneous instrument hook-up (re our memo of May 10).

Memo, Nemzek to Pursel, brief summary of items affecting CH as SCDP review group meeting at HQ on May 13-14, 1963.

- May 21 Memo, Smith to File thru Pursel, re trip report - HQ - SCDP Review Meeting - May 13-14, 1963.
- Memo, Smith to File thru Pursel, re trip report - B&W Sodium Steam Generator Development - May 9-10, 1963.
- Memo, Pursel to Wensch, stating we have reviewed the adequacy of the reduced tube thickness and conclude that the change in tube specification is not significant enough to alter the operating integrity of the steam generator.
- Memo, Nemzek to Mattmueller, extending MSA Contract AT(11-1)-765 through September 30, 1963.
- Ltr, Nemzek to Seifert, asking Alco to send a copy of APAE-122 to J. Wise (NY) and J. Holliday (SAN).
- Memo, Nemzek to Levy, requesting CPAO to ask AI to send one set of SCTI drawings to B&W.
- Memo, Pursel to Mattmueller, concurring with extension of Contract AT(11-1)-1070, University of Wisconsin, if approval for extension is granted by DRD.
- May 22 CC ltr, Probert to Mattmueller, transmitting organization charts for B&W Boiler Division and the Research and Development Division.
- May 23 CC Memo, Mattmueller to J. Lee, requesting supplement to Contract AT(11-1)-666, Alco Products, Inc., providing additional funds.
- May 24 CC ltr, Mattmueller to Staub, stating that MSA should appoint a person who already had a "Q" clearance as Document Custodian.
- CC ltr, Mattmueller to Mooradian, transmitting CH organization charts.
- CC memo, Mattmueller to J. Lee, requesting that a section be amended to Contract AT(11-1)-1280.
- CC ltr, Mattmueller to Seifert, stating with the exception of the submission of the final report and the completion of the Superior Tube order, work under the contract is complete. Also requesting that Alco effect shipment of the welding gun.
- May 24 CC ltr, Dunbar to Crewe, thanking Crew for making W. Simmons available as a member of the Contractor Selection Board for the second steam generator.
- May 27 CC memo, Mattmueller to J. Lee, requesting a modification to Contract AT(11-1)-765 with MSA to extend contract.
- CC ltr, Mattmueller to Seifert, stating we are in process of preparing a modification to AT(11-1)-666 to provide additional funds.
- CC TWX, DeLaura to Pollack, giving schedule and costs for second steam generator.
- May 28 Memo, Smith to File thru Pursel, re phone call with Superior Tube Company on status of Alco-BLH steam generator tubing on May 27, 1963.

Memo, Smith to File thru Pursel, re trip report on the review of progress at BLH and discusses schedule and rate of accomplishment of work with BLH technical staff and management.

Memo, Pursel to Biebert, re SCTI requesting modification of directive No. CP-61-8, stating performance of work is desirable.

May 29 CC ltr, Mattmueller to Staub, stating project engineer under Contract AT(11-1)-765 will be given a "Q" clearance.

CC ltr, Mattmueller to Staub, stating Dale Schoffel will be appointed as Document Custodian for the work under Contract AT(11-1)-765 and will be given a "Q" clearance.

CC ltrs, Bennett to Holliday and Wise, transmitting copies of APAE-112.

Memo, Wensch to Pursel, stating that we should proceed with fabrication of steam generator.

May 31 Memo, Smith to File thru Pursel, re status of duplex tube order at Superior Tube Company - May 29, 1963.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JUNE 1963

I. LISTING OF CURRENT PROJECTS

	<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a.	Heat Exchanger and Steam Generator	Alco Products, Inc. Schenectady 5, N. Y. R. W. Bennett	AT(11-1)-666	CH
b.	Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
c.	Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
d.	Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. Cygan	AT(11-1)-8	CPAO
e.	Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-8	CPAO
f.	Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
g.	Resistivity Meter (Blake Meter) Loop	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
h.	Continuous Oxide Meter	United Nuclear Corp. 5 New St. White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYO
i.	Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
j. Sodium Cold Trap Studies	Westinghouse Electric Corp., Atomic Power Division P. O. Box 355 Pittsburgh 30, Pa. P. Cohen	AT(30-1)-3186	NYO
k. Sodium Pump Development Test Facility	Westinghouse Electric Corp. C. C. Randall	AT(30-1)-3123	NYO

II. STATUS

a. Steam Generator - Alco Products, Inc.

The final report covering the Inconel overlay procedure for type 316 tubesheets for the steam generator, the development of automatic welding procedures for the intermediate heat exchanger and steam generator tube-to-tubesheet joints, and the thermal shock tests of specimens simulating the tube-to-tubesheets joints on the intermediate heat exchanger and steam generator has been completed and issued as APAE No. 123, "Tube-to-Tubesheet Welding Development Programs for 30 Megawatt Prototype Sodium Intermediate Heat Exchanger and Steam Generator."

b. Steam Generator - Baldwin-Lima-Hamilton Corporation

Material

On June 13 the final shipment of production tubing was received at BLH. This gives a total number of production tubes of 309, 300 being needed for this unit. Material which was ordered for the source and detection brackets has also been received at BLH. Fourteen pieces of scrap production tubing 10 feet long plus 34 feet of short sections were received for tube bending die setting and for welding samples.

Engineering

Revisions to the tube drawing will be required after tube bending tryouts are completed. It appears that the developed length will have to be modified.

Fabrication

The X-ray procedure for the welds which connect the 1-inch pipe nozzles to the shell were revised. Using an Iridium source, the X-rays were taken and they proved to be satisfactory. The lifting lugs were welded to the shell and the welds inspected using the dye penetrant method.

Prior to machining the weld preparations on the end of the shell, stiffening rings were installed on each end of the shell. This ring holds the shell in a round position during the machining of

the weld preparations. The actual machining of the weld preparations is now in process.

The welding equipment for the tube-to-tubesheet weld was received from Alco and has been installed in the weld laboratory. The "testing" of this equipment and the weld qualifications will be conducted in this location. The sample tubesheets for use in the tube-to-tubesheet welder qualifications are in the process of being machined.

The final check of the bending dies was conducted using short sections of production tubing. A straightening operation in order to square both ends of the tubes with respect to the tubesheets will be necessary.

Delivery

The latest review by the Production Control Department indicates that the delivery date of November 15, 1963, will be met.

High-Temperature High-Pressure Test Loop

The holding rack which supports all of the tube samples was installed in the upper portion of the tower and the main test specimen was installed in the lower portion of the furnace.

Pressure lines connecting these samples and the main test specimen to the loop proper have all been installed. After the water side of the test loop was completely connected, the system was first flushed and then subjected to a preliminary hydrostatic pressure test. Minor leaks which were in evidence as a result of this test were repaired and the retest of this loop proved to be satisfactory.

Forty-two thermocouples were welded to the main test specimen and to the thermocouple leads. These leads were being installed from the tower to the panel board and are being connected to the recorders.

The condenser feedwater heaters and the electric feedwater heaters have been installed in the tower.

New carbide seats were installed in the control valves and the air controls to these valves have also been checked to see that they operate properly.

All of the drain lines have been connected which will discharge the cooling water into the waste drain.

c. Second Steam Generator - Babcock & Wilcox

Work continued on Phase I of this contract which consists of the following items:

- (1) Preliminary design of 1000 MW Sodium Heated Steam Generator.
- (2) Supporting Research and Development work.
- (3) Preliminary design of 30 MWt Prototype Steam Generator.

The first monthly progress report has been prepared and was mailed. It covers the progress of this contract through the end of May 1963.

Design Work on 1000 MWe Steam Generator

The surface for the steam generator and reheaters for the 1000 MWe size plant has been set and layout drawings are being made. Part load performance calculations are nearly complete. There are some areas where the operating and control characteristics of the steam generators affect the rest of the reactor plant and vice versa. An example of one of these areas is the effect feedwater temperature at low load may have on considerations of a cold sodium incident in the reactor.

The first set of layout drawings that were made for the 1000 MWe boilers revealed a number of areas where further optimization should be done. Work is under way to revise the number of concentric helical coils in the boiler to use some space within the vessel that would otherwise be wasted and thereby allow a shorter vessel with a lower over-all cost.

Another area in which some cost savings may be possible is in the stainless steel superheater inlet and outlet tubes. A study is being conducted to minimize the distance between the shell flanges and the boiler and superheater tubesheets in order to keep the length of the stainless steel superheater inlet and outlet tubes as short as possible.

d. Sodium Components Test Installation - Atomics International

All drawings for the last construction unit have been made. The sodium cooler, fabricated by BLH, was delivered June 14, and the sodium preheater unit was shipped by BLH on June 22.

The desuperheater nozzle has been repaired, inspected, and installed in the desuperheater assembly. Sodium piping spools for the preheater tie-in were installed in anticipation of the preheater delivery. A bid package was put together to install electrical trace heaters and insulation on the major portion of the sodium lines and presented to CH for approval.

e. Second Round Carbon Analysis - Atomics International

Operation of the loop for the preparation of sodium samples with a high level of carbon continued satisfactorily. The tea bag method for introducing the carbon to the sodium was in operation for 60 days. Analytical results of sodium samples taken from the loop indicated the carbon content of the sodium in the test loop was increasing.

f. Physical Properties of Materials - MSA Research Corporation

Summary of Tests 1 and 2

Tests 1 and 2 which consisted of the determination of the physical properties of type 316 stainless steel and 2½ Cr - 1 Mo 1100°F

respectively have been completed except for three type 316 stainless steel and two Cr - Mo steel creep tests in helium, one type 316 stainless steel creep-to-rupture test in helium, and two pre-exposed Cr - Mo steel creep-to-rupture tests in air. These remaining tests are being conducted at the University of Michigan.

Metallurgical examination of the specimens generated under Tests 1 and 2 is continuing. A topical report on the findings of Tests 1 and 2 is being written. Preliminary conclusions based on the results of these tests to date are as follows.

A comparison between the incomplete physical property data and the environment in which the specimens were run indicates the following:

For type 316 stainless steel, 1200°F --

- (1) The creep rates in helium and sodium are higher than in air.
- (2) The number of cycles to failure-in-fatigue in descending order is: helium, sodium, and air. However, at low strains all three environments may show equal life.
- (3) All other physical properties showed little effect.

For 2½ Cr - 1 Mo steel, 1100°F --

- (1) The tensile strength was lower in helium than in air.
- (2) The stress-rupture strength in sodium was slightly lower than for helium or air.
- (3) Pre-exposing the specimens for 4000 hours (in sodium) lowered the stress-rupture strength.
- (4) The creep rate in sodium is higher than in air.
- (5) The number of cycles to failure in fatigue is extended by both helium and sodium.
- (6) The effect of helium on creep is too premature for a comparison.

It is noted that some of the above differences occur in a relatively short time, indicating possible surface effects. Thermodynamics will be used to see if the different oxygen content of the various environments may contribute to different surface compositions.

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

The bypass tank installation for the addition of carbon was completed and the system charged. After some difficulty, the six test pots were charged. The immersion heater in one test pot failed during the charging procedure. All test pots were isolated from the system and the system drained. The test pot with the bad heater was cut out of the system and a new heater installed. At this time it was found that a solid plug had formed in the pot inlet line. This line was cut out, washed, and put back into the system. After installation of the

repaired pot, the system was then recharged. An improperly seated valve at the repaired pot caused a leak at this area and necessitated draining of the system. Wiring was damaged by the leaking sodium in this area as well as the insulation on this pot. When repairs were completed, the system was recharged and flow established through the test pots.

During the next report period the oxide level will be reduced to a saturation temperature of less than 300°F. The carbon level will be determined and then brought to test conditions by the use of the bypass carbon pot. After it has been determined that the proper carbon level has been reached and that it can be maintained, the foils (2½ Cr - 1 Mo, 316 stainless steel, 304 stainless steel, and Armco pure iron) will be installed for a 2-3 week period. After data obtained from these foils have been correlated, Test 3 will be initiated.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High Oxide Sodium

With completion of runs in which foils were exposed for various lengths of time, the pots were drained and the test machine calibrations were checked. Test 4 was initiated by installing the three creep specimens and three creep-rupture specimens.

2½ Cr-1 Mo Steel Fatigue Tests

Fatigue tests have not yet been started. These tests will be initiated during the next report period.

2½ Cr-1 Mo Steel Creep-Rupture Tests

The three creep-to-rupture tests in the high oxide sodium were loaded at stresses of 18,000 psi, 14,000 psi, and 12,000 psi. The specimen at a load of 18,000 psi failed after 48.5 hours. This specimen was removed and a new specimen installed. It was placed under a load of 16,000 psi. The specimen at a load of 14,000 psi failed after 240.6 hours. This specimen will be removed and a fifth test started at a load of 10,000 psi.

If the results of these two tests are indicative of a trend, then the creep-to-rupture in high oxide sodium will show failures in shorter times.

2½ Cr-1 Mo Steel Creep Tests

The three creep tests in the high oxide sodium were loaded at stresses of 7000 psi, 6000 psi, and 4500 psi. Specimens for the exposed creep-rupture tests were installed with these specimens. The tests have not been in progress a sufficient length of time to report results.

2½ Cr-1 Mo Steel Tensile Tests

Tensile tests are not scheduled until the end of the 4000-hour creep tests.

Analytical Results

Extraction of samples from Loop 2 on a weekly basis has continued. Analyses have been run for carbon and for trace elements by emission spectrograph. Average result on Loop 2 to May 7, 1963, was 29 ppm C.

Future Work

While preliminary conclusions have been presented in the above sections, final conclusions will not be made on Tests 1 and 2 until carbon analyses and microhardness determinations have been completed. Metallographic examination reveals the significance of surface effects on fatigue. Changes in specimen carbon content are necessary to correlate compositional effects with the small differences in creep and stress-to-rupture tests observed with the variation in test environment.

Topical reports on Tests 1 and 2 are now in progress and will be completed in the near future on work to date. Since it appears that oxygen, or rather the lack of oxygen, may be a contributing factor, a short study will be made of the thermodynamics involved.

g. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

Modifications to the Rhometer were completed in June, including the installation of an ambient temperature compensator component. A sodium hydride tea bag injection system was fabricated, and pure NaH was extracted in a dry-box process from high-grade commercial hydride in an oil dispersion.

Final calibration of the sodium temperature compensator (after inclusion of the ambient temperature compensator) involved several temperature ramps in the 400-1000°F range. After selection of temperature range on a three-position gang switch, the meter is adjusted by setting (a) the two temperature compensator dials, (b) the four decade dials, and (c) the sensitivity resistor dial. Ambient temperature compensation was achieved by substituting the series-parallel network for R24 in the original meter circuit.

A procedure has been devised to introduce NaH by tea bag into the sodium loop at the gas injection port immediately downstream of the loop pump. NaH will be weighed and handled in a dry-box, transferred in gas filled plastic bags to the injection port, and submerged in circulating sodium. Three styles of tea bags are available: half-ounce milled tubing units with 10-mil slots, 325 mesh wire cloth cylinders, and sintered stainless steel cylinders of 100-150 micron porosity. NaH was obtained from an oil dispersion by hexane extraction, using a soxhlet apparatus in a nitrogen filled dry-box. Isopropyl alcohol was circulated in the soxhlet condenser for safety, and a special balance with a silicone filled dash-pot was employed in the dry-box to avoid contamination (from conventional oil filled dash-pots). The NaH extract was dried and stored in a vacuum desiccator.

h. Mass Transfer - General Electric CompanyLoop 1

The oxide level control was somewhat erratic, with two downward adjustments being necessary, followed by an upward adjustment via the addition of sodium oxide.

Loop 2

Oxide level control continued to be excellent, only one adjustment being necessary, following startup as a result of a leak at H3R sampleholder.

Loop 3

The loop was down for routine sample changing at 1394 test hours. Oxide level control continued good, the only adjustments necessary being those after startup from sample changing, and when Na₂O was added to correct for excessive cold trapping which occurred² when high plugging temperatures were indicated by a malfunctioning recorder.

Loop 4

The loop was down for routine sample changing at 703 test hours. Oxide level control was good after control had been established. Considerable difficulty was encountered after startup in achieving and maintaining flow at the desired cold trap temperature ($\sim 300^{\circ}\text{F}$).

Loop 5

The loop was dumped to end run No. 5. The rest of the month was spent in removal of all samples (regular and in-pipe) for examination, and in preparing the loop for the forthcoming chemistry run.

Loop 6

Ductwork was replaced on the cold trap-plugging indicator system and a thermowell type thermocouple was installed in the cold trap to give more accurate temperatures during oxide level adjustment. Oxide level control was good for the month.

Analysis of Samples

The 1400-hour data for the 316 stainless steel loop (No. 1) continued to show increased corrosion associated with high oxide conditions, and demonstrated that washing influences the "interpretation" of subsequent corrosion data. The corrosion rates at H3 and C3 for this run interval, when compared with the same intervals of the low oxide runs 1-4 and 1-3, show values approximately double those occurring in the previous runs. It should be noted that the oxide levels for this (1-5) run have been slightly higher than the planned 50 ppm (59 ppm at 700 hours and 64 ppm at 1400) due to recorder calibration troubles and absences of oxygen consumption during the run.

The effect of washing samples does not appear to influence the corrosion rate. Since cleaning and handling results in loss of sample material which is not due to Na exposure, it is necessary to interpret corrosion data over only the incremental exposure periods. That is, over-all corrosion rates cannot be applied to these samples unless out-of-loop material loss corrections are applied. It is interesting to note that the application of a handling weight loss, for the five samples involved, yields a total exposure weight change which compares well with the neighboring samples.

The 1400-hour data for the 316 stainless steel - 2½ Cr loop (No. 3) show a normal corrosion profile with weight losses in the hot leg (except H1 and H3R where there was essentially no change) and weight gains in the cold leg in contrast to losses during the first 700 hours of exposure. Again, as anticipated, the corrosion is low in the run.

The 1400-hour data for the 5 Cr loop (No. 6) continue to show a normal corrosion profile as well as confirm the higher corrosion of the high oxide run. The corrosion at H3 is comparable, if not somewhat higher, than that noted in similar runs in other loops.

1. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Development of core drilling techniques for the sampling of sodium cold traps continued using a prototype trap containing demister mesh and filled with sodium to a weight ratio of one steel to four sodium. Motor driven hole saws were tried at temperatures as low as -300°F in a specially designed dry-box. The cores obtained at these low temperatures were malformed and consisted of twisted, compacted mesh. The sodium at -300°F was still plastic and examination of the mesh in the core showed it to be spiralled from the rotation of the coring tool.

A second prototype trap was used to test several tools having a scissor-like (oscillatory) motion.

It is quite probable that core drilling will not prove technically feasible. Techniques of cutting mesh have been developed successfully, but because of the plasticity of the sodium, separation of sodium from the mesh occurs, and representative cores cannot be obtained.

Review and Development of Analytical Techniques

A tentative analytical manual WCAP-2310 was prepared for the chemical determination of sodium monoxide, carbonate, carbide, total carbon, nitrogen, and hydrogen in sodium.

Specific procedures for the determination of impurities in sodium by spectrographic methods and the identification of compounds by X-ray diffraction techniques are not included since no information as to the concentration levels of interest is known; however, these will be written after initial cores from the EFR cold trap have been received.

j. Sodium Pump Development Test Facility (SPTF) - Westinghouse Electric Corporation

Pump Development Program

The initial draft of the pump development program was completed and was being reviewed. Supporting information on hydraulic design, drive motor studies, seal and bearing studies, and selection of pump types for development was included.

Pump Test Facility Design Criteria

The following items will be incorporated in subsequent design work:

- (1) The test facility shall in addition to its primary function as a pump test facility also serve the secondary purpose of testing flow control and flow instrumentation devices.
- (2) The design shall not restrict the use of the SPTF to a single type of pump design.
- (3) Desired tests shall include the evaluation of gas entrainment into the pumped fluid and provision shall be made to measure gas entrainment in each loop.

Design and Cost Estimate of SPTF

Design work on the test facility main loop was initiated on the basis of previously submitted Design Criteria. Work included investigation of main pipe sizes, vessel and tank sizing, preparation of specifications for heat dump cooler, control and instrumentation work, and system analysis.

Evaluation of Test Facility Sites

An inspection of the CANEL site was made for the purpose of ascertaining the general suitability of the site for possible installation of the SPTF. The preliminary conclusions were: The existing buildings should not be considered for the SPTF; however, the CANEL site with its available space and existing service facilities should definitely be considered as a location for the SPTF.

III. MEETINGS

June 3	T. P. Heckman, CH, visited the APDA Quarry Laboratories and discussed the status of resistivity meter, carbon in sodium analysis, and related sodium technology.
June 25	F. C. Mattmueller and F. A. Smith, CH, visited BLH to review the progress of the steam generator fabrication and the assembly of the high-pressure test loop.

IV. REPORTS

AI Progress Letter No. 26 for May, "Sodium Components Test Installation," dated June 3, 1963.

Alco Products, Inc., Program Status Report, May 14 to June 15, Contract AT(11-1)-666, dated June 18, 1963.

APDA Summary Report for May 1963, "Sodium Resistivity Meter," Contract AT(11-1)-865, PA No. 3.

B&W Weekly Letter Reports for the weeks ending June 7, 14, and 21.

B&W Progress Report No. 1 for May 1963, AT(11-1)-1280, dated June 20, 1963.

BLH Progress Report, "Sodium Components Design Program," Contract AT(11-1)-1213, dated May 31, 1963.

GE Progress Letter No. 47 for period of May 1 to May 31, dated June 7, 1963.

MSAR Progress Report No. 33 for May, "Effect of 1200⁰ Sodium on Austenitic and Ferritic Steels," dated June 21, 1963.

University of Wisconsin Letter Progress Report No. 23 for the month of May, "Boiling Liquid Metals Heat Transfer," dated June 13, 1963.

Westinghouse Monthly Progress Report No. 5 for period ending May 31, "Sodium Pump Development and Test Facility Design," dated June 1963.

APAE-123, "Tube-to-Tubesheet Welding Development Programs for 30 MW Prototype Sodium IHX and Steam Generator."

V. CORRESPONDENCE

June 3 Ltr, Sinizer (AI) to Holliday, transmitting cy of trip report on Sodium Mass Transfer Program at GE, San Jose.

June 5 Ltr, Bennett (Alco) to Mattmueller, transmitting inventory of laboratory equipment and related materials used for carrying out the progress of Alco Contract AT(11-1)-666.

TWX, Pursel to Gronemeyer, approving the use of the HNPF pump stand by the SCTI Project, costs associated with the use of the stand by SCTI should be borne by SCII, and stand should be returned to HNPF when no longer needed.

Ltr, Mattmueller to Mooradian (B&W), setting forth the distribution to be given to the monthly and quarterly reports under Contract AT(11-1)-1280.

June 7 Ltr, Donnell (APDA) to Mattmueller, re progress toward calibration of the Blake Sodium Resistivity Meter for Hydrogen Contamination, Contract AT(11-1)-865, PA No. 3.

Ltr, Mooradian (B&W) to Mattmueller, reporting on the estimated costs incurred under Contract AT(11-1)-1280.

June 10 Ltr, Birle (GE) to Brummett, presenting GE recommendations for the continuation of the sodium mass transfer investigations program under Project Agreement No. 15 through FY 1964.

June 11 Ltr, Nemzek to Foster (AI), re utilization of the B&W design of a steam generator in the AI engineering description of a 500 MWe SGR Power Plant.

- June 13 Memo, Mattmueller to OC Contract File, re justification for modification No. 10 to Contract No. AT(11-1)-765 with MSA Research Corporation.
- Ltr, Abderhalden (BLH) to Smith, transmitting copy of latest welding procedures which have been supplied by Alco for the tube-to-tubesheet joint of the steam generator.
- June 14 Ltr Mattmueller to Abderhalden (BLH), stating BLH proposal under AT(11-1)-1213 for the performance of analyses of the data obtained in the SCTI test of the steam generator is still being reviewed.
- June 17 Ltr, Mattmueller to Staub (MSAR), transmitting Modification No. 10 to Contract AT(11-1)-765 for review and consideration.
- Ltr, Cochran (AI) to Probert (B&W), stating that a set of SCTI drawings is being sent to B&W.
- June 21 Ltr, Abderhalden (BLH) to Mattmueller, estimating costs for Contract AT(11-1)-1213 through the month of June.
- Ltr, Mattmueller to Leggett (Alco), transmitting Modification No. 9 to AT(11-1)-666 for review and consideration.
- June 25 Memo, Mattmueller to Wensch, stating that Modification No. 4 to AT(11-1)-865, PA No. 3 was effective on June 24, 1963, and providing for additions to the scope of work and increasing the estimated costs of the work.
- June 26 Memo, Nemzek to Levy, re request for a cost estimate by AI to provide steam gages and attach same to the steam generator at BLH.
- Ltr, Mattmueller to Abderhalden (BLH), recommending action to be taken to ascertain the importance of the $1\frac{1}{2}$ -inch radius to the stress and related design aspects of the water-side inlet and steam outlet nozzles to the channel heads.
- Memo, to File from Mattmueller, re trip report, visit to BLH facilities, June 25, 1963.
- June 28 Memo, Mattmueller to Pursel, re Modification No. 3 to AT(11-1)-1070 for the University of Wisconsin, executed on June 28, 1963.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JULY 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. Cygan	AT(11-1)-8	CPAO
d. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-8	CPAO
e. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
f. Resistivity Meter (Blake Meter) Loop	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
g. Continuous Oxide Meter	United Nuclear Corp. 5 New St. White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NYO
h. Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
i. Sodium Cold Trap Studies	Westinghouse Electric Corp., Atomic Power Division P. O. Box 355 Pittsburgh 30, Pa. P. Cohen	AT(30-1)-3186	NYO

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
j. Sodium Pump Development Test Facility	Westinghouse Electric Corp. C. C. Randall	AT(30-1)-3123	NYO

II. STATUS

a. Steam Generator - Baldwin-Lima-Hamilton Corporation

Outstanding Material

The guide rings were machined complete and the final dimensional inspection indicated that the hole location in these pieces varied to too great a degree to permit assembly in the steam generator.

Replacement material for the guide rings has been ordered and delivery is expected by August 19.

Engineering

Necessary revisions to the tube drawing can now be made as the tube bending tryouts have been completed on production tubing. The developed length required for the bend area will be modified slightly.

Fabrication

Both the shell side and the head side weld kerfs have been completely machined on the upper and lower tube sheets and the necessary dimensional checks taken. These tube sheets are now ready for the tube hole drilling, reaming, chamfering, and trepanning operations. The tube sheets, thermal shields, and guide rings will be machined by a subcontractor using LAHR Gun Drills for better quality.

Delivery

The Production Control Department of BLH has reviewed the current status of all the separate components of the steam generator. They indicate that the delivery date will be set back until the final week of December. A greater effort will be exerted on the steam generator with the hopes of improving this delivery date.

High-Pressure High Temperature Test Loop

All of the thermocouple leads for recording the furnace and the main test tube section temperatures have been connected to the recorder on the panel board and all continuity checks completed.

The final cleanliness and tightness of the water system has been checked by pumping filtered water through the system. At the same time, the high-pressure pumps were checked to determine their operating characteristics.

The loop is now ready for preliminary startup tests using electrical heat. These tests are expected to be started the 1st or 2nd of August.

b. Second Steam Generator - Babcock & Wilcox

Changes in Scope of Contract

To meet the Commission's over-all objective two changes in the scope of the Contract have been agreed to. These modifications to the Contract are as follows:

- (1) The original Contract provided for the design of a 1000 Mwt Sodium-Heated Steam Generator. This modification now provides that in lieu of a 1000 Mwt system design, the Contractor is to design a sodium-heated steam generator system that, together with two identical such systems, will provide sufficient steam for a 1000 MWe plant.
- (2) The steady-state operating steam pressure at the outlet from the steam generating system is changed from 2200 to 2400 psig.

The modification to the steam pressure brings the design conditions for these steam generators into agreement with Preferred Standard design conditions for steam turbines and will result in significant savings in steam turbine costs.

Design Work

The design work under this Contract is proceeding according to the Critical Path Schedule.

To meet the over-all Commission objective of developing economical, practical nuclear power, the steam generator being designed under this Contract will be of the "once-through" type because economic studies have shown that the once-through boiler costs considerably less than a recirculating boiler, especially in large sizes. A single tube wall will be used because it is felt that adequate safety measures can be provided to protect personnel and to protect the boiler against severe damage in the event of a tube rupture, and by using a single tube wall a considerable saving in cost results.

A very compact arrangement of heating surface is possible by using concentric helical coils for both the boiler and superheater. The steam generator is being designed so that the superheater and boiler tube banks are individually removable for inspection or repair should this be necessary. The boiler bank will be made of a low-cost alloy such as Croloy 2½ because the tube temperatures are within the use limits for this material. For the high-temperature superheater, a material must be used having good stress characteristics at high temperature. Stainless steel and several other alloys are being investigated for possible application in the superheater.

30 Mwt Prototype Steam Generator

Design work on the 30 Mwt Prototype Steam Generator will be started after most of the design work has been completed on the full-size unit so that the prototype can be a test model for problem areas uncovered in the design of the large unit.

Research & Development Program

Research and development work has been approved under this Contract on the following projects:

- (1) Material: Carbon transfer and effect on material properties.
- (2) Effect on heat transfer and two-phase flow of coiling tubes.
- (3) Sodium-water reaction.
- (4) Procedure for welding tube to back side of tube sheet.
- (5) Radiographic inspection of back side tube welds.
- (6) Chemical simulation of sodium environment for leak testing.

The problem to be solved and general scope of each project is described below. Work is in progress on designing test apparatus and laying out the various test programs.

Critical Path Schedule

A Critical Path Schedule has been prepared for the design work of Phase I. (This is the preliminary design of the Full-Size Unit and preliminary design of the 30 MWt Prototype.) The schedule will be expanded to include the R&D work as soon as the various projects are laid out in enough detail. The schedule for Phase II (detail drawings, procurement of materials, fabrication and delivery of the 30 MWt Prototype) will be added as soon as possible to facilitate the Commission's planning for SCTI.

c. Sodium Components Test Installation - Atomics International

The installation and testing of the argon system was nearing completion. This job was 98.9% complete.

The contract for the preheating system, electrical and instrument hookup, and the thermal insulation was awarded to Commercial Contracting Corporation in the amount of \$203,500. Work was scheduled to start July 24 and end November 8, 1963.

d. Second Round Carbon Analysis - Atomics International

Samples of the cover gas from the loop were submitted for chromatographic analyses and disclosed high nitrogen content. The gas region was purged with helium and a second analysis indicated only trace amounts of nitrogen present.

The oxide concentration of the sodium continued to be greater than 150 ppm, and the carbon level was between 40 and 60 ppm.

A set of samples of sodium at these conditions was taken in the prescribed nickel sample tubes. These samples, however, were not shipped to the complete list of participants. Rather, a few of the participants will analyze several specimens and evaluate the results at an Ad Hoc Committee meeting scheduled for August 19, 1963.

e. Physical Properties of Materials - MSA Research Corporation

Summary of Tests 1 and 2

Tests 1 and 2, which consisted of the determination of the physical properties of Type 316 SS and 2½ Cr - 1 Mo steel specimens in low oxide sodium, helium, and air at 1200 F and 1100 F respectively, have been completed except for several tests in helium.

Metallurgical examination of the specimens generated under Tests 1 and 2 is continuing. Photomicrographs and discussion of stainless steel fatigue and creep-to-rupture specimens included in this report indicate that while massive oxidation products on stainless steel fatigue specimens are not apparent, as in the case of the Cr-Mo specimens, surface attack is thought to reduce fatigue life. In the case of the stainless steel stress rupture specimens, evidence is shown that carburization is greater in short time stressed specimens than in 4000-hour exposed unstressed specimens. A topical report on the findings of Test 1 and 2 is in progress.

Test 3 - Stainless Steel 316 Specimens in 1200 F High Carbon Sodium

Circulation continued this month through all but one test pot. The outlet line heater for this unit burned out and appeared to have shorted out to the flexible line. It was decided to isolate this pot until this line could be replaced and continue shakedown runs with the rest of the system.

The oxide level was lowered to below a saturation temperature of 300 F and several sodium samples were taken to determine the carbon level of the system prior to circulation through the bypass carbon tank. During this time, periodic checks of the oxide content indicated that the saturation temperature was increasing from less than 300 F to 600-700 F in a three or four-day period. The scatter in the carbon analysis was too great to indicate a satisfactory starting point, so the system was cold trapped continuously for 20 hours in an attempt to clean up the system. Additional sodium samples have been taken for carbon analysis.

Upon determination of the carbon level in the system, the carbon bypass tank will be put into operation and the test conditions obtained. Foil samples will then be installed for a 2-3-week period. After data obtained from these foils have been correlated, Test 3 will be initiated.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100 F, High Oxide Sodium

Testing of the three creep specimens and the creep-rupture specimens continued. Fatigue tests were initiated during this report period.

2½ Cr-1 Mo Steel Fatigue Tests

A 2½ Cr-1 Mo steel fatigue specimen was installed in the test machine in which a 12-inch radius mandrel was used for a low cyclic strain test. This specimen failed after 63,270 cycles. This one test is in good agreement with the fatigue tests in low oxide sodium.

2½ Cr-1 Mo Steel Creep-Rupture Tests

From the three points to date, it appears that the creep-rupture curve for high oxide sodium will be parallel but lower than the low oxide curve determined in Test 2. The specimen elongation measurements are taken from externally mounted dial gages.

2½ Cr-1 Mo Steel Creep Tests

From the preliminary data, 2½ Cr-1 Mo steel tested in high oxide sodium exhibits a lower creep rate for short time tests than those tested in low oxide sodium. These creep rates may change as the test progresses to the 4000-hour time limit. Although the creep rates in high oxide sodium are lower than in low oxide sodium, they are still higher than in air or helium.

2½ Cr-1 Mo Tensile Tests

The 2½ Cr-1 Mo tensile tests are not scheduled until the completion of the creep tests.

Stainless Steel Fatigue Specimens - Test 1

The presence of massive air corrosion product observed within fatigue cracks associated with croloy air tests are not visible in stainless steel air fatigue tests. Microcracks are also apparent in both figures. These microcracks which exist throughout the matrix appear to be intergranular and generally parallel to the stress direction.

Cracking appears to be more intergranular than in the case of specimens not pre-exposed and suggests caustic attack. Incomplete alkali removal during the water wash step is a possible cause of caustic attack and subsequent reduction in cycle life (approximately 50 per cent) of pre-exposed air test specimens as compared to unexposed air test specimens.

Surface cracking is apparent in the air test, and absent in helium or sodium tests. Surface cracking becomes less predominant with decreasing cyclic strain when specimens are tested in air, and become virtually non-existent in He and Na tested specimens.

A small degree of plastic deformation is evidenced in short term high cyclic strain specimens. The plastic deformation at the rupture face is more shallow (2-3 grain diameters from fracture) and not as pronounced as that observed with croloy specimens.

Surface-initiated fatigue cracking is apparent after testing in each of the environments, but is more pronounced in air tests and at high cyclic strain. Evaluation of fatigue test data shows, in general, increasing fatigue resistance from air to sodium or helium. While massive oxidation products on stainless steel are not apparent, as in the case of croloy, air oxidation is thought to reduce fatigue life. Comparison of thermodynamic values for metal oxides would suggest that stainless steel is slightly more effective than croloy as an oxygen scavenger for sodium. Thus, oxide coatings are prevented from forming on croloy but superficial oxide coatings are known to occur on stainless steel when immersed in sodium. These factors could explain the similarity of sodium and helium fatigue data, while the air life is significantly reduced.

Stainless Steel Stress-to-Rupture - Test 1

Examination of the intergranular separation near fracture shows greater air oxidation production than surfaces where cracking did not occur. Longitudinal sections of the failure for air, helium, and sodium tests show an intergranular mode of fracture in each case. Twinning is particularly pronounced in the specimen which had undergone more strain than other samples.

Samples were etched with ferric chloride to define carbides and an increase in the carbide case is evident with increasing time of exposure to sodium.

Examination of a series of photomicrographs shows an expected increase in grain elongation with increasing stress. Intergranular cracks are evident in each case, and considerable carburization is evident in the region of a crack. Carbide precipitation appears to have occurred both at grain boundaries and along dislocation concentrations. Carbide precipitation is also pronounced at twin planes. A phase, as yet unidentified, is evident at grain boundaries in the heavily carburized region.

A striking comparison can be made of carbide penetration between stressed samples and those pre-exposed and subsequently stressed. The extent of visible carburization appears to be essentially dependent upon the duration that a sample is under stress. A sample under stress for as little as 144 hours appears to be carburized to the same extent as a sample exposed to sodium for 4000 hours with no stress.

In samples tested without prior sodium exposure, the carburization rate increases with time and no maximum carbon value is attained over the range examined. The increase in carbon content for a sample exposed unstressed is very low, but upon initiation of stressed conditions the carburization rate is most rapid, reaches a peak, and decreases.

Explanation of the anomaly can only be resolved by carbon analysis of specimens within the gage length. Further evaluation of this effect is planned, which will include repeat analyses of 4000-hour unstressed specimens.

f. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

During the month sodium hydride was introduced into the flowing sodium loop by "tea bag," and the resistivity meter calibrated against the rising level of contamination. The twofold purpose of this run was to: (1) validate calibration values obtained during the March 1963 experiment, in which the sodium loop was contaminated by direct injection of hydrogen gas, and (2) extend this calibration to higher solution levels at elevated temperatures. During this run, the resistivity meter responded satisfactorily to the various contamination levels, as was true during the run in March. Calibration figures will be available when analyses are completed on the sodium samples taken during the run. Correlative effort included evaluation of the recently installed variable-orifice plugging meter and a nickel diffusion-tube hydrogen detector. The difficulty with the new plugging meter, noted in the June report, no longer exists; operating quite satisfactorily, the meter showed a logical progression of values as contamination increased. As with the resistivity meter,

calibration data on the plugging meter are contingent upon analysis of the sodium samples. The nickel diffusion-tube hydrogen detector did not respond to loop environment during this run.

Periods of tea bag immersion, varying from 2 to 10 hours, were determined by response of the resistivity meter, and terminated at steady state (no further reaction). Although the pattern was not precise, hydrogen contamination generally increased immediately after introduction of a tea bag; and then returned to the original "background" value within 20 to 30 minutes.

At the conclusion of the sodium-hydride run, 100 F temperature was elevated to 1000 F for clean-up operations. As in the hydrogen-gas-injection experiment, the sodium hydride in solution did not dissociate completely. An increased signal from the resistivity meter indicated that additional contaminants were being driven into solution. Loop temperature was then lowered in stages from 1000 F to 750 F to 600 F, and the sodium cold-trapped to 240 F. The resistivity meter signal decreased from +0.9% r to the original zero set-point, but rose again to +0.04% r when the loop was reheated. At this point, cold-plugging was observed at 410 F, definitely establishing the presence of residual contamination. Clean-up operations will, therefore, continue with the cold-trap at the lowest possible temperature, while the loop is operated at the peak temperature of 1000 F to hold contaminants in solution.

Several inherent shortcomings exist in the tea bag-injection technique which largely obscure the results of the sodium hydride experiment. Since unidentifiable mixtures of sodium and sodium hydride may remain in the tea bag, the degree of solution of each increment cannot be determined except by chemical analysis of sodium samples. As solution progresses in the tea bag, small particles may escape through the walls of the tube and continue to dissolve in the loop, causing the resistivity-meter signal to rise after the tea bag has been removed from the injection port. At saturation, these particles are subject to solution during a temperature ramp. This effect produces bias in the sample analysis at low temperature and bias in the meter signal at high temperature.

g. Continuous Oxide Meter - United Nuclear Corporation

No report issued for July.

h. Mass Transfer - General Electric Company

During the 1963 GFY test, operations were completed on 35% (8-3/4 runs) of the Five Run Fractional Replicate Test Plan for the five loops (25 runs) plus samples were exposed for 8431 hours of the continuing long-time test in the 316 SS-2½ Cr Loop (No. 2) and for 2800 hours under the Hot-Cold (Downstream effect) test conditions in the 5 Cr Loop (No. 6). The percent completion of the Five Run Fractional Replicate Test Plan is 81% and the expenditure of authorized funding is complete.

Activities during this month were directed toward the operation of the six test loops, analysis of the steel and sodium samples, and evaluations of the corrosion and metallographic data. Continuing

effort this month has been devoted to the Carbon-Sodium-Oxygen-Steel system and in particular in the area of carbon analysis of sodium samples.

The 2½ Cr Loop (No. 5) is scheduled to have a special "chemistry" run prior to metallurgical loop examination. Both Loops No. 4 and No. 5 (which contain some of all three materials under test) will be undergoing metallurgical examination this fall.

The 11,200-hour data for the 316 SS-2½ Cr Loop (No. 2), on an extended run, continue the normal trend, showing weight losses in the hot leg and weight gains in the cold, in proportion to the exposure temperature. While the weight losses in the hot leg (H2 and H3R) during this latest 2800-hour exposure period were comparable to previous periods of that duration, the cold leg weight gains (C1 and C2) were two or more times those of earlier 2800-hour periods.

The 2100-hour data for the 316 SS-2½ Cr Loop (No. 3) also continue the normal corrosion profile. In contrast to the high, inexplicable weight loss of the C2 sample during the first 700-hour period, the companion sample, removed this period, showed a "normal" weight gain. In general, the corrosion of all samples removed was low.

The 700-hour data for the 316 SS-5 Cr Loop (No. 4) show substantially lower corrosion for this Type III (low oxide) run than for the previous run (Type V: high oxide). The C1 sample showed an extraordinarily large weight loss, for no plausible reason when considering corrosion phenomenon. Since the subsequent metallurgical examinations of this sample also indicated nothing particularly unusual in its structure or composition, the likelihood is that the initial weight figure is in error -- the final weight having been confirmed when the large, apparent loss first became evident.

The 2800-hour (end of run) data for the 2½ Cr Loop (No. 5) display the expected normal corrosion profile. As compared to the previous low oxide runs 5-3 and 5-4, the corrosion in this Type V, high oxide, run was from two to five times greater.

All of the data are preliminary (or as observed) since they are issued as promptly as possible for your information. While some of the corrosion rates may appear large, it is convenient to know that a corrosion rate of 100 mg/dm²/mo for material with the density of steel is equivalent to 0.6 mil/yr.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

No report for July received.

j. Sodium Pump Development Test Facility - Westinghouse Electric Corporation

Project Management

Topical Report WCAP-2255, "Survey of Sodium Pump Technology" was completed during the month and transmitted to the New York Operations Office, AEC, for approval.

The Phase I report draft was essentially completed during the month and is being reviewed internally prior to issuance of the "for approval" copy to NYOO during the next month.

A meeting at USAEC, Washington, D. C., on June 11, 1963, was attended by personnel from the Westinghouse Atomic Equipment Department and numerous other companies interested in sodium pumps. The purpose of the meeting was to generally acquaint pump manufacturers with the pump development program and to encourage industry participation in the pump test facility program.

Conceptual Design and Cost Estimate of Sodium Pump Test

Preliminary arrangement studies and conceptual design work have been transmitted to UE and C for review.

Estimated sizes and weights of loop piping were prepared and transmitted to the A-E along with estimated weights of some of the major components. The size of the loop piping and the design temperature were reduced to 30" OD and 1250°F respectively on the basis of information developed through Fluid and Control Systems Section work. This information has been transmitted to UE and C.

A functional specification and request for quotation for the main loop coolers were prepared and sent out for quote during the month.

III. MEETINGS

July 23	AEC, GE, and ANL met at ANL to review the status of analysis techniques for carbon in sodium and compare the ANL and GE attempts to develop new techniques.
July 25	U. S. Industrial Chemical Company visited AEC-CH to propose a program for analytical work on sodium.
July 26	AI visited AEC-CH to discuss status of the SCTI.
July 30	F. C. Mattmueller, F. A. Smith, and G. C. Gower, AEC-CH, visited BLH to review status of the steam generator fabrication.
July 31	AEC met with B&W at CH to discuss R&D program covering H ₂ O-Na reactions.

IV. REPORTS

AI Progress Letter No. 27 for June, "Sodium Component Test Installation," dated July 1, 1963.

AI Surveillance Status and Acceptance Report on the SCTI steam generator, dated July 11, 1963.

B&W Weekly Reports for the weeks ending July 12, 19, and 26.

BLH Weekly Reports for the weeks ending July 6, 13, 20, and 27.

GE Project Status and Cost Report, "Irradiation of Mass Transfer in Liquid Metals," dated July 12, 1963.

GE Progress Letter No. 4 for June 1963, "Mass Transfer Investigations in Liquid Metal System," dated July 5, 1963.

MSAR Progress Report No. 34 for June 1963, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated July 24, 1963.

University of Wisconsin Progress Report No. 24 for June 1963, AT(11-1)-1070, "Boiling Liquid Metals Heat Transfer," dated July 12, 1963.

Westinghouse Monthly Report for period ending June 30, 1963, "Sodium Pump Development and Test Facility Design," dated July 15, 1963.

Westinghouse Sodium Pump Study Project, monthly cost statement for June, dated July 1963.

V. CORRESPONDENCE

- July 1 Ltr, Levy to Wheeler (AI), reaffirming the FY 63 operating funds for SCTI work have been authorized. Stating the Commission will issue a work authorization for FY 64 commitments upon review and approval of the new schedule and cost estimates.

- July 2 Ltr, Anstine (B&W) to Mattmueller, transmitting itinerary for B&W's forthcoming trip to California.

- July 5 Memo, Nelson (SAN) to Mattmueller, transmitting Modification No. 7 to AT(04-3)-189, PA No. 15, GE Mass Transfer.

- July 8 Ltr, Abderhalden to Mattmueller, giving direction for handling and reporting any deviations from the drawings of the upper and lower head of the steam generator.

- July 9 Memo, Gower through Pursel to File - Trip report - AI, July 1 through July 5, 1963, referring to SCTI and Round Robin Carbon in Sodium Analysis.

- July 12 Ltr, Mattmueller to Mooradian (B&W), transmitting Modification No. 1 to AT(11-1)-1280 for review and consideration.

Ltr, Mattmueller to Donnell (APDA), proposing extension to contract AT(11-1)-865, PA No. 3.

- July 15 Ltr, Mattmueller to Staub (MSA), authorizing MSA to provide ORNL with copies of the MSA Progress Reports.

- July 17 Ltr, Mattingly to TLB, transmitting sodium components development program R&D Reports for retention and information.

Memo, Dunbar to Pittman, stating that in order that BLH can provide a resident test engineer at the beginning of the test program for the steam generator, it will be necessary for us to negotiate a Contract Modification to AT(11-1)-1213 as soon as possible.

- July 23 Memo, Pollman to G. Lee, regarding GE request for deletion of patent article from AI Purchase Order N31S23 - 700301 - H (strain gages).

Ltr, Anstine (B&W) to Mattmueller, listing GE Reports that B&W does not have and requesting they receive them as soon as possible.

July 24 Ltr, Mattmueller to Seifert, asking advice as to recommendations to resolve the deviations from Alco specifications on the BLH steam generator.

July 25 Ltr, Abderhalden to Mattmueller, stating the costs under AT(11-1)-1213 for June and July.

Memo, G. Lee to Pollman, re GE's request for deletion of patent article from AI purchase order.

Ltr, Peterson (AI) to Amata (BLH), requesting name and address of the shop selected, if any, to machine tubesheet tube-holes.

July 26 Ltr, Mattmueller to Mooradian, giving distribution list for the monthly and quarterly reports by B&W.

Ltr, Mattingly to TLB, transmitting sodium components development program R&D Reports.

Ltr, Richards to Probert (B&W), transmitting documents requested by B&W engineers during a July 15-16, 1963, visit.

July 30 Memo, Heckman to Pursel, re GE visit to ANL and CH to discuss oxygen-carbon-sodium investigations.

Memo, Mattmueller to J. Lee, asking OC to prepare Modification to AT(11-1)-865, PA No. 3, for additional funds and extension to the contract.

July 31 Memo, Richards to Heckman, stating MSA was sent another sample from run 1A and run II of the sodium samples for carbon analysis.

Ltr, Mattmueller to Lilly (BLH), asking BLH to review all the work remaining on the steam generator and furnish CH with recommendations on steps that can be taken to complete delivery on the estimated date of November 15, 1963.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
AUGUST 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Test Facility	Atomics International P. O. Box 309 Canoga Park, Calif. R. Cygan	AT(11-1)-8	CPAO
d. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-8	CPAO
e. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
f. Resistivity Meter (Blake Meter) Loop	Atomic Power Develop- ment Associates, Inc. 1911 First St. Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
g. Continuous Oxide Meter	United Nuclear Corp. 5 New St. White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NY
h. Mass Transfer	General Electric Co. Atomic Power Equip- ment Department P. O. Box 254 San Jose 12, Calif. R. W. Lockhart	AT(04-3)-189 #15	SAN
i. Sodium Cold Trap Studies	Westinghouse Electric Corp., Atomic Power Division P. O. Box 355 Pittsburgh 30, Pa. P. Cohen	AT(30-1)-3186	NY

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
j. Sodium Pump Development Test Facility	Westinghouse Electric Corp. C. C. Randall	AT(30-1)-3123	NY

II. STATUS

a. Steam Generator - Baldwin-Lima-Hamilton Corporation

Outstanding Material

Replacement material for the guide rings has been shipped direct to the outside vendor who will perform the necessary machining and drilling operations.

Fabrication

Upper and lower tube sheets and thermal shield baffles have been delivered to the vendor's plant for the Lahr gun drilling of the tube holes. The vendor has ordered the necessary drills for the tube hole drilling operation. A better hole finish can be obtained by drilling to size in one operation rather than drilling the holes undersize and then reaming to the drawing dimension. The lower tube sheet is expected to be returned to BLH by September 18 after which the remaining chamfering, trepanning, and inspection operations can be completed.

Delivery

The delivery date is the last week in December as reported last month.

High-Pressure High-Temperature Test Loop

On August 1 and 2, the electrical heat was applied to the test loop. Water temperatures were held at a low level while all electrical controls were checked out. Following a two-week vacation shutdown, the debugging run was resumed. The water temperature was increased gradually in order to determine control characteristics of the test loop. A gasket failure occurred on the inlet coupling of the electric feedwater heater. This gasket design was completed just prior to the transfer of the loop to BLH and was never installed or tried out on the loop. This connection must seal against both the system pressure at operating temperature and also electrically insulate this heating portion from the remainder of the piping system.

In view of this failure, it was decided to redesign this joint using a full face "Fiberfrax" gasket and increase the bolting size and number. New connections are being fabricated. Similar connections are on both inlet and outlet to the feedwater and superheater sections of the test loop, so all four connections will be finished at this time. This new joint was completed and ready for tryout at the end of the month. At this writing, some further development will be required on this joint arrangement.

b. Second Steam Generator - Babcock & Wilcox

Work continued this month on Phase I of the contract which consists of the following:

- (1) Preliminary design of Full-Size Sodium Heated Steam Generator.
- (2) Supporting Research and Development work.
- (3) Preliminary design of 30 MWt Prototype Steam Generator.

Design Work on Full-Size Steam Generator

Design work is proceeding on schedule. Stress analysis work is continuing on tube supports, tube sheets, and thermal sleeves. A sketch of piping between the boiler outlet and superheater inlet was made and piping flexibility calculations have begun. It appears that the first piping arrangement will be too stiff and will result in too high stresses in the tube sheet thermal sleeves.

Analysis of the first reheater design is continuing. It appears it will be possible to make the reheater all of Croloy 2-1/4. There will be significant saving in cost from a reheater using type 316 stainless steel.

Research & Development Program

A proposal for the investigation of sodium-water reactions in sodium-heated steam generators has been submitted to the Chicago Operations Office. A proposal was requested from APDA for portions of the investigation for which they are best qualified.

c. Sodium Components Test Installation - Atomics International

All the sodium system piping together with associated sodium service and inert gas system has been completed. Some rework of welds that failed to pass radiographic inspection still has to be done. Approximately six welds are in this category. Eight welds that had been repaired were radiographed the last day of the month. After all repairs have been completed satisfactorily the entire sodium system will be mass spectrometer leak checked.

The preheater casing panels were repaired by installing new refractory cement with proper anchors and stainless reinforcing mesh. Both the preheater coil and casings have been installed in the preheater stack breeching. The coil has been welded into the sodium piping system, the casings bolted into the breeching, and refractory cement installation completed where the two sections are joined. All the piping associated with the sodium cooler has been installed and welded.

The secondary sodium pump inner assembly was put together incorporating the shaft to impeller spacer ring. This piece was required in order to correctly align the impeller outlet vanes with the diffuser ports. This assembly has been placed in the pump casing in the sodium piping system. The motor and blower units have been installed on the pump unit.

Work on instrumentation, preheating systems, and thermal insulation started on August 19. Progress during the month on this phase of construction included setting in place of the air compressors and air receiver, and the air heating unit. All this equipment is associated with the air preheating system.

d. Second Round Carbon Analysis - Atomics International

Of the 17 companies which were distributed sodium samples for analysis, three have reported the results of their analysis. The results will be summarized upon receipt of all the samples.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

Test 1 which consisted of the determination of the physical properties of type 316 stainless steel in low oxide sodium, helium, and air at 1200° F has been completed except for two creep tests in helium which are in progress.

Test 2

Test 2, which consisted of the determination of the physical properties of 2½ Cr - 1 Mo steel specimens in low oxide sodium, helium, and air at 1100° F, has been completed except for two creep tests in helium which are in progress.

Test 3

Test 3 consists of determining physical properties of type 316 stainless steel in 1200° F high carbon sodium. The test loop is in shakedown operations. The oxygen and carbon contents have fluctuated to such a degree as to delay the start of the test.

Upon determination of the carbon level in the systems, the carbon bypass tank will be put into operation and the test conditions obtained. Foil samples will then be installed for a two to three week period. After data from these foils have been correlated, Test 3 will be initiated.

Test 4

Test 4 consists of determining physical properties of 2½ Cr - 1 Mo steel specimens in 1100° F high oxide sodium (200-300 ppm). Creep-to-rupture tests are approximately 50% complete. Creep and fatigue tests are under way.

f. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

Water injection tests were completed in August, demonstrating the response of the Rhometer, the variable orifice plugging meter, and the nickel diffusion tube hydrogen monitor to the introduction or inleakage of water into an operating sodium loop. During the injection runs, temperature ramps were employed to determine the thermal stability of water reaction products in loop environment. It was hoped that stability data would lead to an advance in cleanup technique and a method for specific identification of water contamination.

Water injections in 1-cc increments were effected by hypodermic. The water charge vaporized in the pressure-probe and was then purged into the loop with argon. Initial injections were made at 15-minute intervals with the loop at 470°F to determine threshold sensitivity of the meters, and later reduced to 5-minute intervals to observe any change in meter response to higher injection rate. In carrying the loop to higher contamination levels, the operating temperature was raised in ramps to 570 and 770°F. Ramps were timed to precede loop saturation which prevented fouling in the loop and probe. The operating temperatures were selected on the assumption that any thermal dissociation or equilibrium shift in the water reaction products would occur during the 570 to 770°F ramp, and that the calibration runs at 570 and 770°F would be in stable environment. The cover gas was also monitored for hydrogen, to indicate dissociation (of NaH or NaOH) during these runs or at any other point in the test procedures. After the 770°F run the loop was raised to 970°F to observe any further effect on the remaining contaminants which could be construed as specific identification of the sodium-water system. Three final injections were made at 970°F before cleanup to test meter responses at high temperature. Throughout the test sodium samples were taken at appropriate intervals to confirm the contamination levels and to determine the shift in composition of water reaction products with changes in loop operating temperature. Analyses are not yet available for evaluation.

g. Continuous Oxide Meter - United Nuclear Corporation

No report issued for August.

h. Mass Transfer - General Electric Company

Activities during the month were directed toward the operation of the six test loops, analysis of the steel and sodium samples, and evaluations of the corrosion and metallographic data. Continuing effort this month has been devoted to the Carbon-Sodium-Oxygen-Steel system and in particular in the area of fabrication and installation of a high temperature (1200°F) Na sampling port and plugging indicator in the $T_{\max}$ region of the 2½ Cr Loop (No. 5). With this equipment, cover gas^{max} and sodium samples and plugging indicator data will be obtained from both the hot and cold parts of the test loop. Changes in the amount or form of sodium impurities in these two locations should be determined. The ability to obtain sodium samples from a 1200°F pot using our standard pre-evacuated pyrex sample thief was demonstrated using a mockup of the new Loop No. 5 sample port.

The status of the test loops and operational results are as follows:

Loop No. 1 (316 SS) was down for modifications and preparations for run 1 - 6. The in-pipe samples which had been removed for examination were welded into the loop, and the heaters and insulators replaced. The oxide level was adjusted, the flow meter calibrated, the samples loaded, and the run started on August 3, 1963.

The 2800-hour data from runs 3, 4, and 5 of Loop No. 1 display the expected corrosion profile. A comparison of the corrosion rates at the highest and lowest sampleholder temperatures for the three run conditions shows the predominant effect of the high oxide and temperature on the corrosion samples.

Loop No. 2 (316 SS - $2\frac{1}{2}$ Cr) continues on run 2 - 5, 1200°F , 500°F Delta T and ~ 10 ppm oxygen with the oxide level remaining fairly constant.

Loop No. 3 (316 SS - $2\frac{1}{2}$ Cr) was shut down after run 3 - 9 and the samples for post-exposure examination removed. During the run the oxide level remained constant only requiring adjustment immediately following startup.

Loop No. 4 (316 - 5 Cr) continues to run at Test Condition III (T_{max} 1100°F , 500°F Delta T, and ~ 10 ppm oxygen).

Loop No. 5 ($2\frac{1}{2}$ Cr) was down all month for modifications and preparation for the forthcoming chemistry tests.

Loop No. 6 was down for modification and installation of in-pipe samples. Insulation was completed followed by oxide level adjustment and flow meter calibration.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

No report received for August.

j. Sodium Pump Development Test Facility - Westinghouse Electric Corporation

The Fluid Systems group reviewed the preliminary design of the facility and started to establish operating parameters for the primary loop and the auxiliary service systems. Pipe sizes, flow rates, temperatures and pressures throughout the systems are now being established. Approximately 90% of the total work to be done by Fluid Systems was completed as of the end of July. Their remaining effort will consist of revising the systems flow diagrams to present the final concept.

Possible suppliers of instrumentation and control equipment for the test facility are preparing proposals for the Control Systems group. The most suitable equipment for the intended service will then be selected from the proposals. Approximately 90% of the Control Systems group effort is complete. Work remaining includes necessary information on space requirements, cost estimates, and the submission of final recommendations.

The Mechanical Components group issued a request for quotation for the large pipe and fittings for the facility. Replies are expected in September. Only one of the vendors contacted for a quotation on the loop coolers has indicated interest by furnishing a proposal. This proposal is being evaluated and general arrangement information will be sent to UE&C next month. Only about twenty per cent of the total work effort required of Mechanical Components has been completed. The remaining work consists of writing specifications for the flow control valves and feed and drain tanks, providing UE&C with space and service requirements of components, and preparation of the final report.

III. MEETINGS

August 20-21 The Sodium Components Working Group met in executive session at Palo Alto, California

August 28 The Ad Hoc Committee for the Analysis of Carbon in Sodium met in San Jose, California

IV. REPORTS

AI Progress Letter No. 28 for July, "Sodium Components Test Installation," dated August 1, 1963.

AI Surveillance Status and Acceptance Report on the SCTI Steam Generator, AT(11-1)-1213, dated August 2, 1963.

APDA Summary Report, AT(11-1)-865, PA No. 3, "Sodium Resistivity Meter Loop," July 1963.

BLH Weekly Report for week ending August 24, 1963, on Steam Generator Contract AT(11-1)-1213, dated August 24, 1963.

BLH Progress Report for July on Sodium Components Design Program, AT(11-1)-1213, dated August 1, 1963.

B&W Weekly Reports for weeks ending August 2, 9, and 23, 1963.

GE Progress Letter No. 49 for July 1963, "Mass Transfer Investigations in Liquid Metal Systems," AT(04-3)-189, PA No. 15, dated August 5, 1963.

GE Project Status and Cost Report for July 1963, "Irradiation of Mass Transfer in Liquid Metals," dated August 9, 1963.

MSA Progress Report No. 35 for July 1963, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels," dated August 15, 1963.

Westinghouse Sodium Pump Study Project Costs Statement for July, dated August 19, 1963.

Westinghouse Monthly Progress Report No. 7, "Sodium Pump Development and Test Facility Design."

V. CORRESPONDENCE

August 1 Memo, Fremling to Mattmueller, re meeting held at CH on July 31, on R&D being done by B&W under AT(11-1)-1280.

Memo, Smith to Wensch, commenting on SCDP Project Co-ordination Report for June 1963, Section II, Status.

Ltr, Nemzek to Crewe (Attn: Bane), requesting ANL participation in August 19 Ad Hoc Group Meeting to evaluate the present status of second round analysis for carbon in sodium.

August 2 Ltr, Radcliffe (SAN) to Probert, stating that GEAP-4182 will be sent to B&W when it becomes available.

TWX, Nemzek to Levy, granting authorization to initiate procurement of strain gages and conduct their installation on the Alco/BLH steam generator.

- August 5 Ltrs, Nemzek to Lockhart (GE), Weinberg (ORNL), and Eggen (AI), inviting them to Ad Hoc Group Meeting to evaluate the present status of second round analysis for carbon in sodium.
- Ltr, Mattmueller to Steffens (BLH), informing that we gave approval for AI to procure and install strain gages for the testing of the Alco/BLH steam generator at SCTI.
- Memo, Smith to File thru Pursel, trip report, BLH visit on July 30, 1963.
- August 7 Memo, Pursel to Mattmueller, re proposed Modification No. 5 to PA No. 3, AT(11-1)-865 and recommending extension of the contract.
- August 8 Ltr, Seifert to Mattmueller, giving comments re the deviation from the Alco specifications covering the steam generator currently being fabricated by BLH.
- August 9 Ltr, Mattingly to Working Group, transmitting SCDP R&D reports for information and retention.
- August 12 Memo, Pollman to Nemzek, re difficulty in preparing sodium samples for "Round Robin" analysis over the desired range of carbon contents.
- August 13 Memo, Wensch to TLB, transmitting minutes of May SCDP Review Group Meeting for comments and corrections.
- August 16 Ltr, Probert to Wensch, transmitting copies of R&D proposal on Sodium-Water reaction problems.
- Ltr, Abderhalden to Mattmueller, giving cost information on Contract AT(11-1)-1213.
- August 20 Ltr, Mattmueller to Mooradian (B&W), asking to be advised as to when copies of B&W trip reports to other AEC facilities will be received; also asking that copies of the reports be sent to Wensch.
- Ltr, Mattmueller to Mooradian, adding Karl Cohen (GE) to the list of persons who are to receive the monthly and quarterly reports under Contract AT(11-1)-1280.
- August 26 Ltr, Anstine (B&W) to Mattmueller, transmitting copies of trip report of visit to MSA.
- August 27 Ltr, Mattmueller to Abderhalden, giving comments on the discrepancies in the B&W letter dated July 8, 1963.
- August 28 Ltr, Mattmueller to Carbon (University of Wisconsin), changing distribution of the monthly report from Smith to Pursel.

Memo, Richards (CPAO) to Sodium Components Working Group members, asking for comments on draft minutes of the August 20-21, 1963, meeting at Palo Alto, California.

August 29 Ltr, Levy to Gackle (AI), stating that AI is authorized to procure and install strain gages on the BLH steam generator.

Ltr, Nemzek to Crewe (Attn: Bane), thanking ANL for participation in the August 19 Ad Hoc Committee Meeting for review of carbon in sodium analysis. Also asking for comments on draft report of the Ad Hoc Committee.

August 30 Memo, Smith to Richards, giving comments on the draft minutes of the August 20-21 SCDP meeting.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
SEPTEMBER 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Test Facility	Atomics International P. O. Box 309 Canoga Park, California R. Cygan	AT(11-1)-8	CPAO
d. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-8	CPAO
e. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
f. Resistivity Meter (Blake Meter) Loop	Atomic Power Develop- ment Associates, Inc. 1911 First Street Detroit 26, Mich. J. Cameron	AT(11-1)-865 #3	CH
g. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NY
h. Mass Transfer	General Electric Company Atomic Power Equipment Department P. O. Box 254 San Jose 12, California R. W. Lockhart	AT(04-3)189 #15	SAN
i. Sodium Cold Trap Studies	Westinghouse Electric Corp., Atomic Power Div. P. O. Box 355 Pittsburgh 30, Pa. P. Cohen	AT(30-1)-3186	NY
j. Sodium Pump Development Test Facility	Westinghouse Electric Corporation C. C. Randall	AT(30-1)-3123	NY

II. STATUS

a. Steam Generator - Baldwin-Lima-Hamilton Corporation

Fabrication

Both the upper and lower tube sheets have been drilled at the Industrial Process Engineers' (IPE) shops. Inspection has indicated that 2 holes of the total 600 drilled will require special repair procedures. BLH will submit a proposed repair procedure for consideration and possible approval.

All the tubing for the tube bundle has been bent and is now ready for pneumatic leak testing and inspection.

Drilling operations performed at BLH resulted in a large percentage of holes in one set of donut baffles (Pc. 4-6) being oversized causing a rejection of the set. New material has been ordered.

Co-ordination between Atomics International (AI) and BLH has resulted in a strain gage installation procedure and tentative schedule.

Delivery

The delivery date is given as the last week in December 1963.

High-Pressure High-Temperature Test Loop

About 2 weeks effort has been devoted to consideration and evaluation of possible designs for effecting an electrical insulator, high pressure (2400 psi)-high temperature ($\sim 1100^{\circ}\text{F}$) joint for four locations in the loop. Ceramic washers have been tried and were partially successful. A "Cranite" gasket has also been used and appears to be holding at this time. A short debugging run has been started. Furnace temperature profile corrections have been made and water leaks repaired on Number One feedwater pump.

b. Second Steam Generator - Babcock & Wilcox

Full-Size Steam Generator

Design work is proceeding on schedule. Stress analysis of the flanges, tube sheets, and thermal sleeves is in progress. Piping flexibility calculations are being made. Analysis of the first reheater design is under way. It is planned to use flat tube sheets on the reheater. A significant cost savings will result if the analysis indicates their use is feasible. An analysis of the economics of 600°F versus 530°F feedwater temperature has been made. A request to change the specifications from 600°F to 530°F has been submitted.

30 MWt Prototype Steam Generator

Preliminary layout drawings are being made to determine problems of arrangement and assembly of the unit. These drawings will suffice as a base to work from in modeling the problems of the full-size unit.

R&D Program

A current description of the R&D work scope including a cost breakdown has been made and submitted.

Materials

The design of the sodium test loop and the one-tube model boiler is in progress. This design will take into consideration the Croloy 2½/316 SS ratio and the exposed surface to sodium volume ratio expected in a typical large size secondary loop.

Heat Transfer and Two-Phase Flow

Design of the curved test section for installation in the existing electrically heated heat transfer apparatus at Alliance is in progress.

Tube-to-Tube Sheet Welding

Information is now available on tube wall thickness and tube sheet configurations. Mock-ups will be forthcoming and experimental welds made.

c. Sodium Components Test Installation - Atomics International

Bids have been received for the installation of the Alco/BLH steam generator, associated hardware, and instrumentation. A contract package is being prepared for submission to the AEC. The present completed piping systems terminate at the top of the test pit. The above bid package takes the work on from this point and completes the secondary system. The 200 HP, 3600 gpm Byron-Jackson free surface sodium pump inner assembly has been installed.

Contractor work now in progress and per cent completed: Equipment setting 75%, auxiliary preheat boiler piping 60%, high pressure air piping 80%, air preheating tubing 30%, instrumentation 25%, electrical work 20%, and thermal insulation 25%.

The Alco/BLH unit is now expected to arrive at the test site on January 1, 1964. (As of 10/15 this delivery date has slipped to June 1964.)

d. Second Round Robin Carbon Analysis - Atomics International

Of the 18 laboratories which have received samples for analysis, 9 laboratories have submitted the analysis results of at least one sample.

e. Physical Properties of Materials - MSA Research CorporationTest 1

Test 1 which consisted of the determination of the physical properties of type 316 stainless steel in low oxide sodium, helium, and air at 1200°F has been completed. A topical report is being written which will include the results of all the environmental runs and will attempt to correlate these results with the analytical and metallurgical findings.

Test 2

Test 2 which consisted of the determination of the physical properties of 2½ Cr - 1 Mo steel specimens in low oxide sodium, helium, and air at 1100°F has been completed. A topical report is being written similar to that described under Test 1.

Test 3

Test 3 consists of determining physical properties of type 316 stainless steel in 1200°F high carbon sodium.

The final phases of the shakedown operation have been reached prior to running the foils and test specimens in sodium with a high carbon concentration. During the next report period, the loop will be operated with the carbon source in stream, followed by operation with foils in the test units. Carbon samples have been taken almost daily with the results ranging from 43 to 220 ppm. Increasing the temperature of the sampling tank is being studied for the effects of carbon fluctuation in the loop. A portion of sodium removed at temperature from the expansion tank is being gettered at 1600°F and sampled for carbon. The carbon concentration is steadily decreasing.

Test 4

Test 4 consists of determining physical properties of 2½ Cr - 1 Mo steel specimens in 1100°F high oxide sodium (200-300 ppm).

The creep tests in sodium have been in operation over 2800 hours. Some fatigue runs have been completed with the results showing fatigue life in high oxygen sodium to be about the same as in low oxygen sodium and helium.

The creep-rupture runs on the original materials are completed and the results show a consistently lower life, but not of a significant amount, in high oxygen sodium compared to low oxygen sodium.

f. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

The final phase of an evaluation study on the Blake Meter for quantitative determination of impurities in a closed sodium loop is under way. Investigations to date have involved calibration of the resistivity meter for various sodium contaminants at the ppm level, modification to the meter for 1000°F service, and experimental runs with two in-line hydrogen detectors and a variable-orifice plugging meter.

Cold trapping occupied the first two weeks of September. The loop was first ramped to 970°F (in 7 hours), and held at 970°F for 140 hours, which increased plugging temperature from 620 to 750 and raised the Rhometer reading 0.5% r. After cold trapping for 160 hours, the plugging temperature dropped to 212°F and the Rhometer reading returned to zero. Trapping resulted in repeated cold shuts. This was eliminated by heating the trap to 1000°F, dumping the 37-gallon inventory into the loop storage tank, and replacing with clean sodium. The plugging meter values decreased consistently during cold trapping, but the Rhometer readings were erratic.

Sodium hydroxide injections were initiated on September 17 with the tea bag apparatus. The charged tea bags were preheated in an argon lock before submersion into the flowing sodium stream, which prevented sealing over of the porous surfaces by the "cold finger" effect noted in the previous sodium hydride contamination experiment.

The experimental design provided for contamination at 470°F to avoid dissociation of sodium hydroxide, predicted at 600°F, the melting point. At 110 ppm (50 gms) it was necessary to raise the loop to 570°F to expedite solution of the charge. Contamination was then carried to 368 ppm for purposes of comparison with the previous water injection experiment. Ten of the twenty weighed increments charged to the loop were not completely dissolved, and these units were weighed in and out to obtain a material balance. Eight sodium samples were taken during the contamination run, and these samples are being analyzed for validation of contamination levels. A surveillance of loop cover gas established that there were no hydrogen losses to the cover gas at 570°F operating temperature. Rhometer response was consistent at both 470°F and 570°F, but the plugging meter values follow the oxide solubility curve more closely than the hydroxide solubility curve, suggesting a partial conversion of the hydroxide during injection.

Loop cleanup was preceded by a closely monitored temperature ramp in 15°F intervals to 970°F. No "break point" in the dissociation of NaOH was detectable by the Rhometer or the plugging meter. Cold trapping followed and a cold plugging temperature of 213°F was reached in 24 hours.

g. Continuous Oxide Meter - United Nuclear Corporation

Authorization was received on September 30, 1963, to resume testing of the electrochemical continuous oxide meter. Efforts are initially directed toward startup of the forced circulation sodium loop in which the electrochemical cells will be tested and the development of a high temperature electrolyte.

Future plans are to install electrochemical cells in three existing flowing sodium systems that will yield field type operational experience.

h. Mass Transfer - General Electric

Activities during September were directed toward the operation of the test loops, analysis of the steel and sodium samples, and evaluations of the corrosion and metallographic data. Continuing effort this month has been devoted to the carbon-sodium-oxygen-steel system and in particular in the area of shaking down the high temperature (1200°F) Na sampling port and plugging indicator in the maximum temperature region of the 2½ Cr Loop (# 5). With this equipment, cover gas and sodium samples and plugging indicator data will be obtained from both the hot and cold sections of the test loop.

Status of the Test Loops

The loop operating time as of 0800, September 30, average flow data and the dates of oxide level adjustment are tabulated below. Following the table are summaries of individual loop operation for the month.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time*</u>	<u>% Rated Flow</u>	<u>Oxide Level Adjusted</u>
316 SS	1-6	622/1338/17568	0.64	(+) 9/7, 9/21
316 - 2½	2-5	672/13899/21631	0.69	None
316 - 2½	3-10	651/550/20795	0.71	(-) 9/25 (+) 9/11
316 - 5	-	0/0/19722	-	-
2½ Cr	5-6P	148/436/15051	-	-
5 Cr	6-6	641/945/17531	0.41	(-) 9/3, 9/16, 9/27, 9/28 (+) 9/30

Loop 1

Operation under type I test conditions (1200°F T Max, 500°F Δt and ~ 50 ppm oxygen) from 9/1 - 9/2 and from 9/4 - 9/30. The loop was down from 1200 on 9/2 until 1600 on 9/4 for routine sample changing at 722 test hours. Oxide level required adjustment after startup (one cold trap run, one Na₂O makeup addition) and then held fairly constant for several days, decreasing on 9/20 below the limits. Na₂O was added on 9/21 and the oxide level held constant for the rest of the month. Flow fouling reminiscent of 1961 operation was indicated.

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

Loop 2

Operation under type II test conditions (1200°F T Max, 500°F Δt and ~ 10 ppm oxygen) all month. No oxide level adjustments were necessary.

Loop 3

Operation from 9/1 - 9/5 under type V conditions, (1200°F T Max, 250°F Δt and ~ 10 ppm oxygen) without samples, for loop seasoning. Samples were inserted in the holders on 9/6 and the loop was started up. The run started on 9/7 and continued through the end of the month. Following the initial adjustment after startup, the oxide level held constant until 9/24 when an unexplained increase was measured. The sodium was cold trapped on 9/25 and the oxide level was constant for the remainder of the month.

Loop 4

The loop was down all month. Representative sections of piping (including the bimetallic joints) and the H3 and C1 sampleholders were cut from the loop to be used for metallurgical examination. A 316 SS sample holder insert was successfully removed from a deactivated sampleholder. Inserts from the aforementioned Loop 4 sampleholders are scheduled to be removed next month.

Loop 5

The loop was down until 9/12 for repair and replacement of damaged parts as a result of the high temperature plugging indicator leak on 8/31. Startup was made on 9/12 and operation continued under isothermal conditions at $\sim 900^{\circ}\text{F}$ until 9/18 for the purpose of oxide level adjustment and thermocouple checking. The loop was dumped on 9/18 when it became obvious that one of the plugging indicator thermocouples needed replacement. Startup was made again on 9/23, while awaiting delivery on the replacement thermocouples, to develop sampling techniques for the new high temperature sample port. After $\sim 1\frac{1}{2}$ hours of operation, a sodium leak was found at the bypass inlet valve so the loop was dumped. The loop was down for the rest of the month.

Loop 6

Operation under type IV test conditions from 9/1 - 9/18 and from 9/20 through the end of the month. The loop was down 9/18 - 9/20 for routine sample changing at 707 test hours. Oxide level increased slowly with time requiring a downward adjustment approximately once a week.

Steel and sodium samples were withdrawn and submitted for analysis from the 316 SS loop (#1) after 722 hours of type I operation and from the 5 Cr loop (#6) after 707 hours of type IV operation.

The 700 hour data for the 316 SS loop (#1) shows anticipated high corrosion, reflecting the combination of 1200°F T_{max} and high oxide level (~ 52 ppm).

The 2800 hour data for the 316-2 $\frac{1}{4}$ Cr loop (#3) display the normal, expected corrosion profile. The corrosion rates are low, typical of low oxide and low (1100°F) maximum temperature conditions. The three flange leaks unfortunately meant that some 2800 hour exposure results were unobtainable. In addition, because of a flowmeter calibration at H1, at the 700 hour sampling period, the intended 2800 hours sample in that holder had to be removed in order to block the outlet passage for flow diversion through the reference flowmeter. Small, but unexpected, weight gains occurred in the #1 and #3 heater samples as well as at the in-pipe samples. It is possible that carbon corrections will explain this anomaly.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Development of Sampling Techniques

A new mockup trap containing York demister mesh and sodium has been designed and components ordered. The trap will be 6" in diameter by 24" long, and fabricated of schedule 5, 304 stainless steel. There will be two layers of mesh, each one 12 inches high. Areas of the mesh will be identified with wires of different materials to determine relative mesh-sodium movement during the coring operation. The feasibility of labeling the sodium to determine its movement is under investigation. One technique that is being investigated is the injection of colored metallic oxides such as Fe_2O_3 by means of hypodermic needles.

For the coring operations, the prototype will be filled with discrete layers with pure sodium and sodium containing oxides to determine the difference in the coring behavior between the sodium-mesh and the sodium-sodium oxide-mesh.

Two double oscillating hole saws will be tested. The inside diameter of the inner cutter will be relieved 60 mils in one tool and 125 mils in the other. The cutting teeth will be triangular in shape with a 30° cutting angle between the teeth. All corings will be done mechanically.

It is planned to remove a minimum of six radial and two axial core, plugging each hole with a solid rod after removing the sample to prevent sodium displacement during subsequent coring.

Sampling of Enrico Fermi Cold Trap

The tools and fixtures required to sample the Enrico Fermi Cold Trap are being designed.

A requisition has been released for the purchase of the Mueller Tapping Machine which will be used as the movable local "dry-box" instead of a large dry-box to house the entire trap.

j. Sodium Pump Development Test Facility - Westinghouse Electric Corporation

Project Management

Work on the Phase I report was continued throughout the month. Further consideration of the over-all development program phase of the report during a final internal review prior to transmittal indicated that considerable revision of this section of the report was desirable. This revision is necessary to provide a clearer picture of the relationship of the pump development program to the over-all target schedule for the development of fast breeder reactors and to provide for a more desirable stepwise approach to large pumps instead of the single program for the development of a maximum size pump that had been previously outlined. The completion of these changes and the incorporation of informal comments received on the partial draft submitted to NYOO will delay submittal of the Phase I report for approval until September.

Conceptual Design and Cost Estimate of Sodium Pump Test Facility

The Fluid Systems Group has established flow rates, temperatures, pressures, and functional requirements for all components and systems. Flow diagrams have been revised in accordance with the final facility design. Approximately 95% to 100% of the total work to be done by Fluid Systems has been completed. Work remaining is the preparation and review of sections of the final report.

Instrumentation and control equipment has been selected and cost data are being tabulated by the Control Systems Group. Information on space requirements and power consumption of instruments and controls has been prepared for submission to UE&C. Approximately 95% of the Control System Group's work is complete with preparation and review of sections of the final report remaining to be started.

The Mechanical Components Group has received quotations on pipe and fittings and cost and dimensional data for all other components and systems of the facility. UE&C has revised the layout drawings and has prepared write-ups on piping flexibility, the inert gas handling system, the sodium unloading system, fire protection, the electrical system, building structural and architectural details and site requirements and has started preparation of the cost section of the report. Approximately 70% of the Mechanical Components Group's work has been completed. Remaining tasks include transmission of data to UE&C and the writing and review of the final report.

III. REPORTS

AI SCTI Monthly Progress Report #29, August 1963 dated September 4, 1963.

AI Surveillance Status and Acceptance Report dated September 9, 1963, SCTI Steam Generator - AI(11-1)-1213, BLH.

APDA Summary report for August 1963, Contract AT(11-1)-865, PA# 3, Sodium Resistivity Meter Loop.

B&W Weekly Letter Reports for the weeks ending September 6, 13, and 27, 1963.

B&W Progress Report #3 for July 1963, on the Sodium-Heated Steam Generator Development, AT(11-1)-1280, dated September 3, 1963.

BLH Weekly Report on Steam Generator, Contract AT(11-1)-1213, for weeks ending September 7, 14, and 21, 1963.

BLH Monthly Progress Report for August 1963 dated September 5, 1963, under AT(11-1)-1213.

GE Project Status and Cost Report, "Irradiation of Mass Transfer in Liquid Metal," for August 1963 dated September 5, 1963.

GE Monthly Progress Letter Number #50 for August 1963, dated September 5, 1963, "Mass Transfer Investigation in Liquid Metal Systems."

MSA Monthly Progress Report #36 for August dated September 17, 1963, "Effect of 1200 F Sodium on Austenitic and Ferritic Steels."

University of Wisconsin Progress Report #26 for August dated September 16, 1963, "Boiling Liquid Metals Heat Transfer," AT(11-1)-1070.

Westinghouse Monthly Cost Statement for August 1963 on the Sodium Pump Study Program dated September 1963.

Westinghouse Monthly Progress Report No. 8 on the Sodium Pump Development and Test Facility Design dated September 1963.

IV. CORRESPONDENCE

September 2, 1963

Memo, Smith to File thru Pursel - Trip Report: Ad Hoc Mass Transfer Meeting, San Jose, California, August 19, 1963 - SCDP Information Meeting, Palo Alto, California, August 20-21, 1963.

Ltrs, Nemzek to Lockhart, GE; Metz, LASL; Weinberg, ORNL - Thanking them for participating in the August 19 Ad Hoc Committee for the review of carbon in sodium analysis. Also asking for comments on the draft report of the Committee.

September 3, 1963

Memo, Mattmueller to Wensch, states Modification 5 to AT(11-1)-865, PA# 3 extends the contract through September 30, 1963, and provides additional funds of \$15,000.

Memo, Mattmueller to J. Lee asking OC to prepare modification to AT(11-1)-865, PA# 3, for additional funds of \$15,000 and extension of the contract through December 31, 1963.

Ltr, Mattingly to SCDP Working Group transmitting R&D reports related to SCDP for information and retention.

September 5, 1963

Ltr, Wensch to Anstine, B&W, re trip report of visit to MSA on July 11, 1963.

Ltr, Mattmueller to Probert stating September 30 as the date for the completion of the Economic Analysis to Justify Contract Modifications.

Ltr, Pursel to O. E. Dwyer, BNL, transmitting B&W R&D work scope for review and comment. (Identical ltr to W. Savage, ORNL)

September 12, 1963

Ltr, J. C. White, ORNL to Nemzek, returning draft of the minutes of the Ad Hoc Meeting for Carbon in Sodium with comments.

Memo, Dunbar to Pittman re personnel assignments to the SCDP - makes Pursel permanent representative and Purcell his alternate.

Ltr, Mattingly to SCDP Working Group transmitting R&D report for information and retention related to SCDP.

Ltr, Eggen AI, to Nemzek with comments on the draft minutes of the August 19 Ad Hoc Meeting for Carbon in Sodium.

September 13, 1963

Memo, Spencer, CPAO to Casey, CH, SCTI invitation to bid re installation of steam generator and safety system.

Memo, Fremling to Mattmueller thru Redecke - trip report to BLH.

September 16, 1963

Ltr, Levy to L. W. Wheeler, AI, re change in schedule of shipping date for the steam generator - November 15 to December 15.

September 18, 1963

Ltr, C. Metz, LASL, to Nemzek re draft minutes of the Ad Hoc Committee Meeting - states he has no comments.

Ltr, Lockhart, GE, to Nemzek - comments and recommendations on the draft minutes of the Ad Hoc Committee Meeting.

Informal ltr, R. W. Bane, ANL, to Nemzek - comments and recommendations on the draft minutes of the Ad Hoc Committee Meeting.

Memo, SCDP Working Group Members from Wensch transmitting a copy of a letter to Dr. Stephenson with regard to his request for information on the SCDP.

September 19, 1963

Memo, Richards to Nemzek re vibration studies - IHX and steam generator at SCTI.

September 20, 1963

Memo, Pursel to Mattmueller asking for extension of the MSA contract, AT(11-1)-765, to October 31, 1963.

September 23, 1963

Memo, Mattmueller to J. Lee, OC, asking for an appropriate modification to AT(11-1)-765, with MSA.

Ltr, O. E. Dwyer, ANL, to Heckman asking for instructions as to analysis of three samples of sodium from AI.

September 26, 1963

Memo, Mravca to Wensch transmitting information which describes the manner in which we propose to carry out the function of the steam generator Ad Hoc Committee.

Memo, Mattmueller to Lee requesting preparation of Modification 3 to AT(11-1)-1213 with BLH.

September 26, 1963

Ltr, Mattingly to SCDP Working Group transmitting reports related to the SCDP for information and retention.

September 27, 1963

Memo, Pursel to Wensch - states Purcell is now Chairman of the Properties of Materials in Sodium and Carbon in Sodium Ad Hoc Committees.

Ltr, Mattmueller to Staub, MSA, transmitting copies of Modification 1 to Contract AT(11-1)-765 for review and consideration.

Ltr, Abderhalden to Mattmueller transmitting prints of IHX and steam generator which will be tested in the SCTI to G. Gower, RE.

Ltr, Probert to Mattmueller re possibility of modifying AT(11-1)-1280 to specify 530° F feedwater temperature instead of 600° F. States there will be no change in the cost of the design work.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
OCTOBER 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Test Facility	Atomics International P. O. Box 309 Canoga Park, California R. Cygan	AT(11-1)-GEN-8	CPAO
d. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-GEN-8	CPAO
e. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
f. Resistivity Meter (Blake Meter) Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit 26, Michigan J. Cameron	AT(11-1)-865	CH
g. Continuous Oxide Meter	United Nuclear Corp. 5 New Street White Plains, N. Y. H. Steinmetz	AT(30-1)-2877	NY
h. Mass Transfer	General Electric Company Atomic Power Equipment Dept. P. O. Box 254 San Jose 12, California R. W. Lockhart	AT(04-3)-189	SAN
i. Sodium Cold Trap Studies	Westinghouse Electric Corp. Atomic Power Division P. O. Box 355 Pittsburgh 30, Pa. P. Cohen	AT(30-1)-3186	NY
j. Sodium Pump Development Test Facility	Westinghouse Electric Corporation C. C. Randall	AT(30-1)-3123	NY

II. STATUS

a. Steam Generator - Baldwin-Lima-Hamilton Corporation

Fabrication

The baffle structure for the steam generator has been scrapped due to the improper drilling of tube holes. New replacement material has been ordered.

Inspection of the upper and lower tube sheets drilled outside the BLH shop indicate that 2 holes in the upper tube sheet will require special repair procedures or hole plugging.

The scheduled completion date for the steam generator is now May 18, 1964.

High Pressure-High Temperature Test Loop

The last attempt to effect a seal for the feedwater and superheater flanges was unsuccessful. Under service the metallized ceramic disc washers cracked resulting in leakage and current flow across the flange. The flanges are being abandoned and removed from the loop and the connections being made up by seal welding. A "Wheatstone Bridge" circuit is planned now where current is fed to a center tap on the heated section and both ends of the section grounded to prevent "stray" currents.

b. Second Steam Generator - Babcock & Wilcox

Full-Size Steam Generator

Design work, stress analysis, and heat transfer efforts are proceeding on schedule. A preliminary start-up procedure for the boiler and superheater is near completion and sizing of the startup system has started.

30 MWt Prototype Steam Generator

Design work on the Prototype Steam Generator is continuing. A scoping list of necessary drawings required for fabrication has been prepared; layout drawings have been made to determine arrangement and assembly problems.

Design Support R&D

A functional design of the test apparatus for the sodium-heated model steam generator has been prepared; design parameters and test apparatus operating conditions will be studied.

c. Sodium Components Test Installation - Atomics International

Construction

Work continued by the Technical Construction Corporation (TCC) contractor on mechanical and electrical portions of the facility. Over-all work by this contractor is 48% complete. Completion of the compressed air preheating system is almost at hand; application of lines to one mixing tee, pressure testing and connection of flex lines are all that remains. Thermal insulation of the steam and water piping has continued and with completion of the above preheat air lines should allow insulation work to start on the sodium lines.

Schedule

All the bids have been rejected on the Alco-BLH steam generator installation work due to the most recent delay in the completion date (May 18, 1964) for this unit. New bids will be solicited when more confidence is gained in a delivery date.

It is anticipated that all construction work, exclusive of installing a steam generator, will have been completed by January 1, 1964. Following the January 1 completion, a cold pre-operational checkout is to begin.

d. Second Round Robin Carbon Analysis - Atomics International

Of the 18 laboratories which have received samples for analysis, 11 laboratories have submitted the analysis results. It has been requested that all analysis results be submitted by November 30, 1963.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

Test 1 which consisted of the determination of the physical properties of Type 316 stainless steel in low oxide sodium, helium, and air at 1200°F has been completed. A topical report is being written.

Test 2

Test 2 which consists of the determination of the physical properties of 2½ Cr - 1 Mo steel specimens in low oxide sodium, helium, and air at 1100°F has been completed. A topical report is being written.

Test 3

Test 3 consists of determining physical properties of Type 316 stainless steel in 1200°F high carbon sodium. Most of the month (up to October 21) sodium was circulated through the bypass only. Test units and the carbon bed were isolated. Sodium samples were extracted and analyzed for carbon approximately once a day. The data indicated that the carbon level was at or near saturation in 40 ppm O₂, 1200°F sodium. On October 22 the carbon bed was put on the line and little or no difference in carbon content was determined by analysis. The plugging indicator showed 428 ppm O₂. The system was then cold trapped and after 34 hours the plugging indicator showed 350 ppm while a duplicating chemical analysis showed 29 ppm O₂.

Test 4

Test 4 consists of determining physical properties of 2½ Cr - 1 Mo steel specimens in 1100°F high oxide sodium (200-300 ppm). The creep tests are scheduled to reach the end of their run (4000 hours) the first week in November. The specimens exposed for 4000 hours will then be available for tests at this time.

The creep rupture runs on the original materials are completed and the results show a consistently lower life in high oxygen compared to low oxygen sodium.

f. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

Checkout of the Blake Resistivity Meter has been concluded with the exception of a rerun of the hydride test. This second hydrogen gas injection run is being conducted approaching a contamination level of

approximately 300 ppm of sodium hydride to establish the response of the upgraded rhometer and the improved plugging meter to sodium hydride contamination. As part of this run, preliminary information on the rate of dissociation of sodium hydride versus temperature for a 300 ppm concentration of the hydride will be obtained.

g. Continuous Oxide Meter - United Nuclear Corporation

Efforts this month have been directed toward startup of the forced circulation sodium loop which will be used to test the electrochemical cells under development.

h. Mass Transfer - General Electric Company

The loop operating time as of 0800, November 4, average flow data and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> *	<u>% Rated Flow</u>	<u>Oxide Level Adjusted</u>
316SS	1-6	623/1934/18188	0.55	(+) 10/28
316-2½	2-5	541/14409/22169	0.70	None
316-2½	3-10	722/1266/21517	0.69	(-) 10/23
316-5	-	0/0/19722	-	-
2½ Cr	5-6P	171/608/15222	-	-
5 Cr	6-6	775/1716/18302	0.40	(+) 10/4 (-) 10/8

The 1400 hour data for the 316 SS loop (#1) continue to display the high corrosion which was noticed at the first sampling period. The high buildup of corrosion products on the cold leg samples has largely been responsible for the flow fouling observed subsequent to this 1400 hour sample change.

The 700 hour data for the 316SS-2½ Cr loop (#3) show the normal corrosion profile and reflect the higher corrosion associated with the high oxide level of this type V (T maximum = 1100°F, O₂ = 46 ppm) run. For example, this run exhibits weight losses in the hot leg which are 5 to 15 times higher than occurred in the previous (type III - low oxide) run 3-9. Unfortunately the cold leg comparison is not possible, since the cold leg samples in run 3-9 during this time period all lost weight.

The 2800 hour (end of run) data for the 316 SS - 5 Cr loop (#4), as anticipated, show a much lower corrosion under type III (T max. = 1100°F, O₂ = 13 ppm) conditions than was evident in the previous high oxide runs (4-6 and 4-1) or at higher T_{max} conditions (runs 4-5, 4-2, and 4-1).

The 700 hour data for the 5 Cr loop (#6) exhibit a normal corrosion pattern. Of particular interest is the comparison of this run data (Type IV T_{max} = 1200, O₂ = 13 ppm) with that of run 6-5 (Type V T_{max} = 1100 F, O₂ = 46 ppm). The weight changes and therefore the corrosion rates are substantially higher in the present run, apparently showing the temperature effect more than outweighing the higher oxide level of the previous run. This was not the case, for example, with the 316 SS loop (#1) when the same comparison was made and where the reverse was noticed. It will be interesting to watch this trend in successive sampling data from the 5 Cr loop.

*The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

All of the AR data are preliminary (or as observed) since they are issued as promptly as possible for your information. While some of the corrosion rates may appear large, it is convenient to know that a corrosion rate of 100 mg/dm²/mo for material with the density of steel is equivalent to 0.6 mil/yr.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

All of the material to fabricate the new mockup cold trap containing the York demister mesh and sodium has been delivered.

Fabrication of the new coring tools and the oscillating mechanism is under way.

The Mueller tapping machine to be evaluated in the second prototype tests for ultimate use in the sampling of the Enrico Fermi cold trap has been delivered.

j. Sodium Pump Development Test Facility - Westinghouse Electric Corporation

During the month a trip was made to ANL, EBR-II and Atomics International for the purpose of discussing operating difficulties that have been encountered with the operation of primary sodium pumps in the EBR-II and HNPF Reactors.

The EBR-II pumps failed after approximately 150 hours of service. Inspection of the first pump indicated that the 15 mil clearance between the shaft and the labyrinth seal had been lost. The trouble was attributed to bowing of the pump shaft. The damage to the pump shaft was aggravated by a modification in the design details of the labyrinth seals that were incorporated in the EBR-II pumps which differed from the design of the prototype pump that was tested. The bowing or warping of the shaft is believed to have resulted from improper heat treatment. Adequately heat treated replacement shafts are being procured and the clearance of the labyrinth seal is being opened up.

The HNPF primary pumps failed and upon disassembly and examination, metal particulate was found lodged in the close clearance. It is believed that the particles were introduced into the sodium during a repair on a system heat exchanger. In addition a diagonal wear pattern was found on the bearings. This was attributed to slight bearing misalignment resulting from circumferential temperature distribution at the bearing elevation. During the repair of the Hallam pumps, the wear ring seal clearances were opened up.

The conceptual design of the facility has been completed. The Fluid Systems, Control Systems and Mechanical Components groups of W APD as well as the architect-engineer have finished their design work. All facility parameters, pipe sizes, flow rates, temperatures, pressures and service requirements of components, systems and instrumentation have been written and used to obtain cost and physical data. The equipment arrangement and building designs have been finalized.

A preliminary draft of the final report has been prepared using information furnished by groups at W APD and by UE&C.

Work remaining includes the assembly of the cost sections of the report and the writing, review and reproduction of the final draft.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. Hallam Nuclear Power Facility

Following a high temperature fuel outlet scram on October 11, secondary sodium pump No. 2 was difficult to rotate during the startup. Another scram occurred on October 12. This time the pump could not be rotated. An attempt to isolate No. 2 loop failed when the actuator on the primary blocking valve broke. (Note that this is not the throttle valve with which previous actuator problems have been experienced.) The reactor was shut down and systems were cooled. Both No. 1 and No. 2 secondary pumps were drained, removed, cleaned, and inspected. No foreign particles or wear were noted on the wear rings or bearings of either pump. Presence of sodium in the annulus around the shaft had prevented restart after the October 12 scram. The No. 2 primary block valve operator had a sheared pin which has been replaced. All loops are now filled and circulating. Hallam returned to power generator on October 26, 1963.

b. Enrico Fermi Atomic Power Plant

A program is under way to modify the Fermi steam generators to eliminate the tube vibration which caused the recent leakage problem. A tube bundle has been removed from the site and installed in a container for flow testing with water.

Prior to modification the nature and severity of the vibration was determined. The maximum amplitude measured at a flow of 5.4×10^6 lbs/hr was 200 mils at 30 CPS. Testing of the bundle under this condition was held at a minimum to avoid damage to tubes.

A shroud type baffle designed to prevent direct impingement from sodium flow through the inlet nozzles was installed on the bundle. The maximum amplitude measured under this condition was 56 mils at 20 CPS.

Tube restraints which consist of hairpin type clips designed to act as clamps were installed at two elevations in the verticle run of tubes above the first tube bend. The maximum tube vibration under restraint was 5 mils at a flow rate of 30%. As flow was increased above this value, the vibration decreased.

A 500 hour maximum flow test is under way to check if tube vibration remains the same over a period of time.

c. Sodium Reactor Experiment

The reactor was operated at 20 MWt with the outlet temperature at 850°F until 2200 on October 24, 1963. Power was reduced to 12 MWt as required for Step 12 in NAA-SR-MEMO-7804. This step, plus analysis of the hot trap tabs exposed during Step 11, will complete the work outlined in NAA-SR-MEMO-7804. Based on information obtained from previous steps, Step 12 is expected to confirm that the reactor can be operated continuously at 20 MWt with the outlet temperature at 850°F without carburizing fuel clad provided that a hot trap is on stream. AI's next objective is to prepare an addendum to NAA-SR-MEMO-7804 showing that the outlet temperature can be safely increased to the design value which is 960°F. Power was reduced to 7 MWt on October 29, 1963, to induce an xenon transient. Data obtained will be used for calibrating the xenon computer. Improvement in the accuracy of the computer is necessary so that it can be reliably used for startup predictions. This will reduce startup time by one hour.

Reactor shutdown has been rescheduled to November 2, at which time reorificing of some fuel elements and the loading of the two PEP prototype elements into the reactor will be done.

d. EBR-II

The sintered stainless steel filter removed from the plugging indicator loop was found to contain a considerable quantity of material believed to be iron oxide and/or iron. Similar material was found at the bottom of the storage tank, the source of which is believed to be the mill scale from the ferritic pipe in the secondary sodium system. The presence of this material can explain the difficulties with high pressure drop experience in the cold trap.

IV. MEETINGS

October 15, 1963

G. Gower, F. Mattmueller, J. Wimberg, visited BLH to review the status of the Alco/BLH steam generator.

October 23, 1963

J. Purcell and G. Gower visited APDA to discuss the status of the Blake Resistivity Meter.

October 31, 1963

J. Wise, NY, J. Purcell, and G. Gower met with ANL to discuss carbon in sodium technology.

V. CORRESPONDENCE

October 1

Ltr Probert to Savage answering question as to whether or not test data B&W obtains on electrically heated high pressure boiling heat transfer apparatus will be applicable to the problems of a sodium heated steam generator.

October 2

Memo Casey to Pursel requesting comments on the installation of steam generator and safety system - SCTI.

October 3

Memo Mattmueller to Wensch transmitting copies of B&W trip report to California. The report was transmitted in accordance with our requirements under AT(11-1)-1280.

October 4

Ltr Mattmueller to Donnell transmitting one executed copy of Modification #6 of AT(11-1)-865, PA #3 to APDA.

Memo Mattmueller to Wensch - states Modification #6 to AT(11-1)-865, PA #3 was executed on October 4. This agreement extends the term through December 31 and provides additional funds.

Ltr Savage to Probert - states the B&W technique for determining the DNB point and the application of results to sodium heated tubes appear to be basically sound. Savage will support B&W's approach.

October 7

Memo Mattingly to Working Group members transmitting reports re the SCDP for information and retention.

October 8

Memo Pollman to Nemzek transmitting AI letter 63AT6424 which advises CH that AI plans to install all the strain gages at BLH instead of some of them at AI after the steam generator is delivered.

October 11

Memo Pursel to Wensch re the requested change in feedwater temperature - AT(11-1)-1280, B&W. States CH recommends that the contract be modified to specify 530⁰F feedwater temperature and asks HQ approval on this action.

TT Pollman to Nemzek requesting a set of approved drawings for the BLH prototype steam generator for C. E. Peterson, AI.

October 14

Memo Nemzek to Pollman transmitting one set of BLH steam generator drawings.

Memo Mattingly to SCDP Working Group - transmitting reports re SCDP for information and retention.

Ltr Mattmueller to Abderhalden transmitting Modification #3 to AT(11-1)-1213 for review and consideration.

Ltr Mattmueller to Abderhalden transmitting Modification #3 to AT(11-1)-1213 for review and consideration.

October 15

Ltr Pursel to Dwyer, BNL, transmitting copy of the instructions to the participants in the Second Round Carbon in Sodium Analysis Program per Dr. Dwyer's request.

October 17

Memo Mattmueller to J. Lee, OC, requesting a modification to AT(11-1)-765 with MSA to extend the contract through November 30.

October 18

Ltr Nemzek to Carbon in Sodium Participants - transmits reporting instructions and asks that the analytical work and reporting the results be done no later than November 30.

Memo Wensch to Mravca - states HQ concurs in our recommendations re the Ad Hoc Steam Generator and SCTI Committees.

Memo Wimberg to File - trip report - meeting with BLH representatives on October 15.

Ltr Lockhart to Purcell giving most recent results that GE has received for the Second Round samples.

October 21

Memo Pursel to Casey re SCTI invitation to bid - installation of steam generator and safety system.

Memo Pursel to Mattmueller asking that arrangements be made to extend AT(11-1)-765 with MSA through November 30.

Memo Wimberg & Gower to File - trip report - meeting with BLH on October 15. The purpose of the visit was to review the progress and status of the Alco/BLH sodium heated steam generator and the high temperature-high pressure test loop.

Ltr Abderhalden to Mattmueller - states the costs in accordance with AT(11-1)-1213 up to the present date.

October 22

Ltr Dunbar to Liston, BLH, re the progress being made under AT(11-1)-1213 which provides for fabrication of a steam generator and research and development work associated with a test loop.

Memo Wensch to Pursel granting approval to modify AT(11-1)-1280 to specify a 530°F feedwater temperature for the design of a sodium heated steam generator.

Ltr Mattmueller to Staub, MSA, transmitting Modification #12 to AT(11-1)-765 for review and consideration to MSA.

Memo Richards to Working Group members - transmits meeting minutes of the August 20-21 meeting. Also states there will be a December 3-4 Working Group Meeting at HQ.

October 22

Ltr Mattmueller to Donnell - states no action should be taken to initiate the proposed work until CH finishes review of the proposal to AT(11-1)-865, PA #3.

Memo Pursel to Wensch - transmits information which describes the manner in which CH proposes to carry out the function of the Properties of Materials in Sodium Ad Hoc Group.

October 24

Ltr Carbon, University of Wisconsin, to Mattmueller transmitting photographs which were omitted from the September Progress Report.

Ltr Weinberg, ORNL; Eggen, AI; Metz, LASL; Crewe, ANL; and Lockhart, GE, from Pursel transmitting final minutes of the Second Review Meeting of the Ad Hoc Committee for the Analysis of Carbon in Sodium.

TT Mattmueller to Donnell - APDA request for an additional \$6,700 for AT(11-1)-865, PA #3 is approved.

Ltr McCown to Nemzek - states McCown is no longer employed by ANL; Mr. Earl Ebersole has taken his place re carbon in sodium work.

Ltr Donnell to Mattmueller - transmits cost estimate for AT(11-1)-865, PA #3. Also discusses additional testing time.

October 25

Memo Mattmueller to Lee, OC, asking for Modification #7 to AT(11-1)-865, PA #3 for additional funds of \$6,700.

October 29

Memo Mattingly to Working Group transmitting reports for retention and information related to the SCDP.

October 30

Ltr Mattmueller to Probert - states that any requests for information re the sodium heated steam generator be co-ordinated with CH.

Ltr MacPherson, ORNL, to Pursel re scope of the B&W R&D program as presented in Section 4.1 and 4.2 of the B&W Progress Report No. 4.

Memo Mattmueller to Lee, OC, requesting preparation of modification to AT(11-1)-1280 - change in feedwater temperature specifications.

Memo Nemzek to Levy - advises that the BLH steam generator scheduled for December 1963 delivery will not be delivered before May 1964.

October 30

Ltr Saul Siegel, APDA, to Nemzek stating C. R. Moore is no longer connected with Carbon in Sodium Analysis; E. J. Havlena takes his place.

October 31

Ltr Mattmueller to Probert - confirms telephone call in which Gower requested that B&W submit to CH a summary of the mass transfer data needed to fulfill obligations under AT(11-1)-1280.

Ltr Pursel to Carbon in Sodium Participants - transmits summary of results received to date on the Second Round Robin Carbon in Sodium Analysis Program.

VI. REPORTS

AI Sodium Components Test Installation Monthly Progress Report, September 1963, dated October 1, 1963.

AI Surveillance Status and Acceptance Reports for the SCTI Steam Generator, AT(11-1)-1213 (BLH) dated October 8, 1963, and October 28, 1963.

B&W Weekly Letter Reports for the weeks ending October 4, 11, 18, and 25, 1963.

B&W Progress Report #4 for August 1963, Sodium Heated Steam Generator Development, AT(11-1)-1280. (Report came in October)

BLH Weekly Reports on the Steam Generator Contract, AT(11-1)-1213, for the weeks ending October 12, 19, and 26, 1963.

BLH Monthly Progress Report on Sodium Components Design Progra, AT(11-1)-1213, for September 30, 1963, dated October 4, 1963.

GE Progress Letter Number 51, "Mass Transfer Investigation in Liquid Metal Systems," dated October 5, 1963, for the month of September.

GE Project Status and Cost Report, "Irradiation of Mass Transfer in Liquid Metal," for September 1963 dated October 10, 1963.

MSA Progress Report #37 for the month of September 1963 dated October 16, 1963, "Effect of 1200°F Sodium on Austenitic and Ferritic Steels."

University of Wisconsin Monthly Report for September 1963 dated October 18, 1963, "Boiling Liquid Metals Heat Transfer."

Westinghouse Montly Cost Statement for the Sodium Pump Study Project, September 1963. (The report came in October.)

Westinghouse Monthly Progress Report #9 - Sodium Pump Development and Test Facility Design for September 1963 dated October 1963.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
NOVEMBER 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Adminstrator</u>
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e. Physical Properties of Materials	MSA Research Corp. Subsidiary of Mine Safety Appliance Co. Callery, Pa. R. C. Werner	AT(11-1)-765	CH
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j. Sodium Pump Development Test Facility	Westinghouse Electric Corporation C. C. Randall	AT(30-1)-3123	NY

II. STATUS

a. Steam Generator - Baldwin-Lima-Hamilton Corporation

Fabrication

The baffle replacement material has been received. New baffles have been drilled by Industrial Process Engineers (IPE) and returned to BLH for final hole reaming and deburring.

The lower thermal shield has been fabricated and assembled around a dummy baffle structure. This shield has been inserted inside the shell for a dimensional check. It was determined that seven inches of this shield will have to be removed to allow proper assembly.

A replacement set of guide rings were fabricated by IPE and were later discarded due to improper hole position. The original set of guide rings which were previously discarded due to improper hole position were retrieved from discard and repaired for use in the steam generator. These guide rings serve the purpose of holding the upper tube-ends in position for insertion into the upper tubesheet tube holes.

High Pressure-High Temperature Test Loop

A "Wheatstone-bridge" circuit has been installed on the feedwater and superheater tube sections of the loop. Loop operation was started on November 18, 1963, and the above circuits were shown to work satisfactorily. Loop operation has continued for the purpose of debugging, etc.

b. Second Steam Generator - Babcock & Wilcox

Full-Size Steam Generator

The design work is proceeding on the Full-Size Steam Generator. Stress Analysis work is proceeding on the various nozzles and tube sheets. Two dimensional temperature plots have been made for these various nozzles and thermal sleeves for steady state conditions and also for some worst case transients.

Stress Analysis work is continuing on the shell disassembly flanges. These flanges will be very large, thick, and expensive if they are designed for the 300 psi design pressure using normal Code allowable stresses.

Work is continuing on writing the start-up procedure for the Full-Size Boiler. Placing the second boiler in service without encountering high thermal stresses in the boiler or in the intermediate heat exchanger is proving to be somewhat of a problem. After the start-up procedure for the Full-Size Steam Generator has been worked out it can easily be modified to become the start-up procedure for the 30 MWt Prototype Steam Generator

30 MWt Prototype Steam Generator

Design work on the prototype steam generator has been temporarily deferred until the large boiler design is sufficiently along to permit incorporation of design features from the large unit in the prototype unit.

Design Support R&D

Research and Development work has been started on the following projects.

1. Materials - carbon transfer and effect on material properties.
2. Effect on heat transfer and two-phase flow of coiling tubes.
3. Corrosion of Croloy 2 1/4 in products of sodium-water reaction.
4. Procedure for welding tube to back side of tube sheet.
5. Radiographic inspection of back side tube welds.
6. Chemical simulation of sodium environment for leak testing.

c. Sodium Components Test Installation - Atomics International

Construction

Work progress on the Technical Construction Corporation (TCC) contract during the past month is as follows: Over-all work completed to date stands at 67.9%. Mechanical work represents 60% of the entire job and its completion is now 46%. The electrical portion of the job represents 40% of the work and completion of this phase to date is 22%.

All the piping, tubing, valves, and equipment for the air preheating system has been installed. Final completion of this system will be made after the last system pressure test. All electrical duct and conduit is in place. All the pneumatic tubing for the sodium heater instrumentation and control system has been installed. Control wiring for this heater system is now being pulled and when completed, checkout work can be started. The electrical heaters for preheating the secondary piping and the sodium service system are being installed. Approximately 30% of these units are not in place. Thermal insulation application for the sodium piping has started. Steam piping insulation is 95% completed.

Schedule

The work on the TCC contract which was started on August 19, 1963, is now 67.9% completed as noted previously. The scheduled work completion for this same date was 92%. This difference represents 3½ weeks of construction time. The additional slippage was in the electrical area. The prime reason was the one month late delivery of electrical heaters by the heater supplier.

The start of instrumentation checkout did not begin as scheduled because the contractor has not completed the installation of the control and instrumentation associated with the sodium heater. This delay in work completion will result in a delay in system checkout completion.

d. Second Round Robin Carbon Analysis - Atomics International

Results from second round sample analysis have not all been reported. Of the reported results there is considerable scatter of data within laboratories and between laboratories.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

Test 1 which consisted of the determination of the physical properties of Type 316 stainless steel in low oxide sodium, helium and air at 1200°F has been completed. A topical report is being written.

Test 2

Test 2 which consists of the determination of the physical properties of 2½ Cr - 1 Mo steel specimens in low oxide sodium, helium, and air at 1100°F has been completed. A topical report is being written.

Test 3

Test 3 consists of determining physical properties of Type 316 stainless steel in 1200°F high carbon sodium. Perhaps the most significant data to date is being obtained from the current operation of Loop 1. The circulation of 1200°F sodium through a carbon bed has resulted in disagreement between plugging indicator runs and oxygen concentrations as revealed by chemical analyses. The preliminary runs for periods of 1, 4, 6, 11 and 20 days with metal tabs of 316 ss, 304 ss, 2½ Cr - 1 Mo steel and Armco Iron has shown appreciable weight gains and increases in carbon concentration of the tabs. This initial data indicates that carbonization during Test 3 should have an appreciable effect on the life of the specimens under the scheduled tests. The creep and creep-rupture runs on the test specimens will begin in the next report period.

Test 4

Test 4 consists of determining physical properties of 2½ Cr - 1 Mo steel specimens in 1100°F high oxide sodium (200-300 ppm). The creep, creep-to-rupture and fatigue tests on original material have been completed. The creep runs show a consistently lower life in high oxygen sodium as compared to low oxygen sodium. The fatigue data shows little difference in fatigue life of Cr-Mo in sodium with high oxygen or low oxygen.

f. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

During the month of November 1963, the loop was shut down for maintenance except for a test run on November 4 in which methane gas was injected in the loop at 620 F. No reaction was indicated during injection by the Rhometer or by the plugging meter, and 100 per cent of the methane charged was reported in the cover gas.

Note: Methane gas exhibits unusual thermal stability at 1 atm. pressure. A 50 per cent dissociation is predicted at 1360°F in some 290 hours -- see Petroleum Refinery Engineering, W. L. Nelson, McGraw-Hill, 1949, page 584. The same source indicates that butane will decompose completely at 1000°F in 380 seconds.

Following the methane injection run, the loop was cold trapped down to a 223°F plugging temperature, the trap isolated, and the entire sodium inventory dumped to the storage tank. A new cold trap was installed and the saturated trap sealed off for future examination. The pump oil seals were overhauled and all system valves disassembled and repacked. Finally the retention tank was removed from the system for reconditioning, and tank connections capped off. Operation of the test loop should be resumed in mid-December.

g. Continuous Oxide Meter - United Nuclear Corporation

During the month a first draft of the program plan for the project was completed. Construction of the pumped loop was resumed. The work dealt with trace heater and thermocouple wiring. In this period one electrochemical cell was evaluated in a thermal convection loop. The reference electrode consisted of a mixture of nickel and nickel oxide powder to which had been added 6.6 w/o of lead. The cell was operated above the melting point of lead. It was hoped that the presence of a liquid phase would improve the cell by speeding up the establishment of equilibrium. However, this cell functioned poorly and the test was discontinued.

h. Mass Transfer - General Electric Company

The loop operating time as of 0800, December 2, average flow data and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> [*]	<u>% Rated Flow</u>	<u>Oxide Level Adjusted</u>
316 SS	1-6	480/2368/18668	0.59	() 11/27
316-2½	2-5	672/15081/22841	0.70	() 11/18
316-2½	3-10	603/1841/22120	0.70	() 11/4
316-5	--	0/0/19722	--	--
2½ Cr	5-6P	646/1254/15868	--	--
5 Cr	6-6	437/2150/18739	0.40	none

The 14,100 hour data for the 316 SS-2½ Cr loop (#2) , which is on an extended run, continue the normal trend insofar as the hot leg sample weight changes are concerned, since these formed all but one of the samples removed this period. Comparisons of sample weight changes in H1, H2 and H3R with previous exposure periods of similar duration at 11,200 and 8,400 hours show essentially the same weight losses. The inadvertent switch in the positions of the H3 samples when re-loaded after the flange leak at 9577 hours, while perhaps obscuring subsequent corrosion data from these samples, nevertheless provided a clear example of the downstream effect. In each instance, the outlet (or downstream) sample lost less weight than its upstream companion. The removal of the lower one inch of all hot leg samples provided interim metallurgical data. The shorter samples were returned for additional exposure.

The 1400 hour data for the 5 Cr loop (#6) continue the expected or normal corrosion profile. Where the previous (700 hr) data showed greater corrosion for this type IV (1200°F, low oxide) run when compared with the previous type V (1100°F, high oxide) run, the 1400 hour data show the reverse to one more nearly that anticipated (the high oxide runs should indicate higher corrosion rates).

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Fabrication of the new mock-up trap, coring tools, and coring fixture were completed. The mock-up was filled with sodium and sodium-sodium oxide layers and coring in the axial and radial direction has begun.

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

Six corings were made. One coring was axial and the other fine wire radial. The first core was axial through the sodium oxide rich layer using the oscillating saw with the inside diameter of the inner element relieved 125 mils. Difficulty was encountered in penetrating to a depth below $1 \frac{7}{16}$ inches. At this point, the core length was $2 \frac{3}{16}$ inches. After withdrawing the coring tool which contained a small amount of sodium and oxide without mesh, the hole in the trap was plugged with a steel rod. The difficulty in the coring operation was traced to the coring fixture. The guide rails were found to be warped, thereby preventing movement of the box containing the miter gears.

The second coring was radial in the sodium-sodium oxide region with the tool whose inner element was relieved 60 mils. The coring operation was stopped after a penetration of $1 \frac{11}{16}$ inches because the cut plug remained 1 inch in length even though the tool penetration increased from 1 inch to $1 \frac{11}{16}$ inches. At penetrations greater than 1 inch, the coring operation became increasingly difficult. The hole was again plugged.

The next two corings were again radial in the oxide rich region with 125 mils relieved tool. The tool penetration during the first of these two corings was only 1 inch. After pushing the plug up into the coring tool, a second coring (fourth) was attempted in the previously drilled 1 inch deep hole. Again the penetration was only 1 inch even though the loading weight on the cutting tool was increased from 150 to 250 pounds. Inspection of the plug and hole showed that the mesh with the sodium and sodium oxide was being cut and the walls of the hole were not ragged but clearly defined. After the inspection, the hole was plugged.

The fifth core was taken from the sodium mesh layer in the radial direction using the cutter with the 125 mil relief. Penetration was $6 \frac{1}{16}$ inches and the coring became increasingly difficult after a penetration of 2 inches. For this coring, a dead weight load of 450 pounds was used. The length of the plug was only 2 inches even though the hole in the prototype trap was approximately $1 \frac{1}{4}$ inches in diameter and 6 inches deep.

The mesh in the coring tool was removed layer by layer after dissolving the sodium in methanol. Sixty-four layers of mesh were removed. The mesh tightly compacted against a shoulder at the root of the cutting teeth appeared to be clearly cut by the oscillating motion of the tool. Four identifying wires (iron, alumel, cupron, and nichrome) were found in the mesh: the longest one was approximately $1 \frac{1}{16}$ inches and is indicative of the cutting diameter of the oscillating saws.

The shoulder on the inside diameter of the inner cutter was unintentionally left in during the fabrication of the tool and was not, unfortunately, found on inspection.

The final (sixth) core was taken radially from a roll of mesh, 6 inches in diameter (64 layers) using the 125 mil relief cutter after the shoulder was completely removed and the inside diameter of the cutting region was enlarged from the smaller dimension of $\frac{13}{16}$ inch to $\frac{15}{16}$ inch. The 6-inch mesh was easily cut using a dead weight load of 75 pounds except for the final estimated $\frac{1}{4}$ inch or 3 layers of mesh which was purposely left to show the number of layers of mesh that could possibly be cut simultaneously. When the coring was stopped, the tips of the cutting were already protruding through the mesh.

j. Sodium Pump Development Test Facility - Westinghouse Electric Corporation

During the month the Phase I report, WCAP-2347 "Sodium Pump Development and Test Facility Design" was revised in accordance with the New York Operations Office comments and distributed. Distribution was made in accordance with contract specified distribution list plus an additional distribution to a specified list of interested groups at the request of NYOO. The additional distribution was made to facilitate review and discussion of pump test facility requirements at a proposed meeting to be called by AEC in December.

The Phase II report WCAP-2526 "Conceptual Design and Cost Estimate for Sodium Pump Test Facility" was completed during the month and will be forwarded for approval next month following an internal review.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

Sodium Boiler Plant - The secondary system was filled and the main secondary EM pump was brought up to rated capacity while the system temperature was at 460°F. The pump behaved well during this short test. The system temperature was increased to 570°F at which temperature the pump also delivered rated flow. It was planned to run the pump under these conditions for eight hours, to determine thermal equilibrium conditions in the pump and its motor-generator set. However, approximately 45 minutes after the start of the test, the breaker supplying the motor-generator set tripped out.

The plugging temperature rose rapidly during this heat-up and reached 520°F about 48 hours after the system temperature reached 570°F. Since the temperatures of some drain lines were below 520°F, the sodium was dumped to the storage tank to circumvent plugging of lines with oxide.

When cold trap operation was attempted, the pressure drop across the crystallizer tank rose rapidly to high values preventing its use at rates greater than 1 gpm. Work is now underway to replace it with a spare and also to install the temporary cold trap previously used in the primary system. The latter cold trap will be installed in the storage tank mixing line. Present plans also call for installation of a magnetic separator in this same line to trap particles of magnetic iron oxide or reduced iron.

b. Enrico Fermi Atomic Power Plant

The 500 hour maximum flow test of the No. 3 tube bundle from the Fermi steam generator has been completed. The tube bundle was tested at maximum flow to demonstrate that the impact baffles and tube lacing eliminate the tube vibration problem which caused the failure of No. 1 tube bundle of the same steam generator. The test results indicate that the modifications were effective in making the unit suitable for operation.

It is planned to modify the No. 2 bundle with baffles and clips the same as the No. 3 bundle. The No. 1 bundle which failed will be repaired. A total of 37 tube banks were removed. The banks removed were all inspected thoroughly. Only those banks immediately adjacent to the sodium-water reaction in front of the inlet nozzles were damaged.

c. Sodium Reactor Experiment

On November 23, 1963, shim rod withdrawal amounting to twenty-three cents was required over a two-hour period to maintain power. The

reactivity history indicates that the loss of reactivity was caused by failure of a moderator can. The amount of reactivity indicates a can near the core reflector interface. NAA-SR-MEMO-7152 (Rev.), demonstrates that the carbon solution rate from the ruptured can will be 4×10^{-5} pounds/hr. Results from hot trap tabs show the validity of the solution rate for second-phase carbon used in NAA-SR-MEMO-7804. At 900°F this rate is 4×10^{-3} pounds/hr., thus the additional carbon input from the ruptured can is nil. Current plans are to continue to operate as scheduled. Further study of the situation is continuing.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
DECEMBER 1963

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract No.</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia 42, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)-GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)-GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)-765	CH
g. Resistivity Meter (Blake Meter) Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit 26, Michigan J. Cameron	AT(11-1)-865	CH
h. Continuous Oxide Meter	United Nuclear Corporation 5 New Street White Plains, New York H. Steinmetz	AT(30-1)-2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)-189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation, Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania P. Cohen	AT(30-1)-3186	NY
k. Sodium Pump Development Test Facility	Westinghouse Electric Corporation C. C. Randall	AT(30-1)-3123	NY

II. STATUS

a. Steam Generator - Baldwin-Lima-Hamilton Corporation

Fabrication

The baffle structure was assembled, thermocouple feed-throughs positioned, and the thermocouple hot junctions located throughout the structure as specified.

The first or inner row of tubes was positioned in the nest, and in the process of fixing the tubes into the positioning guide ring, tube roller expanding problems developed. It became necessary to abandon this procedure for fixing the tubes and in lieu of it authorize a tack-weld procedure recommended by Baldwin-Lima-Hamilton (BLH). All tubes were tack-welded to the guide rings.

The tube-to-tubesheet welding gun was reworked to resolve several problems that were apparent from initial trial welds. BLH feels they are now ready to train and qualify welders.

BLH acknowledges some delay in their most recent schedule, but they feel the date is still realistic (May 18, 1964, shipping date).

High Pressure-High Temperature Test Loop

All work on the high pressure-high temperature test loop was terminated January 9, 1964. Final reports covering operational history and preliminary heat transfer analysis are forthcoming.

On December 18, 1963, the Steam Generator Test Program Ad Hoc Committee visited BLH to review the status of the Alco/BLH steam generator fabrication.

b. Second Steam Generator - Babcock & Wilcox

"Final" arrangement drawings of the full size steam generator are nearing completion. Emphasis has been placed on solving various thermal stress problems arising out of the sodium by-pass system design.

Upon completion of the plant startup procedures, as they apply to the 30 MWt prototype, they will be reviewed by Atomics International (AI) and modified as needed to integrate them into the SCTI operating procedures.

On December 19 and 20, 1963, the Steam Generator Test Program Ad Hoc Committee reviewed the status of the steam generator and R&D work in progress at Barberton and Alliance, Ohio, facilities.

c. Atomics International Modular Steam Generator

This is the first month that the AI modular steam generator has been included as part of this report. To date the work has been primarily R&D associated with design feasibility, welding development, stress analysis, and economics. Four reports have been published. They are:

NAA-SR-8508 - Design, Performance, and Economics Evaluation of Sodium-Heated, Modular, Supercritical, Steam Generators.

NAA-SR-8514 - Experimental Stress Analysis of 37-Tube Modular Steam Generator Head.

NAA-SR-8515 - Photoelastic Determination of Stress in the AI Steam Generator.

NAA-SR-8541 - A Device for Butt-Welding Modular Steam Generator Tube-to-Tubesheet Joints.

On January 8, 1964, authorization was given to AI to fabricate two low-temperature and two high-temperature modules. These two units are to be considered standby steam generators for test in the SCTI. Their combined rating is expected to be approximately 21 MWt.

d. Sodium Components Test Installation - Atomics International

Construction

The SCTI construction is approximately 95 per cent complete. All major equipment items are installed with the exception of the steam generator and its associated hardware. Some delay is expected due to the contractor erroneously installing globe valves instead of gate valves as specified for the process instrument lines.

Seven men have been assigned to the SCTI operating staff in preparation for preoperational checkout and procedure preparation.

Schedule

Instrumentation checkout work is scheduled to start January 20, 1964. Filling the primary system with sodium is planned for some time in May or June 1964, with the completion of the preoperational testing due around the middle of August. Installation of the first steam generator is to begin in June with test operation due to commence the last part of August.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

Test 1 which consisted of the determination of the physical properties of Type 316 SS in low oxide sodium, helium, and air at 1200°F has been completed. A topical report is being written.

Test 2

Test 2 which consists of the determination of the physical properties of 2½ Cr-1 Mo steel specimens in low oxide sodium, helium, and air at 1100°F has been completed. A topical report is being written.

Test 3

Test 3 consists of determining physical properties of Type 316 SS in 1200°F high carbon sodium. The operation in loop 1 with metal tabs of Armco iron, 2½ Cr-1 Mo, 316 SS and 304 SS for 1, 4, 6, 11, and 20 days has been completed. Weight change and carbon analysis of the metal tabs indicated rapid carburization of stainless steels when exposed to carbon saturated sodium.

On December 23, 1963, the oxide control and indicating loop (OCI) plugged. Since operation of the system is with sodium saturated with carbon, it is probable that the plug in the OCI system is due to some interaction of the carbon. To locate, remove, and analyze this plug, several components of the OCI system were isolated and then carefully drained and washed.

Indications of plugs were observed in the shell side of the economizer and the inlet isolation valve. Washings from these areas are being analyzed. The OCI system has been washed, dried, and returned to the loop.

Since test conditions cannot be maintained without the use of the OCI system, initiation of test 3 has been delayed until it is certain the OCI circuit is operable.

Test 4

Test 4 consists of determining physical properties of 2½ Cr-1 Mo steel specimens in 1100°F high oxide sodium (200-300 ppm). The creep, creep-rupture, and fatigue tests in sodium on both original and exposed specimens have been completed. Exposed specimens have been sent to the University of Michigan for creep-rupture and tensile tests in helium. The creep-rupture tests show a shorter life of both the original and exposed specimens in 1200°F sodium with 300 ppm as compared to sodium with 30 ppm. The fatigue tests showed no difference in fatigue life of 2½ Cr-1 Mo steel in sodium with 300 ppm or 30 ppm oxygen.

The creep tests show the stress for a minimum creep rate of 1 per cent in 10,000 hours to be higher (lower creep rate) in sodium with high oxygen than in sodium with low oxygen, but the creep rate is still higher than in air or helium.

f. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

The overhaul of loop hardware begun in November continued through the second week in December. The retention tank was removed from the loop so that it could be cleaned of deposits, and tank connecting lines were capped off to facilitate replacement in the event that this unit is required for future experiments. The loop cold trap was replaced in order to relieve operating limitations that had become increasingly evident in the 15th month of trap service. Plugging of the trap had frequently occurred during fast temperature ramps and could only be avoided by a very deliberate approach to saturation temperatures. Accumulations in this trap from all experimental runs to date are estimated at 6.5 pounds. Although the actual deposit may weigh several pounds more, its weight is far short of the 70-pound design capacity of the trap. This unit was removed and sealed for future inspection of the York-mesh section and filter.

The replacement cold trap is a duplicate of the original unit. During assembly of this trap the York-mesh was compressed in order to prevent the formation of by-pass channels along the walls of the vessel. This resulted in a 3 to 4 psi increase in pressure drop over that in the original trap.

Three line sections were also removed from the loop and examined to determine the effects of 15 months of loop environment. These sections were selected to show extremes of service exposure--from the relatively protected position of the plugging meter cold leg to the Rhometer hot leg, which was exposed to full loop temperature under continuous flow. The cold trap discharge tube was sectioned for examination because of its high cycling experience. No intergranular corrosion was observed and no carburization was indicated, except in the plugging meter cold leg, which had been torched to 1500°F to free the line after a freeze. In this section carburization was approximately one mil in depth.

Maintenance operations completed, the loop was refilled from storage and sodium cold trapped down to a plugging temperature of 215°F. Recalibration of the Rhometer and plugging meter for NaH contamination was then initiated, repeating the metered hydrogen gas injection procedures of the original calibrations. Loop cover gas was monitored before and after each injection for unreacted hydrogen, and appropriate corrections were made to the theoretical NaH contamination level. Sodium samples were also taken from the loop at 0.5 cf injection intervals for confirmation of contamination levels by lab analysis.

Following the contamination run at 570°F, the temperature of the loop was raised in 50°F intervals and held at each new level for a minimum of two hours. The Rhometer, plugging meter, and hydrogen level in the cover gas were observed at each interval to disclose any evidence of NaH dissociation. No such dissociation was indicated at any point up to 970°F, and no hydrogen was evident in the cover gas during a 6-day soak at 970°F. It was, therefore, concluded that NaH is thermally stable at 970°F under an argon atmosphere and that no dissociation rate can be established at this temperature.

Following the high-temperature soak, sodium in the loop was cleaned by cold trapping and drained to storage. The loop was then shut down.

g. Continuous Oxide Meter - United Nuclear Corporation

No report received.

h. Mass Transfer - General Electric Company

Status of Test Loops

The loop operating time as of January 6, 1964, average flow data, and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time*</u>	<u>% Rated Flow</u>	<u>Oxide Level</u>
316 SS	-	73/0/18741	-	-
316-2½	2-5	835/15916/23676	0.69	(+)12/11, (-)12/14
316-2½	3-10	667/2483/22787	0.70	(-)12/3, 12/11
316-5	-	0/0/19722	-	-
2½ Cr	5-6P	835/2089/16703	-	-
5 Cr	6-6	652/2802/19391	0.40	None

Analysis of Samples

The 1400 and 2100 hour data from the 316 SS - 2½ Cr loop (#3) show a normal pattern of corrosion, exhibiting increasing weight losses in the hot leg as temperature increases, and weight gains in the cold leg which decrease with decreasing temperature. This type V, high oxide, run is producing corrosion rates which are approximately 5 to 10 times that produced in the previous type III run (3-9), but as the following table shows, not much different from that observed in the types II and IV runs where the maximum temperatures were 100°F higher.

*The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

<u>Run</u>	<u>3-10*</u>		<u>3-9</u>		<u>3-8</u>	<u>3-7</u>	<u>3-1</u>
Type	V		III		IV	II	I
H3 (Tmax), F	1100		1100		1200	1200	1200
C3 (Tmin), F	850		600		950	700	700
ΔT , F	250		500		250	500	500
Exposure, hrs	<u>1400</u>	<u>2100</u>	<u>1400</u>	<u>2100</u>	<u>1400</u>	<u>1400</u>	<u>1400</u> ***
Oxide Level, ppm	53	53	11	10	11	11	29-65
C.R.**							
H3	-61	-53	-13	-16	-53	-54	-227
C3 (inlet)	+29	-	3	-	11	+43	-
C3 (outlet)	+18	+16	+5	+2	+3	+26	+14

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Development of Sampling Techniques

Because of a shoulder inadvertently left in the inner cutting tool, the layers of mesh compacted and a uniform core could not be obtained. Subsequently, the shoulder was removed and the tool tested with a roll of mesh, free of sodium, in the radial direction. The same result was encountered, i.e., a non-uniform distribution of mesh. As a final test a 6-inch long screw of 3/16 inch diameter was threaded through the mesh radially and a core cut parallel to and surrounding the screw. A full length core was obtained with quite uniform distribution.

j. Sodium Pump Development Test Facility - Westinghouse Electric Corporation

No report received.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

Reactor operations for the wet critical experiment were completed. The reactor was unloaded to the extent of removing the eight core-type inner blanket subassemblies and replacing them with standard inner blanket subassemblies, and replacing one fourth-row core subassembly with a natural uranium core subassembly. At the end of this reactor unloading, sticking of the fuel gripper occurred. It was found that the sticking occurred between the gripper shaft and the reactor vessel cover. This condition was relieved with the lowering of the reactor vessel cover.

The two primary pumps M-1 and M-2 have been removed from the primary tank. During inspection of the M-1 primary sodium pump, the top baffle in the baffle assembly between the shield plug and the pump case was found to be off center with respect to the pump shaft. The minimum clearance between the baffle and the shaft was determined to be less than 0.035 inch. At the suggestion of the pump manufacturer, the baffle

* Present Run

** $\text{mg/dm}^2/\text{mo}$

*** Exposure period 1400-2800 hours

assembly was machined so that the diameter of the baffle opening is 3/8 inch larger than the pump shaft for the top three baffles and 1/4 inch larger for the bottom baffle. All baffles have been remachined with respect to a pilot diameter to assure concentricity.

A preliminary inspection indicates that the M-2 pump failure was due to the pump shaft rubbing against the lower labyrinth. Aluminum bronze metal from the labyrinth had transferred to the worn area on the pump shaft. Pump components are now being cleaned for repair.

b. SRE

The prototype Hallam uranium-molybdenum fuel element has been successfully operated in the SRE beyond its expected life of 4000 MWD/tonne. Inspection shows that dimensional changes are well within limits. Ninety-five per cent of the rod diameter measurements are within plus or minus 3 mils of the as-built dimension, with the maximum at plus 5 mils. The acceptable limit for continued operation is plus 10 mils. Power generation with the element is continuing and its present burnup is 4500 MWD/tonne.

On December 22, 1963, a second peripheral moderator can failed as indicated by a 21-cent loss in reactivity. This occurred with the reactor essentially isothermal at 475°F and with power at 1/2 MWt. NAA-SR-Memos 7152 and 7804 indicate that excess reactivity rather than carburizing potential will be limiting provided that a hot trap is in operation.

c. Hallam Nuclear Power Facility

The reactor operated between 20 and 80 MWe during the month.

d. Enrico Fermi Atomic Power Plant

The No. 3 steam generator tube bundle with baffles and tube lacing arrived at the plant following the vibration test and was placed in the steam generator vessel in preparation for putting it in service. Vibration pickups have been installed in the steam riser tubes to check the tube vibration characteristics under flowing sodium conditions. These data will be compared with vibration data of these same tubes taken during the water flow tests. Prior to sodium fill a mass spectrometer leak test and a 200 psi nitrogen gas test will be conducted on the tube bundle. Preparations have been made to install baffles and lacing on No. 2 steam generator.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JANUARY 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)-GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)-GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)-765	CH
g. Resistivity Meter (Blake Meter) Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)-865	CH
h. Continuous Oxide Meter	United Nuclear Corporation 5 New Street White Plains, New York J. M. McKee	AT(30-1)-2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)-189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)-3186	NY
k. Sodium Pump Development Test Facility	Westinghouse Electric Corporation C. C. Randall	AT(30-1)-3123	NY

II. STATUS

a. Steam Generator - Baldwin-Lima-Hamilton Corporation

Fabrication

The bundle assembly was completed which consisted of assembling guide rings, assembling and positioning the third, fourth, and fifth rows of tubes, positioning and tacking the guide rings together, tack welding the tubes to the guide rings, and roller expanding the tubes into the lower tube sheet.

The tube bundle subassembly was completed by the addition of the shroud which was fitted and welded in accordance with drawing requirements.

In order to determine if any damage had been done to the Inconel lining on the inside of the tubes when the roller expanders were broken, examination of these surfaces were made using a boroscope. In order to have a record of these conditions, pictures were taken through the boroscope. This proved to be a fairly successful venture as clear pictures were obtained.

During the tack welding of the tubes to the guide rings, two tubes had fuse-through and discoloration on the ID tube surfaces. One tube had discoloration which did not appear to be a fuse-through but which showed a crack in the discolored area. This was discovered during the use of the boroscope when examining a condition of the inside of the tubes. Weld samples were made to duplicate this condition and these samples sectioned in order that a more detailed examination could be made. Sectioned samples of fuse-through showed solution of Inconel and stainless steel destroying the integrity of the Inconel barrier.

The tube bundle subassembly was then pulled into the shell without encountering any major difficulties. The time spent previously in fitting the shroud pieces in the shell is the reason that this operation was so successful. The thermocouple connection bosses were brought out through the shell and tack welded into position. The E.B. ring was fitted between the shell and lower tube sheet joint and tacked into position.

In an attempt to improve the quality of the weld, it was decided to substitute submerged arc welding for the metallic arc welding on the tube-sheet-to-shell joints and tubesheet-to-head joints. Considerable welding time would be saved by this substitution, and the weld repairs would also be minimized.

All the weld repairs to the upper tubesheet on holes 2-27 and 1-4 were completed. This tubesheet was finished machined, deburred, cleaned, and inspected. Thermocouples 55, 56, and 57 were installed and welded to the tubesheet. Operational checks which were made to determine if thermocouples were operative proved them to be satisfactory.

Baldwin-Lima-Hamilton considers the May 18, 1964, delivery date to be realistic.

b. Second Steam Generator - Babcock & Wilcox

Full-Size Steam Generator

The first concept of the reheater had a helical coil tube bundle with a flat cover and integral tubesheets. A bundle made completely of 316 SS was tried but proved to be very expensive, particularly because the tubesheets and headers also were stainless steel.

Croloy 2½ steel will be satisfactory for the reheater from a stress consideration but suffers exfoliation on the surface exposed to the steam if the inner surface temperature is too high. Above some temperature the oxide layer on the inside surface of the tube spalls off and is carried away with the steam. The hot tube metal in contact with the steam breaks down the steam into hydrogen and oxygen. The oxygen forms an oxide layer on the tube that subsequently spalls off again and the whole process repeats itself. Under some conditions serious turbine fouling has occurred because of exfoliation. A careful review is being made of actual field experience with exfoliation in reheaters to determine if Croloy 2½ can be used throughout this reheater.

30 MWt Prototype Steam Generator

The 30 MWt prototype will have 27 one-inch OD tubes in the boiler bank and 55, 7/8-inch OD tubes in the superheater. These tubes will have the same effective length as the tubes in the full-size steam generator. The steam generator shell will be approximately 66 inches ID and will be approximately 40 feet over-all height. The prototype steam generator will weigh approximately 30 tons.

At the present time it is not planned to build a prototype of the reheater because it is felt that many problems which will occur in the reheater will also occur in the steam generator to a much more severe degree and, therefore, a prototype of the steam generator will adequately prove the performance of the reheater.

Materials

The design of the test loop and the various components has been completed. Purchasing of various components such as the sodium pump, etc., has begun. Fabrication has been started on a number of components such as the sodium heater, feedwater heater, sodium pump, and sodium preheater.

Assembly of the test loop is scheduled to begin approximately January 20, 1964.

It may be of historical interest that this test loop will be the fifty-second liquid metal test loop B&W Alliance Research Center has built and operated since 1947. Test loops have been operated with sodium, NaK, lithium, bismuth, and lead.

Heat Transfer - Effect on Heat Transfer and Two-Phase Flow of Coiling Tubes

The purpose of this program is to determine the effect of making a tube in a coil configuration on:

- 1) the location of the Departure from Nucleate Boiling,
- 2) the nucleate and film boiling heat transfer conductances.

The helical coil test section has been completed and installed in the existing test apparatus. Calibration of the various instruments for measuring flow, temperature, and voltage has begun. There are thermocouples and voltage taps at 6-inch intervals along the 21-foot heated length of the 27-foot test section. At each 6-inch interval there are 6 thermocouples distributed at 60° positions around the tube to measure nonuniformity in heat transfer due to the curvature of the tube. The coil has a 16-inch radius simulating the inner coil of the full-size or prototype steam generator.

After the calibration of the instrumentation has been completed it is planned to begin test operation in mid-January 1964.

c. Modular Steam Generator - Atomics International

The design package for the low temperature and high temperature modules has been released for fabrication. Tube specifications for the modular steam generator have been revised to agree with the capability of a representative manufacturer and the revised specifications have been released. Since the sequence of steam generator installation has not been determined, the structure for both types of steam generators will be installed and piping spools made up.

d. Sodium Components Test Installation - Atomics International

Construction

All preheating systems for both the main and service sodium piping have been installed. All the motor power wiring and one-half the control and signal wiring has been pulled in the conduits and wireways. Termination of the motor wiring is in progress. Thermal insulation of all piping has been completed. The gate valves, which will replace the globe valves, which were erroneously installed by the contractor have been delivered to the job site. Instrumentation checkout of the sodium heater has started.

Schedule

The work on the Technical Construction Corporation (TCC) contract which was started on August 19, 1963, is now 91.6 per cent completed. The scheduled work completion for this date (taking in account changes and additions) is 97 per cent. Contractor's estimate of completion has been advanced to March 1, 1964. Almost all the work behind schedule is in the electrical portion. The two largest tasks to be completed are installation of the thermocouple wiring and installation of wiring for electrical preheating.

The instrumentation checkout of the controls associated with the sodium heater has started. The instrumentation and control system construction checkout continues to reveal construction errors in these systems which must be corrected before the functional checkout can be initiated.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

Test 1 which consisted of the determination of the physical properties of Type 316 SS in low oxide sodium, helium, and air at 1200°F has been completed. A topical report is being written.

Test 2

Test 2 which consists of the determination of the physical properties of 2½ Cr-1 Mo steel specimens in low oxide sodium, helium, and air at 1100°F has been completed. A topical report is being written.

Test 3

Test 3 consists of determining physical properties of Type 316 SS in 1200°F high carbon sodium. The operation of loop 1 with metal tabs for determining the carburization potential of the sodium with a carbon source has been completed. The addition of carbon affects the operation of the plugging indicator such that saturation values are considerably higher than oxide saturation temperatures obtained by chemical analysis. Although it is difficult to determine if the carbon concentration is affected by cold trapping due to scatter in the data, these plugging runs appear to be lowered by cold trapping. It is possible, however, that this lowering could be caused by loss of carbon from the sodium by carburization of the stainless steel in the system.

Test 4

Test 4 consists of determining physical properties of 2½ Cr-1 Mo steel specimens in 1100°F high oxide sodium (200-300 ppm). The creep, creep-to-rupture, and fatigue tests in sodium on both original and exposed specimens have been completed. Exposed specimens have been sent to the University of Michigan for creep-rupture and tensile tests in helium. The creep-rupture tests show a shorter life of both the original and exposed specimens in 1100°F sodium with 300 ppm as compared to sodium with 30 ppm. The fatigue tests showed no difference in fatigue life of 2½ Cr-1 Mo steel in sodium with 300 ppm or 30 ppm oxygen.

The creep tests show the stress for a minimum creep rate of 1 per cent in 10,000 hours to be higher (lower creep rate) in sodium with high oxygen than in sodium with low oxygen, but the creep rate is still higher than in air or helium.

Preliminary results indicate faster decarburization of 2½ Cr-1 Mo steel specimens in sodium contaminated with oxygen than in clean sodium.

f. Resistivity Meter Loop - Atomic Power Development Associates, Inc.

The evaluation of the resistivity meter has been completed, and a final report covering this work is in progress.

g. Continuous Oxide Meter - United Nuclear Corporation

No report received.

h. Mass Transfer - General Electric Company

Status of Test Loops

The loops operating time as of February 3, 1964, average flow data, and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> *	<u>% Rated Flow</u>	<u>Oxide Level</u>
316 SS	-	0/0/18741	-	-
316-2½	2-5	672/16588/24348	0.69	(+) 1/15
316-2½	3-10	344/2827/23131	0.71	None
316-5	4-8	573/503/20295	0.80	(-) 1/18
				(+) 1/15, 1/23, 1/30
2½ Cr	5-6P	672/2761/17375	-	-
5 Cr	-	0/0/19397	-	-

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

Analysis of Samples

The 1771, 1934, 2104, and 2368 hour samples for the 316 SS loop (#1) show a normal profile of corrosion and continue the trend of high corrosion observed after the first two sampling periods of this type I run. (T max = 1200°F, $\Delta T = 500^\circ\text{F}$, and O_2 level is ~ 50 ppm.) This high corrosion manifested itself in the form of heavy deposits on the cold leg samples, effectively reducing the area of the flow passages to such an extent that loop flow decreased to the point where rated test temperatures could no longer be maintained. This situation necessitated the removal of samples at 1771 and 1934 hours for alleviation of the fouling, and ultimately, in conjunction with a pump cell failure, forced the premature ending of the run. The corrosion rates observed here were exceeded only by those of the first run in this loop, where temperatures were 100°F higher at all sample locations (T max was 1300°F in the first run versus 1200°F this run). Due to more frequent oxide level monitoring the oxide level of the present run was higher (closer to prescribed test conditions) than run 1-1.

Examination of the in-pipe sample data shows that newly-installed hot leg samples behaved differently (with one or two exceptions) from their previously exposed neighbors, by losing significantly less weight than the latter.

The 2100 hour data from the 5 Cr loop (#6) display weight changes consistent with the expected corrosion profile. The two hot leg samples show little corrosion, while that of the three cold leg samples (as measured by weight gains) seems to be increasing when compared with data from the first two sampling periods.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

See December 1963, monthly co-ordination report.

j. Sodium Pump Development Test Facility - Westinghouse Electric Corporation

No report received.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

Reactor Plant - The M-1 primary sodium pump was reassembled and installed in the M-1 nozzle on January 10, 1964, in preparation for test operation. Break-away torque to turn the pump and motor manually was found to be 5 ft-lb, with the pump submerged in the sodium. The temporary plug which was removed from the M-1 nozzle has been cleaned and is being prepared for storage.

Reassembly and final inspection of the M-2 primary sodium pump were completed in the presence of a representative of the pump manufacturer. The pump is ready for installation in the primary tank, pending receipt and installation of the NaK-filled pressure transmitter assembly.

The plugged secondary cold trap was removed from the purification system. Preparation of the replacement cold trap for installation is continuing.

The fuel gripper has been cleaned and is apparently satisfactory. A substantial buildup of oxides was found. This oxide buildup is now believed to have been the cause of the malfunction. The gripper will be reinstalled after work on the cover lifting screws has been completed.

b. SRE

During the month the reactor power was limited most of the time to 15 MWt by fuel channel temperature spread and moderator can ΔT .

The reactor was shut down between January 9 and January 14, 1964. During the shutdown the stainless steel tab from the dummy element in R-2 was retrieved after an exposure of 17 months for cumulative carburization analysis. Additional sample tabs, consisting of zirconium and Zircaloy 2 with and without welds, were inserted in the upper plenum by using the recently-completed core exposure facility. A damaged snorkel was found on a second corner-channel dummy and the dummy was replaced with a modified center-channel dummy.

A "bowable" element having 25 thermocouples was inserted in the reactor. This element is designed to give the channel temperature distribution as a function of fuel rod position in order to provide basic information for understanding temperature oscillations. The lower baffles on the non-oscillating elements were removed to determine their effect on temperature oscillations.

c. Hallam Nuclear Power Facility

The reactor operated between 15 and 50 MWe during the month.

d. Enrico Fermi Atomic Power Plant

The No. 1 primary sodium pump was removed from the primary system for the replacement of the check valve which is part of the pump. The pump has been disassembled in the maintenance pit and reassembled with the new check.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
FEBRUARY 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)-GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)-GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)-765	CH
g. Resistivity Meter (Blake Meter) Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)-865	CH
h. Continuous Oxide Meter	United Nuclear Corporation 5 New Street White Plains, New York J. M. McKee	AT(30-1)-2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)-189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)-3186	NY
k. Sodium Pump Development Test Facility	Westinghouse Electric Corporation C. C. Randall	AT(30-1)-3123	NY

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

On both the lower and upper tubesheet-to-shell welds all the submerged arc welding was completed. On the former joint, radiographic inspections disclosed a small shallow area which did not meet the requirements. This area was ground out and weld repairs made. On the latter joint, the radiographic examination revealed defects which were fairly deep in the weld. Before rewelding the ground out areas in the upper tubesheet-to-shell weld these areas were cleared by radiographic examination. Subsequent welding proved to be acceptable both by dye penetrant and radiographic examination. Both the upper and lower tubesheet-to-shell welds have been completely cleared and are acceptable.

Representatives of the Steam Generator Testing Program Ad Hoc Committee inspected the tube-to-tubesheet weld qualification mockups of all four welders. A portion of the weld joints in each sectioned welder qualification mockup showed a crack or misfusion at the root pass area between the tubesheet and the tube. When the two-tube consistency sample which was supplied by Alco was also examined, similar conditions existed at the root pass area. Further BLH samples were examined in which the trepan lip had been swaged tightly against the tube at the top of the trepan before welding was started. All welders exhibited proficiency at being able to perform all weld passes except at the root pass where there was cracking. This seemed to be a deficiency in the basic tube-to-tubesheet welding procedure since part of the welds met specifications. Subsequent minor modifications to the welding procedure permitted acceptable welder qualification plates to be prepared and facilitated the qualification of three welders.

All of the steam generator tubes were cleaned full length in order to remove any foreign substances from inside surfaces.

The tubes on both the upper and lower tubesheets were trimmed to the final drawing dimension which is used prior to welding.

The remaining test covers were assembled to the shell side nozzles.

b. Second Steam Generator - Babcock & Wilcox

Full Size Steam Generator

Stress analysis work is proceeding on various nozzles and thermal sleeves. It appears that the sodium inlet nozzles and distributor system do not present as severe a problem from thermal stresses as had been anticipated.

An analysis has been made of the cycling thermal stresses in the various steam generator tubes where they come up through the sodium level to go to the various tubesheets. At the sodium surface there is a sharp change in heat input to the tubes because the heat transfer conductance from sodium to a tube is much greater than from inert gas to a tube. Any movement of the sodium surface such as local turbulence will cause the point of discontinuity in heat input to fluctuate up and down a tube so that any point in the tube wall sees a fluctuating temperature and fluctuating thermal stress. The analysis has shown that these fluctuating stresses are within allowable limits and should not present any problem during the 30-year life of the steam generator.

The thermal sleeve attaching the stainless steel superheater outlet tubesheet to the Cr 2½ vessel shell has a dissimilar weld in it.

Careful analysis is being made of this area on the Full Size Steam Generator, and the 25 MWt Prototype Steam Generator will be designed to model this area as closely as possible.

The design of the full size reheater is proceeding. For the pressure and temperature conditions of the reheater it has been possible to use ferritic alloys throughout the reheater thereby avoiding the problem of a dissimilar weld in each reheater tube and the more expensive stainless alloys on the high temperature portions of the tube bank.

For the high temperature tubes at the steam outlet end of the reheater Croloy 5 appears to be satisfactory. This is a ferritic alloy that can be welded directly to the Croloy 2½. It will have adequate strength for the temperatures at this outlet section and is more resistant to exfoliation at high temperatures than Croloy 2½. The use of all ferritic alloys in the reheater will result in a considerable cost saving over a design having either all or part stainless steel tubes.

Work has been started on writing of the preliminary design report on the Full Size Steam Generator. It is planned to summarize the results of the design calculations in the body of this report and have the actual calculations reproduced as an appendix. The appendix containing the actual calculations will be available on request.

25 MWt Prototype

At the present time it is felt that to model the dissimilar weld between the stainless steel superheater inlet and outlet tubesheets and the Croloy 2½ shell the prototype should have tubesheets that are the same size as the Full Size Steam Generator, although there will be fewer tubes in the tubesheets. It appears that the prototype can be designed with full size superheater tubesheets and still fit within the pit at SCTI.

R&D Program

Heat Transfer - Effect on Heat Transfer Two-Phase Flow of Coiling Tubes

Test data have been obtained at water mass velocities from $.28 \times 10^6$ to 1.4×10^6 lb/hr-ft². These data indicate that curving a tube moves the DNB to higher qualities than would be expected for a straight tube, and curving the tube spreads the DNB out over a considerable length of tube so that the temperature fluctuations observed in the tube wall at the location of DNB are much less than has been observed for straight tubes. These observations are based on preliminary calculations from the raw test data. A more thorough analysis of the data using the digital computer at B&W Alliance Research Center is being made. The design of a new test section to simulate a much larger radius of curvature is under way. This will give a comparison of the data taken for the small radius of curvature, a large radius of curvature, and a straight tube.

Materials - Simulation of Carbon and Materials Transfer of the Full Size Sodium Loop

Fabrication of the various components for this test loop to simulate the loop conditions of a full size steam generator is nearing completion, and erection of the test loop is under way. The instrumentation should be checked out and calibrated and test operation under way by April 1, 1964.

Sodium-Water Reaction

The contract with APDA to have them perform a mathematical analysis of sodium-water reaction problems in the B&W Full Size and 25 MWt Prototype Steam Generators has been drawn up and is being submitted to APDA for signing and to the Commission for approval.

Procedure for Welding Tubes to the Back Side of a Tubesheet

Tubing of the same size and material as the Full Size Steam Generator has been ordered. This tubing will be used to demonstrate this welding procedure on a mockup of a tubesheet. The devices that grip the inside of the tube and draw it up against the tubesheet for welding have been fabricated to be ready for the tubing when it arrives.

c. Modular Steam Generator - Atomics International

The majority of material needed to fabricate the modules has been ordered. Tooling design is under way. Due to unexpected difficulty (porosity in the weld) in making acceptable tube-to-tubesheet welds with 5 Cr- $\frac{1}{2}$ Mo AI intends to fabricate first two high temperature stainless steel modules then follow with the two evaporators thus allowing time to improve the 5 Cr- $\frac{1}{2}$ Mo welding technique. The present schedule indicates completion of the two high temperature superheater modules by July 26, 1964, and two low temperature evaporator modules by September 20, 1964.

The criteria for the modular steam generator test program have been established. Drafts of this program will be available for review June 1964.

d. Sodium Components Test Installation - Atomics International

Construction and Checkout

The Technical Construction Corporation (TCC) contractor has made plans to institute a 60-hour work week in order to finish by April 1, 1964. This will allow AI technicians to begin preoperational checkout of the equipment. This checkout was due to start January 20, 1964; however, union workers forbade AI to energize the equipment. Checkout of part of the pneumatic instruments was accomplished by a joint occupancy agreement. (See attached SCTI Construction and Testing Schedule.)

Operation

Work is under way on writing the preoperational test procedures. Several have been completed, and three remain to be approved of the 17 procedures planned. The operations manual is 30 per cent complete. This document will cover the facility organization, duties and responsibilities of the personnel, plant rules and regulations, plant description, and the standard operating procedures for the SCTI. The plant description is 70 per cent complete, and 10 per cent of the operating procedures have been written.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200° F Sodium with Low Oxygen."

Test 2

Test 2 which consists of the determination of the physical properties of 2½ Cr-1 Mo steel specimens in low oxide sodium, helium, and air at 1100°F has been completed. A topical report is being written.

Test 3

Test 3 consists of determining physical properties of 316 SS in 1200°F high carbon sodium. The operation of this loop with metal tabs for determining the carburization potential of the sodium with a carbon source has been completed. Current operations are to maintain the carbon concentration such that the plugging temperature of the system is ~800°F and at the same time maintain an oxygen level below 30 ppm. These conditions are to be maintained for 21 days at which time the difficulties encountered and the feasibility of beginning Test 3 under these conditions will be evaluated. This operation began February 21, 1964.

Prior to this, operations were being performed to determine if the carbon potential of the system could be monitored with the plugging indicator and if the oxygen level could be controlled by the cold trap. It is evident that the plugging indicator is being affected in a reproducible pattern by the operation of the carbon bed and cold trap. The carbon concentration can be lowered by cold trapping with the carbon bed isolated. The oxide concentration cannot now be determined by the plugging indicator under these high carbon levels. It has also been shown that the oxygen level of the carbon-saturated sodium can be reduced to a low value by cold trapping and, at the same time, the carbon concentration maintained by circulating through the carbon bed. The difference between the plugging indicator and oxygen analysis can easily be observed.

Test 4

Test 4 consists of determining physical properties of 2½ Cr-1 Mo steel specimens in 1100°F high oxide sodium (200-300 ppm). This test has essentially been completed. Results will be forthcoming upon completion of the metallographical studies.

Test 5

Test 5 consists of determining physical properties of 316 SS in 1200°F high oxygen sodium. This test has just begun.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

The 4-inch loop which was constructed for the checkout of the Blake Resistivity Meter is being modified to carry out the following program.

1. Development and evaluation of in-line instruments for the detection and determination of impurities in sodium.
2. Development and evaluation of sodium purification techniques and devices.
3. Investigation of the chemical and physical behavior of impurities in sodium loop environment.
4. Complementary development and refinement of analytical techniques for the determination of sodium contaminants.

g. Continuous Oxide Meter - United Nuclear Corporation

Construction and preoperational checkout of the pumped loop was completed. A plugging meter was fabricated and installed on the loop.

Tests were completed to determine the effects, on cell emf and response, of carbon and hydrogen impurities in the sodium. Carbon additions had no effect. Hydrogen additions produced an immediate drop in cell emf. The emf returned to about its original value after a few days. After recovery, cell response was about the same as before addition.

Conceptual mechanical designs for the prototype and field units were prepared. These are concerned primarily with seals and physical configuration of the sensor. Alternate designs are being evaluated prior to selection of the field unit sensor configuration.

h. Mass Transfer - General Electric Company

Status of Test Loops

The loop operating time as of March 2, 1964, average flow data, and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> *	<u>% Rated Flow</u>	<u>Oxide Level</u>
316 SS	LME**	0/0/18741	-	-
316-2½	2-5**	368/16956/24716	0.68	(+) 2/12
316-2½	LME	0/0/23131	-	-
316-5	4-8	607/1038/20902	0.82	(+) 2/24, 2/26
2½ Cr	5-6P	57/2818/17432	-	-
5 Cr	6-7	307/125/19704	0.39	None

Analysis of Samples

The 2800 hour (end of run) weight change data from the 5 Cr loop (#6) generally show a normal profile of corrosion while displaying some anomalous weight gains at several of the hot leg sample locations and a large weight loss at one of the cold leg sample locations. This latter is almost certainly the result of an erroneous initial weight determination while the small weight gains in the hot leg samples represent little or no corrosion in these samples and the consequent uncertainties in weighing. The corrosion rates in this run ($1200^{\circ}\text{F } T_{\text{max}}$, $250^{\circ}\text{F } \Delta T$ and 12 ppm O_2) are approximately half of that noted in the previous run 6-5 ($1100^{\circ}\text{F } T_{\text{max}}$, same ΔT , 49 ppm O_2) and about double those of run 6-2 (same T_{max} , $500^{\circ}\text{F } \Delta T$ and the same O_2).

As has been previously noted the new "in-pipe" samples behaved differently from their "seasoned" companions. In all cases the new samples gained significant weight in the locations where they were expected to lose weight (e.g., H3-H3R) or where their previously-exposed neighbors lost weight or only gained very slightly (e.g., ST-Pump).

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

** Loop Metallurgical Examination.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Westinghouse work continued to establish a satisfactory technique in cold trap sampling. Evaluation of drills and oscillating scissors is continuing. Preliminary work is in progress on a "harpoon" method of cold trap sampling. This method employs a cylindrical projectile which is shot into the mesh with an explosive charge.

j. Sodium Pump Test Facility - Westinghouse Electric Corporation

Work is completed under this project and is reported in the following:

WCAP 2255 - Survey of Pump Technology, June 1963.

WCAP 2347 - Sodium Pump Development and Pump Design, August 1963.

WCAP 2526 - Conceptual Design and Cost Estimate, November 1963.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

The primary sodium pump No. 2 was installed in the primary tank on February 25, 1964, following the replacement of the pressure transmitter. The motor was installed on the pump, and the breakaway torque required to turn the pump and motor manually was found to be 4 ft-lbs with the pump submerged in sodium.

Installation of the replacement cold trap in the secondary system is nearly complete. The rotating plug seals are being checked out following the installation of the new seal heater control system.

b. SRE

The reactor was shut down in preparation for the Power Expansion Program (PEP) modifications. The main secondary, the auxiliary secondary, and the main primary sodium systems were drained.

c. Hallam Nuclear Power Facility

Operation of the plant was turned over to the Consumers Public Power District on February 6, 1964. The reactor operated on a load following basis during the month except for an eight-day outage for routine maintenance. The principal repairs included a No. 1 primary pump upper seal leak, a steam leak on the special probes in the No. 1 steam generator, and a steam leak on the outlet steam block valved on the No. 3 steam generator.

A flux depression in the southeast quadrant of the core indicated ruptured moderator cans in that region. A further investigation indicated that possibly three cans had failed.

d. Enrico Fermi Atomic Power Plant

The reactor was brought to criticality for the first time since early December. The oral portion of the AEC operator's license examination was carried out, and reactivity worth measurements of core subassemblies were begun.

The sodium impurities meter in the No. 3 secondary sodium circuit was put in service and tested.

Preparations were completed for the removal of the No. 3 primary sodium pump prior to installation of the new check valve on this component.

Enclosure:

SCTI Construction and Testing Schedule

SCTI CONSTRUCTION AND TESTING SCHEDULE

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
MARCH 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)-GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)-GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)-765	CH
g. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)-865	CH
h. Continuous Oxide Meter	United Nuclear Corporation 5 New Street White Plains, New York K. Goldman	AT(30-1)-2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)-189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)-3186	NY
k. Sodium Pump Development Test Facility	Westinghouse Electric Corporation C. C. Randall	AT(30-1)-3123	NY

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

The steam generator was placed in a pit (~ 10 feet deep) in the vertical position, and scaffolding was erected to support the welding equipment and welders. The first pass of the tube-to-tubesheet joint was made and preparations made to conduct a helium leak check (MS).

When the mass spectrometer leak test was conducted to check the over-all leak rate of the root pass of the tube-to-tubesheet welds, it was found that the over-all leak rate exceeded the specifications.

Each tube-to-tubesheet joint was checked using the mass spectrometer to locate any appreciably measurable leaks. Twenty-two leaks were found and were repaired by welding. An over-all mass spectrometer test was then run to determine the over-all leak rate of the 300 tube-to-tubesheet joints. The total allowable leak rate permitted by the specifications (5.0×10^{-7} cc/sec) was still exceeded as evidenced by this test. It was found that small individual leaks accounted for a greater portion of this total leak rate, so the tubesheet was divided into sections to determine an over-all leak rate for each section. Additional leaks were found and repaired. A subsequent MS test indicated an over-all leak rate of 3.3×10^{-6} cc/sec.

The 3.3×10^{-6} cc/sec leak rate was accepted. After the remaining 13 or 14 weld passes per tube-end are completed, another MS test will be performed on the upper tubesheet joints. The dye penetrant examination which followed the MS test mentioned above indicated 80 questionable areas of which 17 were of the linear type. Most of these indications proved to be irrelevant, and very little difficulty was encountered in preparing the surfaces for an acceptable dye penetrant test.

b. Second Steam Generator - Babcock & Wilcox

Full Size Steam Generator

Work is under way on the preliminary design report for the full size steam generator. The transient stress analysis work on various portions of the steam generator is being completed. The manufacturing process description is being written. This process description forms the basis for estimating the cost of the steam generator. The design of the reheater was delayed because the first design concept proved to be too expensive. Work is under way to regain the lost time on the reheater so that it can be included in the preliminary design report.

30 MWt Prototype

Layout drawings have been started on the prototype steam generator. A preliminary manufacturing process has been written and a preliminary manufacturing schedule prepared to show the span time required for manufacturing the 30 MWt prototype. This schedule has shown that material having a long lead time should be ordered very soon to prevent late delivery of this material from delaying the manufacturing of the prototype. Another area that may be a problem is preparing the detailed drawings soon enough to use in manufacturing, yet not require detail drawings to be made before the prototype design is firmly established. These potential scheduling interferences are being investigated.

The piping arrangements required to start up, operate, and test the 30 MWt prototype steam generator are being compared with the system already in existence at SCTI to see what revisions, if any, will be required to test the B&W prototype. It appears that the revisions to SCTI piping will be

minor. After the rough drafts of the startup and shutdown procedures are written these will be discussed with Atomics International.

Layout drawings are under way for the 30 MWt prototype steam generator. One of the objectives of the prototype steam generator is to model the problem areas of the full size steam generator. The prototype is being designed to model the important stress and operating problems as closely as possible, but also is being designed to model some of the fabrication problems as they become apparent from the study of the fabricating procedures for the full size steam generator. By fabrication problems are meant such things as tolerances required in order to be able to assemble the tube bundles and provisions for access for welding and nondestructive testing.

R&D Programs

Heat Transfer - Effect on Heat Transfer and Two-Phase Flow of Coiling Tube

Testing of the small diameter coil simulating the inner coil of the full size steam generator has been completed, and the data are being processed. Fabrication of a large diameter coil simulating the outer coil of the full size steam generator has been completed. This coil has been installed in the test apparatus, and the thermocouples are being connected to the recording instruments. Testing of this diameter coil should begin in approximately one week (March 13, 1964). After the test data are taken for the large diameter coil, they will be compared to data taken from the small diameter coil and to straight tube data to establish the effect of curvature on the location of Departure from Nucleate Boiling and heat transfer.

Because of the interest shown in this heat transfer project at the last Sodium Components information meeting it is planned to devote a major share of the B&W time at the next information meeting to a review of this project. This will be rather timely because the test operation on this project will just have been completed.

c. Modular Steam Generator - Atomics International

Tube-to-tube welds of 5 Cr- $\frac{1}{2}$ Mo for the modular steam generator have been made and found acceptable. The test piece from a representative vacuum melt 5 Cr- $\frac{1}{2}$ Mo tubesheet has been procured and is currently being machined. A control system analysis is continuing for the modules; all steam and feedwater equations have been established.

The Steam Generator Test Program standing committee visited AI on March 12 and 13, 1964, to review progress and development plans. A modification to the modular steam generator design to permit approximately nine thermocouples to be attached on specific tubes in the gas space of each evaporator module is under study.

d. Sodium Components Test Installation - Atomics International

Construction and Checkout

With the exception of some final electrical tie-in and miscellaneous "punchlist" items construction of the SCTI has been completed. Plans are under way to have installed additional steam traps, pressure relief valves, and check valves on the steam/water side.

The design packages for installation of the support structures for both the Alco/BLH and modular steam generators have been released for bids.

Operation

Modifications to the instrument air system and electrical power system test procedures to incorporate pertinent comments supplied by the AI Co-ordinating Committee and Engineering Department are under way. Preparation of natural gas and primary preheat procedures is continuing.

e. Second Round Carbon Analysis - Atomics International

Of the 19 laboratories participating in the second round program 15 submitted some information. Ten of these reported complete analytical data on all three samples.

To evaluate the analytical data a statistical analysis was performed which deals with the variability between laboratories and sample averages, with the variability within a sample, and compares variability between laboratories with variability within a sample. Several interesting trends are indicated regarding samples and the associated methods.

Ledoux, NASA, and APED whose analytical methods are characterized by low temperatures show good agreement with one another. The within-sample variance for Ledoux is significantly smaller than for the other laboratories indicating greater precision. However, NASA which utilizes the same analytical method as Ledoux compares with the other laboratories rather than Ledoux suggesting that Ledoux's better precision is laboratory dependent.

The best sensitivity claimed for the methods was on the order of 5 to 10 ppm. The wet oxidation techniques are limited by the magnitude of the reagent blank while the dry methods seem to be limited by restrictions on the size of sample which may be analyzed. Thus far, it does not appear that there are limitations on the sensitivity caused by the inability to determine the small amounts of carbon gases evolved.

The statistical analysis of the results obtained on the test samples showed that the low temperature techniques, either wet or dry, lead to a higher average total carbon result than do the high temperature oxidations. This analysis also shows that the laboratories using the low temperature oxidation show considerably better agreement among each other than do the other laboratories.

The data from the United Kingdom laboratory which were obtained by a technique utilizing vacuum distillation to remove free sodium from the samples consistently indicated very low carbon impurity. The reasons for the low results are not readily apparent. Because the data do not appear to be part of the population of data, they were not used in the evaluation.

f. Physical Properties of Materials - MSA Research Corporation

Test 1

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2

Test 2 which consists of the determination of the physical properties of 2½ Cr-1 Mo steel specimens in low oxide sodium, helium, and air at 1100°F has been completed. A topical report is being written.

Test 3

Test 3 consists of determining physical properties of 316 SS in 1200°F high carbon sodium. The second 20-day run to determine the feasibility of conducting Test 3 was completed successfully during this report period. This operation was carried out with the carbon concentration such that the plugging temperature was ~800°F and, at the same time, the oxygen level, by chemical analysis, was below 30 ppm. These conditions were maintained by periodic operation of the cold trap and varying the flow through the carbon bed. These conditions duplicated the first 20-day run and showed identical carburization results. Upon receipt of the material for the recently-scheduled impact tests, Test 3 will be initiated.

Test 4

Test 4 consists of determining physical properties of 2½ Cr-1 Mo steel specimens in 1100°F high oxide sodium (200-300 ppm). The tensile runs in helium being tested at the University of Michigan under the direction of Dr. Freeman were finished during this report period. This completes all phases of Test 4. Preliminary results indicate that some effect of high oxygen sodium can be observed in the creep rupture, creep, and tensile tests. However, the data are still being analyzed and further metallurgical examinations are considered necessary before the final results are conclusive.

Test 5

Test 5 consists of determining physical properties of 316 SS in 1200°F high oxygen sodium. The number of specimens and the length of tests will be similar to that of Test 4. The initial operation of Loop 2 has been started. The preliminary tab tests will begin as soon as the oxygen and carbon equilibrium have been established.

g. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Modification of the 4-inch Blake meter loop is continuing. The specifications for the 200-gallon storage tank have been completed, and bids for this item are being solicited.

h. Continuous Oxide Meter - United Nuclear Corporation

Shakedown tests on the pumped loop were started. The loop has operated satisfactorily.

Tests were started to determine the effects of certain operating variables on cell performance. Purging purified argon over the reference electrode did not significantly improve performance of a $\text{ThO}_2\text{-Y}_2\text{O}_3 \parallel \text{Cu:Cu}_2\text{O}$ cell. Satisfactory cell voltage measurements were made with a simplified but less sensitive instrument setup.

Thoria-yttria $\parallel \text{Cu:Cu}_2\text{O}$ cells continue to operate satisfactorily for periods of over one to three months. Two thoria cells approach a desired degree of reproducibility and stability for the field test units.

Detailed design of the finned tube frozen seal field test prototype was continued. The concept appears mechanically feasible.

i. Mass Transfer - General Electric Company

The per cent completion of the five run fractional replicate test plan is 97 per cent including completion of the plan for loops #1, #3, #4, and #5. Loop #4 has been metallurgically examined and has resumed test operation.

Status of Test Loops

The loop operating time as of March 30, 1964, average flow data, and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> [*]	<u>% Rated Flow</u>	<u>Oxide Level</u>
316 SS	LME ^{**}	0/0/18744	-	-
316-2½	2-5	548/17460/25264	0.68	(+)3/11, 3/13
316-2½	LME ^{**}	0/0/23131	-	-
316-5	4-8	368/1407/21270	0.82	(+)3/2
2½ Cr	5-6	454/335/17886	-	(-)3/18,3/19,3/24,3/2
5 Cr	6-7	644/693/20348	0.39	(-)3/5
				(+)3/16

j. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Experimentation with the "harpoon" sampling technique continued. A blank cartridge is used to propel a tube at high velocity into the sample material. A stud gun was used which could fire .32 or .44 caliber cartridges. A regular .32 shell fired a 1-1/8-inch ID tube 1-1/2 inches into sodium-mesh. A regular .44 shell with the same tube resulted in a 2-inch sample. A .44 magnum with the same tube took a 3-1/2-inch sample. Without removing the tube in the last case a second .44 magnum shell was fired causing the tube to go 1 inch deeper. Then a .44 magnum shell was used with a 3/8-inch ID tube. It penetrated the full 6-inch diameter of the test pot and hit the back wall of the pipe. All samples were easily removed leaving straight clean holes. The samples will be weighed, dissolved in alcohol, and weighed again. This will determine if the sodium-to-mesh ratio has changed. Since these results were so encouraging this technique will be pursued next month. The following variations will be tried: axial samples, long sample tubes, different diameters, different weights, and the effect of free travel in air.

k. Sodium Pump Test Facility - Westinghouse Electric Corporation

Work is completed under this project and is reported in the following:

- WCAP 2255 - Survey of Pump Technology, June 1963.
- WCAP 2347 - Sodium Pump Development and Pump Design, August 1963.
- WCAP 2526 - Conceptual Design and Cost Estimate, November 1963.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORSa. EBR-II

The primary tank bulk sodium was heated from 270°F to 580°F over a five-day period. The last bit of wiring for induction heating is being completed on the second system, and the system is almost ready to be filled with sodium. The primary system sodium will be reduced and both systems raised in temperature together. The primary pumps were test operated on March 26, 1964, for a one-hour period.

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

** Loop Metallurgical Examination.

b. SRE

Moderator element G-12 in position R-44 was removed on March 11, 1964, by exerting a 4000-pound pull. Prior to removal two adjacent moderator elements were removed from the core to facilitate the operation. A visual examination showed that the top of the moderator can skin was circumferentially split exposing about 1-1/2 inches of graphite. A dimensional check across the flats indicated about a 5 per cent increase in size as compared to the expected value of 1-1/2 per cent.

All the fuel elements and control rods have been removed from the core and placed in storage cells. To date 22 fuel elements have been canned and shipped to the Radioactive Materials Disposal Facility. Dismantling of the main secondary system has started.

c. Hallam Nuclear Power Facility

The reactor was shut down when an increase in pressure in the instrumented moderator can from 5 to 17.8 psia indicated failure of this can. A reactivity loss of 18 cents occurred at the same time. Following successful rod drop tests and a safety review committee meeting the reactor was returned to power on March 9, 1964. A review of the fuel channel outlet temperatures indicates that four of the moderator cans have failed.

d. Enrico Fermi Atomic Power Plant

The No. 3 primary sodium pump was removed from the system and the dummy plug was inserted in its place. This plug includes an extension which serves to duplicate the function of a closed check valve in preventing back flow through the No. 3 loop with the pump removed. The plug also is designed to carry out the shielding function of the actual plug.

The first water injection tests were carried out in the No. 3 steam generator. Two test runs were conducted, one with the sodium at 600°F and the other with the sodium at 517°F. In each test a total quantity of about 34 cc of water was introduced into the flowing sodium at the bottom of the steam generator. The rate of introduction was about one drop every five seconds, and the introduction extended over a period of about one-half hour.

In each test the hydrogen gas analyzer showed a strong indication of the presence of water in the system. The first indication of a leak was approximately seven minutes after the first drop of water was introduced into the steam generator. The results of these tests have been extremely encouraging and tend to indicate that extremely small leaks of water into the sodium can be detected before sufficient time has elapsed to allow the leak to reach serious proportions.

IV. REPORTS

AI-64AT2148, Sodium Component Test Installation - March 1964.

APDA-163, Operation of the Sodium Technology Loop for Contamination Meter Evaluations, March 25, 1964.

B&W Research Report No. 5452, Progress Report on the Model Sodium Heated Steam Generator, March 6, 1964.

GEAP-4602, Review Draft of the Results of the USAEC Round Robin Analysis for Carbon in Sodium, March 1964.

GE Progress Letter No. 57, Mass Transfer Investigation in Liquid Metal Systems, for March 1964.

MSAR Progress Report No. 43, Effect of High Temperature Sodium on Austenitic and Ferritic Steels, March 1964.

UNC Progress Letter No. 22, Development of a Continuous Meter for Oxygen in Sodium, March 1964.

WCAP-4311, Sodium Cold Trap Studies Monthly Progress Report No. 11, March 1964.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
APRIL 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pa. R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)-GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)-GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)-765	CH
g. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)-865	CH
h. Continuous Oxide Meter	United Nuclear Corporation 5 New Street White Plains, New York K. Goldmann	AT(30-1)-2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)-189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)-3186	NY
k. Sodium-Water Reactor Studies	Atomic Power Development Associates, Inc. J. Morabito	AT(11-1)-865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

All the remaining welding was completed for the upper tube-to-tubesheet welds.

The final mass spectrometer test was run on the upper tubesheet with a resulting leak rate of 2.5×10^{-5} standard cc/sec of air. This leak rate was considerably greater than that allowed by specifications.

Baldwin-Lima-Hamilton made the following recommendation to the AEC which was approved. The mass spectrometer test for the upper tube-to-tubesheet welds would be postponed and would be conducted with the unit in the horizontal position after the lower tube-to-tubesheet welds are completed and tested.

The completed upper tube-to-tubesheet welds were inspected using the dye penetrant method.

The unit was turned over placing the lower tubesheet in the top position. The root pass welding was completed on the lower tube-to-tubesheet welds. A dye penetrant examination was conducted on the root pass weld. In accordance with an approved procedure, the second weld pass was then completed on the lower tube-to-tubesheet welds.

Prior to the mass spectrometer test, the shell side of the unit was pressurized to approximately 70 psi using nitrogen. The welds were covered with acetone in order to determine if any visible leaks were present. All leaks found in this manner were repaired by welding. The mass spectrometer test was conducted with an indicated over-all leak rate of 7×10^{-5} cc/sec on the second weld pass of the lower tube-to-tubesheet welds. This leak rate was in excess of allowable specifications.

A dye penetrant examination of the welds was made. All indications resulting from the dye penetrant examination were either removed or repaired by welding as necessary. The mass spectrometer test was rerun with a leak rate of 7×10^{-8} standard cc/sec of air, well within the allowable specification of 5×10^{-7} cc/sec.

During the welding and MS testing of the lower tube-to-tubesheet joints it became apparent that approximately one quart of vacuum pump oil had entered the shell side of the steam generator by way of the vacuum piping. It is not clear how this happened. Before the unit is removed from the vertical position, this oil will be removed by some suitable solvent. Investigation is being conducted in order to determine which is the best material to use for this operation.

The lower tube-to-tubesheet welding was continued and at the end of May approximately one-third of the seventh weld pass was completed.

Prior to inverting the steam generator, it was necessary to remove a protective can which had been installed over the lower tubesheet and thermocouples. The purpose of this can was to seal the lower end of the unit so that a vacuum could be pulled on the shell side. During the removal of this protective can, damage occurred to several of the thermocouples which are installed on the inside of the lower tubesheet and pass outside the unit to the bosses on the lower tubesheet.

One cluster of three thermocouples (G-4, G-5, and G-6) was sheared off completely at the weld connecting the thermocouple sheath to the thermocouple connector. On the second cluster of three, thermocouple G-7 had the sheath-

to-connector weld cracked all the way around without any apparent damage to the thermocouple wires. G-9 had the sheath-to-connector weld cracked, and thermocouple G-8 was apparently undamaged, but it was bent. The only apparent damage to the third cluster of three (G-1, G-2, and G-3) is that G-2 is bent. After the lower tubesheet welds are completed and tested and the steam generator placed in the horizontal position, this damage will be completely evaluated by the T/C manufacturer and an attempt made to restore them to service.

Delivery

At the end of the month fabrication is approximately 4-1/2 weeks behind schedule. In view of this a new delivery date for the unit is now anticipated to be the latter part of June 1964.

Welding Development

A weld nugget was deposited using the weld wire and flux which is intended to be used for the submerged arc welding of the tubesheet-to-head welds. When the analysis of this deposited weld material was applied to the Schaeffler diagram, it indicated a delta ferrite content of less than 1 per cent. Results of this test were submitted to the AEC.

High Pressure-High Temperature Test Loop

On April 13, 1964, all the material from the test loop which had been designated for Argonne National Laboratory was shipped. During the remainder of the month, all the remaining components were torn down and all BLH material segregated. The only remaining work to be done is the tear down and disassembly of the tower proper. This has been scheduled for the first part of May. After this operation is complete, all this material will be scrapped.

b. Second Steam Generator - Babcock & Wilcox

Full Size Steam Generator

Design work is nearing completion on the full size steam generator and reheater. Cost estimates are being made, and the preliminary design report is being written.

Work is proceeding on the study of the integral reheater steam generator design. A study is under way of utilizing a tubesheet submerged in sodium for the outlet of the boiler bundle. Preliminary results indicate that this tubesheet can be utilized without a thermal shield. If further calculations confirm this preliminary observation, the problem of protecting these tubesheets against high temperature gradients may not be nearly as serious as had been assumed.

30 MWt Prototype Steam Generator

Layout drawings are proceeding on the 30 MWt prototype steam generator to model the problem areas of the full size steam generator. It had been anticipated that thermal stress problems would be severe at the superheater inlet and outlet tubesheets, and the first layouts of the prototype had a superheater inlet and outlet tubesheet that were the same size as the full size steam generator. As calculations were completed on the full size unit the thermal stress problems were not as severe as thought. It is planned to reduce the size of the superheater tubesheets on the 30 MWt prototype to a size suitable for the fewer tubes and put the full size tubesheet at the boiler water inlet.

R&D ProgramsMaterials - Simulation of Mass Transfer and Effects on Material of Full Size Steam Generator

The sodium loop was heated up last week for the first "shake down." Difficulty was experienced with the reactance of the electric heater circuit. The power factor for the transformer was very low, and the current limit of the power transformer was exceeded before full heat output was obtained. Analysis of the electrical characteristics of the test loop indicated that mutual inductance between some portions of the test loop caused the electric heater section to draw a lagging current. The loop is being modified slightly to bring the inductive reactance of the loop down. It is expected the loop will be ready to start up later this week.

Heat Transfer - Effect of Coiling Tubes on Heat Transfer and Two Phase Flow

Testing of the two different radii of coiled tubes has been completed unless further data are required to confirm certain points. Briefly the data show that curving a tube prolongs nucleate boiling to a higher quality than is observed for a straight tube. The Departure from Nucleate Boiling (DNB) occurs first on the side of the tube nearest the center of the coil and occurs considerably later on the side of the tube farthest from the center of the coil. The smaller the radius of curvature the more pronounced this effect is. Prolonging the nucleate boiling regime inside the tube affords a savings in steam generator cost because less heat transfer surface is required. In addition to this, the problem of cycling tube temperatures at the location of DNB is almost eliminated in a curved tube because the temperature change between nucleate and film boiling is considerably less than for a straight tube. The results of this program have already been factored into the design of the prototype steam generator.

Procedure for Welding Tubes to the Backside of a Tubesheet

Sample welds have been made to a tubesheet mockup having the same size tubes and same materials as the full size steam generator. The making of the weld appears to present no problem, but a problem has occurred in making a meaningful X ray of this weld. Because of the high degree of integrity required of welds for a sodium-heated steam generator ways must be found of proving the integrity of these welds if this procedure is to be used. Work is continuing on this problem.

c. Modular Steam Generator - Atomics International

All modular steam generator materials have been ordered. Instrumentation for the evaporator modules (nine thermocouples located on the tubes in the gas space) has been included in the design. The present schedule for the first superheater unit is July 20, 1964. Evaporators should follow in September.

The 321 SS (titanium stabilized) vacuum melt material was rejected because the titanium was inadvertently left out. A second 321 SS batch contained voids and inclusions preventing its use to fabricate the forged head. Voids in the 5 Cr- $\frac{1}{2}$ Mo forgings have been cause for concern also. An evaluation of the situation with the vendor has been made. May 31, 1964, is the earliest date forgings will be available if it becomes necessary to start over again.

Both the 5 Cr- $\frac{1}{2}$ Mo and 321 SS tubing will be shipped back to the manufacturer because of incorrect inspection.

d. Sodium Components Test Installation - Atomics International

Effort is under way to dry the SCTI test pit, provide area drainage, and fence the area. Design work has begun to provide adequate lighting around the loops. During initial testing of the instrument air system, numerous leaks were discovered. It is estimated that of the 50 threaded joints in the line from the compressors to the receiver tank, 40 per cent were not leak tight necessitating repairs.

Bids were received on the structural and pipe spools for the dual steam generators installation. Contracts will be let before April 30, 1964.

e. Physical Properties of Materials - MSA Research Corporation

Tests 1 and 2

Test 1 (316 SS in low oxygen sodium) and test 2 (2½ Cr-1 Mo in low oxygen sodium) have been completed. Test 1 is reported in MSAR Report 64-18. A report covering tests 2 and 4 is being written.

Test 3

Test 3 consists of determining physical properties of 316 SS in 1200°F high carbon sodium. Preliminary operations have been completed and the loop has been shut down for minor repairs. Test 3 is expected to begin during May. The carburization diffusion coefficients have been calculated for 304 and 316 SS at 1200°F. This work is based on the results of the 20-day tab tests and indicates diffusion coefficients of 1.81×10^{-11} cm²/sec for 316 SS and 3.99×10^{-11} cm²/sec for 304 SS. In similar work, Atomics International showed a value of 4.12×10^{-11} cm²/sec for 304 SS. The following over-all conclusions have been reached thus far:

1. MSAR and AI show relative agreement on diffusion coefficients, surface saturations, and case thicknesses.
2. The thick black case observed on tabs and specimens includes carbon concentrations from 3 per cent at the surface to 0.5 per cent at the edge of the case.
3. The predicted carbon profile of a 4000-hour 316 SS specimen has a carbon case to a depth of 20 mils for the 65-mil specimen.
4. The calculated differences in diffusion coefficients for 304 and 316 SS appear to be real, as borne out by both chemical analysis and visual observations.
5. The carburization of stainless steel appears to follow the basic theoretical diffusion relationship.

Test 4

Test 4 consists of determining physical properties of 2½ Cr-1 Mo steel specimens in 1100°F high oxide sodium (200-300 ppm). This test has been completed. The final metallography and data analyses are being completed. The elongation-with-time data, collected during the creep-rupture tests, were used to establish the minimum creep rate versus stress for these tests. These data showed good agreement with the actual creep rate tests and strengthen the values of all the sodium creep rate data. The results of test 4 will be reported in Topical Report No. 3 along with test 2.

Test 5

Test 5 consists of determining physical properties of 316 SS in 1200°F high oxygen sodium. During the month the loop was operated and oxygen was monitored by plugging indicator runs and chemical analysis. Two "breaks" were found in the plugging curves. The first break generally occurred between 640 and 660°F with the second break initially occurring between 550 and 560°F. The chemical analysis data were somewhat scattered but generally fell between the first and the second break. The first break can be eliminated by cold trapping at 400°F or lower. Cold trapping for long periods of time (~ 36 hours) at 500°F did lower the first break temperature from ~650°F to 600°F.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Modification of the 4-inch Blake Meter loop is continuing. Construction drawings of the loop layout and the supporting steel framework are 75 per cent complete, and procurement of major equipment is 50 per cent complete. Operation of the loop will not begin until the fall.

The supporting chemistry for this project is under way. Work on the development of new methods or the improvement of existing methods of chemical analysis of sodium for total carbon, carbonate, oxygen, and hydrogen is in progress.

g. Sodium-Water Reaction Studies - Atomic Power Development Associates, Inc.

This project is in the engineering design and procurement phase and progressing on schedule. The dump tank has been ordered and will be delivered the end of July. The entrainment separator, reaction water supply vessel, and rapid response recording oscillograph have been designed and are out on bid. The design of the reaction vessel is approximately 50 per cent complete.

h. Mass Transfer - General Electric Company

Status of Test Loops

The loop operating time as of May 4, 1964, average flow data, and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> *	<u>% Rated Flow</u>	<u>Oxide Level</u>
316 SS	LME**	0/0/18744	-	-
316-2½	2-5**	840/18300/26104	0.68	(+) 4/13, 4/30
316-2½	LME	0/0/23131	-	-
316-5	4-9	409/92/21679	0.39	None
2½ Cr	5-6	366/701/18252	0.38	(-) 4/6, 4/9
5 Cr	6-7	720/1406/21068	0.38	(-) 3/30
				(+) 4/17

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Experimentation with the "jackhammer" sampling technique was carried out during the month. One-foot long samples one-half-inch and one-and-one-eighth-inch diameter samples were successfully taken from the cold trap

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

** Loop Metallurgical Examination.

mockup. The "jackhammer" technique is apparently the most promising technique available.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

Preliminary checkout of the instrumentation and control of the primary sodium pumps was completed. The pumps were both operated for approximately 70 hours, 55 hours of which were at full power.

On April 15, 1964, the leak detector in the case of the main secondary linear induction pump sounded an alarm. Visual inspection confirmed that the pump duct has developed a leak. The cover of the pump with the attached upper stator was removed for inspection. The upper surface of the pump tubesheet was then visually inspected and found to have developed two cracks about 2 to 3 inches long. The possibility of two smaller cracks in the same area was noted. The sodium which had leaked was apparently pumped toward the high pressure end of the pump until it hit a baffle at the high pressure transition and then sprayed sideways.

b. Hallam Nuclear Power Facility

The reactor operated between 18 and 35 MWe until April 20, 1964, when an electrical storm caused a turbine trip and a reactor scram. After approximately 4 hours the reactor was back on the line. The reactor was shut down April 24, 1964, for the purpose of repairing a valve in the primary sodium service system cell.

c. Enrico Fermi Atomic Power Plant

After the No. 3 steam generator was filled with water, an increase in the hydrogen concentration in the sodium cover gas was observed indicating a possible leak. Water was removed from the steam generator and the unit was tested with helium under pressure. The helium test indicated no leakage.

IV. REPORTS

Atomics International First Monthly Progress Report of the Sodium Components Development Program, April 1964. (Includes SCTI and Modules.)

APDA Sodium Technology Loop Summary Report, April 1964.

BLH Progress Report #COO 1213-23, April 1964.

GE Progress Letter No. 58, Mass Transfer Investigation in Liquid Metal Systems, April 1964.

MSAR Progress Report No. 44, Effect of High Temperature Sodium on Austenitic and Ferritic Steels, April 1964.

WCAP-4312, Sodium Cold Trap Studies Monthly Progress Report No. 12, April 1964.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
MAY 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)-GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)-GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)-765	CH
g. Sodium Technology Loop	Atomic Power Development Associates, Inc 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)-865	CH
h. Continuous Oxide Meter	United Nuclear Corporation 5 New Street White Plains, New York K. Goldmann	AT(30-1)-2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)-189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)-3186	NY
k. Sodium-Water	Atomic Power Development Associates, Inc. J. Morabito	AT(11-1)-865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

The remainder of the lower tube-to-tubesheet welding was completed. The dye penetrant examination was completed and approved.

Tests were conducted for methods of removing the vacuum oil which was inside the shell. Results indicated that a light naphtha would be suitable for this cleaning procedure. Using light naphtha, the oil was flushed out. Samples were taken of the third and fourth flushings, and tests indicated them to be free of oil. Chemical analyses will be obtained on the oil and flushing compound to determine the extent of chloride contamination.

After the oil removal operation a mass spectrometer test on the upper tube-to-tubesheet joints was performed. An over-all leak rate of 4.56×10^{-7} standard cc/sec. of air was indicated. This is just under the specification limitations. The unit was placed in a horizontal position and taken to the Can Shop for further fabrication.

The lower head was fit and tack welded in position, and all the head-to-tubesheet welding, excluding the overlay, was completed on the inside of the upper and lower heads. The welding was continued on the outside portion of the upper and lower head-to-tubesheet welds up to the point where the submerged arc procedure was to be used. Submerged arc welding was started, and a cracking condition was experienced at the center portion of the weld. The geometry of the weld preparation evidently resulted in a concave weld with the center portion being rather thin. The weld which had been deposited by the submerged arc process was removed by grinding. BLH reverted back to using the hand metallic arc process originally specified by Alco.

BLH was informed that AI would not be able to install high temperature flame bonded strain gages on the steam generator at BLH as planned. AI reported that they were unable to obtain the gages. BLH has procured low temperature gages and will install these in lieu of the high temperature gages.

Delivery

With the add-on work and fabrication difficulties experienced this past month it appears that the steam generator should be ready for shipment the second week of July 1964.

b. Second Steam Generator - Babcock & Wilcox

Design Work on Full-Size Steam Generator

Design work on the Full-Size Steam Generator is complete. The cost estimate on the Full-Size Steam Generator is nearly complete. The rough draft of the Preliminary Design Report is approximately 90 per cent completed and is being edited and corrected as the final portions are being written.

30 MWt Prototype Steam Generator

Design work on the 30 MWt Prototype Steam Generator is proceeding. The first layout drawings have been completed and preliminary stress analysis calculations have been made to determine the thicknesses of the various portions of the steam generator. The main prototype shell is designed

thicker than the minimum required for a 300 psi design pressure because of the many unknowns with respect to sodium-water reactions at this time. This degree of conservatism was not used in the design of the Full-Size Steam Generator because a thorough analysis of sodium-water reaction problems will have been made before the final design report on the Full-Size Steam Generator is written and certainly before the Full-Size Steam Generator is built.

R&D Program

Materials - Carbon Transfer and Effect on Materials Properties Simulating Full Size Plant

The modified heater section of the loop was operated at full load, and a severe 120 cps vibration was observed. This vibration was determined to be caused by vibration of the hollow core tube inserted within the heater for power factor correction. The centering lugs on the core tube were banging against the inside of the heater tube. To change the natural frequency of the core tube and make it insensitive to the 60 cycle magnetic forces the core tube was removed and filled with sand, resealed, the reinstalled in the heater tube. This modification corrected the vibration problem, and the test loop was operated to full temperature without difficulty.

The failure of an electric immersion heater in the water circuit of the loop forced the loop to shut down for approximately 24 hours.

Temperature measurements made around the loop indicated that the steam temperature leaving the boiler section and entering the superheater was higher than predicted and also higher than desired to model the performance of the Full-Size Steam Generator. Some minor revisions are being made to the loop piping to adjust this temperature.

Heat Transfer - Effect on Heat Transfer and Two-Phase Flow of Coiling Tubes

The final report on this project is being written. This report will be issued as a topical report.

Corrosion of Croloy 2½ in Products of a Sodium-Water Reaction

Preliminary examination of the data being gathered under this project indicates that the corrosion rates in aqueous sodium hydroxide solutions are in the same order of magnitude as was observed at the Enrico Fermi Atomic Power Plant following a tube leak. Corrosion rates for sodium hydroxide dissolved in sodium appeared to be low and probably will not present any problems.

Procedure for Welding Tubes to Back Side of Tubesheet

Producing electric resistance butt welds in the materials and thicknesses for the steam generator has not proved to be a problem, but proving the integrity of these welds has. The metal extruded out during the welding process obscures an X ray so that a crack in the weld cannot be distinguished from a sound weld.

R&D work on this particular welding process has been discontinued, and a summary report is being written on the findings.

c. Modular Steam Generator - Atomics International

Sixty-eight of the stainless steel tubes have been accepted; fifteen others are questionable and may have to be replaced. Seventy-four tubes for the two units are required; nine are spares. The 5 Cr- $\frac{1}{2}$ Mo tubes are presently being inspected at the vendors. The 321 SS and 5 Cr- $\frac{1}{2}$ Mo billets for the steam generator heads have passed inspection and are now being machined. The completed SS heads are due at AI on June 27, 1964. The 5 Cr- $\frac{1}{2}$ Mo heads are to follow soon after. The 321-H SS shell material is due June 9, and the 5 Cr- $\frac{1}{2}$ Mo shell pieces are due June 10, 1964.

A 5 Cr- $\frac{1}{2}$ Mo tube-to-tubesheet weld specimen failed to pass a bend test. It is apparent that some additional post-weld heat treating is needed on the boiler unit tube-end welds. AI reports that the previous problem of porosity in the 5 Cr- $\frac{1}{2}$ Mo tube-end welds has been resolved.

Several of the handling tools such as slings and strongbacks have been designed and built. The welding jigs and fixtures have also been designed and fabricated. The remaining assembly tools, etc., are currently in design, fabrication, or being procured.

Schedule

The current schedule for the module fabrication indicates that the two stainless steel high temperature modules will be completed next August, and the two low temperature Croloy units are to follow in mid-October.

d. Sodium Components Test Installation - Atomics International

During this report period five of the seventeen planned preoperational tests were in progress. The Instrument Air, SCTI-P-011, was completed, and the remaining four are 50 per cent complete. Color coding and identification of piping, including the associated equipment, was initiated and is approximately 20 per cent complete.

Preparation of preoperational test procedures and standard operating procedures is continuing.

Several areas of major construction effort are being done using the services of a time and materials contractor. These are: modify the drainage of the steam generator test pit; modify inert gas manifold; modify air preheat valves; install water conditioning system; install sodium cooler preheater; modify cold trap system and provide sampling stations; provide improved lighting; provide access platforms, walkways, ladder, etc; install additional safety and check valves in feedwater system; and provide boom to clean water tower screens. In addition, other areas are under study, such as the quick drain for the sodium heater and a fire-fighting system for the steam generator test pit. A major portion of the work will be completed in June.

A detailed safeguards study is in progress. Preliminary evaluation indicates that no missile hazards exists to the environs (out of the test pit). No sodium oxide (hydroxide) fallout problem exists for a tube failure in the sodium heater or tube failure in the steam generator which vents through the provided blowdown tanks.

Contracts were placed for the pipe spools, hangers, and foundations and support structures for both (or either) steam generators. Completion dates are August 11, July 8, and July 14, respectively. All other materials and equipment are on hand except a special high pressure valve for the modular steam generator.

The installation package for the Alco unit is ready to be bid.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

Test 1 (316 SS in low oxygen sodium) has been completed and is reported in MSAR Report 64-18.

Tests 2 and 4

Test 2 ($2\frac{1}{2}$ Cr-1 Mo in low oxygen sodium) and test 4 ($2\frac{1}{2}$ Cr-1 Mo in high oxygen sodium) have been completed, and a topical report covering both tests is being written.

The metallographic studies are being completed for the forthcoming topical report. One of these studies is the comparison of macrohardness data of Cr-Mo specimens exposed in tests 2 and 4. The results indicated:

1. There is a reduction in hardness from R_B 75-77 to R_B 69-71 as a result of exposure of specimens to high purity sodium (test 2) for 4000 hours.
2. There is a decline in macrohardness from R_B 75-77 to R_B 65 as a result of exposure to high oxygen sodium (test 4) for 4000 hours.
3. While few specimens were exposed to a helium or air environment for as long as 4000 hours, only a very slight decline in macrohardness (2 to 3 R_B units) occurred in these non-sodium environments.

The macrohardness results, taken from a significant number of samples in the case of sodium exposures, point to a compositional change in the alloy as a result of exposure to sodium. This change appears to be more marked in the case of test 4 (high O_2) than in test 2. Tests are to be run on specimens exposed to an 1100°F helium environment for comparison. If it can be assumed that decarburization is responsible for these hardness changes, the results appear to support an earlier conclusion on the increase of decarburization in the presence of high oxygen. Macrohardness results will be compared in detail in the forthcoming topical report.

Test 3

Test 3 consists of determining physical properties of 316 SS in 1200°F high carbon sodium. After test conditions were obtained, three creep runs were started at stress levels of 27,500, 24,000, and 21,500 psi. Flow could not be established through the 27,500 psi test unit, and another unit is being prepared to conduct the test. The creep runs are being delayed until the elongation data from these initial creep-rupture tests can be evaluated. The stress levels for the creep tests may then have to be adjusted to obtain the desired 0.1 per cent per 1000 hour creep rate.

Charpy notch tests are to be conducted on 316 SS and $2\frac{1}{2}$ Cr-1 Mo specimens after exposure to sodium containing high carbon. Specimens 2.5 mm and 1.6 mm thick were chosen as opposed to 10 mm thick specimens to provide greater sensitivity to surface embrittling effects. This type specimen also provides a thickness only slightly greater than stressed specimens and corrosion tabs to be exposed in test 3.

Test 5

A 10-day exposure test with tabs of Armco iron, $2\frac{1}{2}$ Cr-1 Mo, 304 SS, and 316 SS is under way. The purpose of this tab test is to determine the

carbon activity and check the oxidation potential in the loop. The regular portion of the test will follow the tab test.

In attempting to establish test conditions, with respect to oxygen and carbon, the operation became involved with double break plugging indicator curves, sodium samples that would not react to standard oxygen analytical procedures, and disagreements between oxygen analyses and PI runs. Several studies were made in order to resolve these problems. One of these was the measure of hydrogen in the sodium and in the cover gas.

Hydrogen in the cover gas was measured with a gas chromatograph as the cold trap temperature was verified. The results show that the hydrogen concentration in the cover gas increases with increasing cold trap temperatures.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Modification of the sodium loop which was used to evaluate the Blake Rhometer is continuing. The modified loop will be used to determine the thermal stability of sodium contaminants and to evaluate new processes designed for sodium purification.

Piping and equipment layout design is 50 per cent complete, and the erection of platform steel is well advanced. All required electrical and instrumental equipment is on hand with the exception of the system heaters. Tanks and exchangers are on order or out for bids, as are the sodium sampling dry box and hydroclone. Sodium sampling coils, a filter cascade, and a cold trap are presently in the design stage.

Supporting chemistry for this project has continued with efforts to develop analytical methods for measuring carbon, carbonate, oxygen, and hydrogen in sodium.

g. Continuous Oxide Meter - United Nuclear Corporation

Test results continue to demonstrate the superiority of thoria electrolyte over previously tested zirconia electrolyte cells. The thoria cells have longer useful life and exhibit less voltage drift at 600°F. Reproducibility of cell voltages and agreement with theoretical cell emf has improved. This improvement is attributed to control of oxygen content in the gas space above the reference electrode.

Thoria 15 w/o Y_2O_3 || Cu:Cu₂O cells have been selected for use in the field test units. Design of the frozen sodium seal housing was completed. Fabrication sketches are being prepared. Vendor quotations were received on most components. Delivery schedules for the thoria tubes may delay assembly and testing of the field units.

Design of instrument package was started. Measurements are being made to establish the allowable current drain from the cell. This influences the type of instrument package necessary to provide continuous indication of cell voltage.

h. Mass Transfer - General Electric Company

The loop operating time as of 0800, June 1, average flow data and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> [*]	<u>% Rated Flow</u>	<u>Oxide Level</u>
316	LME ^{**}	0/0/18744	-	-
316-2½	2-5	672/18972/26776	0.71	(+) 5/26
316-2½	LME ^{**}	0/0/23131	-	-
316-5	4-9	628/720/22307	0.40	(+) 5/7
2½ Cr	5-7	317/259/18569	0.41	Frequent
5 Cr	6-7	430/1809/21498	0.37	None

Analysis of Samples

The 16,956-hour data for the 316SS-2½-Cr loop (No. 2), on an extended Type II run ($T_{\text{max}} = 1200^{\circ}\text{F}$, $\Delta T = 500^{\circ}\text{F}$, oxide level = ~ 10 ppm), continue to show a normal or expected profile of corrosion. Comparisons with previous exposure periods show essentially the same corrosion rates in both the hot and cold legs. An exception, which so far is unexplained, occurred in samples removed from the Cl holder due to a flange leak at 14,149 hours. The weight gain of these samples is not consistent with existing data. That is, the samples with the longest exposure would have been expected to show the greatest weight gain and those with less exposure should have less weight gain. Possible reasons for this observation include that some of the originally deposited material was subsequently removed, either by loss during sample removal or by dissolution during loop operation, or that the buildup of material on the samples caused unequal sodium flow past them.

The 2800-hour (end of run) data for the 316SS - 2½-Cr loop (No. 3) generally display results consistent with those expected during Type V (high oxide runs). Comparison of weight changes with those of previous runs show the dominant effect of the oxygen of this run on corrosion wherein rates comparable to those of the 1200°F runs (versus 1100°F of this run) and more than double those of the previous (Type III- 1100°F , 11 ppm O_2) run occurred. The profile of corrosion of this run was normal, and the weight changes reflected both downstream and velocity dependence.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

The low power experiments prior to the approach to power were begun on May 22, 1964. After completion of preparatory work which included insertion of a second antimony-beryllium source in the inner blanket region, eleven enriched subassemblies were loaded incrementally into the reactor. The current loading consists of 71 enriched subassemblies including 11 control and 2 safety rods together with the boron oscillator assembly in place of the twelfth control rod. The reactor was made critical on May 25, 1964, with approximately 250 in-hours excess reactivity.

The secondary AC electromagnetic pump has been repaired and reinstalled in the secondary system.

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

** Loop Metallurgical Examination.

b. Hallam Nuclear Power Facility

The bellows was replaced on the valve in the primary sodium service system and the reactor was back on the line producing power May 6, 1964. The reactor operated between 13 and 28 MWe until May 19, 1964, when the plant was shut down to run rod drop tests. On May 15, 1964, an approximate loss of 17 cents of reactivity indicated the apparent failure of another moderator can.

c. Enrico Fermi Atomic Power Plant

The reactor continues to be shut down while tests and maintenance work are carried out. Testing of the No. 3 steam generator continued. Analysis of the oxygen content of the sodium indicates that an increase in sodium oxide of about 30 ppm has taken place. This may be due to a water leak, but at present the data resulting from this test are puzzling. As an example, the hydrogen content of the cover gas has been decreasing with an increase in the water pressure. Further tests are planned.

IV. REPORTS

Atomics International Monthly Progress Report of the Sodium Components Development Program, May 1964. (Includes SCTI and Modules.)

APDA Sodium Technology Loop Monthly Report, May 1964.

GE Progress Letter No. 59, Mass Transfer Investigation in Liquid Metal Systems, May 1964.

MSAR Progress Report No. 45, Effect of High Temperature Sodium on Austenitic and Ferritic Steels, May 1964.

UNC Progress Letter No. 23, Development of a Continuous Meter for Oxygen in Sodium for April and May.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JUNE 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
b. Second Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)- GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)- GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
g. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)- 865	CH
h. Continuous Oxide Meter	United Nuclear Corporation Five New Street White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)- 3186	NY

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
k. Sodium - Water	Atomic Power Development Associates, Inc. J. Morabito	AT(11-1)- 865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

The outside portion of the upper head to tube sheet weld was completed using the manual metallic arc procedure. Radiographic examination disclosed minor defective areas in this portion of the weld. These defects were removed by grinding and the areas rewelded. Radiographic and dye penetrant examination proved the welds to be within the specification limitations. The Inconel overlay was completed on the inside of the head. Dye penetrant, X-ray, and ultrasonic examination of the overlay proved it to be satisfactory.

The outside portion of the lower head to tube sheet weld was completed using the manual metallic arc processes. Radiographic examination of the weld indicated certain areas which did not meet specifications. These defective areas were repaired and radiographic and dye penetrant examinations proved the welds to be within the specification limitations. The Inconel overlay was completed on the inside of the head. Dye penetrant, X-ray, and ultrasonic examination proved this portion of the weld to be satisfactory.

The thermocouples on the upper tube sheet were installed in accordance with drawing specifications. The thermocouple pads were welded to the tube sheet and the thermocouple bosses welded to the tube side outlet nozzle.

The exterior of the shell was cleaned and the insulation supports and the liquid level indicator brackets were welded in position on the exterior of the shell.

Delivery

The delivery date for the unit is presently estimated to be the last week in August.

b. Second Steam Generator - Babcock & Wilcox

Design Work on Full-Size Steam Generator

Design work on the Full-Size Steam Generator has been completed. The Preliminary Design Report for the Full-Size Steam Generator has been completed and advance copies have been given limited distribution to facilitate a Phase I review.

30 MWt Prototype Steam Generator

Design work on the 30 MWt Prototype Steam Generator is proceeding. The cost estimate for the 30 MWt Prototype Steam Generator has been completed. In making this cost estimate the latest arrangement

drawings were used, all of the significant material was listed item by item, and the cost of each item of material was calculated. To determine the manhours required for fabrication a detail manufacturing process was written, a Gant chart was made showing the critical path and slack paths in the manufacturing processes, and the manhours for each operation were estimated.

R&D Program

Materials - Carbon Transfer and Effect on Materials Properties Simulating Full Size Plant

The model loop has operated for a total period of 785 hours. It is planned to shut down the loop on about July 12, 1964, for the removal of the first samples. After the removal of the samples the operation of the loop will be continued.

c. Modular Steam Generator - Atomics International

Parts required for the fabrication of the Modular steam generator units are being received and most items are in-house. Parts which have not been received are: (1) stainless steel tube sheets, (2) the stainless steel shells which are now being re-sized and retested, (3) two of the four chrome-moly tube sheets, and (4) thermocouple assemblies. A decision has been made to fabricate the chrome-moly units first since the chrome-moly tube sheets were received first. The estimated completion date of the last module is still October 10, 1964.

The checkout of the equations describing the transient characteristics of the evaporator and superheater unit on the analog computer has experienced considerable difficulty. Basic equations have been checked by the Mathematics group and seem to be fundamentally sound. A new approach to programming the analog computer will be tried.

Fatigue testing of the 2½ Cr 1 Mo tube sheet assembly has completed 33,600 cycles with no discernible fatigue damage. Additional tests will be performed on test specimens of 5 Cr ½ Mo and 2½ Cr 1 Mo material to compare their fatigue characteristics.

d. Sodium Components Test Installation - Atomics International

SCTI Operations

During June two preoperational tests, Natural Gas System and Inert Gas Systems were completed; fourteen preoperational tests remain to be completed of which four were in progress at the end of June. In the meantime, preparation of preoperational test procedures and standard operating procedures is continuing to progress satisfactorily.

Operating crews have been assigned to rotating shift seven days a week. Efforts are channeled toward completing and appropriate preoperational tests and making preparations for filling and establishing sodium circulation in the primary heat transfer system.

SCTI Construction

All modifications scheduled for Fiscal Year 1964 were completed and the time and materials (T&M) contract used to accomplish this work

was terminated. Due to the exceptional progress of this effort, additional modifications which had been allocated to be accomplished next fiscal year were rescheduled and completed in FY 1964. Modifications essential to the operation of the SCTI which still remain to be accomplished are presently being assembled into a bid package for release.

Component Installation

The installation of structural steel support for the steam generators and related piping is proceeding on schedule and at the present time is approximately 90% complete. All the below-grade structural steel, including setting of the sodium relief tanks, has been accomplished. The work remaining consists of erecting the support tower for the Modular steam generator and finish painting the structural steel.

The mechanical and electrical installation design package for the ALCO steam generator was completed and sent out for bid. The ALCO instrumentation design package is being revised to include a gas chromatograph for detection of hydrogen, thus determining a steam generator leak.

The installation drawings and specifications for the Modular steam generator will be completed sometime in July. Instrumentation drawings necessary for installation of the modules are about 30% complete.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

Test 1 (316 SS in low oxygen sodium) has been completed and is reported in MSAR Report 64-18.

Tests 2 and 4

Test 2 (2½ Cr-1 Mo in low oxygen sodium) and Test 4 (2½ Cr-1 Mo in high oxygen sodium) have been completed, and a topical report covering both tests is being written.

As previously reported, the results of Tests 2 and 4 showed significant differences in the short-time Cr-Mo tensile tests in 1100°F air, helium and sodium. Creep-rupture specimens that had been exposed for 4000 hours in 1100°F sodium also showed a significant reduction in strength. In view of these results, tests have been scheduled with specimens that will have been exposed for 4000 hours in 1100°F helium to see if it is possible to observe any thermal effects as compared to the effects of the different environments. The exposure of these specimens is about to begin in a three-zone furnace and helium capsule especially designed for these tests. To check out the heating equipment and controls, a series of Cr-Mo specimens were exposed to helium at 1100°F for 100 hours. This run was successful and indicated the exposure capsule had a maximum top-to-bottom temperature gradient of 3°F. The specimens from this test, along with unexposed control specimens, were tensile tested at room temperature. The results of these tests indicate that there are no significant differences in our short-time tensile specimens due to 100-hour exposure in 1100°F helium as compared to unexposed specimens.

The 4000-hour exposure operation will begin early in July. The specimens from this run will be subsequently tensile tested at both 1100°F and room temperature, stress ruptured (at three different stress levels) in helium at 1100°F, and impact tested at room temperature.

Test 5

The preliminary tab runs for Test 5 (316 SS in high oxygen sodium) were completed this month and metallographic examination and data analysis are in progress. Upon completion of the tab run the system was drained and minor repairs were made. The mechanical test specimens are being installed into the test units. Operation is scheduled to begin in early July.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Piping and equipment layout drawings for the loop modification were completed in June, as was the procurement for the piping system. All major equipment is now on order with the exception of the cold trap. Bench testing of the modified Rhometer circuits was concluded this month, and the meter boxes installed in the main control panels, which are now approaching completion. Construction was started on the thermal decomposition tank unit and the material was received for the tank heating system.

The Chemistry Section has continued its efforts to develop analytical techniques for the confirmation of indicated impurity levels in sodium.

Total Carbon by High Temperature Combustion

The calibration of the analytical methods for determining carbon in sodium has continued in an effort to establish the reliability of this method. The precision of the method is reflected in the typical data on standard samples summarized in Table I. Information on the effect of different operator techniques will be reported next month.

TABLE I

<u>Type of Sample</u>	<u>Carbon Contained, (μg)</u>	<u>Carbon Found, (μg)</u>
Primary Standard, Sodium Carbonate	68	68.1
	125	119.0
	206	204.0
	408	416.0
Standard Leco Carbon - Oxygen Sample	30	25.0
	30	26.5
	30	42.6

Carbonate Carbon by Alcohol Dissolution

The emphasis of work performed on the analytical method for determining carbonate carbon in sodium has been confined to checking standard samples and in establishing system parameters to insure high accuracy and precision.

The results of this work appear in Table II.

TABLE II

<u>Type of Sample</u>	<u>Carbon Contained</u> (μ g)	<u>Carbon Found</u> (μ g)
Primary Sodium Carbonate	10.0	9.5
Primary Sodium Carbonate	20	18.0
Primary Sodium Carbonate	20	21.5
Primary Sodium Carbonate	40	39.0
Primary Sodium Carbonate	40	37.6
Primary Sodium Carbonate	40	31.6
Primary Sodium Carbonate	40	39.7
Primary Sodium Carbonate	60	57.4
Primary Sodium Carbonate	60	51.6

It was established that the procedure required accurate temperature control to produce good results. An improved temperature controller has been installed. The precision of the method and the reagent blank continue at the level reported previously

Work on the detection of oxygen in sodium by mercury amalgamation and the detection of hydrogen by vacuum mercury refluxing was also carried on this month.

Small Leak Sodium-Water Reaction Tests - Atomic Power Development Associates, Inc.

The engineering and design of a small leak, sodium-water reaction test loop is in progress. The loop will be used to conduct a series of twelve small leak tests, covering a range of small leak rates, to determine the effect of small leaks on tube wastage.

The status of the engineering and design is as follows:

1. The Reaction Water System is completely engineered, with the exception of the Trigger Mechanism, and approximately 30% designed.
2. The Circulating Water System is approximately 60% engineered 40% designed.
3. In the Sodium System, the Test Unit, Filter Tank, and Settling Tank have been engineered and designed. The piping has been engineered and is being designed and cold trap and plugging indicator are in the engineering phase.
4. The Reaction Products Vent System leading to the Centrifix separator is approximately 75% engineered and 50% designed.

The Steady State Reaction Vent System has not yet been engineered.

5. The conceptual design for the Test Stand Structure is about 40% complete. Specifications and concept drawings showing dimensions, equipment locations, and loads will be furnished to a contractor who will be required to structurally design, procure material,

and erect the test stand support structure. The structure contract will be let by the end of July so that structure and most of the stand components will be erected by late autumn.

6. Most of the electrical, instrumentation, and auxiliary systems such as the nitrogen and treated water systems still remain to be engineered.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

Following the completion of the zero power flow decay measurements the primary tank was cooled down to 330°F to permit probing for the dropped subassembly. The probing operation began on June 10, 1964. The assembly was found in the catch basin as expected and was successfully removed from the reactor tank the same day.

b. Hallam Nuclear Power Facility

Installation of new top works on the three primary system throttle valves and three secondary system throttle valves was completed. During testing of the throttle valves, relocation of the position indicators was found to be required because they were installed on the driver side of the new slip clutches.

All reactor fuel element orifice drive assemblies were removed to heat treat, mill slots in the threaded brass component, and to chase threads. Installation and adjustment of these drive assemblies was in progress at the end of the month.

c. Enrico Fermi Atomic Power Plant

A mass spectrometer leak test performed on the No. 1 steam generator tube bundle indicates that there is still a small leak in the tube bundle, about 20 cc/day.

The No. 2 steam generator was filled with water. When a small flow was started through the steam generator to No. 4 heater soon after the fill, the hydrogen increased at about 2 ppm/minute. The flow was stopped but the hydrogen increased. When hydrogen reached 110 ppm, the unit was isolated. The next day the No. 2 steam generator was refilled. Again hydrogen showed an increase of about the same rate. Hydrogen finally leveled off at about 300 ppm. Since the second fill it has varied between 250 - 350 ppm.

The primary and secondary sodium systems temperature was reduced to about 465°F and the No. 3 steam generator was filled with water. Soon after the fill the hydrogen content of the cover gas started to increase. In three days the hydrogen increased from 20 ppm to 110 ppm and has remained fairly constant at 100 ppm.

IV. REPORTS

Atomics International Monthly Progress Report of the Sodium Components Development Program, June 1964. (Includes SCTI and Modules)

APDA Sodium Technology Loop Monthly Report, June 1964.

APDA Status Summary of APDA Small Leak Sodium-Water Reaction Test Program, June 30, 1964.

Baldwin-Lima-Hamilton Progress Report No. C00-1213-25, June 30, 1964.

GE Sodium Mass Transfer: XI 1963 Test Run Reports, January - June.

MSAR Progress Report No. 46, Effect of High Temperature Sodium on Austenitic and Ferritic Steels, June 1964.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JULY 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)-1213	CH
b. Second Steam Generator	Babcock and Wilcox Barberton, Ohio P. B. Probert	AT(11-1)-1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)-GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)-GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)-GEN-8	CPAO
f. Physical Proper- ties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)-765	CH
g. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)-865	CH
h. Continuous Oxide Meter	United Nuclear Corporation Five New Street White Plains, New York K. Goldmann	AT(30-1)-2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)-189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)-3186	NY
k. Sodium-Water Reaction	Atomic Power Development Associates, Inc. J. Morabito	AT(11-1)-865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

All of the strain gages were installed on the steam generator and balanced out. The shell side of the unit was filled with distilled water and hydrostatically tested at 620 psig. The hydrostatic test was carried out to fulfill the ASME Code test requirements and to nondestructively test specific design areas of the unit with the aid of the strain gages.

Distilled water was used in the hydrostatic test. A conductivity check of the water was made as it was being loaded into the tank truck for shipment to BLH. This same check was repeated as the water entered the shell side of the vessel. A conductivity of 8.5 micromho was indicated in both cases which corresponds to a purity of approximately 4 ppm total dissolved solids. The chlorine concentration of the water was less than 0.1 ppm.

Following the shell side test the water was pumped from the shell side into the tubeside of the unit and preparations made to conduct a hydrotest of the waterside. To prevent the potential galling problem between the stainless steel nuts and studs used to seal the steam generator manway covers during the hydrotest, low carbon steel nuts have been purchased and will be used in lieu of the stainless nuts. The stainless nuts will be shipped with the unit for installation by AI.

b. Second Steam Generator - Babcock and Wilcox

Design Work on Full-Size Steam Generator

Design work on the Full-Size Steam Generator is complete. The cost estimate for the Full-Size Steam Generator, including freight, erection, start-up system, and feedwater heaters has been completed.

30 MWt Prototype Steam Generator

The cost estimate of the Prototype Steam Generator has been made based on the layout drawings that have been completed to date. Design work on the prototype is proceeding. Stress analysis work has begun on the tube-sheets and thermal sleeves to insure that these portions of the prototype model the problems of the full size unit.

R&D Program

Materials - Carbon Transfer and Effect on Materials Properties Simulating Full Size Plant

The loop was shut down on July 10, 1964, after 1000 hours of operation at design temperatures and flow for the removal of samples. In addition to microscopic and microprobe examinations it is planned to do chemical analysis of surface layers to detect any small amount of mass transfer. The loop was scheduled to be back in operation July 20, 1964, to start the second 1000 hour run.

Procedure for Welding the Tubes to the Sodium Face of a Tubesheet

Tube samples of the same material and thickness as the Full-Size Steam Generator have been welded using the electrical resistance process.

Although this process produced sound welds the configuration of the weld is such that it is not possible to prove the integrity of this weld by x-raying. A report is being written on the results of this investigation, including a photograph of sample tubes that have been welded then sawed in half to show the weld. No further research work is being done on this project, however, alternate methods to make the tube-to-tubesheet welds will be explored.

Heat Transfer - Effect of Coiling Tube on Heat Transfer and Two-Phase Flow

All of the testing has been completed under this project and the final report is being written. It is planned to issue the report on approximately July 31, 1964. In the body of this report it is planned to include a description of the testing that has been done, the test apparatus, and curves summarizing the results of the testing program. It is planned to include the actual test data in an Appendix that will be printed in fewer copies than the main portion of the report.

c. Modular Steam Generator (MSG) - Atomics International

All materials for the Modular Steam Generator are on hand. Reworked stainless steel pipe for the shells has been received. The forged blanks for the stainless steel tubesheets have been ultrasonically inspected and accepted for machining.

The first seven tubes have been welded to the upper evaporator tubesheet. X-rays and quality control tests confirm that the techniques and procedures are satisfactory. Two electrode passes were necessary in five of the seven welds to obtain complete fusion. This difficulty has been attributed to the thermal effects associated with the distance between the tube clamping position and the tubesheet. The problem is being studied.

The mathematical model for the analog study of control stability has been resolved. Implementation of this very complex model is now being studied by an analog computer specialist.

Fabrication Schedule

<u>Unit</u>	<u>Scheduled Completion Date</u>
First Evaporator	September 14, 1964
Second Evaporator	September 30, 1964
First Superheater	October 12, 1964
Second Superheater	October 23, 1964

d. Sodium Components Test Installation - Atomics International

The major effort during July consisted of making preparations for filling the primary heat transfer system with sodium. All of the preoperational test procedures which are prerequisites for filling have been completed with the exception of Primary System Preheating and Primary System Purging. Both of these procedures are presently in progress. Several system discrepancies were found during initial preheating of the primary system, which has resulted in some delay. The majority of these problems have been resolved and the filling operation is expected to start in the near future.

Four additional preoperational test procedures were completed making a total of ten out of the required seventeen procedures completed to date. The preparation of the preventive maintenance schedules for mechanical equipment and instrumentation was carried to approximately 95% of completion.

An analysis was completed for determining the operating requirements for the sodium heater in the event a leak in the tubing is discovered. The earlier plan called for rapid dumping of the sodium from the heater to the drain tank. This study indicates that draining of the heater tubes before the refractory cools could raise the temperature of the empty tubes to the point where serious damage would occur. The study recommends that the fires be shutdown, the blocking valves be used to isolate the heater, and the blowers be left on to cool the furnace. The air from the blowers also dilute the sodium smoke from the stack to the degree where no oxide concentration of concern prevails downward.

The structural steel supports for the steam generator installation were completed. This installation included the support structure for both the ALCO and the Modular Steam Generator.

The design package for the installation of the ALCO Steam Generator instrumentation was completed. Bids for this work, as well as the previously completed mechanical and electrical design package, were received.

The design package for the installation of the MSG mechanical and electrical has been completed and reviewed. The instrumentation package is 80% complete. Some revisions are expected in the MSG package to reflect the installation of the ALCO Generator.

A design package for modifications to the steam and feedwater systems; including the additional steam traps, pressure relief valves, and check valves in the feedwater pumps authorized last year, is 70% complete. Sodium sampling and metallurgical tab locations are being included.

e. Physical Properties of Materials - MSA Research Corporation

Test 1

Test 1 (316 SS in low oxygen sodium) has been completed and is reported in MSAR Report 64-18.

Test 2

Test 2 (2½ Cr-1 Mo in low oxygen sodium) has been completed and is reported in MSAR Report 64-81.

Test 3

Test 3 (316 SS in high carbon sodium). The creep, creep-rupture and fatigue tests are in progress. Two creep-rupture runs have been completed showing a reduction in the ductility of the specimens. The short-time run showed a decrease in rupture life, but the longer-time run showed a large increase in rupture life as compared to Test 1.

Metallurgical examinations of the specimens showed a distinct case and a microhardness gradient through the specimens but with no apparent relation between the case depth and the hardness plot. No significant data is available yet from the creep and fatigue tests in progress.

Test 4

Test 4 (2½ Cr-1 Mo in high oxygen sodium) has been completed and is reported in MSAR Report 64-81.

Test 5

The preliminary tab runs for Test 5 (316 SS in high oxygen sodium) were completed during the last report period and the system was drained for minor repairs which have now been completed. Early during this report period the mechanical test specimens were installed in their respective units and Test 5 was initiated.

The creep and creep-rupture runs were initiated during this report period. Two of the creep-rupture runs have been completed. The trend indicates an increase in rupture life with a decrease in ductility.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Activity this month was marked by the completion of procurement and the beginning of new equipment installation. Labor contracts were let to increase the work force and to accelerate the welding and insulation programs. Piping fabrication was expedited by setting up a field office to execute subassembly shop sketches by contract labor, and an assembly line was established to produce the piping subassemblies in an adjoining building.

The Rhometer bench tests initiated in May were completed with very gratifying results. These tests demonstrated the effectiveness of incorporating Vernistats in the signal summation system of the Rhometer for the purpose of tuning out minor transformer ratio errors in the extended temperature compensator circuit.

An extensive examination of the system blank and operator effect on the analytical procedure for carbon in sodium has been completed; the results of this study lead to the following conclusions:

1. The system blank is very sensitive to leaks in the combustion train and to temperature changes. It has been demonstrated that a two-hour blank can be extrapolated from a 30-minute run at 1100°C, without introducing an error in excess of 1 ppm carbon.
2. The analytical procedure is capable of yielding excellent results when run by an experienced technician following the procedures established at this time.

The Jarrell-Ash Atomic Absorption Spectrometer has been delivered, installed, and calibrated for determining trace amounts of sodium. This instrument will be used to cross-check the titration technique for measuring sodium oxide in the residue after amalgamation.

Initial runs on the procedure for determining hydrogen in sodium by vacuum-mercury refluxing using an induction heater to heat the mercury were completed. The induction heater provided a controllable source of heat which produced a moderate boiling action at approximately 165°C, with 1 micron pressure over the mercury. Results of this test suggest that a progressive breakdown of NaOH is achieved as the refluxing temperature is increased.

g. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Sampling of the Fermi cold trap is continuing. The sampling technique has been standardized in the following areas:

1. One inch ID sample tube ($\frac{1}{2}$ inch tube gave large surface to volume ratio).
2. Fifteen-sixteenths inch ID tip on sample tube to give sufficient undercut with no sacrifice in tube cutting edge quality.
3. Tube sledge-hammered into trap (not as sophisticated as a stud-driver or jackhammer, but just as effective and much simpler.) A jackhammer is a suitable alternate.
4. Techniques of using portable glove box and of transferring sample from tube to plastic container have become routine.

Samples taken from the Fermi cold trap were sent to APDA for analysis as well as being analyzed by Westinghouse. Analysis of adjacent samples indicated a factor of two difference between the two laboratories. Further exchange analysis of adjacent samples is planned.

In attempting to analyze samples from the lower holes (characterized by high oxygen content), it was discovered that contaminants existed in the sample which prevented complete analysis. Four approaches were used to try to get around the problem.

1. Using the amalgamation technique, which includes vigorous shaking, it was not possible with even four pounds of mercury to completely wash the sodium from a 1 gram sample. A black powdery residue formed which apparently prevented complete contact of the mercury and sodium. An analysis of this black residue using x-ray fluorescence showed mercury to be the major constituent with a trace of iron also present. This technique is not sensitive for elements with atomic numbers lower than that of calcium. This includes sodium, carbon, and oxygen.
2. Next a new sample was dissolved in methanol. It went completely into solution except for a small off-white residue. This was filtered out with a half micron filter. When the residue was washed with water it turned black. X-ray analysis of the residue showed minor amounts of zinc, iron, nickel, and chromium and a large quantity of copper (about .03% of the original mesh-free sample).
3. Then a new sample was dissolved in water. No visible residue remained. No further analyses were carried out.
4. A new sample was dissolved in methanol. Benzoic acid was added to convert the Na_2O and NaOH to free water. Karl Fisher reagent was added to determine the free water. However, a black residue was formed and no end point could be reached. X-ray fluorescence of the residue showed very high copper, a trace of zinc, and a trace of stainless steel. An x-ray examination of the blank (reagents but no sample) showed none of these.

h. Sodium Water Reaction Studies - Atomic Power Development Associates, Inc.

Design of the small leak sodium-water reaction test loop is in progress. The dump tank, the entrainment separators, the reaction-water supply vessel, the filter tank, and the oscillograph have been delivered. The

pressurizer, the heat dump, and the test unit are out for bid. The site has been cleared for construction.

Preoperational testing is presently scheduled for April 1965 with the testing program beginning the same month.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

Operation of the reactor plant at power levels above 1 MWt was initiated on July 25, 1964, at which time 5 MWt was reached. Ten MWt was achieved on July 29, 1964, and transfer function measurements were begun at this power level. Transfer function data and heat balance data have been obtained at zero power and at 5 MWt. Data were obtained at 100% and 74% of full flow. Reactor power has been dissipated by dumping steam via the bypass control valves to the turbine condenser.

b. Hallam Nuclear Power Facility

The reactor remained down during the month to complete plant modifications started earlier in the outage. Difficulties were encountered when one control rod failed to insert full when test-dropped from six inches out. A spare control rod assembly was inserted in the reactor. This assembly could not be operated with the normal drive mechanism. Careful examination of both control rods and the thimble indicated the following:

1. Original Control Rod Assembly SN-10: The slight hang-up at the end of travel was attributed to slight cocking of the latch cup as a result of unequal loads on the three pull tubes. These pull tubes are not adjustable. During the last inch of travel, most of the frictional load results from seating two O-rings, one on the latch cup and one on the purge valve assembly. A slight cocking of the latch cup increases the seating load considerably.
2. Spare Control Rod Assembly SN-20: After four test drops the rod could not be withdrawn with the normal drive mechanism. Upon removal of the rod from the thimble with the fuel handling machine and subsequent examination it was determined that the three snubbers were missing thus explaining the difficulties.
3. Control Rod Thimble C-56 Core Position: Visual examination, length measurements, and plug gaging with a 12-inch long cylinder which was 0.040 inches larger in diameter than the operating portion of the rod proved the thimble to be satisfactory for continued use.

c. Enrico Fermi Atomic Power Plant

The reactor was reloaded on July 19, 1964, by replacing the four dummy subassemblies with fuel. The reactor was then operated at power levels up to 40 Kw in order to obtain U-235 and U-238 fission counter response as a function of axial location in the temporary instrument thimble. Foils were removed from the first core foil subassembly and counting indicates that the flux distribution is about as expected.

Three small leaks were found in the tube to tubesheet welded joints of the No. 1 steam generator. The shell was pressurized to 48 psig with argon and helium and then the tubes were filled with demineralized water to cover the tubesheets. The leak showed up as a fine series of small bubbles.

IV. REPORTS

Atomics International Monthly Progress Report of the Sodium Components Development Program, July 1964, (includes SCTI and Modules).

APDA Sodium Technology Loop Monthly Report, July 1964.

MSAR Progress Report 47, July 1964.

Sodium Cold Trap Studies Monthly Progress Report No. 15, July 1964.

Sodium Mass Transfer VIII, Corrosion of Stainless Steel in Isothermal Regions of a Flowing Sodium System by J. D. Mottley.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
AUGUST 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
b. Second Steam Generator	Babcock and Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)- GEN-8	CPAO
e. Physical Proper- ties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
f. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)- 865	CH
g. Continuous Oxide Meter	United Nuclear Corporation Five New Street White Plains, New York K. Goldmann	AT(30-1)- 2877	NYO
h. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
i. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)- 3186	NYO
j. Sodium-Water Reaction	Atomic Power Development Associates, Inc. J. Morabito	AT(11-1)- 865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

At the end of July preparations were being made to hydrotest the tube-side of the steam generator.

In order to tighten the manway nuts to the specified 6,080 foot pound torque it was necessary to obtain special equipment. This equipment consisted of two special "torque multipliers." Using this equipment, the nuts were torqued without any difficulty.

The third and final portion of the strain gage test sequence entitled "Tubeside Hydrostatic Test" was completed. The ASME approval for the tubeside of the unit was approved with the completion and witnessing of the tubeside hydrostatic test.

All of the strain gages were removed from the vessel and the surfaces recleaned where the strain gages had been attached to the vessel. All of the distilled water was drained from both the tube- and the shell-sides of the vessel. The steam generator was then moved to the annealing furnace.

Both the tube- and shellside of the unit were dried by the use of external heat (400°F with unit in an annealing furnace) purging with dry nitrogen, and evacuating inside of the unit with a vacuum pump and purging with dry nitrogen. Using the combination of these methods, the specification limitation of a minus 40°F dew point was reached.

The test covers were removed, the openings to the vessel were appropriately masked off with tape and wooden plugs to prevent entrance of chips and other foreign matters into the unit. The tube inlet and outlet nozzle, the shell inlet and the outlet nozzle and the shell rupture disc nozzle were machined to length and kerfed per drawing requirements. The four lifting lugs were machined and drilled per drawings requirements.

The three tubes which had possible damage to the Inconel lining were plugged.

Exterior surfaces were cleaned and expandable rubber plugs were inserted into the two tubeside and three shellside nozzles. The thermocouples were secured to the exterior of the shell. One group of three thermocouples was also repaired.

The unit was loaded on a truck where the final preparation for shipment was performed. The unit was purged with nitrogen and shipped with approximately four pounds nitrogen pressure on the vessel with a bottle supply of nitrogen to maintain the required pressure or to replenish any gas which escaped. Final photographs were taken of the unit as it was on the truck. The truck left BLH late Friday evening, August 21, 1964. The unit arrived at AI, Canoga Park, California, on August 28, 1964, was unloaded from the truck and placed within the test pit. Upon arrival at AI it was noted that the unit did not have an indication of N₂ gas pressure on the shell- or tubeside nor was there gas in the reserve tank.

b. Second Steam Generator - B&W Design Work on Full-Size Steam Generator

The design report on the Preliminary Design of the Full-Size Steam Generator is being revised based on the Commission's comments during the August 12, 1964, meeting. The major share of the printing work on the

Design Report BW-67-2 is completed. The corrected pages will be inserted and the reports bound and distributed.

30 Mwt Prototype Steam Generator Design

The first general arrangement drawing of the prototype is nearing completion. Three other arrangement drawings were made showing the three major pieces that constitute the steam generator - the shell, the boiler bundle, and the superheater bundle and head.

As a result of a discussion between the Commission and B&W on August 23, 1964, it has been decided to proceed with the preparation of specifications for long lead items such as the coiling machine, the superheater tubes, and the various forgings.

Competitive bids will be solicited on these items and bid packages prepared for each of these items soliciting Commission approval to purchase these specific long lead items, (the coiling machine will be rented rather than purchased). Work is proceeding on the Preliminary Design Report for the Prototype Steam Generator.

R&D Program

Materials - Carbon Transfer and Effect on Material Properties Simulating Full-Size Steam Generator

Metallurgical examination of the samples removed from the loop after 1000 hours is proceeding. Preliminary examination of the microstructure of these samples indicates no significant decarburization of the Croloy 2½ or carburization of the Type 316 stainless steel. (Previous mass transfer experiments have shown significant decarburization in times less than 1000 hours, and for that reason this absence of apparent decarburization may be significant.) A chemical analysis of the surface layers of the samples is being made to make sure that examining the microstructure has not missed some mass transfer that has actually taken place.

The design of the loop is such that samples of the pipe wall can be removed and the piping welded up again without adding any new surface exposed to the sodium.

The model steam generator test loop has shut down after 2000 hours of full temperature operation for the removal of the regular 2000 hour pipe specimens. It is expected that the loop will remain out of service for approximately one week, then return to normal operation.

Since the 1000 hour samples showed no measurable carbon or mass transfer there is a great deal of interest in these 2000 hour samples to determine if the Full-Size Steam Generator and the rest of the secondary sodium system will really undergo mass transfer to the extent that all previous data had predicted.

Heat Transfer-Effect of Coiling Tube on Heat Transfer and Two-Phase Flow

Work on this project is complete. B&W Research Report Number 4438, "Heat Transfer in Coiled Tubes with Two-Phase Flow" has been issued.

c. Modular Steam Generator (MSG) - Atomics International
Fabrication of the Modular Steam Generator

The first evaporator unit has the upper tubesheet welded to the tubes, the upper tube-to-tubesheet welds have been post heat treated, the shell section has been assembled on the tube bundle and 19 tube-to-tubesheet welds have been completed on the lower tubesheet. The subassemblies on the second evaporator unit are complete and the subassemblies for the two superheater units are about 30% complete.

The equations describing the transient behavior of a once through steam generator using variable node lengths have been programmed on the analog computer. Considerable trouble has been experienced in checking out the program.

The additional fatigue tests on the 5 chrome- $\frac{1}{2}$ Moly and 2 $\frac{1}{2}$ chrome-1 Moly test specimens are being made by an outside testing laboratory.

The Modular Steam Generator Final Design Topical Report is being typed in rough draft form for review. The topical report on the test program for the MSG is about 20% complete. The topical report on the fatigue test program for the MSG is pending results of additional fatigue tests.

Schedule

<u>Unit</u>	<u>Scheduled Completion Date</u>
First Evaporator	9/14/64
Second Evaporator	9/30/64
First Superheater	10/12/64
Second Superheater	10/23/64

d. Sodium Components Test Installation - Atomics International

Preheat of the SCTI primary system is nearly complete, and the inert gas purge has started. Preparation for sodium filling is nearly complete. Preoperation tests are about a month behind schedule because of longer than anticipated heat-up times and several system discrepancies. Additional personnel are being used and it is expected that the schedule will be current by the time the ALCO installation is complete.

A period of 120 hours was utilized for drying out sodium heater refractories. Then the temperatures were raised to preheat recommended temperatures, 350°F at heater outlet.

Preoperational test procedure, "Primary Sodium System Purging" has been started. Immediately on checking out the system, discrepancies were found in signal lines being incorrectly connected to the valve operators. The check out of the remotely operated valves continues.

Test Unit Installation in SCTI

The ALCO steam generator shipped from the factory at Eddystone, Pennsylvania, on Friday night, August 21, 1964, arrived at the SCTI site during the early hours of Friday, August 28, 1964. The vessel was set in the pit on its supports in preparation for bolting down. Inert gas purges were connected to the shell and tube sections (gas purge had been lost during shipping).

Work preparatory to installing the ALCO unit was started August 19, 1964, and installation is scheduled to be completed by mid-November. Additions of a calorimeter connected to the main steam line, a drain line to the main feedwater line, and a chromatograph for hydrogen detection have been made to the basic installation contract.

Modification to the SCTI steam, feedwater, and treated water systems of steam traps, additional pressure relief valves, and sampling lines have been designed and will be bid to be completed by the time the installation is complete.

Drawings and specifications for the installation of the Modular Steam Generator are complete and the instrumentation section is currently being reviewed.

e. Physical Properties of Materials

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and the results reported in MSAR Report 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air, and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

Operation

Operation of Test 3 continued during this report period. It is being conducted in Loop 1 with an environment of 1200°F sodium containing carbon as the contaminant while maintaining the oxygen concentration at a nominal 30 ppm or less.

At the completion of the 21,500 psi creep-rupture test conducted in Test Unit 1, the inlet valve bellows was removed for inspection. The residual sodium caused some difficulty in the removal procedure. When the bellows was finally removed and inspected, it was found that the outer ply of the double-ply bellows (in contact with the sodium) had apparently disintegrated in the removal procedure and only small pieces which were very brittle were obtained. There was no indication that the bellows had actually failed during the operating period.

On August 21, 1964, it was discovered that a leak had developed in the bellows which seals the specimen pull rod to the test-unit flange on the 15,000 psi creep test unit. This bellows was subjected to less than 1/16 inch elongation with less than 1 psi pressure and was located in the cover-gas phase. This test was, therefore, prematurely terminated and the test unit drained on August 31, 1964. Examination of the failure has not yet been completed. All other operations were carried out without incident.

Creep-Rupture Runs

Three creep-rupture runs have now been completed and a fourth run is in progress. This run has now been in progress at a load of 20,000 psi for 1780 hours.

From the data generated to date, it appears that the rupture strength and elongations may be significantly altered by the high carbon sodium environment. Greater rupture strengths with a corresponding decrease in ductilities appear to be the trend.

Fatigue Runs

The second specimen at the same cyclic strain level failed after 45,360 cycles. During this run, several specimens were exposed stress free for 272 hours to Test 3 conditions.

Creep Runs

Two of the creep runs at stresses of 15,000 and 13,000 psi were started during the last report period.

The specimen at a stress level of 15,000 psi had been in progress approximately 1400 hours when a leak in the bellows that seals the test unit to the pull rod caused premature termination of the run. The run will be restarted during the next report period. The second run at a stress level of 13,000 psi has now been in progress 1442 hours.

A third run at a stress level of 11,000 psi was initiated during this report period and has been in progress 249 hours.

These runs have not been in progress sufficiently long to determine how the high carbon sodium is affecting the creep rates.

Test No. 3 - Metallurgy

Exposure of test specimens to high carbon sodium has, as previously reported, provided interesting and, in some cases, unexpected results. Samples of 304 SS, 316 SS, 2½ Cr-1 Mo, and Armco Iron, representing 110, 667, and 1740 hours of exposure at 1200°F to carbon-saturated sodium have been examined. In keeping with the results of prior investigators, both austenitic steels, 304 SS and 316 SS, show carburization in the form of a surface case and grain boundary precipitation. Metallographic, microhardness and chemical analysis show that carburization of the 304 SS proceeds at a faster rate than that of 316 SS. (See MSAR 64-102 for additional details.)

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High Oxygen (300 ppm) Sodium

The recently added 4000-hour helium exposure run, which will help to further evaluate the data of Test 4, as reported in Topical Report 3 (MSAR Report No. 64-81), "Results of Physical Property Test of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air, and Helium Environments at 1100°F," has now been in progress for approximately 1250 hours.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High Oxygen (300 ppm) Sodium

Operation of Test 5 continued during this report period. It is being conducted in Loop 2 with an environment of 1200°F sodium while maintaining the oxygen level at a nominal 300 ppm.

Operations

The problems of establishing flow through the fatigue unit, as reported in the last progress report, were alleviated by rewiring the trace heaters, making it possible to obtain a higher preheat temperature. On August 16, 1964, a sodium-to-air leak developed in this same general area. That portion of the system was isolated and drained, making it unnecessary to interrupt or disturb the tests in progress. The failure occurred in a straight run section of pipe and may have been the result of the trace heater arcing to the pipe, but this could not definitely be determined. The section of piping was replaced and the OCI system put back on stream.

On August 15, 1964, the bellows of the inlet valve on Test Unit No. 6 failed. It was necessary to prematurely end the 17,750 psi test being conducted in this unit. The valve has been repaired and a repeat of this run will be initiated during the next report period.

Creep-Rupture Runs

Two creep-rupture runs have now been completed and a third run is now in progress. This run at a stress of 21,500 psi has been in progress 688 hours.

Fatigue Runs

The first fatigue run at the low cyclic strain was completed during this report period. It failed after 17,910 cycles. This run will be repeated since a malfunction of the actuator motor midway through the run may have over-flexed the specimen.

Creep Runs

Three creep runs at stress of 10,500, 11,500, and 12,500 psi are now in progress at times of 1328, 1333, and 1179 hours respectively.

As in the case of the Test 5 creep runs, these runs have not been in progress sufficiently long to analyze the effects of high oxygen sodium on the creep rates.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Test facility activity during the month of August was largely confined to the erection of loop hardware, and the installation of instruments, heaters, and thermal insulation. Sodium fill was initiated on Monday, August 31, 1964.

Total Carbon by High Temperature Combustion

Two samples of primary standard sodium carbonate were analyzed for total carbon in the presence of sodium to demonstrate the accuracy of the method. Results of this work are shown in Table I.

TABLE I

<u>System Blank</u> <u>μg Carbon</u>	<u>Carbon Present in</u> <u>Standard Na₂CO₃</u> <u>μg Carbon</u>	<u>Carbon Present</u> <u>in Sodium μg</u>	<u>Total Carbon</u> <u>Present, μg</u>	<u>Total Carbon</u> <u>Found, μg</u>
2.9	34.7	6.3	41.0	39.1
2.0	57.0	6.6	63.6	61.8

Carbonate Carbon in Sodium

The most recent results obtained on standard Na₂CO₃ samples are shown in Table II.

TABLE II

<u>Carbon Present</u> <u>as Na₂CO₃, μg</u>	<u>System Blank</u> <u>μg Carbon</u>	<u>Net Carbon</u> <u>Found, μg</u>	<u>% Recovery</u> <u>of Na₂CO₃</u>
10	5.0	11.2	112.0
20	5.6	18.7	93.5
20	4.3	20.6	103.0
20	4.0	18.6	93.0
30	3.6	28.0	93.3
30	3.7	26.0	88.7

Hydrogen by Vacuum-Mercury Refluxing

Work has continued on investigating the effectiveness of the vacuum-mercury refluxing technique to promote the disassociation of NaH and NaOH in the presence of sodium. The refluxing temperature in these experiments was 410°F and the initial pressure was 1 micron. The NaOH showed no tendency to break down under these conditions, but the hydrogen resulting from the NaH reduction was recovered quantitatively. In order to recover all the hydrogen from the NaH, it was necessary to recycle five times. Results of this work are shown in Table III.

TABLE III

<u>Laboratory</u> <u>Sample No.</u>	<u>H₂ in</u> <u>Sodium, μg</u>	<u>H₂ Added, μg</u>	<u>Total H₂</u> <u>Recovered, μg</u>	<u>% Recovery</u> <u>of added H₂</u>
135	10.7	67.9 (as NaH)	79.1	100.7
135	11.5	45.8 (as NaH)	56.7	98.7
135	21.1	52.5 (as NaOH)	20.8	-----

Hydrogen by Water Absorption

The high vacuum glass rack has been modified to incorporate a palladium diaphragm and a Cahn Electrobalance for converting hydrogen to water and measuring the amount of water absorbed on magnesium perchlorate contained on one pan of the electrobalance. Over 20 experimental runs were made on commercial sodium to develop a more reliable analytical trend and to establish a base-line hydrogen value in the sodium for use in future

experiments where standard additions of NaH and NaOH will be made. An analytical procedure has been developed as a result of these 20 runs.

g. Continuous Oxide Meter - United Nuclear Corporation

No report received for the period.

h. Mass Transfer - General Electric Company

No report received for the period.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

No report received for August activities in time to include in this write-up.

j. Sodium Water Reactions-- Atomic Power Development Associates, Inc.

The reaction water system is completely engineered with the exception of the trigger mechanism. Design of this water system is about 70% complete. The circulating water system is approximately 70% designed. The sodium system engineering is about 75% complete. The cold trap vessel and cooling system are about 85% designed.

Bids from subcontractors interested in building the test-rig tower structure were received. All bids contained exceptions to the tolerances specified and as a result no bids were accepted. Redesign of portions of the test-rig is in progress and the specification will be rewritten prior to asking for another round of bids.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

On August 2, 1964, following a reactor scram the secondary EM Na pump experienced an electrical equipment malfunction causing the pump to operate in a complete flow reversal situation. A subsequent examination showed no apparent damage to the system.

On August 9, 1964, certain core elements temperatures were observed to be erratic. Reactor was shut down and the subsequent examination revealed sodium inleakage into a thermocouple well causing a shorting of the thermocouples.

During reactor operation on August 17, 1964, an air leak into the main condensor was discovered. The plant was placed on standby and arrangements made allowing continued plant operation.

The transfer arm locking device was found to be stuck during fuel handling operations. After partial dismantling it was freed. Cause of the sticking has not been determined.

The reactor has been critical a total of 649 hours and 343 MWD of power generation has been accumulated.

b. Hallam Nuclear Power Facility

Tests on Nos. 2 and 3 steam generators were made. No. 3 was tested to 96% of full load (240,000 lb/hr) and No. 2 to 100% of power (251,000 lb/hr). No significant carryover was observed.

The reactor generated 20.0 million kw-hr of electricity in August for a total of 170.2 million kw-hr since criticality. Daily output varied from 0 MWDe on August 1, 1964, to a maximum of 45.8 MWDe on August 7, 1964. Average daily output was 26.9 MWDe. Steam was put to the turbine 89.7% of the month.

c. Enrico Fermi Atomic Power Plant

The No. 2 steam generator tubesheets were leak tested. Sixty-four leaks were located by pressurizing the shell to 50 psig with argon and helium. Demineralized water covered the tubesheets. All leaks were in the welded joints.

The cask car has been reassembled after having been down for repairs. Operation of the car at 300°F will be checked at the glove box position.

The reactor was operated up to 40 kw to obtain U-235 and U-238 fission counter response.

Compiled and Edited by
George C. Gower

IV. REPORTS

1. Atomics International Monthly Progress Report on Sodium Components - August 1964
2. APDA Sodium Technology Loop Monthly Report - August 1964
3. MSAR Progress Report 48 - August 1964
4. APDA Small Leak-Sodium Water Reaction Studies - August 1964

**SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
SEPTEMBER 1964**

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
b. Second Steam Generator	Babcock and Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)- GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)- GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
g. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)- 865	CH
h. Continuous Oxide Meter	United Nuclear Corporation Five New Street White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)- 3186	NY

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
k. Sodium-Water	Atomic Power Development Associates, Inc. J. Morabito	AT(11-1)- 865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

Reduction of the data from the hydrotesting of the steam generator continued. This data will be put into final report form.

Baldwin-Lima-Hamilton has been asked to prepare a fabrication report covering their activities with respect to the fabrication and testing of the steam generator.

b. Second Steam Generator - Babcock and Wilcox

Design Work on Full-Size Steam Generator

Volume I of the Design Report on the Preliminary Design of the Full-Size Steam Generator has been completed. Volume II of the Design Report is being printed.

30 MWt Prototype Steam Generator

The layout drawings and the general arrangement drawings showing the full assembly of the Prototype Steam Generator have been revised to remove the center sodium by-pass valve mechanism. By removing this 10-inch valve and the pipe in which it operated it has been possible to leave an unobstructed 30-inch diameter opening up through the center of the boiler and superheater coil bundles identical with the similar opening on the Full-Size Steam Generator. This will improve modeling in the Prototype of the relieving of products from a possible sodium-water reaction. Because the tubes in the Prototype Steam Generator are full size of the tubes in the Full-Size Steam Generator the amount of reaction products to handle will be the same for either steam generator.

Stress analysis work is proceeding on the riser and downcomer tubes utilizing the piping flexibility computer program. Although the configuration of these risers and downcomers does not exactly duplicate the Full-Size Steam Generator because of differences in over-all size of the units, the same analysis procedures are being used on the Prototype as were used on the Full-Size Steam Generator.

R&D Program

Materials - Carbon Transfer and Effect on Material Properties Simulating Full-Size Steam Generator

The model steam generator test loop operated during the month at normal load and full temperature. Examination of the 2000 hour sample removed from the Cr 2- $\frac{1}{2}$ piping between the boiler and superheater has shown that decarburization to a depth of approximately 0.005 inch has occurred. Examination of the samples of stainless steel removed from the loop after 2000 hours of operation has shown no carburization. Migration of other constituents such as nickel and chromium has not begun to appear yet.

Sodium-Water Reaction

A meeting was held with APDA on September 30, 1964, and October 1, 1964, to draw up a work scope for an expanded effort on sodium-water reaction problems in the B&W Full-Size and Prototype Steam Generator. As soon as this revised program has been reviewed by both companies it will be submitted to the Commission for approval. All of the work that APDA has done on the existing subcontract is applicable to this new program, and by a minor redirection of their effort APDA is now working on the early items in the revised program while the details of the work scope are being finalized for Commission approval.

c. Modular Steam Generator (MSG) - Atomics International

The steam nozzles on the first evaporator module have been welded in place. The final seal closure welds are in progress and will be followed by the hydrotests. All of the tube-to-tubesheet welding on the second evaporator unit has been completed and the assembly has been removed from the fabrication pit for heat treating and final assembly. The first tube-to-tubesheet welds have been made on the first superheater unit. Work on the superheater units appears to be moving more smoothly than on the evaporator units. It is expected that all of the modules will be completed before the first of December.

Operational control of the test modular steam generator will be based on the results of an analog study recently done. Although the analog model did not give a completely stable set of data, enough information has been generated to prepare the control specifications and conditions.

Fatigue tests done on bar specimens of 2½ Cr and 5 Cr have been completed. The data indicate clearly that the 5 Cr-½ Mo material is superior in fatigue strength to the 2-½ Cr-1 Mo. Therefore, the fatigue tests done on the 2-½ Cr heads is sufficient to assure adequacy of the 5 Cr heads used in the test module units.

A topical report on the design of the modular steam generator is being prepared for publication. A report on the proposed test program is currently being written.

Schedule

<u>Unit</u>	<u>Scheduled Delivery Date</u>
First Evaporator	October 16, 1964
Second Evaporator	October 16, 1964
First Superheater	November 16, 1964
Second Superheater	November 16, 1964

d. Sodium Components Test Installation (SCTI) - Atomics International

Purging of the primary system has been completed using nitrogen until the dew point of the effluent air was less than -30°F and the oxygen content less than 0.5%. The system has been pressurized to a level of 10 psig using nitrogen. As a result of this operation, excessive nitrogen consumption was observed. It was later determined that vent piping on the top of the THX had been improperly routed, allowing an interconnection between the primary and secondary sides. At the time the fix was accomplished, additional heaters and thermocouples were installed on the vent header to freeze trap #3 and improperly sealed fittings in the lower head of the LHX were welded into place. Sodium leak detectors were installed at both the top and bottom man-way covers.

The ALCO steam generator was received towards the end of last month and installation is proceeding quite satisfactorily. A small amount of oil was found in one of the capped 10 inch secondary lines during preparation to connect it to the ALCO PTH steam generator. It has been determined that there is probably no other oil in the system and the installation is continuing. The unit was delivered without studs for attaching the skin thermocouples with iron nuts on the man-way covers and without some of the integral thermocouples which had been broken off during hydro-testing. Arrangements are being made to install the thermocouples in the field, either attach the thermocouple studs or use an alternate attachment method, and the stainless steel nuts are on hand. However, there is a question concerning the advisability of using the stainless nuts on the stainless studs (galling).

The design package for certain modification work on the steam side, including: steam traps, check valves, relief valves, and relief support structures, and carburization in the sodium system, has been prepared and will be contracted for completion in parallel with the ALCO steam generator installation. A design package for the installation of the modular steam generator has been completed and is being filed pending its time of need.

Prior to filling the primary heat transfer system with sodium an engineering review was conducted to determine the volume of the primary and secondary systems. The primary system capacity at 1100°F is almost 6000 gallons. The primary sodium fill tank capacity is 5000 gallons. The secondary system capacity is 4500 gallons and the secondary sodium fill tank capacity is 3000 gallons. An additional 4000 gallon tank will be added and connected to both systems.

e. Physical Properties of Materials - MSA Research Corporation

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and the results reported in MSAR Report No. 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air, and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

The creep, creep-rupture and fatigue tests are in progress. The fatigue life of 316 SS in air and helium after short time exposure to high carbon sodium shows a significant reduction in the number of cycles to failure. Three creep-rupture runs have been completed. The results are compared with Test 1 and shows an increase in rupture life but a reduction in the ductilities of the specimens. Chemical extraction of phases from all specimens so far exposed to the high carbon sodium environment has been completed. X-ray diffraction patterns of the residues have been obtained and chemical analyses along with microprobe measurements are in progress.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High (300 ppm) Oxygen Sodium

Test 4 has been completed and the results reported in MSAR Report No. 64-81, along with the results of Test 2.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High (300 ppm) Oxygen Sodium

The creep, creep-rupture and fatigue runs are in progress. Three of the creep-rupture runs have been completed. The results to date indicate a slight increase in the rupture strengths of these relatively short time tests with a decrease in ductility. The metallographic and carbon analyses are not complete, but the indications are that the 2½ Cr-1 Mo is decarburizing and the 304 SS and 316 SS are carburizing. Initial impact tests are showing the 2½ Cr-1 Mo steel specimens becoming more impact resistant with increase in exposure times, while conversely the 316 SS specimens become less impact resistant with increase in exposure times.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Shakedown operations were initiated in September to check out the new loop hardware and establish operating routines for the continuing research and development program.

For primary determination of contamination levels in the loop and to arrive at material balances during future contamination runs, a survey was made of sodium inventory in the various loop components. Direct measurement and calculated volumes were checked against depletion of storage sodium during the fill. Computed flowmeter performances were also checked against changing tank inventories during the initial flushing operations. Sodium in the loop extension was circulated at 570°F and cold trapped to an impurity level of 20 ppm. On September 30, 1964, a thermal ramp to 900°F was initiated to confirm Rhometer temperature compensator performance as established by the preliminary bench tests to determine temperature profiles in the loop hardware, and to detect any secular drift in the impurity level from environmental contamination. These procedures will also mark the first operation of the new flowing sodium sample stations and the first application of supporting chemistry to monitor impurities.

The Chemistry Section has continued its efforts to develop analytical methods for sodium impurities with the following objectives for September:

1. Completion of the final draft of a detailed report on the equipment and procedures recommended for determination of total carbon in sodium.
2. The initiation of a report on recommended equipment and procedures for determining total oxygen in sodium.
3. A continuation of the program to establish the accuracy and precision of the present methods for determining total carbon, and carbonate carbon in sodium.

These objectives were attained. The results on carbon analyses using APDA established procedures show that the recovery of carbon from a weighed quantity of a standard sample varies between 104 and 111% and

the per cent recovery is not affected by the presence or absence of sodium metal.

Standardization runs using standard carbonate samples show improvement over previous results but further improvement is desirable. A modification of the method to minimize its sensitivity to temperature fluctuations which occur during the sodium-ethanol reaction is being studied.

The determination of hydrogen in sodium continues to be a difficult problem. Two methods are being evaluated, neither of which is accurate and reliable at this time. Development work has continued on defining the experimental conditions which lead to quantitative recovery of hydrogen from sodium by vacuum-mercury refluxing. This method appears to be capable of giving reproducible results when hydrogen is added as sodium hydride, but whether the method can be applied to the analysis of hydrogen from added sodium hydroxide is not yet clear. The procedure is still undergoing modifications.

The palladium diaphragm method is based on the application of the following principles:

1. Hydrogen is removed from sodium by heating it in a vacuum.
2. Hydrogen is removed from the gas space above the sodium by "pumping" it through a palladium diaphragm and catalytically converting it to water with oxygen on the other side of the palladium diaphragm.
3. The resulting water is weighed on a sensitive electrobalance enclosed in the system on the water-oxygen side of the palladium diaphragm.

The principles have been shown to be sound in that water is observed on the oxygen side of the diaphragm almost as soon as hydrogen starts to evolve. A plot of hydrogen recovered versus hydrogen added is a straight line. However, its slope is less than 45° and the line has a negative "y" intercept. This seems to indicate that the sodium is getting some of the evolved hydrogen and an attempt is being made to minimize this difficulty.

The first samples from the loop were taken in support of the shakedown run of the new loop equipment. Samples taken from the surge tank showed 33 ppm of oxygen and the auxiliary storage tank contained 36 ppm oxygen. The main storage tank sodium contained 115 ppm oxygen. Additional clean-up runs will be necessary to establish a satisfactory sodium purity level for the initiation of experimental studies.

g. Continuous Oxide Meter - United Nuclear Corporation

No report received for the period.

h. Mass Transfer - General Electric Company

No report received for the period.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

No report received for September activities in time to include in this write-up.

j. Sodium Water Reactions - Atomic Power Development Associates, Inc.

Engineering design, procurement and construction of the small leak test stand are continuing. Diehl and Diehl Architects will engineer and design the support structure and supply APDA a set of drawings of the structure. The bid package on the support structure is due in CH the end of October. The delivery date of the test unit is January 4, 1965, and the delivery date on the pressurizer is set at November 23, 1964.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

Plant maintenance and repair activities were carried out during this reporting period. The principal job was repair of the main fuel gripper, which had been damaged during the preparation for installation of a replacement oscillator rod in the reactor.

Damage and Repair of the Main Fuel Gripper. During preparations for installation of Oscillator Rod No. 2 in the reactor, the funnel of the main gripper contacted the holddown as the gripper was being lowered at a speed of 6 in/min. Normally, the gripper will pass through the central hole of the holddown without interference. It is deduced that the gripper shaft became misaligned as the result of distortion caused by temperature changes in the shaft as it was being lowered in the sodium. It had been previously maintained in the "up," cool position for considerable time before it was lowered.

Since the gripper has been damaged so that it is no longer usable, the plant coolant systems were cooled to about 320°F preparatory to removing the gripper mechanism from the primary tank. Spare parts were procured for replacement of the funnel and jaw assembly.

After removal of the gripper from the primary tank, examination of the jaw assembly showed that the guide funnel had been twisted about its support so as to rotate the funnel approximately 6°. This displacement was sufficient to prevent complete closure of the gripper jaws.

Gamma radiation at 2 inches from the bottom end of the gripper was about 6 R/hr. Therefore, shielding was required during disassembly and repair.

The gripper mechanism was replaced in the primary tank and plant heatup was started. When the primary sodium temperature reached 580°F, the gripper and other fuel-handling components were checked. During preliminary checkout of the gripper, it was found that complete opening of the gripper jaws was not possible with the electrical drive, and the sensing rod could not be moved. Soaking in the hot sodium and manipulation of the gripper mechanism led to freer movement of the gripper jaws and sensing rod. It is believed that sodium oxide deposits were responsible for the initial difficulties. As the report period ended, the gripper was restored to operative condition, and checkout of the fuel-handling systems was proceeding. Checkout of the oscillator drive mechanism was also in progress.

Inspection of Primary Sodium Pump Motors. The drive motors of the primary sodium pumps were partially disassembled in place (without being removed from the pump shafts) to permit investigation of the cause of oil loss from the reservoir which supplies lubricant to the top thrust bearing of the motor. This loss had been observed in both pump motors during prior operation, and excessive oil consumption was confirmed by reviewing maintenance records.

Examination of the interior of each motor after removal of the thrust bearing and the top cover of the motor case showed no visible extensive oil deposition on the motor shaft, top gas flow baffle, or the visible metallic parts of the rotor. There was a thin film of oil on the underside of the motor top cover, that appeared to have come through a gas pressure-equalizing pipe which communicates with the oil reservoir. There also seemed to be a very thin uniform film of oil substance on the stator windings accessible to inspection.

However, in each pump motor, about $2\frac{1}{2}$ quarts of oil were found in a welded "box" adjacent to the oil reservoir, which forms part of a structure through which the power leads enter the pump case. It communicates with the oil reservoir via a small hole near the top of the box through which pass the electrical leads from the tachometer located immediately above the oil reservoir. Oil apparently had been thrown or splashed through this small hole by the action of the bearing, particularly at high pump speeds. Once the oil entered the box, it could not return to the reservoir until the level in the box reached the entrance hole.

The quantity of oil found was sufficient to account for the observed losses from the oil reservoir. It is believed that only a very small amount of oil, probably as a fine mist entrained in the argon coolant gas, actually entered the motor case; this probably accounts for the oily film on the stator windings.

The top end of the gas equalizing pipe between the motor case and the oil reservoir was provided with a more effective shield to reduce the probability of splashed oil droplets entering the pipe.

With the apparent loss of oil from the reservoir adequately explained, the pump motors were reassembled. During assembly, the welded "box" described above was filled with oil to the level of the hole for the tachometer leads. Thus, this box no longer will act as a trap for the oil splashed from the normal reservoir.

b. Hallam Nuclear Power Facility

The reactor generated 21.8 million kwhr of electricity in September for a total of 192.0 million kwhr since criticality. Daily output varied from a maximum of 53.3 MWDe on September 9, 1964, to a minimum of 0 MWDe on September 28, 29, and 30, 1964. Average daily output was 30.2 MWDe. The reactor put steam to the turbine 84.9% of the month.

Reactor operation was marred during the month by three additional moderator element failures for a total of eight, by three scrams, and by shutdown of the reactor on September 27, 1964, for rod drop tests and to remain down for the moderator replacement outage. The reactor was the primary source of steam for most of the month with the conventional boiler on "cold standby" except for two short periods.

Successful steam generator testing was completed for 100% and 110% steam flows during individual loop tests. Steam generator testing and reactor full power tests culminated on September 24, 1964, with a reactor load of 85.8 MWe gross (80.3 MWe net) which was maintained for two hours. The steam flow was 774,000#/hr (103% full rated flow) with carryover of about 0.1% (limit - 0.25%). Three power ramp cycles from 100% to 80% power at 5% power per minute were performed.

c. Enrico Fermi Atomic Power Plant

The No. 1 steam generator was filled with sodium to permit cleanup of the system and to perform water injection tests. The testing of the

No. 1 is a continuation of testing done on No. 3 steam generator in March.

Welding tests are in progress at BLH to evaluate a method for making repairs to the welds of No. 2 steam generator.

The angular thrust bearings on the No. 1 primary sodium pump motor became overheated requiring the pump to be taken out of service. The bearings were replaced with new bearings having a 200 pound preload.

Compiled and Edited by
John J. Purcell

IV. REPORTS

1. Atomics International Progress Report on Sodium Components - September
2. APDA Sodium Technology Loop Monthly Report - September
3. MSAR Progress Report 49 - September

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
OCTOBER 1964

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f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
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h. Continuous Oxide Meter	United Nuclear Corporation Five New Street White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)- 3186	NY
k. Sodium-Water	Atomic Power Development Associates, Inc. J. Morabito	AT(11-1)- 865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

Work is continuing on the reduction of data from the hydrostatic test of the steam generator and preparation of the steam generator fabrication report.

b. Second Steam Generator - Babcock and Wilcox

Design Work on Full-Size Steam Generator

Work on the Full-Size Steam Generator has been completed and the Design Report Volumes 1 and 2 are being distributed.

30 MWt Prototype Steam Generator

The general arrangement drawing showing the Prototype Steam Generator assembled and broken down into three major components have been prepared and are being checked. The Prototype Steam Generator will have the same major components as the Full-Size Steam Generator, the shell, the spool piece and boiler bundle, and the upper head and superheater bundle.

Layout drawings are in progress of the arrangement of the Prototype Steam Generator in the SCTI test pit to show the routing of the sodium and steam piping, etc. Some interferences with existing steel work and presently installed equipment have delayed completion of these drawings. These are questions which will be resolved with AI at a later date.

Stress analysis work is complete on the boiler riser and downcomer tubes. Some of the tube supports have been revised to bring the stresses down to acceptable limits. Work is in progress on the superheater riser and downcomer tubes using the piping flexibility computer program. Although the configuration of these risers and downcomers does not exactly duplicate the Full-Size Steam Generator the same analysis procedures are being used on the Prototype as were used on the Full-Size Steam Generator. Work is proceeding on the analysis of tube wall temperature fluctuations caused by liquid metal in flows across tubes.

R&D Program

Materials - Carbon Transfer and Effect on Material Properties Simulating Full-Size Steam Generator

The model steam generator test loop operated during the month at normal load and full temperature. The next scheduled outage will be after 4000 hours of operation, which should occur in mid-December.

Sodium-Water Reaction

The existing mathematical model to determine the effects of a sodium-water reaction has been modified by APDA to more closely represent the conditions existing in the 1000 MW steam generator. Preliminary runs are being made on the computer.

c. Modular Steam Generator (MSG) - Atomics International

Final closure welds on the two evaporator modular steam generator units have been completed and are being heat treated prior to the hydrostatic tests. Tube-to-tubesheet welds were completed on the upper head of the first superheater module. Due to high porosity in one of the tube-to-tubesheet welds, it may be necessary to plug one channel. The tube, if plugged, will be capped and left in the bundle and plugged in the other tubesheet head. Welding has started on the lower tubesheet.

In order to affect certain economies in the fabrication and since the need for the modular units is not required as soon (ALCO steam generator has been installed in the SCTI), completion of the modular units will be delayed to January. Every precaution and care is being exercised to carefully fabricate and maintain high quality control at a minimum cost in order to provide a suitable prototype test unit when it is needed.

d. Sodium Components Test Installation (SCTI) - Atomics International

As was reported last month both the primary and the secondary drain tanks are undersized. The proposed method of correcting this problem is to install a new 7500 gallon tank in the primary system and move the present 5000 gallon primary tank to secondary replacing the present 3000 gallon secondary tank.

Additional manpower has been assigned to the preoperational test staff to expedite the preparation of procedures, the conduction of tests, and the preparation of test reports. The preoperational tests have been rescheduled to utilize the manpower, and the cooling water system is undergoing preoperational tests at the present time. The cooling water circulating pump, condensate pump, and condensate booster pump have been dismantled, inspected, cleaned, reassembled, and alignment checked. The surface condenser manway covers were removed and the condenser cleaned. The reversing chamber walls, inlet and outlet water boxes are being painted to prevent further corrosion. During electrical power outage, it was found that the gas engine driven, instrument-air compressor would not maintain system pressure. Diagnosis found that water had condensed in the discharge air header which is common to the main compressor header and had drained back into the auxiliary air compressor. A drip leg has been installed in the main air discharge header to drain the condensed moisture before it reaches the auxiliary air compressor.

Installation of the ALCO steam generator is progressing well. Most of the pipe, including the exhaust lines from the rupture tanks, have been installed. The skin thermocouples have been attached. Instrumentation is being installed and the installation of the insulation has been started. An evaluation of the manway cover studs on the ALCO steam generator is being made by AI engineers. It is anticipated that galling between the 347 SS nuts and the 316 SS studs may prevent retorquing, if necessary, after initial operation. Preliminary thinking on this matter has prompted the possible solution of replacing the existing 316 studs with 19-9 DL material which is reported to have less tendency to gall with 347 SS.

Delays in delivery of certain fittings and the interference caused by tying in the primary and secondary drain tanks together is expected to delay completion of the ALCO steam generator installation to the first week in December.

Modification to the steam system, i.e., additional relief valves, steam traps, check valves, and structural support for the pressure relief valves, has been started. Installation of the auxiliary fill and drain tank is expected to start toward the end of the month and be ready for the secondary system sodium fill by the first of the year.

e. Second Round Carbon Analysis

GEAP-4602, "Results of the USAEC Round Robin Analysis for Carbon Impurity in Sodium," has been distributed.

f. Physical Properties of Materials - MSA Research Corporation

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and the results reported in MSAR Report No. 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air, and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) in 1200°F, High Carbon Sodium

Three creep-rupture runs have now been completed and two additional creep-rupture runs are in progress. The fourth run has now been in progress at a stress of 20,000 psi for approximately 3250 hours. A fifth run has just been started in the recently modified test unit at a stress of 22,500 psi.

From the creep-rupture data generated to date, it appears that the rupture strength and elongation may be significantly altered by the high carbon sodium environments. Increase rupture strengths with corresponding decrease in ductilities appear to be the trend. It, therefore, was necessary to increase the stress level from that of Test 1 for the remaining runs in order to maintain the over-all time schedule of Test 5.

Specimens which had been previously exposed in sodium stress free for 272 hours were fatigue tested in air and helium at a high cyclic strain. In comparing the results of these tests with results of specimens exposed in Test 1 (low carbon sodium) it was found that the carburizing effect of the Test 3 environment greatly reduced the cycles to failure. The average cycles to failure of pre-exposed specimens during Test 1 were 308 in air and 1033 in helium and compared to 161 and 266 respectively during Test 3.

The three creep runs at stresses of 11,000, 13,000, and 15,000 psi have been in progress for 1672, 2310, and 2670 hours respectively.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High (300 ppm) Oxygen Sodium

Test 4 has been completed and the results reported in MSAR Report No. 64-81, along with the results of Test 2.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High (300 ppm) Oxygen Sodium

Three creep-rupture runs have been completed and two additional runs are in progress. These runs at loads of 17,750 and 18,000 psi have been in progress for 1400 and 970 hours respectively. The results to date indicate a slight increase in the rupture strengths in these relatively short-time tests with a corresponding decrease in ductility.

The fatigue runs in high oxygen sodium at low cyclic strain have been completed. The three runs failed after an average of 12,458 cycles. This average can be compared to 39,460 cycles in low oxygen sodium indicating a decrease in fatigue life with increasing oxygen in the sodium.

g. Sodium Technology Loop - Atomic Power Development Associates, Inc.

As indicated in the September report new equipment shakedown operations had progressed by October 1, 1964, to the point where the initial circulation of sodium at 900°F was satisfactory and the level of impurities that can be removed by cold trapping was approaching an acceptable value. Several short comings became apparent in the arrangement of line heater circuits and controls. Individual heater elements operated in groups by a single switch had been originally scattered throughout the loop geometry to avoid localized circuit failure and possible freezing. This design philosophy was abandoned when it was observed that the line load could be reduced, hot spots in non-circulating lines and resulting heater failures could be eliminated and more functional control could be achieved by regrouping heater elements in a manner that would reflect the process flow for future loop experiments. The line systems have been rewired accordingly. Shakedown operations have been reinstituted at the point of the initial ramp of the system from 500°F to 900°F and will be followed by tests runs to determine:

1. The system "blank" values for in-line meters and any indication of signal drift or change in the actual contamination level over an extended operating period.
2. The magnitude of "hide-out" errors generated by the loop geometry which may occur during a plugging run, during the isolation of anyone of the several new working components, or by the deactivation of groups of heaters.
3. The performance characteristics of the heat exchangers which will establish the temperature profiles between the hydroclones and the remainder of the loop system by deactivating the heaters and removing the necessary insulation. This process will be required to produce a cold spot favorable to the separation of solids.
4. The precision of the "mass balance" realized by equating a metered increment of impurity to a contamination level in the loop as determined by sampling and chemical analysis.

Within the present limited, short-term experience, it would appear that the various line joints of the new loop hardware (Swageloc, Flexitalic, and Grayloc) perform satisfactorily. The standard solid disc OS&Y gate valves (with special packing) are also adequate for current, low-pressure operations, but cannot be throttled down without

developing leaks in the bonnet seals. Globe valves have not given this trouble. Within the limited observations to date, the indication is that the newly installed sample stations are collecting homogeneous sodium specimens from the sodium circulating through the loop.

h. Continuous Oxide Meter - United Nuclear Corporation

The major activity during October was the continued life tests on ThO_2 -15 w/o Y_2O_3 || $\text{Cu}:\text{Cu}_2\text{O}$ cells. The tests on the cells and observations on other cells have produced a consistent pattern for thoria cell life. Useful cell life appears to be about three months at 600 to 650°F. During this period, cells respond rapidly and theoretically to changes in cold trap temperature. Subsequently, response becomes sluggish and less than theoretical. The cells eventually (four to seven months) become unresponsive to oxygen activity changes although they continue to produce constant voltages of about the correct value.

With continued exposure to sodium, most thoria cells fracture suddenly and for no apparent external reason. The color of the thoria tube changes from a deep chocolate brown to a lighter brown or beige after long exposure to sodium. The appearance of the fracture for these tubes is significantly different from tubes broken by thermal shock or other mechanical means. The latter break cleanly in rather large pieces, generally near the liquid-gas interface (i.e., above the active cell). After long sodium exposure, tubes tend to shatter into many small fragments near the $\text{Cu}:\text{Cu}_2\text{O}$ reference electrode.

Field unit prototype evaluation tests continued. The insulation and operation of the first two units have indicated the need for some minor design modifications. These include:

1. Substitution of a pipe cross for the tee. This will permit removal of the basket assembly from the side rather than through the smaller diameter fin tube.
2. Redesign of the electrode assembly to provide additional intermediate supports and to remove the spring load from the insulated lead-through.
3. Redesign of the seal for the insulated lead-through. This proved difficult to seal during evaluation tests.

In addition, the order of the assembly will be changed to simplify loading the getter pellets into the upper housing.

About 80 per cent of the required drawing changes have been completed.

i. Mass Transfer - General Electric Company

Status of Test Loops

The loop operating time as of 0800, November 2, 1964, average flow data and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> *	<u>% Rated Flow</u>	<u>Oxide Level</u>
316 SS	LME **	0/0/18744	---	---
316-2½	2-6	389/1056/28967	0.69	(f) 10/20, 10/22
316-2½	LME	0/0/23131	---	---
316-5	---	0/0/24418	---	---
2½ Cr	5-8	556/1133/20391	0.41	(-) 10/14 - 15
5 Cr	LME	0/0/22512	---	---

The 19,792 hour (end of run) data for the 316 SS-2½ Cr loop (#2) continues to show the expected profile of corrosion as well as essentially the same corrosion rates of the previous exposure period (14,101 to 16,956 hours). The downstream sample, #2916, in C3 (700°F) which underwent exposure during the entire run showed an unexpected weight loss. It is possible that the initial weight of this sample is in error. The weight changes of the in-pipe samples are consistent, with losses and gains occurring in the hot and cold leg region, respectively to about the extent anticipated also.

The 172 and 389 hour exposure data for the 316 SS-2½ Cr loop (#2), on a Type II run for studies of weight change "initial effect," are interesting but inconclusive. The weight changes for these short run intervals, except at H3, are so small that measurement errors in all likelihood have resulted in the scatter and wide variations of the data, thus obscuring the model. This has also resulted in such anomalies as weight losses at C1 and C3 (during the first exposure period), where gains were expected. It is likely that carbon transfer from the 2½ Cr to the 316 SS (cold to hot leg) is contributing to the small weight changes during these short exposure periods.

The 2111 hour data for the 316 SS-5 Cr loop (#4) show approximately the same corrosion rates as in the previous sampling (1443 hr) period. The corrosion rates, as noted previously, are significant and undoubtedly result from the higher oxide level in this run as compared with the Type III (low oxygen) run where temperatures and velocities were essentially identical.

Metallurgical examination of the 5 Cr test loop (6) was initiated this month. Representative loop sections were selected for macroscopic examination. These sections have been cut, examined, and photographed. After the macroscopic examination, specimens for more detailed microscopic examination were selected. To date, preliminary examination of all loop sections exposed to the highest operational temperatures have shown some grain boundary attack. An apparent sub-surface attack is also noted in some of the above sections. Work on remaining loop sections is continuing.

Incremental machining of the surfaces of all remaining 316 stainless steel carbon diffusion rods exposed during loop #7 runs 7-9 to 7-14 have been completed. Samples have been dispatched for carbon analysis.

j. Sodium Cold Trap Studies - Westinghouse Electric Corporation

No report has been received for this reporting period.

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

** Loop Metallurgical Examination.

k. Sodium-Water Reaction - Small Leak - Atomic Power Development Associates, Inc.

The project is in engineering, design, procurement, and construction phases. Engineering and design of most of the system components are complete, and those components have either been delivered or are being fabricated. The few components which remain to be designed are the hydrogen cooling tank, plugging indicator cooler, air-blast water cooler, and sodium vapor trap pots for the various gas system lines.

The various systems with their associated piping, instrumentation and electrical work, and insulation remain as the major portion of the engineering and design work to be completed.

The structure design package being furnished by the firm of Diehl and Diehl, Architects, has been reviewed by APDA and is being revised by the architect. It is likely that the revised draft, specifications and drawings can be submitted to the AEC for comments about the first of November.

A revised schedule for this program, based on a structure completion date of March 31, 1965, is shown in the attached chart. A new schedule will be prepared at the time a contract is issued for the erection of the structure.

The status of the various systems is listed below, and the procurement status of various components on October 31, 1964, is given on the attached table.

1. The reaction water system is completely engineered (with the exception of the trigger mechanism) and approximately 70 per cent designed.
2. The circulating water system is approximately 85 per cent engineered and 80 per cent designed. The air-blast water cooler remains to be designed.
3. Engineering of the sodium system is about 90 per cent complete. Some piping remains to be laid out, and all the piping must be detailed and the specifications written.
4. The reaction products vent system leading to the Centrifix separator is completely engineered and 85 per cent designed. The steady state reaction vent system is approximately 85 per cent engineered and 50 per cent designed.
5. The test stand structure design package furnished by the architect has been reviewed and is being revised by the architect.
6. The electrical systems and instrumentation are about 40 per cent engineered. Detail design of the electrical and instrumentation systems has not been started. Auxiliaries such as the nitrogen and treated water systems are about 30 per cent complete.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

The reactor was operated at 37.5 MWt and 100 per cent primary flow from October 13, 1964, until an instrument malfunction caused a

scram on October 19, 1964. After the scram it was noted that control rods Nos. 7 and 9 remained at the "operate" position (approximately 11.5 inches inserted). All the remaining rods dropped in the normal manner.

Rod No. 9 was freed by applying 200 pounds downward force to the drive assembly. Subsequent drop tests indicate normal operation. By observing the rod drives and oscillator mechanism, it was determined that both rod drive assembly No. 7 and the oscillator thimble hold down tube were binding in the reactor cover. Disassembly of control rods 7 and 9 is planned for next month.

b. Hallam Nuclear Power Facility

Unloading the reactor core was begun on October 13, 1964.

Three sodium temperature elements were removed. Twenty-six dummy fuel elements of a total of 32 were removed. Those adjacent to moderator cans suspected to have failed were not moved. Six fuel elements of a total of 150 were removed before serious leaking of fuel storage pit No. 2 halted this operation on October 19, 1964.

The work in Pit No. 2, which consisted of chipping out pockets of honeycombed concrete, grouting, and sealing, was completed on October 28, 1964. Similar work on the wall in the Pit No. 1 side was in progress at the end of the month. Other work in Pit No. 1 is to brace the defective wall to the opposite wall of the pit.

On October 18, 1964, a sodium leak was observed at the junction of the pump overflow line to the secondary expansion tank. No fire or smoke was observed. A level loss in the No. 3 loop was verified by instrumentation and draining operations were started immediately. Removal of sheathing and lagging in the area of the leak was initiated on October 29, 1964. The lagging was very hard and adhered stubbornly to the pipe and expansion tank; therefore, observation of the leak area was not possible at the end of the month.

c. Enrico Fermi Atomic Power Plant

Repairs of the tube welds on the No. 2 steam generator have been completed. A total of 230 welds were repaired. The unit will be heated up to dry out the tubes prior to pump down for a mass spectrometer test.

Repair of the tube welds is in progress on No. 1 steam generator. Sixty-four welds have been repaired. Dye penetrant testing shows that an additional 69 more welds require reworking.

Compiled and Edited by
J. J. Purcell

IV. REPORTS

- a. SCTI and MSG Progress Report - October 1964
- b. Results of the USAEC Round Robin Analysis for Carbon Impurity in Sodium - GEAP-4602
- c. MSAR Progress Report No. 50 - October 1964
- d. APDA Sodium Technology Loop Monthly Report - October 1964
- e. UNC Continuous Oxide Meter Monthly Report - October 1964
- f. GE Mass Transfer Investigations in Liquid Metal Systems - October 1964
- g. APDA Small Leak Sodium-Water Reaction Test Program - October 1964

**SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
NOVEMBER 1964**

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
b. Second Steam Generator	Babcock and Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 D. T. Eggen	AT(11-1)- GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)- GEN-8	CPAO
e. Second Round Carbon Analysis	Atomics International D. T. Eggen	AT(11-1)- GEN-8	CPAO
f. Physical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
g. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan J. Morabito	AT(11-1)- 865	CH
h. Continuous Oxide Meter	United Nuclear Corporation Five New Street White Plains, New York K. Goldmann	AT(30-1)- 2877	NYO
i. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
j. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)- 3186	NYO
k. Sodium-Water	Atomic Power Development Associates, Inc. J. Morabito	AT(11-1)- 865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

Baldwin-Lima-Hamilton has prepared a quality control manual which will be distributed soon. The strain gage data resulting from the hydrotesting of the steam generator has been reduced and preliminary reports have been submitted to the Commission for comment. The fabrication report is about 60% complete. Rough drafts of the report are due in January 1965.

b. Second Steam Generator - Babcock and Wilcox Company

The layout and arrangement drawings are complete except for changes that may be required as study work proceeds on vibration problems and on sodium-water reaction problems. Work has begun on arranging the instrumentation in the steam generator to obtain the required data during the testing at SCTI. Layout drawings are underway showing the steam generator in the existing pit at the SCTI.

Several methods are being studied to prevent vibration and wear of boiler and superheater tubes which have been removed from the support bar for flexibility reasons. The object of the studies is to prevent the vibration of these tubes at the inlet and outlet of the bundles and still allow for differential expansion of the riser and downcomer tubes with respect to the support structure.

R&D Program

Materials - Carbon Transfer and Effect on Material Properties Simulating Full-Size Steam Generator

The model steam generator test loop was shut down as scheduled on December 3, 1964, for the removal of piping samples from the hottest portion of the test loop following 4000 hours of full temperature operation. Analysis of these samples should be extremely interesting, because these samples will be the first that should show any carburization of the Type 316 SS. The depth of penetration of the decarburization of the Croloy 2½ of these samples as compared to the 2000 hour samples will be helpful in determining the rate of carbon migration at the temperature of these samples. From the appearance of the samples removed after 4000 hours it should be possible to predict whether the scheduled 8000 hours of the model boiler will be a long enough time period to get adequate data on carbon and mass transfer in the simulated steam generator. In other words these samples will help predict whether or not significant mass transfer should be seen in the model boiler tube when it is cut up for examination.

Procedure for Welding Tubes to Sodium Face of Tubesheet

The design of the welding head utilizing a TIG Process and cold wire feed is complete. Fabrication of this welding head is in progress. This welding device should be ready to make the first demonstration welds in approximately one and one half weeks.

Sodium-Water Reaction

Plots of hydrogen bubble pressure versus time have been received from APDA. These calculations were made with the simplified

mathematical model in order to get order of magnitude pressures as early as possible. The effect of these pressures on the structure of the B&W Full-Size Steam Generator is being studied. Drawings of the Prototype-Steam Generator have been sent to APDA for their Preliminary Review of this steam generator.

c. Modular Steam Generator (MSG) - Atomics International

It has been decided to repair the damaged superheater tube rather than plug it. Welds were completed on the lower section of the first superheater unit and the unit was removed from the fabrication pit. Tooling has been designed and is being fabricated to machine the tubesheet nozzle suitable for rewelding. A splice section will be welded to this tubesheet nozzle and when satisfactory, a splice to tube weld will be performed which will properly repair the superheater unit.

The second superheater unit has been inserted into the fabrication pit preparatory to tube-to-tubesheet welding of the top head. Heat treatment of some of the closure welds on the evaporator units was accomplished during the month. Final closure welds will be done in the near future.

Preparation for the hydrostatic tests is in progress. Use of sodium nitrite, hydrazine, or some other suitable deoxidant to the demineralized test water is under consideration.

Topical reports on the final design of the modular steam generator and fatigue testing of the modular steam generator heads is in final stage of preparation. A proposed testing program for the modular steam generators is being written. The revised schedule for the modular steam generator is being prepared and will be included in next month's report.

d. Sodium Component Test Installation - Preoperational Tests

Further evaluation was made regarding the shortage of storage capacity in the primary and secondary systems. It has been decided that the primary fill tank will be replaced with one of greater capacity (7500 gallons) and that the existing tank will replace the secondary tank at the bottom of the test pit. Installation of T-1 in the test pit will provide more than adequate supply of sodium for the ALCO/BLH and modular steam generator test units and the secondary system. Because of very large capacity proposed for the B&W test unit, additional storage capacity or other provisions for dumping the secondary system will be required at the time it is installed.

Several of the preoperational test procedures will be rewritten to reflect a change in sequence of testing (the original plan included the test of the primary sodium system, the secondary sodium system, and the steam system. Because of the availability date of the different systems it is now planned to test the steam system first, then the secondary, and finally, the primary system).

The circulating cooling water system preoperational test has been initiated and is approximately 50% complete. The circulating cooling water pump has been operated at full flow and water circulated through the surface condenser and the cooling tower. The gasket leak in the condenser manhole cover has been repaired. A continuous

blow down has been initiated to remove suspended solids from the cooling water.

Preoperational procedures for the primary system filling, secondary system filling, secondary system preheating, and secondary purging, are being revised to reflect the latest change for the installation of the sodium fill and drain tanks. Testing of the water side systems and preliminary check out and procedure writing is being accomplished. Most of the plant control system preoperational tests have been written and reviewed. Plant performance procedures on the rise to power and sodium heat transfer system have been initiated. Test procedures for the ALCO steam generator and IHX components have been started.

Repairs on the sodium outlet header heaters have been made. It was found that one heater lead was broken and another shorted to ground. Additional heaters have been installed on the outlet headers to provide adequate heating capacity without operating at full rated power. The stainless steel shim stock has been wrapped around the heaters to isolate them from the loose insulation and provide better distribution of heat. These units will be back in use as soon as the contractor has reinstalled the plates.

Installation of the sodium piping has been completed and the closure welds have been made on the steam and feedwater lines. Hydrostatic testing will be done during the preoperational tests. Modifications of the flash tanks have been completed and the tanks have been hydrostatic tested. However, approval of the state inspector has not been obtained since all of the data sheets from the vendor were not available.

e. Mechanical Properties of Materials - MSA Research Corporation

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air and Helium

This test has been completed and the results reported in MSAR Report 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

The creep, creep-rupture and fatigue tests are in progress. The fatigue life of 316 SS in air and helium after short-time exposure to high carbon sodium shows a significant reduction (48% in air and 74% in helium) in the number of cycles to failure as compared to similarly exposed specimens in low oxygen sodium (Test 1). Three creep-rupture runs have been completed. The results are compared with Test 1 and show an increase in rupture life but a reduction in the ductilities of the specimens.

Some differences have been observed between Types 304 and 316 SS. These differences include higher carburization rates, greater carbon case depths, higher microhardness values and the formation of a ferrite phase by the removal of chromium from solution by precipitation as the carbide.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High (300 ppm) Oxygen Sodium

Test 4 has been completed and the results reported in MSAR Report No. 64-81, along with the results of Test 2.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High (300 ppm) Oxygen Sodium

The creep, creep-rupture and fatigue runs are in progress. Three of the creep-rupture runs have been completed. The results to date indicate a slight increase in the rupture strengths of these relatively short time tests with a decrease in ductility. The 12,458 cycles in high oxygen sodium as compared to the 39,460 cycles in low oxygen sodium. However, the differences in cyclic failures and hardness tests among the low strain specimens indicate the presence of some ambiguity. The exposed specimens when tested in helium showed an average fatigue life of 491 cycles as compared to an average life of 1032 cycles for corresponding specimens exposed to low oxygen sodium. The average fatigue life of exposed specimens tested in air showed an average life of 303 cycles as compared to 308 cycles for corresponding specimens exposed to low oxygen sodium.

Special Fatigue Runs for AI

Special fatigue runs are being run on Type 304 SS, 17 mil thick, sheet stock from an "as fabricated" moderator skin assembly as supplied by AI. Three runs have been completed at 1200°F in air and high oxygen sodium at 2.5% strain with average failures of 271 cycles in the air and 128 cycles in the sodium. Further tests at intermediate and low strains are scheduled.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

As scheduled in our October report, equipment shakedown in November began with a ramp to 900°F to observe the performance of newly-installed heaters and controls, and to determine system blank values for in-line meters operating with high purity sodium. One of the rhometer temperature compensator coils failed and was repaired. Gaskets that have leaked have been temporarily replaced with Cranite gasket material which is holding satisfactorily. However, this material has a limited service life rating above 750°F. Samples of Chevron pattern stainless steel and asbestos gaskets, recently developed for this service, have been received and will be evaluated. Spark plug level probes in the 1200°F thermal decomposition tank frequently failed by shorting out from vapor deposits and seal failure. Similar probes in the 1000°F surge tank also gave trouble. The new flowing sodium sample coils were operated successfully and no difficulty was experienced with the Swagelok couplings during the initial evacuation or in containment while operating at 900°F. Although the 304 stainless steel coil was thoroughly cleaned, carbon determinations were not uniform along the length of the coil until presampling circulation was extended to a 4-hour cycle. This effect was probably due to subsurface contamination of the tube that could have been introduced by cold working.

Cleanup of the new 1-inch portion of the loop was delayed when contaminants were introduced from the double-pipe heat exchangers. The loop was cold trapped down to 230°F to eliminate the oxide. During this period, oxygen was reported at the 20 ppm level and plugging runs alternately checked out at 230°F, or froze at 220°F with no definite plugging point. A continuous rise in oxide content when the cold trap was isolated and consistently high nitrogen values in the cover gas (2000-3000 ppm) reflected the problem of possible seal failure in the valve bonnets and level probes. The operation of a zirconium hot trap at 1200°F for approximately 40 hours did not yield conclusive results regarding the effectiveness of the present hot trap. However, it is believed that a stable and sufficiently low impurity level has been achieved in the sodium in the loop to initiate the calibration of the Rhometer temperature compensator.

g. Continuous Oxide Meter - United Nuclear Corporation

Field unit prototype tests were completed on November 13, 1964. The performance of the three prototype meters was very satisfactory. The voltages of the three cells were within ± 10 mv of each other and their response to changes in cold trap temperature were in good agreement with theoretical predictions. The meters also showed similar response to direct addition of sodium oxide to the loop.

Prototype evaluation tests have indicated the need for some minor design modifications in the meter housings. These include:

1. Substitution of a pipe cross for the tee. This will permit removal of the basket assembly from the side rather than through the smaller diameter fin tube.
2. Redesign of the electrode assembly to provide additional intermediate supports and to remove the spring load from the insulated lead-through.
3. Redesign of the seal for the insulated lead-through. This proved difficult to seal during evaluation tests.

The required design and drawing changes have been completed. Nine complete meter housings and four upper housings incorporating these design modifications are being fabricated for use in the field tests. These should be available for shipment by mid-January 1965.

After completion of the field unit prototype tests, the pumped loop was shut down to permit installation of two additional meter housings. Four housings are now available on the pumped loop for testing and calibrating field test sensor probes.

An alternate method for acceptance testing field meter sensor probes was tried and appears to be acceptable. The assembled sensor probe is packed in graphite powder and heated in a sealed vessel to 600°F. The cell $C:CO_2/CO // ThO_2-15 \text{ w/o } Y_2O_3 // Cu:Cu_2O$ is created where $C:CO_2/CO$ simulates the oxygen activity of sodium. The voltage generated by this cell is measured. A voltage close to the theoretical value for the cell indicates that the thorium electrolyte and reference electrode are functioning properly.

A cell was set up which generated about 0.3 volts. The voltage varied as expected with CO₂ pressure during the course of the test. The theoretical voltage at 600°F and 1 atmosphere CO₂ pressure is 0.364 volts. Further tests are planned in which CO₂ pressure over the graphite can be precisely controlled.

h. Mass Transfer - General Electric Company

Status of Test Loops

The loop operating time as of 0800, November 30, 1964, average flow data and the dates of oxide level adjustment are tabulated below.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> [*]	<u>% Rated Flow</u>	<u>Oxide Level</u>
316 SS	Stored	0/0/18744	-	-
316-2½	2-6	344/1400/29311	0.69	(+) 11/2
316-2½	3-11P	310/281/23441	-	-
316-5	Standby	0/0/24418	-	-
2½ Cr	5-8	603/1732/20994	0.42	None
5 Cr	Stored	0/0/22512	-	-

Analysis of Samples

The 727 hour "initial effects" run data from the 316 SS-2½ Cr loop (#2) show the normal profile of corrosion rates around the loop. The magnitudes of the weight changes, especially in the cold leg, are somewhat greater than were observed from the samples exposed 172 and 389 hours. Presumably this indicates that carbon transfer from the 2½ Cr cold leg to the 316 SS hot leg samples has diminished from its earlier value.

The 727 and 1451 hour run from the 2½ Cr loop (#5) indicate normal corrosion behavior in the hot leg, but show unexpected weight losses in all of the cold leg samples examined. The corrosion rates, as anticipated for the test conditions of this run, are very low. Carbon corrections have not been made, so it is possible that when the carbon analyses are available the weight losses for the cold leg samples will become positive. The same phenomenon on even a larger scale was observed in run 5-3 at the same sampling intervals as shown in the following comparison.

The 2802 hour (end of run Type III) data for the 5 Cr loop (#6) confirms the trends previously noted. The hot leg samples as well as in the in-pipe samples (1100°F) region, show such small weight changes that sometimes the sample gains weight and sometimes loses weight. This is not unexpected with the low temperature and low oxygen level test conditions. Chemical analysis of sodium samples from run 6-7 will be reported when they are analyzed.

Material Examination

The metallurgical examinations of corrosion samples removed at the end of run 6-7 were completed this month.

The loop metallurgical sections from the low temperature portion of the 5 Cr loop (#6) were examined this month. Microexamination of the lower temperature portions of the loop revealed some grain boundary attack to depths of 1 mil. This can be compared to

higher temperature portions of the loop, which showed the same type of attack to depth of 3 mils.

X-ray fluorescent analysis of the pipe surfaces was also completed this month. The measured compositional surface changes followed the trend established by the "hockey stick" corrosion samples exposed in the loop.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Report for November not received at the time of this writing.

j. Sodium Water Reactions - Small Leak - Atomic Power Development Assoc.

The project in engineering, design, procurement, and construction phases. Engineering and design of most of the system components are complete, and those components have either been delivered or are being fabricated. The few components which remain to be designed are the hydrogen cooling tank, air-blast water cooler, and sodium vapor trap pots for the various gas system lines.

The various systems with their associated piping, instrumentation and electrical work, and insulation remain as the major portion of the engineering and design work to be completed.

The status of the various systems is listed below.

1. The reaction water system is completely engineered (with the exception of the trigger mechanism) and approximately 70% designed.
2. The circulating water system is approximately 85% engineered and 80% designed. The air-blast water cooler remains to be designed.
3. Engineering of the sodium system is about 90% complete. Some piping remains to be layed out, and all the piping must be detailed and the specifications written.
4. The reaction products vent system leading to the Centrifix separator is completely engineered and 85% designed. The steady state reaction vent system is approximately 85% engineered and 50% designed.
5. The structure package is out for bid.
6. The electrical systems and instrumentation are about 40% engineered. Detail design of the electrical and instrumentation systems has not been started. Auxiliaries such as the nitrogen and treated water systems are about 30% complete.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

Control rod drive shafts No. 7 and No. 9 were removed from the primary tank and inspected. Steel balls were found in the upper labyrinth. It is postulated that the linear ball bushings failed and allowed the balls to work down and become jammed in the annular clearance between the drive shaft and the reactor vessel cover.

b. Hallam Nuclear Power Facility

The reactor remained down the entire month for fuel removal in preparation for replacement of failed moderator elements. By November 30, 1964, a total of 125 fuel elements (including 6 in October) had been removed from the reactor. Difficulty was being experienced in removing 34 fuel elements which were mostly adjacent to known failed moderator elements. A CPPD approved temporary procedure, T-29, "Removal of Stuck Elements and Other Core Components," was being used to allow higher fuel handling machine loads with good success. The load limit was increased from a normal 2000 pounds to 4000 pounds, maximum, based on the recommended core unloading procedure with these limits received from Atomics International especially for this removal work.

A summary of this work is as follows:

- 150 total fuel elements in the core.
- 116 removed at normal loads (2000 pounds or less).
- 9 removed at loads from 2200 pounds to 3700 pounds.
- 12 remained stuck at a load of 4000 pounds.
- 13 stuck at 2000 pounds and not yet tried at 4000 pounds.

Cleaning of the outside of the No. 3 expansion tank and 8" nozzle was completed on November 20, 1964. A leak was discovered in the nozzle adjacent to the nozzle-to-pipe weld. A pipe section was removed adjacent to the tank followed by removal of the tank wall section which included the 8" nozzle on November 16, 1964. An internal crack in the vessel wall penetrating completely through the wall was located in the internal baffle which is adjacent to the leaking nozzle. It is now suspected that this crack is the location of the initial leak. Chemical and metallurgical analyses and stress analyses are presently being performed by Atomics International on the nozzle and tank section to determine the cause of the failure in order to prescribe remedial action.

The tank has been removed to the auxiliary bay and repair methods are being studied. Nondestructive examinations are in progress on the No. 1 and No. 2 secondary sodium loops expansion tanks and associated piping in order to verify their integrity.

c. Enrico Fermi Atomic Power Plant

Weld repairs have been completed to the welds of No. 1 steam generator. A total of 169 welds were repaired. Preliminary helium checks indicate no leaks.

A check on the gripper fingers of the offset handling mechanism indicates that the fingers are all in their proper places and operating satisfactorily. The cask car has been taken out of service for investigation of the uranium shielding in the front end of the car and for other modifications to eliminate rotor binding and to improve torque sensing and gripper position readout.

Written and edited by:
John J. Purcell

IV. REPORTS

- a. SCTI and MSG Progress Report - November 1964.
- b. MSAR Progress Report No. 51 - November 1964.
- c. APDA Sodium Technology Loop Monthly Report - November 1964.
- d. UNC Continuous Oxide Meter Monthly Report - November 1964.
- e. GE Mass Transfer Investigations in Liquid Metal Systems - November 1964.
- f. APDA Small Leak Sodium-Water Reaction Test Work.

SODIUM COMPONENTS DEVELOPMENT PROGRAM

PROJECT CO-ORDINATION REPORT

DECEMBER 1964

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
b. Second Steam Generator	Babcock and Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CPAO
d. Test Facility	Atomics International R. Cygan	AT(11-1)- GEN-8	CPAO
e. Mechanical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
f. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
g. Continuous Oxide Meter	United Nuclear Corporation Five New Street White Plains, New York K. Goldmann	AT(30-1)- 2877	NYO
h. Mass Transfer	General Electric Company Atomic Power Equipment Department, P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
i. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1) 3186	NYO

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
j. Sodium-Water	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH
k. Under Sodium Scanner	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH

II. STATUS

a. First Steam Generator - Baldwin-Lima-Hamilton Corporation

The strain gage report has been reviewed by the Commission. It is slated for distribution in February 1965. The fabrication report is about 80% complete. Rough drafts of the report are due in January 1965. As-built drawings are being prepared by BLH for Commission review.

b. Second Steam Generator - Babcock and Wilcox Company

30 MWt Prototype Steam Generator

The bid package for rental of the coiling machine is being assembled for submission to the Commission for approval. This is the first item of the long-lead items under Phase II of this Contract. Detail drawings have been started in order to be able to order the stainless tubing for the superheater. This is the next long-lead item after the coiling machine.

Layout drawings of the steam generator in the SCTI pit are being checked and corrected. The support base on which the Prototype will stand in the pit has been checked out for earthquake forces. It appears that the Prototype Steam Generator and its support base will survive the earthquake loadings specified in the California Code without using supplemental ties to the pit wall part way up the height of the vessel. Even though this steam generator checks out all right it may be desirable to add these ties to the pit wall as an additional safety factor.

R&D Program

Materials - Carbon and Mass Transfer Simulating Full-Size Steam Generator Plant

The model steam generator test loop continues in normal operation at full temperature. Preparation of the 1000, 2000, and 4000 hour specimens for simultaneous etching and micro-photography is continuing. The more careful polishing and etching of these samples will show more precisely the rate of decarburization of the Croloy 2½ steel and will confirm the preliminary observation from the 4000 hour stainless steel samples that carburization of the stainless steel has not begun to appear yet.

Procedure for Welding Tubes to Sodium Face of Tubesheet

Fabrication of the TIG torch and wire feeding mechanism is essentially complete and the first demonstration welds should be made early next month.

Invitations have been sent out for bids on the device to x-ray the tube-to-tubesheet welds. It will be remembered that this originally was a subject for R&D work, but was cancelled because it appeared that such devices were commercially available.

c. Modular Steam Generator Fabrication

Both evaporator units have all tube-to-tubesheet welds completed. The tubesheet nozzle forgings have been welded onto the heads and the majority of the shell welds including the long clam shell weld completed. The items remaining are final shell closure welds, hydrotesting, and protective painting.

All of the tube-to-tubesheet welds on superheater No. 1 have been completed, however, a tube is faulty and will be reworked when special tooling becomes available. None of the shell closure welds or hydrotests have been started. Twenty of the tube-to-tubesheet welds on the upper head have been completed on superheater No. 2. All of the shell subassemblies are completed and the shell has been mounted on the tube bundles. The items remaining to be completed on the second superheater are the rest of the tube-to-tubesheet welds, shell closure welds, and the hydrotests.

Topical report on the final design of the modular steam generator (NAA-SR-9826) has been published. A topical report on the testing program (NAA-SR-9828) for the modular steam generator is approximately 75% complete. A topical report on the fatigue stress and development tests (NAA-SR-9827) is being typed and will be published in the near future.

d. Sodium Component Test Installation - Atomics International

Preoperational tests on circulating cooling water systems have been completed. Leaks in the cooling tower have been repaired. Provision has been provided for bypass during screen cleaning. Due to cold weather and the fact that no heat is being generated in the system, the cooling tower froze at the discharge nozzles at the distribution aqueducts. No damage was sustained. Cooling water system has been completely cleaned and flushed and the water has been dumped and refilled. Treated water and chemical feed system tests have been completed up to the final polishing demineralizers. Specifications for cleaning the feedwater and steam system have been prepared and will be performed by a commercial cleaning contractor.

Preoperational test procedures are being revised to reflect the current schedule and order in which the tests will be conducted. Plant control system procedures have been written for twelve of the plant control systems. The first section of the rise-to-power performance test procedure covering operation to 10% power has been completed and the effort continues on the plant performance procedures for the sodium heat transfer systems and the steam and feedwater system. Repairs on the heater outlet header have been completed and the outer roof casing for the sodium fired heater has been reassembled by bolting the plates into place. Minor leaks were stopped using Duct Seal compound. Because of inclement weather during the repair phases, some of the furnace refractory became water saturated and it will be necessary to dry this out using the pilot burners.

All pipe, instrumentation, and electrical connections have been completed and the insulation has been placed over all of the pipes in the body of the steam generator. Insulation is being applied to heads and 19-9-DL stud bolts are being installed in the manhole covers. This work should be complete by January 15, 1965.

The addition of check valves in the feedwater and booster pump inlet, additional steam traps, pressure relief valves, and equipment for maintenance and operational purposes is approximately 80% completed and should be complete by January 15, 1965.

e. Mechanical Properties of Material in Sodium - MSA Research Corporation

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and the results reported in MSAR Report 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air, and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

The creep and creep-rupture tests on original material are coming to an end and the creep-rupture and tensile tests on 4000-hour exposed specimens will begin shortly. Metallurgical examinations of the specimens generated under this test are beginning. The fatigue testing is continuing. Preliminary interpretation of the results to date indicate that carbon contamination in sodium will significantly reduce the fatigue life and the impact strengths, increase the creep-rupture life, but reduce the ductility of 316 SS.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High (300 ppm) Oxygen Sodium

Test 4 has been completed and the results reported in MSAR Report No. 64-81, along with the results of Test 2.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High (300 ppm) Oxygen Sodium

The status of this test is approximately the same as Test 3. The preliminary results are harder to interpret and appear to be more complex. Preliminary evaluations based on partial results may be misleading and therefore will await additional test results along with metallurgical studies.

Extensometer Development

This program is just getting underway but, following the receipt of a differential transducer for 1200°F service, an extensometer based on the use of this device will be evaluated by measuring the creep rate of a specimen in 1200°F air and finally in 1200°F sodium.

Special Fatigue Runs for AI

Special fatigue runs are being run on Type 304 SS, 17 mil thick, sheet stock from an "as fabricated" moderator skin assembly as supplied by AI. Three runs have been completed at 1200°F in air and high-oxygen sodium at 2.5% strain with average failures of 271 cycles in the air and 128 cycles in the sodium. Four runs have been completed in 1200°F air at 1.0% strain with an average failure of 2044 cycles. Three runs in 1200°F sodium at the 1.0% strain level are scheduled.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

The three modified Rhometer units in the sodium technology loop have been calibrated over the first two operational ranges, covering temperatures from 400 to 900°F. Calibration within the third range, which would extend loop operations to 1000°F, has been deferred until calibration stability of all the instruments is confirmed and the full temperature coverage is required.

Erratic zero shifts, which frustrated present calibration efforts as well as early efforts on the original Rhometer, appear to have been diagnosed and corrected. It has been found that a small movement of the winding assembly on the toroid transformer can produce a large upset in the meter reading, particularly if the coil axis is skewed relative to the core axis. As manufactured, the winding form is fitted loosely on the core leg (perhaps deliberately to allow air circulation) with about 1/4 inch of axial and transverse play. It was demonstrated that piping disturbances in the vicinity of a Rhometer, which can occur while hand valves are being turned, can shift the reading by 0.10 to 0.12%. This percentage is roughly equivalent to an error of 50 to 60 ppm Na_2CO_3 impurity, an exceedingly large value. To fix the windings in place, narrow wedges of Maranite have been placed at the four corners inside the form window. Tests have demonstrated that the coil shift effect has been reduced to a negligible level.

The gas sampling technique has been reviewed. Several tests were run to establish the normal in-leakage of air, with the cover gas system under positive pressure (1.5 psi). In-leakage to the active loop system was noted to be barely detectable, but in-leakage to the auxiliary storage tank was evidenced by a significant build up of nitrogen over several days of isolation.

On December 24, 1964, the cold trap was isolated from the loop and sodium carbonate was injected to calibrate the Rhometers and the plugging meter against laboratory-determined loop contamination levels. The first injection period was limited to two hours because of the lack of definite Rhometer response. Only 4.03 grams of the original 9.69 grams of Na_2CO_3 charged to the teabag appears to have dissolved in the sodium during this injection. Further, the plugging temperature continued to rise after injection, from 350 to 418°F. The increase in total carbon, as shown by sodium analysis, was much greater than could be caused by the quantity of carbonate introduced. This amount of carbonate is too small to allow an accurate material balance to be made by use of either Rhometer response or by laboratory analysis. The laboratory analyses of the base line sample showed a higher impurity level than originally estimated by earlier plugging runs. The foregoing results indicate the probability that considerable contamination

entered the loop during the teabag injection. The loop, therefore, will be cleaned up and the first injection repeated.

g. Continuous Oxide Meter - United Nuclear Corporation

No report has been received for the period.

h. Mass Transfer - General Electric Company

Status of Test Loops (Original)

The loop operating time as of 0800, January 4, 1965, average flow data and the dates of oxide level adjustment are tabulated below. Following the table are summaries of individual loop operation for the month.

<u>Loop Material</u>	<u>Run No.</u>	<u>Operating Time</u> *	<u>% Rated Flow</u>	<u>Oxide Level Adjustments</u>
316 SS	Stored	0/0/18744	-	-
316-2½	Standby	0/0/29311	-	-
316-2½	3-11	305/144/23740	0.67	None
316-5	Standby	0/0/24418	-	-
2½ Cr	5-8	749/2477/21743	0.41	(+) 12/22
5 Cr	Stored	0/0/22512	-	-

The 2800 hour (end of run) data for the 316 SS-5 Cr loop (#4) continued to display the normal corrosion profile noted in preceding sampling periods. The test conditions of this Type VI run are essentially identical with the Type III run (run 4-7), except for the oxide level. Thus the comparison of corrosion rates between these two runs affords a measure of the effects of oxide level on the corrosion.

The in-pipe samples lost or gained weight about as expected, depending on their location, except for an apparently anomalous gain by sample #P4F49 in the "D" packet of the H3R-C1 samples. Apparently the initial weight of this sample is in error.

The "in-pipe" samples located in the C1 and C2 sample holders (new location for this program) showed significant weight gains, 9 to 13 mg, compared with the C3 outlet in-pipe samples of <2 mg. It is interesting to note this amount of deposition occurring in these regions of the loop, which were not previously so monitored except by the nearby regular corrosion samples in C1 and C2. The regular samples are exposed to sodium having 10 times the velocity past the "in-pipe" samples, but the corrosion rate is only about 3 times as high (uncorrected for downstream effect).

Material Examination

The metallurgical examination of corrosion samples removed at the end of the Type VI run 4-9 was completed. The results are similar to the other high oxygen type runs for this loop. The surface of the hot leg samples indicated pockets of light colored second phase (high in Ni and Cr) to a depth of 0.5 mil, while the

* The first number of hours before the slant line is for the month, the second number of hours is for the present run, and the third number is the total number of hours that sodium has flowed in the loop.

surface of the 5 Cr cold leg samples exhibited a 0.2 mil metallic deposition layer overlaying a light etching zone of about the same thickness.

The carbon analyses from samples machined (in thin layers) from the loop #3 heater thimbles indicated a surface carbon concentration of 0.3 w/o in the low temperature first heater ($T_{Na \text{ max}} = 1200 \text{ F}$). These concentrations can be compared with the 0.05 w/o base material concentration.

Sodium and Cover Gas Chemical Analysis

The system for the determination of hydrogen in sodium using a modification of the Pepkowitz-Proud technique has been operated successfully. Known quantities of sucrose added to sodium have been recovered quantitatively ($100 \pm 5\%$). Sodium from the mass transfer loops has been analyzed and found to contain hydrogen in the range of 2 to 5 ppm.

Based on the analysis of three samples, there appears to be no correlation between the hydrogen concentration and the plugging meter "double break" phenomenon which has been reported. Indeed, the concentration of hydrogen in three of the SMT loops, #2 (no double break), #5 (serious double break), and #6 (some double break) is identical within the error limits of the determination.

Task 2 - Primary System Loop Program

Detail drawings for the loop components and sample cartridges have been completed with the exception of test section lengths and radial dimensions. Except for the test sections and the inlet and outlet fitting to the surge tanks which depend on test section dimensions, all other components are ready for final design review before fabrication.

The test loop support structure has been designed and will be ready for fabrication when the final locations of loop components are determined. Constant support hangers are used to minimize the stresses due to thermal expansion.

An itemized cost estimate for the two test loops except for the high heat flux heater development, power supply and heater was prepared and submitted to the Commission. Final detailing of the test sections are not expected to affect the cost estimate significantly.

The corrosion formulas developed from the Program's "isothermal" data have been utilized to determine the changes in the amounts of corrosion products in each unit volume of sodium flowing through selected sections of the four 1000 MWe reactor design studies. The relationship used is $\Delta S = k \overline{CR} A/Q$ where ΔS is the change in solute (ppm), $\overline{CR}$ is the average corrosion rate; A is the area of section and Q is the volumetric flow rate. The new test loops are designed to be corrosion models that have the same ΔS in each section. The dimension of the test loop sections will be determined by solving the above equation in terms of section length, wetted perimeter, and configuration for a given loop flow rate.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

Report for December not received at the time of this writing.

j. Small Leak Sodium Water Reaction Studies - Atomic Power Development Assoc.

The project is in engineering, design, procurement, and construction phases. Engineering and design of most of the system components are complete, and those components have either been delivered or are being fabricated. The few components which remain to be designed are the hydrogen cooling tank, air-blast water cooler, and sodium vapor trap pots for the various gas system lines.

The various systems with their associated piping, instrumentation and electrical work, and insulation remain as the major portion of the engineering and design work to be completed.

The date for completion of the structure is July 1, 1965.

The status of the various systems is listed below, and the procurement status of various components as of December 31 is given in the attached table.

1. The reaction water system is being modified to reflect a change in the design philosophy of the trigger mechanism. The original concept of a mechanical trigger device has been changed to that of a device which bursts a rupture disc covering an orifice. Engineering and design is approximately 75% complete.
2. The circulating water system is approximately 85% engineered and 80% designed. The air-blast water cooler remains to be designed.
3. Engineering of the sodium system is about 90% complete. Some of the piping remains to be laid out; all the piping must be detailed and the specification written.
4. The reaction products vent system leading to the Centrifix separator is completely engineered and 85% designed. The steady state reaction vent system is approximately 90% engineered and 65% designed.
5. The electrical systems and instrumentation are about 40% engineered. Detail design of the electrical and instrumentation systems has not been started.
6. Auxiliaries such as the nitrogen and treated water systems are about 50% complete.

k. Under Sodium Scanner Test Program - Atomic Power Development Assoc.

The scope of the under sodium scanner test program is to define the attenuation of sound waves in liquid sodium and to provide a concept for a general-purpose scanning system. Such a system would permit objects in liquid sodium to be discerned by means of sound waves and would, therefore, simplify maintenance and fuel handling procedures. Although the principle of transmitting and attenuating sound in water is well established, the application of this principle to liquid sodium is not well known. Thus, it is important to define the parameter of the attenuation of sound in sodium before a concept for a general-purpose scanning system can be established.

Attenuating tests will be conducted in a sodium facility specifically designed and fabricated for the task. Two ultrasonic transducers will be installed in the facility in such a way that they can be rotated and thus separated by distances ranging from 1/2 inch to 10 inches. Attenuation measurements will be made over these distances.

The electronic system, which was used for previous underwater scanning tests, is being modified for use in this project. Because the gain of the electronic receiver is nonlinear with respect to the amplitudes of input pulses, a wide-band attenuator extended to microwave range for precise measurements is required. The unit has been selected and is on order. To improve the 500-v, 2-mc, pulse-modulated transmitter and the 90-db, wide-band receiving system, a network was inserted between the amplifiers in the receiving system to filter out line-induced noises and to increase the stability of sweep on the oscilloscope. A transistorized wide-band pulse preamplifier has been designed, built, and tested.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

The sticking oscillator assembly was removed this month. The oscillator holddown and drive shaft assembly was freed from the Stellite-lined No. 8 control rod hole in the reactor vessel cover on December 11. An upward pull of about 2500 lb, supplemented by impact, was required to free the drive. The reactor vessel cover was raised manually 14 in. to permit insertion of the two "ball catcher" tools, inserted through the No. 7 and No. 9 control rod drive holes. The tools were oriented, opened, and then raised to the thermal baffle adjacent to these control rods on the under side of the cover. The oscillator drive shaft was then removed from the reactor cover and the primary tank on December 14. The "ball catcher" tools were removed, and the reactor vessel cover closed manually and locked.

Inspection of the oscillator holddown and drive shaft assembly showed a series of vertical grooves caused by metal particles jamming in the clearance between the Stellite sleeve in the reactor vessel cover and the oscillator shaft during removal operation. No balls or debris were found in either "ball catcher." Balls were not imbedded on the oscillator drive shaft or in the labyrinth section except in the vertical grooves mentioned above. During cleaning of the assembly one small steel particle, about 1/8 x 3/64 x 5/64 in., was recovered.

After cleaning, the lower end of the holddown assembly was disassembled. The ball bushing located about 58 in. above the bottom of the holddown tube was found to be intact; however, the lowest ball bushing was disintegrated.

All ball bearings (about 100) were missing. All but one of the ball retainers were severely damaged, and were found outside and just above the bearing. The two end rings of the bushing were badly worn and loose on the shaft. The snap ring bushing retainer was in place, but bent.

b. Enrico Fermi Atomic Power Plant

The number 1 steam generator was filled with condensate. This is the second water fill of this unit. The first fill with water was in December 1962. At that time, after 12 days operation, severe vibration of the tubes resulted in several large water leaks into the sodium. Now after retubing the damaged sections, eliminating the tube vibration problem and repairing small leaks at the seal welds, the unit is undergoing a 500 hour water test.

The number 2 steam generator was filled with water on the tube side and pressurized with gas on the shell side to perform a bubble test. Seven pin-hole type leaks in the welds joining the tubes and the tube sheets were observed. The unit is being dried out prior to dye penetrant testing of the weld area.

The number 3 steam generator has performed satisfactorily for several months.

c. Hallam Nuclear Power Facility

The reactor remained down all month for fuel and control rod removal, core examination, and fabrication and testing of equipment required for removal of stuck core components.

Fuel removal continued on December 1 and 2 using temporary operating procedure, TOP-29, "Removal of Stuck Element and Other Core Components." Eight fuel elements were pulled at loads greater than 2000 pounds of which three would not move at 4000 pounds. Five were pulled at loads of 3100 pounds to 3800 pounds; however, two of these pulled free of the process tubes. Use of TOP-29 was discontinued at this time and attempts to remove thirteen fuel elements at normal loads were unsuccessful.

One control rod and thimble was removed from core position C-56 on December 2 at 3300 pounds (adjacent to failed can M-38). Two additional assemblies were removed at normal loads on December 8. Fifteen of the remaining sixteen control rods and thimbles were removed on December 19 and 20 at normal loads. The control rod and thimble in core position C-1, adjacent to failed moderator can M-3, would not move at 2000 pounds.

On December 21, attempts to remove fuel elements at 2000 pounds resulted in removal of one additional element at 1350 pounds without the process tube. A decision was made to discontinue further attempts at fuel removal until the core lattice had been loosened by lifting and chocking selected moderator cans.

A summary of core component removal is as follows:

Fuel elements:	116 removed at normal loads
	12 removed from 2200 to 3700 pounds
	3 separated from process tubes (3300,
	3800, and 1350 pounds)
	<hr/> 131 removed
	14 stuck at 4000 pounds
	<hr/> 5 stuck at 2000 pounds
	<hr/> 19 remaining

Control rods: 1 removed at 3300 pounds (C-56 in November)
 17 removed at 900 to 2000 pounds
 18 removed

 1 remaining stuck at 2000 pounds (C-1)

Source: remaining in C-4 adjacent to failed
 moderator can M-3

Written and edited by: John J. Purcell

IV. REPORTS

- a. SCTI and MSG Progress Report - December 1964.
- b. MSAR Progress Report No. 51 - December 1964.
- c. APDA Sodium Technology Loop Monthly Report - December 1964.
- d. APDA Small Leak Sodium-Water Reaction Test Work - December 1964.
- e. APDA Under Sodium Scanner Test Program - December 1964.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT CO-ORDINATION REPORT
JANUARY 1965

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. ALCO/BLH Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
b. B&W Steam Generator	Babcock and Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. AI Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CP
d. Sodium Component Test Installation	Atomics International R. Cygan	AT(11-1)- GEN-8	CP
e. Mechanical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
f. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
g. Continuous Oxide Meter	United Nuclear Corporation Five New Street White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
h. Mass Transfer	General Electric Company Atomic Power Equipment Department, P.O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
i. Sodium Cold Trap Studies	Westinghouse Electric Corporation Atomic Power Division P. O. Box 355 Pittsburgh, Pennsylvania J. H. Wright	AT(30-1)- 3186	NY
j. Sodium-Water	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH
k. Under Sodium Scanner	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH

II. STATUS

a. ALCO/BLH Steam Generator - Baldwin-Lima-Hamilton Corporation

The ALCO Steam Generator Fabrication and Inspection Report and as-built drawings were reviewed by AEC personnel. This report is slated for final issue and distribution in March, 1965.

b. Babcock and Wilcox Steam Generator - Babcock and Wilcox Company

30 MWt Prototype Steam Generator

Detail drawings are being made of the stainless steel superheater riser and downcomer tubes to set the ordering lengths for these tubes. The stainless tubes in the superheater bundle and superheater risers and downcomers are one of the long lead items on this Contract. Forging drawings are being made in order to be able to get competitive bids on the forgings for the tubesheets, shell flanges, etc. The bid package for rental of the coiling machine and purchase of a special attachment is being prepared.

Earthquake calculations are being completed on the Prototype Steam Generator as located in the SCTI pit. These calculations have indicated that an intermediate tie to the pit wall will be required.

R&D Program

Materials - Carbon Transfer and Corrosion Simulating Full-Size Plant

The one tube model steam generator continued in normal operation in the sodium loop. The loop now has logged slightly over 4500 hours of operation at full temperature.

Flow Model of Sodium Distributor

Work is underway on designing the plastic model for this distributor system. The end configuration of the sodium distributor pipes will be arranged so that a number of configurations can be proven out in the model and the optimum end configuration selected for installation in the Prototype. The distributor configuration that is demonstrated in the model and used in the Prototype can be used in the Full-Size Steam Generator with reasonable assurance

that the parameters proven out in the model will also apply in the Full-Size Steam Generator.

Sodium-Water Reaction - APDA Subcontract

The preliminary analysis of the sodium-water reaction problems in the Prototype Steam Generator is proceeding. APDA has requested from B&W the maximum pressure that the steam generator shell can stand during the time interval from zero to ten seconds. These calculations were made assuming that a reaction occurred at the inner wall of the liner and that the temperature at the wall went instantaneously to 1800°F with a heat transfer conductance between the reaction and the liner wall of infinity. As the heat penetrated the wall of the liner, the pressure this liner can withstand to failure decreased, but in all cases the liner protected the shell from the high temperature of the reaction. This analysis has shown that the liner is very important to protect the shell against the high temperatures of a sodium-water reaction during the relatively short time before the rupture disk ruptures and relieves the pressure within the steam generator shell.

c. Modular Steam Generator Fabrication - Atomics International

The current status of the fabrication is as follows:

Evaporator No. 1 has the clam shell welds complete but not X-rayed. Items remaining are the sodium outlet nozzle extensions, the thermocouple fitting outlet cap and the hydrotest.

Evaporator No. 2 has the following items remaining: the clam shell cone closure welds, the sodium nozzle extensions, the thermocouple fittings, and the hydrotests.

Superheater No. 1 is currently being reworked to repair the one tube-to-tubesheet weld. After the rework, the items remaining are the shell closure welds and the hydrotest.

Superheater No. 2 has all the tube-to-tubesheet welds complete and accepted on both ends. The items remaining are the shell closure welds and the hydrotests.

The rough draft of the topical report on the testing program (NAA-SR-9828) for the modular steam generators in the SCTI is being reviewed.

d. Sodium Component Test Installation - Atomics International

The ALCO steam generator has been installed including all steam and sodium piping, heaters, thermocouples, instrumentation, associated electrical gear, and insulation. Bids have been received for the installation of the larger fill and drain tanks, correction of steam side instrumentation and chemical cleaning of the steam and feedwater system.

During checkout of the control system on the sodium cooler, the discharge-louvers, control tie bar snapped due to misalignment in the louver linkage. Adjustments and repair have been made to correct the situation. The same type of misalignment was discovered on the louver on the forced fan and has also been repaired. Lower discharge valve assembly of the air compressor failed and has

been replaced. Earlier the upper valve assembly of the compressor had failed and was replaced.

Tests have been performed to determine if the two instrument-air compressors provided sufficient flow capacity. With all pneumatic instruments in service, the motor driven compressor operated at approximately one-third of its capacity. The auxiliary compressor could not keep up with the demand and the system decayed slowly. Some action may be required to provide emergency capacity.

Modifications to the steam-generator-preheat-boiler auxiliary equipment have been completed as recommended by the insurance boiler inspector. Considerable time has been spent in checking out pneumatic signal leads in the plant control system. In several instances, the leads were reversed or missing.

Because of the freezing problem in the cooling water tower under no-load plant conditions, it is not operated on a continuous basis. However, the system has operated for a period of at least four hours, weekly, to thoroughly wet down and soak the wooden cooling tower and permit water treatment. During shutdown conditions, the condenser and all lines are maintained full of water. When the weather warms up, more frequent operation will be considered.

Preoperational test procedures for the steam and feedwater system cleaning and filling, steam generator preheat, secondary-sodium and primary-sodium flow control system, have been written, reviewed and are ready for use. The plant performance test and schedule on rise to power is approximately 75% complete. A component test procedure covering the sodium system expansion joints has been prepared. The objective of this test is to determine the axial deflection of expansion joints during plant operation and to verify that the deflection at maximum temperature is within design limits. Preoperational test procedures for the plant control system are approximately 95% complete. Completion is contingent upon the review of the plant-control shutdown system and a study currently being performed to determine the free-convection, sodium flow through the sodium heater and cooler required to determine the heat removal capacity of the sodium cooler under conditions of complete plant power failure.

e. Mechanical Properties of Materials in Sodium - MSA Research Corporation

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air and Helium

This test has been completed and the results reported in MSAR Report 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

The creep and creep-rupture tests on original material have been completed. The creep-rupture and tensile tests on 4000 hour exposed specimens have been initiated. Metallographic examinations of the specimens generated under this test are in progress. The fatigue runs are continuing. Preliminary interpretation of the results to date indicates that carbon contamination in sodium will significantly reduce the fatigue life and the impact strengths, increase the creep-rupture life, but reduce the ductility of 316 SS. The creep rate curves show considerable influence of the carbon environment and make the interpretation of the minimum creep rate ambiguous.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High (300 ppm) Oxygen Sodium

Test 4 has been completed and the results reported in MSAR Report No. 64-81, along with the results of Test 2.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High (300 ppm) Oxygen Sodium

The creep-rupture and fatigue testing on original specimens is continuing. The creep tests have been completed, and the testing of 4000 hour exposed specimens will begin shortly. The results to date indicate only a slight increase in the creep-to-rupture strengths with a corresponding decrease in ductility. A slight decrease in the minimum creep rate has also been observed. Metallographic examinations are continuing, and the presence of alpha and gamma iron has been observed. Analyses of the loop indicate the carbon level to be 20 to 25 ppm. The presence of 1.23% hydrogen gas in the cover gas during this report period agrees well with a previous measurement of 1.07%.

Extensometer Development

The design of the test rig is underway, and a design for a differential transducer for 1200°F service has been received and is being evaluated.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.Rhometer Calibration

Difficulties connected with the erratic reading of the Mark II Rhometers have continued, particularly with regard to the inlet Rhometer. Inherent design problems and variations in operating procedure appear to be the chief trouble areas.

The method of compensator adjustment has been standardized to minimize operator error. An error of $\pm 0.03\%$ can be introduced as a result of adjusting the compensator for temperatures within a range of 5°F; this error is less than 0.01% for a temperature change of $\pm 10^\circ\text{F}$. A variation of 0.01% R to 0.02% is introduced by different operators observing the same Rhometer reading.

The drift of the inlet Rhometer may be caused by an inherent design defect in the Mark II Rhometer. During loop cleanup operations after Na_2CO_3 injection ($T = 900^\circ\text{F}$), the inlet

Rhometer, over a 24-hour period, gradually drifted 0.30% in a negative direction - a reading roughly equivalent to the effect of 150 ppm of Na_2CO_3 . When the temperature was reduced to 450°F, the resistivity remained at the -0.30% level. When the temperature was again increased to 850°F, the Rhometer shifted to -0.54% (270 ppm Na_2CO_3). The second shift occurred over a period of several days. Both shifts appear to be related to an irreversible change in the temperature compensator. This is expected to be confirmed by a program in which the voltage stability of the primary circuit will be checked, all circuit connections and cables will be inspected, and the loop will be ramped to a temperature of 900°F with clean sodium to verify that the drift is not caused by sodium impurities. If the difficulty is found to be caused by a stretched temperature compensator, it will be re-wound.

Test Results - Sodium Carbonate Injection

In preparation for Injection No. 2, the previously described 7-inch teabag was loaded with 11.17 grams of granular Na_2CO_3 (20-45 mesh), which was prepared by fusing primary standard Na_2CO_3 in a platinum crucible followed by crushing and screening. During this test, the teabag was immersed approximately 4 inches in the flowing sodium stream for 4 hours at a temperature of 450°F. Inspection of the teabag after transferal into the glove-box revealed that sodium had contacted the outside of the teabag, but did not fully penetrate into the teabag through the 0.011-inch slots. A total of 11.05 grams of Na_2CO_3 was recovered from the teabag, indicating that no injection was obtained.

Because the Na_2CO_3 did not go into solution, the use of the teabag as a means of adding Na_2CO_3 was evaluated. Teabag tests No. 1 and No. 2 were run under the same conditions as injection No. 2, i.e., 450°F loop temperature, 13- to 30-mil Na_2CO_3 particle size, 200-gpm flow rate past the teabag, and 4-hour injection time. In each case, the results indicated that a large portion of the Na_2CO_3 remained free of sodium. Teabag test No. 3 was run at 850°F, with the other conditions remaining the same. Preliminary results show that the sodium did not penetrate into the teabag, but an insignificant amount of Na_2CO_3 was dissolved out of the teabag. Final results of the teabag analysis showed that 9.18 grams of a total 9.97 grams remained in the teabag.

It was concluded that the teabag method is unsatisfactory under the conditions tested and should, therefore, be modified or discarded. The teabag injection method has been discontinued at this time.

Several alternate methods for adding Na_2CO_3 to the sodium were considered:

1. Mixture of sodium and molten Na_2CO_3 .
2. Side contamination loop.
3. Hot finger method.
4. Addition of Na_2CO_3 directly into the sodium.
5. Forced flow through Na_2CO_3 .

The first alternate, mixture of sodium with molten Na_2CO_3 , was discarded because of the technical difficulties and the high temperature involved (1550°F).

The second alternate, side contamination loop, is in the preliminary stage of planning.

The third alternate, the hot finger method, was tested for effectiveness. The hot finger, which is basically a reversed cold trap, is a $\frac{1}{2}$ -inch pipe, into which is placed the Na_2CO_3 . The hot finger is coupled into the bottom of a flowing sodium line and is heated, whereupon the dissolved sodium carbonate is supposed to diffuse through the stagnant sodium in the finger (approximately 5 inches in this test) into the flowing sodium stream. (Thermal convection currents may aid the diffusion process.) Since very little Na_2CO_3 was dissolved, upon testing, this method of adding sodium carbonate was also discarded.

Alternate number four, the direct addition of Na_2CO_3 into the sodium, was tried to determine whether Na_2CO_3 will dissolve in the presence of large amounts of sodium. It appears that the additions caused an increase in the impurity content, but the sodium analyses show no increase in the carbonate carbon content. This suggests that the Na_2CO_3 could be dissolved and decomposing. This method is not suitable for standard operation because there is no direct method of accounting for the residual Na_2CO_3 .

The fifth alternate, forced flow through Na_2CO_3 , is being developed.

g. Continuous Oxide Meter - United Nuclear Corporation

No report has been received for this period.

h. Mass Transfer - General Electric Company

No report has been received for this period.

i. Sodium Cold Trap Studies - Westinghouse Electric Corporation

No report has been received for this period.

j. Small Leak Sodium-Water Reaction Test Program - Atomic Power Development Associates, Inc.

The work on this project to date has consisted of engineering, design, procurement, and construction. The design of most of the components for the test system is complete. The components that have been designed are either being fabricated or have been delivered to the test site. The only component that remains to be designed is the hydrogen cooling tank.

The various systems with their associated piping, instrumentation and electrical work, and insulation remain as the major portion of the engineering and design work to be completed.

The test stand structure is being erected and is progressing on schedule. All the concrete footings have been poured, and approximately 60% of the structural steel for the tower has been erected.

The status of the various systems is listed below:

1. Engineering of the reaction water system is finished. The design and layout is about 50% complete.

2. The circulating water system is approximately 95% engineered and 80% designed. An order has been placed for the air-blast water cooler.
3. Engineering of the sodium system is about 90% complete. Some piping remains to be layed out, and all the piping must be detailed. The piping specifications must be written.
4. The reaction products vent system leading to the Centrifix separator is completely engineered and 85% designed. The steady state reaction vent system is approximately 95% engineered and 65% designed.
5. The electrical systems and instrumentation are about 50% engineered. Detail design of the electrical and instrumentation systems will be started in February.
6. The nitrogen systems are engineered, but the piping remains to be layed out.
7. The treated water system is about 50% complete.

k. Under Sodium Scanner Test Program - Atomic Power Development Assoc.

Fabrication of the test facility proceeded on schedule. Minor design modifications were made to the sodium pot to adapt the facility to a dry-box. Delivery of all hardware is expected by February 15, 1965, at which time assembly of the facility will begin.

Efforts to modify the electronic system, used for previous under-water scanning tests, for use in this project were continued. The wide-band pulse preamplifier and a bandpass filter were installed in the receiving system. The gain of the receiving system is 120 dbs. The entire electronic system was tested with two transducers operating in water at room temperature. With a distance of 20 inches between the transmitting transducer and the receiving transducer, the amplitude of the output receiving pulse is more than 150 volts.

Because the frequency of the ultrasonic wave is an important factor in the study of attenuation, a 500-kc frequency band has been added to the transmitter. The wide-band receiver, except the band-pass filter, covers this frequency range. A frequency band of 4 mc is planned after testing is begun, if the need arises.

A high-intensity ultrasonic source will be required for the test program. A push-pull power amplifier, with an expected peak-to-peak output voltage greater than 1000 volts, has been designed. Fabrication of the amplifier is scheduled for February.

To avoid inaccuracies in the attenuators in the receiving system, it is necessary that the independence in the input and the output circuits be matched. This work is planned for February.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II

To permit unlocking of the No. 8 control rod thimble, six fuel subassemblies were removed from the vicinity of the No. 8 control

rod. A gear in the fuel gripper drive differential was broken during pre-transfer checkout. After inserting six dummy subassemblies in the positions vacated by the fuel subassemblies and experiencing some difficulty in unlocking the No. 8 thimble, the control rod thimble, oscillator rod thimble, and oscillator rod were withdrawn and inspected. Upon disassembly in the hot cell, 27 balls were found, 19 jamming and scoring the oscillator rod in the lower region of the guide sleeve. The reactor has been reloaded, and control rod drives are being reassembled in preparation for power operation.

Four subassemblies (2 fuel, 1 control, and 1 blanket) were transferred to the fuel cycle facility and dismantled for examination. The components appear normal. The Row 2 fuel subassembly is estimated to have 0.26% peak burnup.

b. Enrico Fermi Fast Reactor

The reactor has been operated at approximately 18 Kw and 475°F to obtain transfer function data. The data agrees with the calculated zero power transfer function within 3% in amplitude and 1.5 degrees in phase over the oscillator speed range of 0.005 to 5 cps. The low frequency, <0.001 cps, discrepancy is somewhat larger.

Repair of No. 2 steam generator is complete.

c. Hallam Nuclear Power Facility

The reactor remained down all month to complete core observations and to initiate checkout and operation of tools to raise and chock moderator elements for loosening the core lattice.

There were no additional core components removed from the reactor during the month.

Core Observations

The use of the corescopes, borescope and induction probe continued through January 19, 1965, indicating the following:

- 7 known failed moderator elements.
- 2 cracks observed below top head-to-sheath weld.
- 12 additional elements badly scratched.
- 15 additional elements presently associated with stuck core components.

Raising and Supporting Moderator Elements

Efforts to lift moderator elements at 4400 pounds net load (weight of moderator element plus friction) according to Standard Operating Procedure 5133 was completely unsuccessful on nine elements attempted. At this time agreement was reached to proceed with lifting load limits recommended by AI based on buckling of the scallops.

A summary of raising and chocking status at the end of the month is as follows:

- 4 moderator elements raised and chocked at $10\frac{1}{2}$ ".
- 3 additional elements raised approximately 3" and are too tight to permit chocking.
- 1 additional element raised $18\frac{1}{2}$ " and is too tight to chock.
- 7 elements would not move at 4400 pounds load.
- 2 elements would not move at 11,000 pounds load.
- 17 total attempted.

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IV. REPORTS

- a. SCTI and MSG Progress Report - January 1965.
- b. MSAR Progress Report No. 52 - January 1965.
- c. APDA Sodium Technology Loop Monthly Report - January 1965.
- d. APDA Small Leak Sodium-Water Reaction Test Work - January 1965.
- 3. APDA Under Sodium Scanner Test Program - January 1965.

SODIUM COMPONENTS DEVELOPMENT PROGRAM

PROJECT COORDINATION REPORT

FEBRUARY 1965

I. LISTING OF CURRENT PROJECTS

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a. ALCO/BLH Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
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d. Sodium Component Test Installation	Atomics International P. O. Box 309 Canoga Park, California R. Cygan	AT(11-1)- GEN-8	CP
e. Mechanical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
f. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
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i. Sodium-Water	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH
j. Under Sodium Scanner	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH

II. STATUS

a. ALCO/BLH Steam Generator - Baldwin-Lima-Hamilton Corporation

No significant progress during the month.

b. Babcock and Wilcox Steam Generator - The Babcock and Wilcox Company

Prototype Steam Generator

Inquiries have been sent out for bids on all the long lead material. Some quotations have been received from the various vendors. These quotations will be assembled into bid packages and submitted for Commission approval.

Work is underway on the writing of the Preliminary Design Report. The material specifications, which are a portion of the design report, are being used in the rough draft form as a basis for the bids on long lead materials. The rest of the specifications on fabrication and operation are being written.

Work is continuing on a design of the instrumentation for the Prototype Steam Generator. It is hoped that transient performance data can be obtained so that the transient performance of the Prototype Steam Generator can be extrapolated up to predict the transient performance of the Full-Size Steam Generator. This is a problem separate from the problem of modeling nozzles, thermal sleeves, etc. of the Full-Size Steam Generator. The problem occurs because the Prototype is smaller and there is less heat stored in the metal parts and fluids. By writing a mathematical model for the performance of the Prototype Steam Generator and proving the adequacy of this model by careful measurements of the transient performance of the Prototype, it will be possible to predict the transient performance of the Full-Size Steam Generator with reasonable assurance.

R&D Program

Materials - Carbon Transfer and Corrosion Simulating Full-Size Plant

The sodium test loop and model boiler continued in normal operation at full temperature during the month. It is estimated that the loop will complete the 8000 hours of scheduled operation in early June, 1965. The one tube model steam generator and significant portions of the loop will be cut up and examined for mass transfer and corrosion.

Sodium-Water Reaction

Data has been obtained on the strength of pressure vessels for pressure excursions of very short time durations. Using these data as a basis,

the Prototype Steam Generator is being analyzed for the strength of the liner and shell during the first few milliseconds after an assumed sodium-water reaction. This analysis is not complete, but it appears that it will be possible to show that the Prototype Steam Generator shell will not fail even if all twenty-five tubes in the boiler bundle are assumed to fail simultaneously. As soon as these calculations are completed, a special report will be written including both the APDA (Atomic Power Development Associates, Inc.) and the B&W (Babcock and Wilcox) calculations on the Prototype Steam Generator. This report will be the background for the review with the Commission of the handling of sodium-water reactions in the B&W Prototype. It is felt that these analyses both by APDA and B&W are extremely conservative and that it will be possible to demonstrate that the Prototype Steam Generator will not become a hazard to nearby personnel even under the conditions of a worst credible accident.

c. Modular Steam Generator Fabrication - Atomics International

The two evaporator units were completed February 6 and hydrostatically tested February 8 and 10, respectively. A dilute solution of sodium nitrite in distilled water was used for the test. The units were tested at 7550 psig on the steam side and 780 psig on the shell (sodium) side. The units were washed thoroughly with distilled water, drained, and dried. All openings have been sealed and a dry nitrogen gas is being maintained while in storage. Surveillance will be maintained to assure that the units are kept dry and inspections made from time to time.

The two superheat units are in the final stages of fabrication. Final shell welds are in progress.

d. Sodium Component Test Installation - Atomics International

The 7500-gal tank for primary sodium storage was received February 23. The old secondary system tank was removed from the steam generator pit and replaced with the old primary tank complete with a full load of sodium without mishap. The new tank has been set in the primary drain pit and work is progressing on the piping, electrical, and instrumentation hookup.

The steam and feedwater system was chemically cleaned. In general, the operation proceeded smoothly. The only major difficulty was a flow blockage which occurred in the boiler feed-pump discharge line caused by rags lodged in the inlet side of the straightening vanes. After this problem was eliminated, the cleaning operation was carried to completion with no further problem. At the conclusion of the cleaning, the entire system was filled with demineralized water and chemical treatment established for oxygen removal and pH control.

The alkaline boilout of the steam generator preheat boiler has been completed. The faulty safety relief valve has been replaced by the vendor.

Modification of the gas-fired-heater for the air preheat system has been completed. Modifications included installation of a convection section on the upper end of the heater and the addition of a small induced draft fan. As a result of the increase in heat transfer surface area, the rated output of the heater was increased from 5×10^5 to 6.5×10^5 Btu/hr.

e. Mechanical Properties of Materials in Sodium - MSA Research Corporation

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and the results reported in MSAR Report 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

The creep and creep-rupture tests on original material have been completed. The creep-rupture and tensile tests on 4000-hour exposed specimens are in progress. Metallographic examinations of the specimens generated under this test are nearly complete. The fatigue runs are continuing. Preliminary interpretation of the results to date indicates that carbon contamination in sodium will significantly reduce the fatigue life and the impact strengths, increase the creep-rupture life, but reduce the ductility of 316 SS.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High (300 ppm) Oxygen Sodium

Test 4 has been completed and the results reported in MSAR Report No. 64-81, along with the results of Test 2.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High (300 ppm) Oxygen Sodium

The creep-rupture and fatigue testing on original specimens is continuing. The creep tests have been completed and the testing of 4000-hour exposed specimens is in progress. The results to date indicate only a slight increase in the creep-to-rupture strengths with a corresponding decrease in ductility. A slight decrease in the minimum creep rate has also been observed. Metallographic examinations are continuing.

Extensometer Development

The design of the test rig is underway and a design for a differential transducer for 1200°F service has been received and is being evaluated.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Loop Operation

Evaluation of various methods of dissolving sodium carbonate in recirculating sodium was continued. The method evaluated during this period involved the forced flow of sodium through a specially designed container loaded with 10.82 grams of granular Na₂CO₃. The sodium flow rate through the unit was about 7.5 gal/min during the 28-hour test period. The temperature of the sodium was maintained at about 850°F. A chemical analysis of the material remaining after

the container was removed from the loop showed that none of the sodium carbonate had dissolved.

During the above test, the outlet Rhometer showed an increase in resistivity of the sodium. This increase has not been explained.

An APDA representative was sent to United Nuclear Corporation, White Plains, New York, to attend a five-day course on the in-line oxygen meter covering the theory of operation, installation, and instrumentation of the meter. Four probe units will be supplied for the APDA loop instead of three as originally designed by United Nuclear. Three of the four probes will be located at the three Rhometer positions. The fourth probe will be located in close proximity to one of the other probes as a check on the reproducibility of data from two separate probes located in the same relative position in the loop. The instrument package is being modified by United Nuclear Corporation to accept an input from four meters. The proposed plan for testing the meters is being developed.

Chemistry Support

Because the results of the loop tests indicated the solubility behavior of sodium carbonate is substantially different from published literature, it was decided that an attempt to substantiate the solubility data of sodium carbonate in sodium reported by Williams was necessary. Suitable equipment for these studies is being designed. The APDA equipment will differ in size and material of construction. It was decided to use stainless steel throughout (Williams' equipment was glass) to prevent contamination by the action of sodium on a glass system. Some preliminary experiments were made during this period. In these tests, a mixture of sodium and sodium carbonate was heated to a temperature of approximately 870°F and maintained at this point for a period of several days. After extraction of the mixture with alcohol and water, a black residue remained in each case. In test No. 1, the residue was identified as carbon. In test No. 2, the residue was tentatively identified as carbon, but was lost in filtering before positive identification could be made.

The combustion trains used for carbon analysis have yielded very low blanks during this report period. The carbon levels for a two-hour period have been below two-μg carbon, and usually below 1.5-μg carbon. Precision of the method has remained very good.

g. Continuous Oxide Meter - United Nuclear Corporation

Construction of the meter housings and instrument packages for use in the field tests was completed. The lower housings and instrument packages are ready for shipment to the field sites.

Assembly of sensor probes for the field test program was started. Four sensors were assembled. Acceptance testing against a C:CO₂ electrode is in progress, and all of the sensors appear to operate satisfactorily.

Assembly of the remaining sensor probes for the field test program will be postponed until the respective sites are ready to install the probes.

Calibration of prototype sensors in the forced circulation sodium loop was continued. The results show that the Electrochemical Oxygen Meter is a sensitive indicator of changes in the oxygen

content of sodium. The response of the sensors to changes in oxygen content is very reproducible and in reasonable agreement with theory.

Representatives from three field test sites spent four days at UNC receiving instructions in the principles, installations, and operation of the Electrochemical Oxygen Meter. The instructions included both discussions and actual laboratory practice with the meters. Specific problems anticipated at the individual sites were also discussed.

Tentative agreements were reached on the location of the meters in the field test loops. Four meters will be installed in the APDA Sodium Technology Loop. Three meters will be installed in an EBR-II model piping loop at Argonne National Laboratory, which is currently being used to study the vacuum distillation technique for determining oxygen in sodium. Two meters will be installed in a Cold Trap Na Supply loop at Los Alamos Scientific Laboratory. All of the loops are equipped with cold traps, plugging meters, and Rhometers. The Electrochemical Oxygen Meters have been located in each loop to permit correlation between it and purity indications given by the Rhometer, plugging meter, and sampling sections.

h. Mass Transfer - General Electric Company

No report received for the period.

i. Small Leak Sodium Water Reaction Test Program - Atomic Power Development Associates, Inc.

The work on this project to date has consisted of engineering, design, procurement, and construction. The design of all of the components for the test program is complete. These are either being fabricated or have been delivered to the test site.

The major items which remain to be completed are the piping layout, electrical work and instrumentation, and the insulation. The piping specifications are being reviewed. The piping layout drawings for the sodium system are complete and the layout drawings for the nitrogen and water systems are being finalized. The piping bid package will be sent out for quotations no later than March 12, 1965.

The test stand structure, being erected by the James & Savage Corporation, was delayed eleven days by bad weather; the scheduled completion date is now March 15, 1965. Erection of the structural steel for the tower is complete and approximately 80% of the siding is installed. The roof, doors, and components remain to be installed.

The status of the various systems is below:

1. Engineering of the reaction water system is finished. The design and layout is about 80% complete.
2. The circulating water system is engineered and 90% designed.
3. Engineering of the sodium system is complete. The design is approximately 90% complete.
4. The reaction products vent system leading to the Centrifix separator is completely engineered and designed. The steady-state reaction vent system is completely engineered and 95% designed.

5. The electrical and instrumentation bid package is about 50% complete. Approximately 40% of the electrical components, equipment, and heaters have been delivered or are ordered.

j. Under Sodium Scanner Test Program - Atomic Power Development Associates, Inc.

Fabrication of the major components of the sodium facility was completed, with the exception of two items. Assembly of the facility was begun.

A four-megacycle frequency band was added to the pulse modulated oscillator of the ultrasonic transmitter.

A damping circuit, consisting of two adjustable damping resistors in series and parallel with the pulsed oscillating tank circuit, was used to provide the critical damping of transient oscillation. The optimum pulsed oscillation has been obtained.

The fabrication of the push-pull power amplifier for the transmitter was completed, and testing was begun.

After the assembly of the three attenuators in cascade, the input and output impedances of the attenuation system were checked for each attenuation step from 0.1 db to 60 dbs. The impedances are 50 ohms with a 1% error.

The circuits for impedance matching between receiving transmission line, attenuators, and preamplifier were designed.

III. Sodium Component Information from Operating Reactors

a. EBR-II - Argonne National Laboratory

Fuel was loaded into the reactor, and the reactor operated at low power. The hydrogen content in the primary cover gas was found to have increased from 1900 ppm to 16,000 ppm. This increase was attributed to the admission of moisture and air into the primary tank during the removal of the oscillator rod and thimble. With the primary system in operation, a cold trap was used to reduce the plugging temperature from 320° to 250° F. The secondary recirculation system was placed in operation and special tests were made on the electromagnetic pumps. It is apparent from initial study of the test results that the pumps have quite different electrical characteristics.

Following a low power test, the reactor was operated at 45 MWt with the turbine generator producing power. There were no problems with the reactor or sodium systems at this power, but the steam system controllers required considerable attention.

In preparation for hydrostatic test of the steam generator, chromate-treated water (approximately 1400 ppm CrO₄) was drained from the steam generator. The water had been in the evaporators and superheaters for wet layup since November, 1964. Following the draining, water was found in the air space between the water and sodium tube sheets of Evaporator 702, indicating a leak in the tubesheet, tubes, or tube-to-tube sheet welds. A pinhole leak in a tube-to-tube sheet weld was located by bubble testing and confirmed by dye-penetrant test. The leak was repaired and the evaporator helium leak tested.

Examination of eight tubes in the evaporator with a borescope showed them to be uniformly covered with a film of black magnetic oxide. The upper portions of some tubes also contained whitish water-soluble stains similar to deposits of boiler water solids. Further inspection of six tubes revealed shallow pits having a maximum depth of approximately 10 mils and the majority less than 1 mil. In many cases, the pit appeared to be a break in the oxide film.

Since the last entry into the argon cell, approximately one year of highly satisfactory operation in the inert atmosphere has been experienced. At differential pressures of 2 to 3 inches of water below atmospheric, inleakage of air has typically been held to 0.2 to 0.3 ft³/hr, and the purity of the atmosphere has been maintained in the ranges of 30 to 60 ppm oxygen, 25 to 50 ppm water vapor, and about 5% nitrogen. The typical consumption of argon gas, including that required for purging of transfer locks, has been about 3500 ft³/wk.

b. Enrico Fermi Fast Reactor - Power Reactor Development Associates

The No. 2 steam generator is being reassembled following repairs to the tube bundle. The unit will be dried prior to filling the shell side with sodium and testing the tube bundle at 600 psig nitrogen pressure.

The second 100-hour carburization test is in progress. About 75 hours have been accumulated to date. Primary sodium at 1200°F is being circulated over stainless steel test specimens located in the hot trap loop.

Tests of the secondary sodium system were run to investigate the relationship between sodium temperature and hydrogen concentration in the argon cover gas of the steam generators.

c. Hallam Nuclear Power Facility

The reactor remained down all month with primary effort a continuation of lifting and chocking moderator elements in an attempt to free the stuck core components. All efforts to lift moderator elements and remove stuck fuel elements and other core components were discontinued on February 28, 1965, and preparations were started for cutting hanger tubes to allow rotation of the loading face shield.

Attempts to loosen the core lattice by raising and chocking comparatively free moderator elements was unsuccessful. Although several moderator elements which initially could not be raised were partially freed, moderator elements adjacent to known failed moderator elements were not freed.

A summary of these efforts is as follows:

56 moderator elements raised at least three inches, 40 were chocked but the others were too tight to chock since their weight would not overcome friction forces.

35 moderator elements adjacent to failed moderator elements or stuck core components; 33 of these were tried and would not move at the 4400-pounds limit for these elements.

7 confirmed failed moderator elements; one of these (M-51) was tried at 11,000 pounds with no movement.

10 moderator elements were stuck; 7 at 11,000 pounds lifting load and 3 at 17,000 pounds lifting load. Four elements originally stuck at 11,000 pounds were eventually loosened enough to lift.

33 moderator elements in the outer rows contacting core clamps were not tried; 19 of these have only one access hole through the loading face shield, and 14 have no access.

141 total number of cans in the core.

Core Component Removal

Attempts were made to remove the remaining core components beginning on February 22, 1965, at the normal fuel handling machine load of 2000 pounds.

Three fuel elements (C-97, C-98, and C-99) moved out several inches before reaching this limit. The allowable pulling limit was then raised to 4000 pounds and two fuel elements (C-97 and C-98) and the last remaining control rod (C-1) were removed. Both fuel elements were removed without the process tubes. One additional fuel element (C-99) became separated from the hanger tube by impact forces after it fell 13 inches from the fuel handling machine grapple to the full down position.

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IV. REPORTS

- a. SCTI and MSG Progress Report - February 1965.
- b. MSAR Progress Report No. 52 - February 1965.
- c. APDA Sodium Technology Loop Monthly Report - February 1965.
- d. APDA Small Leak Sodium-Water Reaction Test Work - February 1965.
- e. APDA Under Sodium Scanner Test Program - February 1965.
- f. UNC Continuous Oxide Meter - January-February 1965.

SODIUM COMPONENTS DEVELOPMENT PROGRAM

PROJECT COORDINATION REPORT

MARCH 1965

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. ALCO/BLH Steam Generator	Baldwin-Lima-Hamilton Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
b. B&W Steam Generator	Babcock and Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. AI Modular Steam Generator	Atomics International P. O. Box 309 Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CP
d. Sodium Component Test Installation	Atomics International R. Cygan	AT(11-1)- GEN-8	CP
e. Mechanical Properties of Materials	MSA Research Corporation Subsidiary of Mine Safety Appliances Company Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
f. Sodium Technology Loop	Atomic Power Development Associates, Inc. 1911 First Street Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
g. Continuous Oxide Meter	United Nuclear Corporation White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
h. Mass Transfer	General Electric Company Atomic Power Equipment Dept., P. O. Box 254 San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
i. Sodium-Water	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH
j. Under Sodium Scanner	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH

II. STATUS

a. ALCO/BLH Steam Generator - Baldwin-Lima-Hamilton Corporation

Work is continuing on the final preparation of the fabrication report COO-1213-26 and the hydro-testing and strain gage report COO-1213-27. These reports are now slated for issue in April and May respectively.

b. Babcock and Wilcox Steam Generator - The Babcock and Wilcox Company

Prototype Steam Generator

Bids are being received for the various long-lead materials for the Prototype Steam Generator. The bids on the stainless steel tubing are beginning to arrive. This item is being watched very closely because the stainless steel tubing is one of the earliest materials required for fabrication.

Work is continuing on the writing of the specifications. The specifications will form a portion of the Preliminary Prototype Design Report, and will be used in the fabrication of the Prototype Steam Generator.

The location of thermocouples and strain gages is being worked out. The thermocouples that will be located inside the steam generator will be of the sheathed type and will be brought out through seals located in the shell above the surface of the sodium.

R&D Program

Materials - Carbon Transfer and Corrosion Simulating Full-Size Plant

The sodium test loop and model boiler continued in normal operation at full temperature last month.

In the specimens now available for analysis, decarburization of the Croloy 2½ steel is being observed. The absence of observed carburization of the Type 316 Stainless Steel so far has caused considerable speculation. No particles of carbon have been observed when the pipe samples were removed. Perhaps the ratio of stainless steel to carbon steel simulating a full-size plant (including the IHX and piping) is such that carburization of the stainless steel will not occur rapidly. More information will be available on this when the loop is shut down and sectioned for examination.

c. Modular Steam Generator - Atomics International

Superheaters Nos. 1 and 2 have all the tube-to-tubesheet welds completed and accepted. The items remaining are the shell closure welds, hydro-tests, and helium leak checks.

The topical report on the testing program (NAA-SR-9828) for the modular steam generators in the SCTI was completed and sent to the AEC steam generator review committee for their comments. The report will be deferred in order to incorporate information gained during the ALCO tests.

d. Sodium Component Test Installation - Atomics International

Contractors have installed the new primary fill tank. Electrical connections have been completed, heater circuits checked out, and insulation finished.

Subsequent to the chemical cleaning of the SCTI steam and feedwater systems, both heads of the ALCO steam generator were removed for inspection of tubesheets and of the steam and feedwater chests. A very small quantity of weld splatter and flakes of scale had collected at the low point in the lower end; otherwise, conditions were very good. Thermocouples attached to the upper tubesheet and led out through the steam exit pipe had been installed with excess material length. It was necessary to secure these to the vessel wall to prevent their being torn off by steam at high flow velocities. Both heads were replaced with new ring joint gaskets, and the new studs were put in.

Hydrostatic testing of the steam and feedwater systems was accomplished. This test was necessary in order to satisfy code requirements of steam and feedwater piping installed with the ALCO steam generator. All leaks were corrected, the test pressure of 3750 psig was held for two hours, and after eleven hours the pressure had decayed to 3140 psig.

After completion of the hydrostatic test, blind flanges were removed from the piping, and treated water was circulated through the system using the condensate booster pump. A bypass stream was taken through the polishing demineralizer for several days to bring the purity of the water within required limits. The recommended pH and hydrazine content of the water was established as a prerequisite to preheating operations with the steam generator.

The 900 HP motor which drives the boiler feed pump was operated for the first time. This motor draws a large starting current - but the initial operation was done without disturbing other critical power loads connected to the same subsystem.

A high-temperature alarm for the secondary sodium pump motor stator has been installed. As built, the plant did not have an alarm to annunciate the failure of cooling blowers required for proper operation of the pump drive. An annunciator has been added to the coil-type level probe functions as an override if the bubbler-type level controller fails.

e. Mechanical Properties of Materials - MSA Research Corporation

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 ss Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air and Helium

This test has been completed and the results reported in MSAR Report 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

The creep and creep-rupture tests on original material have been completed. The creep-rupture and tensile tests on 4000-hour exposed specimens are in progress. Metallographic examinations of the specimens generated under this test are nearly complete. The fatigue runs are continuing. Preliminary interpretation of the results to date indicates

that carbon contamination in sodium will significantly reduce the fatigue life and the impact strengths, increase the rupture life, but reduce the ductility of 316 ss.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High (300 ppm) Oxygen Sodium

Test 4 has been completed and the results reported in MSAR Report No. 64-81, along with the results of Test 2.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High (300 ppm) Oxygen Sodium

The creep-rupture and fatigue testing on original specimens is continuing. The creep-tests have been completed, and the testing of 4000-hour exposed specimens is in progress. The results to date indicate only a slight increase in the rupture strengths with a corresponding decrease in ductility. A slight decrease in the minimum creep rate has also been observed. Metallographic examinations are continuing.

Extensometer Development

The final design of the test rig is in progress, and the differential transducer for 1200°F service and read-out instrumentation has been ordered.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

The loop program during this period consisted of a series of water injections. The water was injected by means of a syringe into a heated tube through which a 400 cc/min purge of argon was flowing. The water (as vapor) was carried by the argon into the sodium stream or gas space. The injection probe used was similar to the probe used for the water injection program reported in APDA-163, "Operation of the Sodium Technology Loop for Contamination Meter Evaluations." The temperature of the loop was maintained at about 750°F throughout the program herein reported. The Rhometers generally showed an increase in resistivity with the injection of the water, but the response is not consistent throughout the injection program. The same inconsistent effect may be seen from the plugging meter runs. An exploration of the relative behavior of these two instruments has not been made.

During injections 5 through 8, the Fisher Partitioner was employed as a continuous analytical tool for the cover gas in the surge tank. But because of a slow response time (about an hour) and the insensitivity of the partitioner, no meaningful data were obtained.

During this month, an attempt was made to determine the cause of the negative unbalance of the inlet Rhometer, but the cause was not discovered.

Construction on the loop to accept the oxygen meters from United Nuclear Corporation will begin upon reception of the bellows seal valves. Installation is scheduled for the week of April 12, 1965.

Chemistry Support

An analysis of the residue which was filtered out of the loop during the last report period indicated the presence of carbon and iron; no nickel was detected.

During this period a Gas Chromatograph, Model 720, was installed under the loop and is connected to the gas recirculating system. A standard

procedure for the operation of the gas analysis system has been written and is in use.

Fabrication of the equipment for the sodium carbonate solubility program has been completed and has been checked out. Work on the program is underway.

All of the data for the APDA report on the analysis of "oxygen" in sodium has been collected, and the final draft has been written.

A preliminary design of the system to test the feasibility of a continuous monitor for hydrogen in sodium has been made, and the materials necessary for fabrication are now on order.

g. Continuous Oxide Meter - United Nuclear Corporation

No report was received for this period.

h. Mass Transfer - General Electric Company

No report was received for this period.

i. Small Leak Sodium Water Reaction Test Program - Atomic Power Development Associates, Inc.

The work on this project to date has consisted of engineering, design, procurement, and construction. The design of all of the components for the test system is complete. These items, with the exception of the water cooler, are either erected in the structure or on the site.

The piping bids have been reviewed, and the contractor has tentatively been chosen.

The major design items remaining to be completed are the electrical work, the instrumentation, and the insulation. The electrical work and instrumentation is essentially finished; however, approximately two to three weeks are required to tie down details and refine the specification for the bid package. Discussions with electrical contractors indicate that the electrical and instrumentation work can be done simultaneously with the insulation work without difficulty.

The insulation specification should be completed the 23rd of April.

The erection of the structure is complete with the exception of a few items that have been compiled on a punch list to be taken care of as the project progresses.

The status of the various systems is listed below:

- (1) Engineering and design of the reaction water system is finished.
- (2) The circulating water system is completely engineered and designed.
- (3) Engineering of the sodium system is complete. However, the pump impeller diameter remains to be turned down.
- (4) The reaction products vent system leading to the Centrifix separator is completely engineered and designed. The steady-state reaction vent system is also complete.

- (5) The electrical and instrumentation bid package is about 80% complete. Approximately 90% of the electrical components, equipment, and heaters have been delivered or are ordered.

j. Under Sodium Scanner - Atomic Power Development Associates, Inc.

Fabrication of all components for the sodium test facility was completed, and assembly of the facility continued. The assembly work is approximately 75% completed and proceeding on schedule. Sodium fill is expected on or before April 15, 1965.

The input circuit of the preamplifier has been modified for impedance matching between the attenuator and the preamplifier. The attenuator output was checked against the db-meter on a Model 650-A Hewlett-Packard test oscillator. No significant error was observed.

A small test tank with two piezoelectric disks on the top and bottom of the tank was designed, fabricated, and tested. The purpose of the test tank is to check the sensitivity of the electronics. Two kinds of media, water and mercury, have been used in the tests. Both gave sufficiently strong receiving signals that decrease exponentially with distance.

Other improvements and modifications to the electronic system are continuing.

III. Sodium Component Information from Operating Reactors

a. EBR-II - Argonne National Laboratory

During the first half of the month, the reactor was operated at powers up to 100 KW for physics measurements and for a series of foil irradiations. Also, the control rods were calibrated by period measurements, and operators were requalified. Repair of the leaking evaporator was completed about March 15, and the secondary sodium system was filled, as described below. Permission to proceed to higher power was obtained on March 26, and the reactor was brought to a power level of 10 MW. On March 27, a power level of 45 MW was attained and the reactor is operating steadily and without problems at this power level at the end of the month.

Prior to operation, ten materials surveillance subassemblies were loaded into the primary tank, eight into inner blanket positions, and two into the storage basket. Four core-type and two inner blanket-type flux-wire subassemblies were also loaded into the reactor grid and irradiated for 10 KWh to measure relative distributions of radial and axial fission rates, and plutonium production in the core and inner blanket. These subassemblies were then removed from the primary tank, cleaned, and the flux wires submitted for radiochemical analysis. One additional sixth row, core-type subassembly, was loaded into the reactor to provide a total excess reactivity of 312 β h at 700°F and zero power.

Flux-wire irradiations were carried out at 650°F, after which the bulk sodium temperature was lowered to 365°F to allow filling the secondary sodium system. After filling, the primary system was heated to 700°F by a combination of electrical heating and reactor operation at a power level of 100 KW.

The composition of the blanket gas in the primary system remained relatively constant, showing about 2% nitrogen and 0.3% hydrogen. The composition of the blanket gas in the secondary system also remained relatively constant, at about 0.3% nitrogen and 10 ppm hydrogen.

After the secondary sodium system was filled, the plugging temperature slowly rose to 300°F. By operating the cold trap for two days, the plugging temperature was reduced to less than 250°F.

The plugging temperature of the primary system remained below 250°F, so its cold trap was not operated.

Power Plant operations were at first limited to those required to support low-power operation of the reactor. With the advent of higher power operation, it was operated in the normal manner. The bypass valves on the cooling tower were closed for the first time since October 1964, to allow full tower operation. This dislodged a considerable amount of dirt and debris which caused plugging of cooling-water strainers in various equipment. Raw water was supplied to the reactor auxiliaries for a period while the cooling-tower basins were cleaned up. Until the system has been completely cleaned, this situation is expected to reoccur.

Investigation of the failure of the 400-KW diesel-generator has indicated that this may not have been caused by loss of lube oil pressure, although this cannot be ruled out as a possibility. The control wiring and mechanical systems have been checked thoroughly without indication of the real cause of the failure. Several load tests have been performed since the incident, and the unit has performed perfectly each time. Investigation is continuing, and further loss-of-normal-power tests are contemplated.

b. Enrico Fermi Fast Reactor - Power Reactor Development Company

The reactor has been shut down for steam generator testing.

Repairs to the No. 2 steam generator have been completed. A 600 psig nitrogen pressure test indicates a considerable improvement in the leak rate of this unit following the repair of tube-to-tubesheet welds. Quartz glass windows were installed in the steam generator to allow visual inspection of the sodium surface and argon atmosphere during testing.

The No. 3 steam generator was checked for leaks with 600 psig of a helium-nitrogen mixture on the tube side. Calculations indicate no significant change has occurred since the unit was boiled dry.

Three moisture injection tests were run on Nos. 1 and 2 steam generators. Water was injected continuously until the cover gas hydrogen content leveled out at values between 1600 ppm and 5000 ppm. The water injection rate was then increased to prove that detectable increase in cover gas hydrogen would occur.

Work continued on the steam generator cover gas chromatograph to determine readability of the instrument at high hydrogen concentrations. Hydrogen step changes of approximately 300 ppm from various base points on the 1-10,000 ppm range were made. Results indicate that these changes are readable at the high concentrations.

The fuel and repair building is undergoing modifications in two major areas: the steam cleaning system, and the transfer tank of the

sodium cleanup system. Work in the steam cleaning system includes the addition of two new electric relay cabinets, additional limit switches on valves, new manual stop valves for steam, water, and recirculation gas, and changes to the graphic control panel. Modifications in the transfer tank include the removal of an old cold trap and installation of a larger cold trap and overflow tank.

c. Hallam Nuclear Power Facility

The reactor remained down all month for a continuation of the program for removal of failed moderator elements. The work consisted mainly of severing the hanger tubes of stuck core components, followed by unsuccessful attempts to rotate the loading face shield.

Chock Removal

Fourteen chocks were removed from moderator elements selected to be replaced by spacer elements. In order to remove chocks, they must be held upright by contact with a moderator element; therefore, they must be removed before the element being supported is removed.

11 chocks were removed from March 1 to March 6

3 chocks were removed on March 15

14 chocks removed total

Core Component Cutoff

Severing fuel element hanger tubes and miscellaneous components attached to the loading face shield began on March 7. Previous successful cuts were made with the tungsten electrode on mockups of components to sever. All cuts were completed by March 14 as summarized below:

16 fuel element hanger tubes

2 dummy element hanger tubes

1 source thimble

1 moderator element, M-3, extension

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IV. REPORTS

- a. SCTI and MSG Progress Report - March 1965.
- b. MSAR Progress Report No. 53 - March 1965.
- c. APDA Sodium Technology Loop Monthly Report - March 1965.
- d. APDA Small Leak Sodium-Water Reaction Test Work - March 1965.
- e. APDA Under Sodium Scanner Test Program - March 1965.

SODIUM COMPONENTS DEVELOPMENT PROGRAM

PROJECT COORDINATION REPORT

APRIL 1965

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. ALCO/BLH Steam Generator	Baldwin-Lima-Hamilton Corp. Philadelphia, Pa. P. S. Otten	AT(11-1)- 1213	CH
b. B&W Steam Generator	Babcock & Wilcox Co. Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. AI Modular Steam Generator	Atomics International Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CP
d. Sodium Component Test Installation	Atomics International Canoga Park, California R. Cygan	AT(11-1)- GEN-8	CP
e. Mechanical Properties of Materials	MSA Research Corp. Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
f. Sodium Technology Loop	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
g. Continuous Oxide Meter	United Nuclear Corp. White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
h. Mass Transfer	General Electric Co. San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
i. Small Leak Program	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
j. Under Sodium Scanner	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
k. Fermi Compilation	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
l. Heat Exchanger Evaluation	United Nuclear Corp. White Plains, New York K. Goldmann	AT(11-1)- 1452	CH

II. STATUS

a. ALCO/BLH Steam Generator - Baldwin-Lima-Hamilton Corporation

"As built" drawings of the ALCO/BLH Steam Generator were submitted to the Atomic Energy Commission and distributed to the interested parties.

Steam Generator Fabrication Report No. COO-1213-26 was issued to Sodium Component Development Program (SCDP) members. The Strain Gauge Report No. COO-1213-27 is now slated to be issued in May 1965.

b. Babcock & Wilcox Steam Generator - Babcock & Wilcox Company

Prototype Steam Generator

The Preliminary Design Report on the Prototype Steam Generator is being written. The stress analysis calculations have been completed and are being summarized for the design report. It is planned to organize this design report on the same general basis as the Preliminary Design Report on the Full-Size Steam Generator. Summaries of the significant calculations will be included in the design report, and the actual calculations will be bound separately and will be available on request.

Research and Development Program

Materials - Carbon Transfer and Corrosion Simulating Full-Size Plant

The one tube model steam generator and sodium loop continued in operation. This test loop has completed a total of 7,200 hours of operation. It is anticipated that the loop will have accumulated the scheduled 8,000 hours of operation during the first week in June. The loop will then be shut down, and the steam generator and other portions of the loop will be cut up and examined for mass transfer and corrosion.

c. Modular Steam Generator Fabrication - Atomics International

Fabrication of the two superheater modules is continuing. The estimated completion date is June 1, 1965.

d. Sodium Component Test Installation - Atomics International

Preoperational Tests

Melting of all sodium required for the filling of the new primary drain tank has been completed. The tank now contains 41,000 pounds of sodium and is being maintained at 350°F. After several minor incidents in getting started with the melting operation, problems were alleviated, and the filling proceeded smoothly. Sodium in the secondary fill tank has been melted and is also being held at 350°F.

Testing of the steam and feedwater systems was completed. Operating characteristics of the boiler feed pump were determined, and proper operation of all three water pumps - condensate, condensate booster, and boiler feed pump - was also determined.

Preheating of the secondary sodium piping is complete, and the system is being held at 350°F. Similarly, the ALCO steam generator has also been preheated and can easily be maintained at the 350°F preheat temperature.

The established procedure for filling of the two sodium systems calls for two filling and draining operations to flush out any undesirable loose material that may be resident in the piping. These two flushings

will be followed by a third filling which will be the final operation before circulation. The two such filling and draining operations of the secondary system have been accomplished.

The performance of all preoperational testing of the plant control system has been completed with the exception of the final section. This final section, which concerns plant safety shutdown, has been written and reviewed internally. Performance of this section is dependent on having both sodium systems filled and in normal operation.

e. Mechanical Properties of Materials - MSA Research Corporation

Test 1 - Stainless Steel (316) Specimens in 1200°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and reported in MSAR Report 64-18, Topical Report No. 2, "Results of Physical Property Tests of 316 SS Specimens in 1200°F Sodium with Low Oxygen."

Test 2 - 2½ Cr-1 Mo Steel Specimens in 1100°F, Low Oxygen (30 ppm) Sodium, Air, and Helium

This test has been completed and the results reported in MSAR Report 64-81, "Results of Physical Property Tests of 2½ Cr-1 Mo Steel Specimens in Sodium with High and Low Oxygen, Air, and Helium Environments at 1100°F."

Test 3 - Stainless Steel (316) Specimens in 1200°F, High Carbon Sodium

The creep and creep-rupture tests on original material have been completed. The creep-rupture and tensile tests on 4,000-hour exposed specimens are in progress. Metallographic examinations of the specimens generated under this test are nearly complete. The fatigue runs have been completed. Preliminary interpretation of the results to date indicates that carbon contamination in sodium will significantly reduce the fatigue life and the impact strengths, increases the creep-rupture strength, but reduces the ductility of 316 SS.

Test 4 - 2½ Cr-1 Mo Steel Specimens in 1100°F, High (300 ppm) Oxygen Sodium

Test 4 has been completed and the results reported in MSAR Report No. 64-81, along with the results of Test 2.

Test 5 - Stainless Steel (316) Specimens in 1200°F, High (300 ppm) Oxygen Sodium

The creep-rupture and fatigue testing on original specimens is continuing. The creep tests have been completed, and the testing of 4,000-hour exposed specimens is in progress. The results to date indicate only a slight increase in the short-time rupture strengths with a corresponding decrease in ductility. A slight decrease in the minimum creep rate has also been observed. Metallographic examinations are continuing.

Extensometer Development

The final design of the test rig has been completed. The differential transducer for 1200°F service and read-out instrumentation have been ordered, and some test material has been delivered.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Loop Operation

During this reporting period, the exploratory water injection program has been completed. The results have been tabulated and are reported in the Quarterly Technical Progress Report on AEC-Sponsored Activities for the period of January-March 1965.

Preliminary to checkout of the sample tube cleaning procedure, four sets of sodium samples were taken for analysis to verify the reproducibility of the analysis between the two sampling stations. Analysis of these samples is 80% completed. Pending the results of the analysis of the samples, the cleaning procedure checkout will be continued.

Sodium leakage at the valve packings during maintenance operations necessitated shutdown of the loop for repair of the valves. During the shutdown, the four lower housings for the oxygen meter probes were installed. The instrument package and the four oxygen cells were received at the end of this reporting period. Only one of the connecting cables has been received, with the remaining cables scheduled for delivery at the beginning of the next reporting period.

Three bellows seal valves are being installed in the loop: one on the discharge of the thermal decomposition tank, one on the main drain lines, and the other is replacing the by-pass valve between the inlet header and the effluent header. Several gate valves, in which the stems had frozen, are being repacked.

Chemistry Support

Routine analyses of the loop sodium for oxygen, carbon, and carbonate carbon has continued with the precision remaining at the previously reported low values. Work has again been started on the determination of hydrogen by the thermal decomposition and catalytic oxidation method. The precision of the method has been demonstrated to within 2 ppm for hydrogen content in the 2- to 5-ppm range. Work will progress to establish the accuracy and precision of the method.

Because of the erratic behavior of the dry box atmosphere, progress on the sodium carbonate program has been delayed. Work will continue after moisture and oxygen can be maintained at acceptable levels.

g. Continuous Oxide Meter - United Nuclear Corporation

During the month, seventeen sensor probes for use in the field test program were completed and acceptance tested. Meters and instrument packages were shipped to Atomic Power Development Associates (APDA) and Los Alamos Scientific Laboratory (LASL). The meters and instrument package for Argonne National Laboratory (ANL) are ready for shipment. Four of the above thirteen meters are being tested in the forced circulation loop at United Nuclear Corporation.

h. Mass Transfer - General Electric Company

No report was received for this reporting period.

i. Small Leak Sodium-Water Reaction Tests - Atomic Power Development Associates, Inc.

Construction of the sodium-water reaction test rig is continuing. The major items to be completed are the electrical work, the instrumentation, and the insulation. The electrical and instrumentation

design is finished, and the specifications are being typed. The draft of the insulation specification is being typed.

j. Under Sodium Scanner - Atomic Power Development Associates, Inc.

During the reporting period, assembly of the facility for attenuation testing was completed. Subsequent leak testing of the system revealed no significant leakage. The purification system, which provides a dry box atmosphere having a moisture content less than 0.1 ppm and an oxygen content less than 1.0 ppm was operated. An evaluation of the effectiveness of this system is not complete. The test facility should be filled with sodium by May 3, 1965, followed by operation of the ultrasonic transducers. Preliminary data on the attenuation of sound waves in liquid sodium is expected to be accumulated in May.

k. Fermi Compilation - Atomic Power Development Associates, Inc.

The purpose of the project is to make available to the fast reactor development program the experience that has been gained from the Enrico Fermi Reactor Plant project. The scope of the effort is to compile into reports suitable for general use the noteworthy experiences starting with the evolution of the design and progressing through the fabrication, construction, testing, and operation of the Fermi plant. It is anticipated that important components and systems will be treated in individual reports each of which will include sufficient descriptive and background material to make it a reporting entity.

The following reports are being written:

- EFFBR Primary System Development
- EFFBR Fuel Handling in the Reactor Vessel
- EFFBR Nuclear Test Program
- EFFBR Low Power Nuclear Test Results
- EFFBR Steam Generators
- EFFBR Sodium System Flowmeters
- EFFBR Sodium System Level Detectors
- EFFBR Control and Safety Rod Drives
- EFFBR Fuel and Blanket Subassemblies
- EFFBR Sodium Sampling Procedures

1. Heat Exchanger Evaluation - United Nuclear Corporation

Under this project, the contractor will analyze and evaluate the thermal, hydraulic and structural performance of several liquid-metal heat exchangers under steady-state and transient conditions. The analyses and evaluation of these units will be based on data derived from testing in the Sodium Components Test Installation. At present, the following heat exchangers are scheduled to be tested:

- One 30 MWt Intermediate Heat Exchanger manufactured by ALCO Products, Inc.

- One 30 MWt Steam Generator designed by ALCO Products, Inc. and manufactured by Baldwin-Lima-Hamilton Corporation

- Two Modular Steam Generator Units (approximately 21 MWt) manufactured by Atomics International

- One 30 MWt Steam Generator manufactured by Babcock & Wilcox Company

III. Sodium Component Information from Operating Reactors

a. EBR-II - Argonne National Laboratory

A continuous power run of twelve days duration at 45 MWt and 14 MWe was completed as scheduled. During subsequent shutdown, difficulty was experienced with gripper actuation of two control rod drives which required replacement of the affected grippers. At the end of the month, the reactor was again in operation at 45 MWt and halfway through its next scheduled run which is expected to carry the maximum fuel burnup to 0.64 a/o. Preliminary inspection of fuel elements removed from the reactor after 0.5 a/o burnup maximum indicated them to be in excellent condition.

b. Enrico Fermi Fast Reactor - Power Reactor Development Associates

The reactor was reloaded on April 21, 1965, by replacing four dummy subassemblies with four fuel subassemblies which had been removed in March. During the remainder of the month, the reactor was operated to obtain additional oscillator data and for shield evaluation measurements.

Water injection tests were completed this month in the steam generators at sodium temperatures of 475°F, 529°F, and 750°F. They correspond approximately with the sodium temperature attained between reactor startup and 200 MW operation. Water injection rates of 0.1, 0.3, 0.6, 1.0, and 2.0 cc per minute were selected for these tests to demonstrate the ability to detect minute water leaks from a steam generator by means of the presently installed instrumentation.

Modifications were completed on the thermal conductivity instruments of all three steam generators. The modifications corrected the causes of zero drift in the instruments and improved their sensitivity. Test results indicate that hydrogen step changes of less than 100 ppm are detectable at high hydrogen concentrations.

c. Hallam Nuclear Power Facility - Atomics International

The reactor remained down all month for the continuation of the program for the removal of failed moderator elements. Rotation of the loading face shield was achieved with the design and development of a "perimeter-difference-drive" system. Physically, this system consists of sixteen hydraulic jacks secured to the floor around the periphery of the shield, positioned to apply a radial force to the shield and connected to an automatic hydraulic controller. Rotation is achieved by sequentially actuating the jacks such that the point of contact between the shield and the cavity liner is moved around the periphery of the shield. This results in "rolling" the shield around the inside of the cavity liner.

Written and edited by:

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IV. REPORTS

- a. SCTI and MSG Progress Report - April 1965
- b. MSAR Progress Report No. 53 - April 1965
- c. APDA Sodium Technology Loop Monthly Report - April 1965
- d. APDA Small Leak Sodium-Water Reaction Test Work - April 1965
- e. APDA Under Sodium Scanner Test Program - April 1965
- f. Fermi Compilation Monthly Report - April 1965
- g. Heat Exchanger Evaluation Monthly Report - April 1965
- h. APDA Quarterly Report (APDA-170) - January-March 1965
- i. BLH Steam Generator Fabrication Report (COO-1213-26)

SODIUM COMPONENTS DEVELOPMENT PROGRAM

PROJECT COORDINATION REPORT

MAY 1965

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. ALCO/BLH Steam Generator	Baldwin-Lima-Hamilton Corp. Philadelphia, Pennsylvania R. B. Abderhalden	AT(11-1)- 1213	CH
b. B&W Steam Generator	Babcock & Wilcox Company Barberton, Ohio P. S. Probert	AT(11-1)- 1280	CH
c. AI Modular Steam Generator	Atomics International Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CP
d. Sodium Component Test Installation	Atomics International Canoga Park, California R. Cygan	AT(11-1)- GEN-8	CP
e. Mechanical Properties of Materials	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
f. Sodium Technology Loop	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
g. Continuous Oxide Meter	United Nuclear Corporation White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
h. Mass Transfer	General Electric Company San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
i. Sodium-Water	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
j. Under Sodium Scanner	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
k. Fermi Compilation	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
l. Heat Exchanger Evaluation	United Nuclear Corporation White Plains, New York K. Goldmann	AT(11-1)- 1452	CH

- m. Development of Techniques
for Measurement of
Impurities in Sodium

MSA Research Corporation
Callery, Pennsylvania
R. C. Werner

AT(11-1)-
765

CH

II. STATUS

a. ALCO/BLH Steam Generator - Baldwin-Lima-Hamilton Corporation

The strain gauge report, COO-1213-27, has been issued and distributed to the interested parties.

b. Babcock & Wilcox Steam Generator - The Babcock & Wilcox Company

Purchase orders have been placed for all of the long lead material. These orders were placed presuming starting fabrication June 1. The start of fabrication has been delayed approximately one month. Hold orders have gone out to vendors of some of the material that will not be required as soon as anticipated.

A layout drawing has been completed showing the sodium distributor developed in the water flow model under the research and development portion of this contract.

Minor modifications to the distributor design were made to make it easier to fabricate. This layout drawing is being reviewed by the Alliance Research Center personnel who did the model test to make sure it agrees with the distributor they developed. The general arrangement drawings of the Prototype Steam Generator are being revised to show this type distributor.

Research and Development Program

Materials - Carbon Transfer and Corrosion Simulating Full Size Plant

The sodium test loop continued in operation last week. It is anticipated that this test loop will complete 8,000 hours of scheduled operation in early June. It will then be shut down for examination. Careful examination of specimens removed after the 1000, 2000, and 4000 hours of operation show significant gradients in carbon and other elements throughout the walls of the pipe samples, but most of these effects were either in the as-received piping or were changes due to operation for a number of hours at elevated temperature, and have nothing to do with the sodium environment itself. There is a small indication of decarburization of the Croloy 2½ after 4000 hours, but there is no detectible carburization of the type 316 stainless steel. It is planned to remove samples and make a quick analysis after 8000 hours of exposure before the Information Meeting to be held in Chicago on June 16 and 17.

Procedure for Welding Tubes to Sodium Face of Tube Sheet

Work has begun on the welding head having a cold wire feed mechanism. The welding of the 5/8-inch O.D. tubes did not require any filler metal so the TIG welding head for this diameter did not incorporate the wire feed mechanism. A mockup of the welding head for larger size tubes was made to find the problems of feeding the wire into the weld. After some exploratory work, filler wire has been ordered that should be of the proper diameter and temper to feed reliably into the weld zone. After the welding and wire feeding techniques are perfected, the welding head itself will be optimized. Locating and centering devices will be added to the torch head to reduce it to a practical, useable design of the same general nature as the one for the 5/8-inch O.D. tubing.

Sodium-Water Reaction - Atomic Power Development Associates, Inc. (APDA)
Subcontract

The detailed analysis work pertaining to the full-size steam generator has started. Calculations have shown a possible problem of overheating tubes in the reaction zone which, if real, would produce an excessive rate of tube failure propagation after an initial leak occurred.

Attempts to derive values of the heat transfer coefficient on the outside of the tubes exposed to the reaction from test data for use in an analysis have failed. Currently, a search is under way to obtain coefficients for other processes which produce conditions similar to those found in the reaction zone. From APDA test data, it appears that temperatures near 2200 F can occur in the reaction products. An assumed heat transfer conductance of 4000 BTU/hr-ft²-F results in tube failures regardless of whether water or steam is inside the tube. When 200 BTU/hr-ft²-F is assumed, there is no danger of this mode of tube failure.

Also underway is the application of the parallel-path piston mathematical model to the unit, using various leak rates to predict bubble pressure versus time.

Finite-Difference Mathematical Model

The computer code for the application of this model to the full-size unit has been completed. The determination of the constants and the checkout of this code is underway.

The small air-water and helium-water test rig that is part of the subcontract work has been built and operated. The results of these tests are being analyzed and will serve as a basis for modifying the computer program to more accurately represent the fluid movements on the shell side as it is forced away from the reaction zone. All the computer analysis work so far has assumed flows represented by the "piston mathematical model."

The other test rig that is part of the APDA subcontract effort is designed to explore tube thinning in and around the reaction zone. This rig is currently undergoing shakedown test. Initial runs made so far have shown the need for improvement in the blow-out disk assembly. This device is part of the trigger mechanism which serves to inject the reaction water into the sodium. Data from this rig is aimed at providing some insight into the possible tube failure propagation rate.

The analysis work pertaining to the prototype unit is complete and will be included in a special report titled "Dynamic Bursting Strength of the B&W 30 MWt Sodium Heated Steam Generator during a Major Sodium-Water Reaction."

c. Modular Steam Generator - Atomics International

The first of the two superheater modules has been completed including hydrostatic tests using distilled water. The second superheater module is nearing completion. Some difficulty has been experienced in weld drop-through on final closure welds. Fabrication completion is expected by mid-June.

d. Sodium Component Test Installation - Atomics International

The primary sodium loop of the Sodium Component Test Installation (SCTI) was filled and drained twice.

During these initial two fillings of the primary loop, the level control system for the primary pump functioned satisfactorily. However, when the pump was started for the first time, surging of the free surface of sodium in the pump case resulted in the plugging of the bubbler-type level controller. Subsequently, operation of this system has depended upon a level coil controller to maintain proper level in the pump case. This coil system has worked very well, but it was originally considered to be only the backup system.

Three bellows-seal valves in the primary loop have failed, resulting in eleven days outage of the plant. The first bellows to fail was in a valve at the outlet of the cold trap. Examination of the bellows revealed a crack in a convolution. This valve was replaced with a bellows valve of a different design. The second failure was the bellows on the plugging meter valve. This was a welded disc bellows, and a pin hole was found in an outer weld; in this case, the bellows assembly was replaced. The cause of the third failure has not been determined. In the third case, leakage through the bellows vent resulted in spilling about 100 pounds of sodium in a location which caused extensive damage to instrument circuits in a wireway. This third valve has been replaced with a freeze stem valve. Similarly, another bellows valve which has not failed, but which is in a very vulnerable location in the bottom of the steam generator pit, is to be exchanged for a freeze stem valve before the secondary system is filled again. It is intended that over a period of months all the bellows valves will be replaced with freeze-stem seals, either as necessity demands or as schedule permits. Repair of damage caused by these three leaks has been completed, and the plant is back in service.

Preoperational tests are nearly finished. Completion of these tests is dependent on the results of cold trapping and the attainment of plugging temperatures below 350°F in both loops.

e. Mechanical Properties of Materials - MSA Research Corporation

Test 3

The mechanical testing in the high carbon sodium system is being conducted in Loop 1. Operations were continued following the completion of the sodium phase of the mechanical tests on April 19, 1965, in order to establish final sodium conditions with regard to carbon, oxygen, and other contaminants. On May 10, 1965, the loop was drained for scheduled between-test maintenance, repairs, and obtaining sections of the loop piping and components for metallographic examination. It is anticipated that all repairs will be completed during the next report period and the preliminary operations for the next test initiated. The next test to be conducted in this loop has been scheduled as 304 SS in 1200°F sodium with high carbon.

Specimens exposed for 4000 hours to the high carbon sodium and helium environments are currently being mechanically tested in air and helium at the University of Michigan. These runs are scheduled for completion by August 1, 1965.

Test 4

In an effort to further evaluate the data of Test 4, additional specimens were exposed for 4000 hours to a helium environment. Exposure has been completed, and the mechanical testing of these specimens in air and helium is presently being done at the University of Michigan.

Test 5

The mechanical testing in a high oxygen-sodium system is being conducted in Loop 2. Operation of Loop 2 continued with the testing of the two final creep-rupture specimens. Failure, due to high temperature oxidation, of the main pump terminal temporarily interrupted the testing for a period of one hour during which time flow was isolated (but temperature maintained) in the two test units. The terminal was replaced, and normal operations continued. On May 21, 1965, the fifth of the scheduled creep-rupture specimens ruptured. This specimen, under a stress of 18,000 psi, failed after 5688 hours. The final run at a stress of 20,000 psi is continuing.

As in the case of Test 3 exposed specimens, the 4000-hour sodium and helium exposed specimens of Test 5 are presently being tested in air and helium at the University of Michigan and are partially completed.

Tests 6 and 7

Test 6 will be conducted in Loop 2 and is presently scheduled as 304 SS in 1200 F high oxygen-sodium. Test material for this run, as well as for Test 7, has been procured and the machining of specimens nearly completed. Test 7 has been scheduled for Loop 1 and will be 304 SS in 1200 F high carbon sodium. The loop is presently being made ready for operation, and it is anticipated that preliminary operations for Test 7 can be initiated during the next report period.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.Oxygen Meters

During May the four oxygen meter probes from United Nuclear Corporation were installed in the housings, and sodium flow was resumed. The evaluation of the meters has begun, but a complete set of data, including sodium analysis, is not yet available. A typical set of readings from the four oxygen meters is 1.053, 1.031, 1.052, and 0.990 volts, at approximately 600 F. This indicates that the meters are properly installed, since these voltages are within the expected range. The variation between meters is not significant since each cell has a different base-line voltage. The meters will be evaluated at all temperatures below 650 F.

The oxygen meters will be calibrated at various impurity levels, based on chemical analysis, and the meter readings will be compared to the Rhometer and plugging meter during the water and oxide injections and during the cleanup cycles.

Rhometers

A final check, consisting of a ramp to 900°F from 600°F and return to 600 F, was performed to determine the cause of the negative unbalance in one of the Rhometers. The cause was determined to be a stretching of the platinum compensator winding (probably a stress relieving of the platinum at the higher temperature). This Rhometer can be compensated only after recalibration or application of a correction factor not yet determined.

Super-Centrifuge

The program to develop the design of a super-centrifuge for installation in the sodium technology loop is underway. The scope of the program is as follows:

Phase I - prepare functional specifications for the super-centrifuge.

Phase II - prepare a conceptual design of the method of installation of the super-centrifuge in the sodium technology loop.

Phase III - prepare a design of the super-centrifuge.

Phase I and part of Phase II are scheduled for completion in June.

g. Continuous Oxide Meter - United Nuclear Corporation

Preparatory work for the Electrochemical Oxygen Meter field tests was completed. Meters have been shipped to the three designated field sites (Atomic Power Development Associates, Inc.; Los Alamos Scientific Laboratory; and Argonne National Laboratory). In-loop calibration tests at United Nuclear of four of the seventeen Sensors produced for the field test program have been completed. Operation of the Sensors will be continued to obtain additional information on stability and life. Sensor calibrations showed excellent reproducibility and are in agreement with previously tested units.

Field testing of four of the meters has been started at APDA. Difficulties in operation of the sodium loops at Argonne and Los Alamos have delayed installation and testing of the oxygen meters at these sites. Installation and startup of the meters went smoothly, and no difficulties have been encountered in this operation. The meters have been in operation for approximately three weeks. They have been used to monitor loop cleanup operations and during a series of water injection tests.

h. Mass Transfer - General Electric Company

No report was received for the subject period.

i. Small Leak Sodium-Water Reaction Program - Atomic Power Development Associates, Inc.

The work on this project to date has consisted of engineering, design, procurement, and construction. The design of all of the components for the test system is completed. These items are all erected in the structure.

The piping is approximately 90% erected, and the contractor will complete pressure testing the system by June 11. Completion date for the piping contract has slipped from May 22 to June 11. This slippage is mostly due to problems in valve delivery. Some valves in all of the systems (gas, water, and sodium) have experienced delayed deliveries. The major items to be completed are the electrical work, instrumentation, and insulation.

j. Under Sodium Scanner - Atomic Power Development Associates, Inc.

The purification system for the dry box was operated continuously and was found to be very satisfactory. On May 17, 1965, the facility was filled with sodium. Visual observation of the molten sodium several days after filling revealed that the surface had a shiny appearance, similar to that of mercury.

An attempt to operate the ultrasonic transducers immediately after the sodium fill was unsuccessful. Subsequent analyses indicated that both the transmitter and receiver exhibited low electrical resistances to ground. The transducers were removed from the dry box and disassembled. The low resistances were traced to the lead metaniobate crystals. Apparently the crystals had absorbed moisture after they were installed in the sodium facility but before the dry box purification system was started. The crystals were removed from the transducers and heated in a vacuum furnace. The electrical resistance for one of the two crystals

increased to infinity in a short time, whereas the other one increased slowly. The latter was discarded, and a new crystal was installed in the transducer. The transducers were reinstalled in the facility, and testing was started. The transducers are presently operating satisfactorily.

k. Fermi Compilation - Atomic Power Development Associates, Inc.

In May, work was initiated on four topical reports, and work continued on the two reports initiated last month. Accomplishments in May on each of the six reports are as follows:

1. EFFBR Primary System Development

Researching of internal records was completed. A revised detailed outline of the report was prepared, and its internal review was started.

2. EFFBR Nuclear Test Program

A revised detailed report outline was prepared, reviewed internally, and approved. Work was initiated on the first draft of the report.

3. EFFBR Low Power Nuclear Test Results

A revised detailed report outline was prepared, reviewed internally, and approved. Work was initiated on the first draft of the report.

4. EFFBR Sodium System Level Detectors

The detailed outline of the report was prepared, reviewed, and approved. The first draft of the entire report was written and was being reviewed internally at the end of the month.

5. EFFBR Control and Safety Rod Drives

Researching of the literature was completed. A revised detailed outline was prepared, reviewed internally, and approved. Two meetings were held with consultants who are contributing to the portion of the report on evolution of the design. Preparation of the first draft was well underway at the end of the month.

6. EFFBR Sodium Sampling Procedures

Researching of the literature was completed. A detailed outline was prepared and was being reviewed internally by the end of the month.

1. Heat Exchanger Evaluation - United Nuclear Corporation

A review of the "as-built" design drawings and reports, as well as the manufacturing and test report for the ALCO intermediate heat exchanger and the ALCO-Baldwin-Lima-Hamilton steam generator, was completed. Information pertaining to the installation and operation of these units was obtained during a visit to the Sodium Component Test Installation (SCTI).

Procedures are being prepared for reducing the test data from the SCTI and preparing comparisons between the test results and the manufacturer's performance predictions. These procedures will use the methods established by the component manufacturer to adjust the predictions to suit the actual test conditions. Computer routines are being developed to assist in these computations.

The procedure for evaluation of the structural performance of the tube sheet, shell, and barrel region is about 50% complete. Other structural areas in which work has been started are sine wave tubes, upper steam generator head, tube to tube sheet joints, and heat exchanger shells.

Preparation of the evaluation procedures for the overall thermal-hydraulic performance of the heat exchangers is in progress. Detailed thermal hydraulic analyses are being prepared for evaluation of the heat transfer characteristics of the different regions of each heat exchanger, temperature distributions in the tube sheet areas, axial temperature distributions in the exchangers, and flow distribution in the intermediate heat exchanger shell.

m. Development of Techniques for Measurement of Impurities in Sodium - MSA Research Corporation

This project involves the investigation of new techniques for the analytical determination of carbon, oxygen, and hydrogen contaminants in sodium. The project includes the investigation of the following:

1. laboratory techniques

high-temperature mass spectrometry
magnetic effects
surface tension
organic solvent extraction

2. instream techniques

physical property change of metals due to carburization
electrical sensing of particles
electrical potential concentration of sodium oxide
continuous hydrogen monitoring

The investigations of the laboratory techniques are estimated as being 15% complete at this time.

The four instream monitor programs are essentially in the basic testing or calculating phase of testing feasibility. This represents approximately 25% completion of this phase

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II - Argonne National Laboratory

Difficulty with the No. 8 control rod gripper was due to the shearing off of one of two small cam pieces that work the gripper jaws. The cam had overtraveled the upper cam surface of one jaw, causing deformation of the upper edge of the jaw and the failure of two screws holding the cam to the jaw sleeve. The No. 8 gripper was repaired as well as the No. 11 gripper, which had shown burnishing of one cam piece and matching jaw.

Difficulty has been experienced with the turbine-driven feedwater pump. Upon removal of the pump covers, it was found that two buckets were missing from the first row of the turbine. Both rows of buckets on the wheel and the stationary intermediate buckets had been damaged by the loose buckets. Replacement parts were received and the pump reassembled.

The repair of the control rod grippers was performed during a shutdown in April for removal of fuel surveillance subassemblies (0.5 a/o burnup). Following fuel handling and maintenance work, the reactor was operated at 45 MWt until the peak burnup reached 0.64 a/o. The reactor was then shut down and fuel removed and the first reprocessed fuel and the first customer fuel (General Electric) were added. The reactor was again operated until the peak burnup reached .78 a/o. The reactor was shut down and some .78 a/o fuel removed. At this time, the secondary system was drained and the piping cooled so that leak testing of the secondary piping penetrating the containment shell could be made.

b. Enrico Fermi Fast Reactor - Power Reactor Development Company

Six of a scheduled ten foil irradiations have been completed, with the reactor operating at 500 KW. The reactor was also operated at 900 KW for shield test. After the present foil irradiations program is completed, preparations will be made to place the new neutron source, No. 6, in the lattice.

The safety valve settings on the three steam generators are being increased 3% beyond their present settings of 1000, 1010, and 1020 psi. Operating experience indicates that the present settings are too close to the operating pressure for reliable operation.

c. Hallam Nuclear Power Facility - Atomics International

The reactor remained down all month for a continuation of the program for removal of failed moderator elements and stuck core components.

Moderator Element Removal

Replacement of eight moderator elements in the M-51 core area was completed by May 23. A positioner element was left in the M-30 core position to assist in removal of the failed element in core position M-3.

By the end of the month, eight additional moderator elements had been removed adjacent to the failed element in the M-42 core position. Positioner elements were installed in all eight core positions, and M-42 was ready for removal.

Removal status at the end of the month was as follows:

15 total moderator elements removed
8 elements returned to the core
7 elements out of core; 6 in storage; 1 in maintenance cell for examination

Failed Moderator Element Examination

The work on element S/N 110 (M-51) at the HNPf maintenance cell has been completed. This work consisted of thorough visual examination of the accessible areas, dye penetrant inspection of welds and surface irregularities, photography and sampling of areas of interest, and width measurements. Sheathing and graphite samples and the top head assembly were shipped to the Atomics International Hot Laboratory for metallographic examination.

A small vertical crack approximately one-inch long was located in the sheathing of element S/N 110 with center about $3\frac{1}{2}$ inches below the top head-to-sheath weld bead and on the scallop edge of a corner support finger between flat and scallop. The fractured surfaces of the crack are characteristic of a stress-rupture failure, indicating that cracking occurred at elevated temperature under a load (estimated to be about 40,000 psi) imposed for a relatively long period of time (estimated 1000 hours or longer). Metallographic examination of sections through the crack indicated that the stress for rupture was caused by a combination of tensile and bending loads with resultant intergranular cracking. There was no evidence that the failure mechanism was fatigue under cyclic loading. No other suspected failure areas or modes were located.

Written and edited by:

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IV. REPORTS

- a. SCTI and MSG Progress Report - May 1965
- b. MSAR Mechanical Properties of Materials - May 1965
- c. MSAR Development of Impurity Techniques - May 1965
- d. Sodium Technology Loop - May 1965
- e. Continuous Oxide Meter - May 1965
- f. Small Leak Program - May 1965
- g. Under Sodium Scanner - May 1965
- h. Fermi Compilation - May 1965
- i. Heat Exchanger Evaluation - May 1965

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT COORDINATION REPORT
JUNE 1965

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
a. ALCO/BLH Steam Generator	Baldwin-Lima-Hamilton Corp. Philadelphia, Pa. R. B. Abderhalden	AT(11-1)- 1213	CH
b. B&W Steam Generator	The Babcock & Wilcox Co. Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. AI Modular Steam Generator	Atomics International Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CP
d. Sodium Components Test Installation	Atomics International Canoga Park, California R. Cygan	AT(11-1)- GEN-8	CP
e. Mechanical Properties of Materials	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
f. Sodium Technology Loop	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865	CH
g. Continuous Oxide Meter	United Nuclear Corporation White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
h. Mass Transfer	General Electric Company San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
i. Sodium-Water Reaction - Small Leak Program	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
j. Under Sodium Scanner	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
k. Fermi Compilation	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865	CH
l. Heat Exchanger Evaluation	United Nuclear Corporation White Plains, New York K. Goldmann	AT(11-1)- 1452	CH

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
m. Development of Techniques for Measurement of Impurities in Sodium	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH

II. STATUS

a. ALCO/BLH Steam Generator - Baldwin-Lima-Hamilton Corporation

There was no significant progress during the month.

b. B&W Steam Generator - The Babcock & Wilcox Company

Design Analysis Work

Further analysis is being made of the sodium-water reaction problems in both the Full-Size and Prototype Steam Generator as a result of questions that developed during the meeting with the Sodium Components Committee on June 18.

The possibility of collapse of the center pipe during a sodium-water reaction is being investigated, and Atomic Power Development Associates, Inc. (APDA) is investigating what the pressure would be if the center pipe should collapse and seal off this escape route for the products of a sodium-water reaction.

Research and Development Program

Materials - Carbon Transfer and Corrosion Simulating Full-Size Plant

Work was begun this month on the destructive examination of the one tube model steam generator and sodium test loop. Samples will be removed from a number of locations in the steam generator and in the loop piping. Examination of both the inside and outside surface of the steam generator tube will reveal any mass transfer or corrosion that has gone on on both the sodium side and the water side. Examination of the rest of the loop piping will reveal corrosion or mass transfer on the sodium face of the piping, and a visual examination of the outer surface of the piping will reveal any unusual condition that may have been developing under the insulation. This may shed some light on a problem that occurs occasionally of stress corrosion of stainless steel piping beneath the thermal insulation if moisture has been present.

c. Modular Steam Generator - Atomics International

Fabrication of the modular steam generator was completed in June. Hydrostatic testing of the two superheater modules was performed satisfactorily. The four units are now being stored in the building adjacent to the LCTL and Sodium Components Test Installation (SCTI) where an inert gas pressure (approximately 5 psig) is maintained and monitored periodically by the SCTI operational crew. The units were thoroughly cleaned and dried before layup and storage.

d. Sodium Components Test Installation - Atomics International

During initiation of the final preoperational tests of the SCTI, the secondary sodium loop was filled and preparations were made to start circulation. All parts of the system had been thoroughly checked.

When an attempt was made to start the pump motor, a short to ground occurred causing all breakers to trip. As a result of this failure, the entire motor has been shut down. An investigation into the cause of the motor failure is underway.

e. Mechanical Properties of Materials - MSA Research Corporation

Test 3 - Stainless Steel (316) Specimens in 1200^oF, High-Carbon Sodium

The operational phase of this test has been completed with the exception of the testing in air and helium at the University of Michigan of specimens exposed to this sodium environment for 4000 hours. Metallographic examinations of the specimens generated under this test are nearly complete and show carburization as a function of time. All of the 316 SS specimens formed carbide cases which influenced the mechanical properties of the alloy. Interpretation of the results to date indicates that carbon contamination in sodium will reduce the fatigue life (as compared to clean sodium, but it is still greater than in air) and the impact strengths, increases in creep-rupture strength, but reduces the ductility of 316 stainless steel. The creep tests are so greatly affected by the continuing carburization as to make the interpretation of the results almost impossible. The 304 stainless steel monitoring tabs continue to show a greater degree of carburization than the 316 stainless steel.

Test 5 - Stainless Steel (316) Specimens in 1200^oF, High Oxygen (300 ppm) Sodium

The operating history during this test included repeated plugging experiences and observance of film and scale formations. The mechanical tests are nearly complete. The data from these tests are in general more scattered with little differences noted in effects on rupture life and creep rates. The fatigue tests show a differently shaped failure-versus-time curve than the other environments and the preliminary conclusions have attributed this to the oxygen scaling. Impact tests show a loss in impact strength but not as great as in Test 3. All specimens show scattered weight changes, carburization, mass transfer and coatings. Metallographic studies of all the specimens are in progress.

Test 6 - Stainless Steel (304) Specimens in 1200^oF, High Oxygen (300 ppm) Sodium

This test will be initiated following the completion of Test 5 in Loop 2.

Test 7 - Stainless Steel (304) Specimens in 1200^oF, High Carbon Sodium

The preliminary operation of this test in Loop 1 is scheduled for next month.

Extensometer Development

The development of an extensometer for the measurement of creep in specimens immersed in high-temperature liquid metals has been repeatedly delayed by the poor delivery of the specially designed low voltage differential transformer units. The delivery of these units is expected daily with preliminary testing to start immediately thereafter.

f. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Water Injection Program

During the month of June the water injection program was completed. A total 55 ml of water were added to the sodium in increments of 5 ml.

During the injections, the cover gas was monitored to observe the increase and decay of the hydrogen concentration, and periodic sodium analyses were made corresponding to each temperature-compensation check point in the program. The injections were made at 450°F, 525°F, 600°F, and 675°F, and were followed by a temperature ramp to 675°F after each series at a particular temperature level.

Rhometers

During the water injections, the temperature compensator of the Rhometers continued to present difficulties which were apparent when changing loop temperature and when switching compensator ranges.

The study directed toward the development of an improved automatic temperature compensator has shown that a gold winding, in place of platinum, combined with a supplementary servo system may be recommended for further development.

Oxygen Meter

The oxygen meters continue to operate satisfactorily; however, no direct correlation with actual oxide concentration can be made until more information is available on the effect of individual impurities on the behavior of the meter.

Supercentrifuge

Phase I, preparation of functional specifications, and Phase II, the conceptual design of the method of installation of the supercentrifuge in the technology loop, are completed.

In-Line Hydrogen Meter

Final construction of the in-line hydrogen meter has begun and is scheduled for completion in July or August.

Hydrogen Solubility

Construction of the apparatus is nearly completed. A checkout of the equipment will be made in July.

g. Continuous Oxide Meter - United Nuclear Corporation

Four meters have been in operation in the Atomic Power Development Associates, Inc. (APDA) sodium technology loop since May 12, 1965. Installation and startup of the meters at APDA went smoothly, and no difficulties have been encountered in their operation. They have been used during a series of loop cleanup operations and water injection tests.

Meters have been shipped to Argonne National Laboratory and Los Alamos Scientific Laboratory. However, loop operational problems at these sites have prevented installation of the oxygen meters. Both sites expect to be able to install the meters and begin testing during July.

Four oxygen meters fabricated along with the field test meters have been retained at United Nuclear Corporation. These meters are being tested at approximately 600°F in the forced circulation loop to obtain calibration and life data. Two have been operating for approximately 2½ months. The four meters respond reproducibly to cold trap temperature changes, but there is approximately 70 millivolt difference in absolute voltages.

These tests will be continued until the end of July. During August, is is planned to operate the meters at 700 to 800 F to obtain elevated temperature calibration and performance data.

h. Mass Transfer - General Electric Company

Task 1 - Original Six-Loop Program

The 316 stainless steel loop (#3) was operated all month under Type VI test conditions. Preparation of the topical reports describing Task 1 results continued.

Task 2 - Primary System Loop Program

All major components except the high heat flux heater and power supply unit, for assembling the two new loops are available. Electric power distribution and loop assembly has begun.

Components for the tubular cathode, high heat flux test heater are available at the subcontractor and are being assembled. Manufacture of the hair pin cathode heater has been delayed due to Tungsten cathode grinding difficulties. The new components of the high heat flux test power supply have been received and are being assembled by the vendor. The test power supply is scheduled for delivery early next month.

The 316 stainless steel loop (#1) has been reassembled for the single rod high heat flux heater tests.

Task 2 - Sodium Impurities Identification

Sodium has been reacted in both the amalgamation and liquid ammonia separating systems. The distillation separation system assembly has been delayed due to late delivery of one of the vacuum system flanges. The assembly is estimated to be 90% complete. Techniques and procedures for accumulating, capsulating, and analyzing impurity components continued.

i. Sodium-Water Reaction - Small Leak Program - Atomic Power Development Associates, Inc.

The work on this project to date has consisted of engineering, design, procurement, construction, delineation of tests, and establishing operating procedures. All the components for the test system have been erected in the structure.

The piping work was completed June 18. The systems were pressure tested in accordance with the specifications and were accepted. Only a few minor punch list items remain to be finished.

The electrical contractor has begun to install the resistance heaters and thermocouples on the vessels and piping. In this way, the insulation contractor can cover the loop while the electrical contractor installs the cable trays and cables. The electrical work will be complete July 24.

j. Under Sodium Scanner - Atomic Power Development Associates, Inc.

The transducers with lead metaniobate piezoelectric disks have performed satisfactorily in liquid sodium at temperatures from melting point to 500 F.

Preliminary data of ultrasonic attenuation in liquid sodium has been obtained with a frequency of 4 mc/sec at a temperature of 400°F. The preliminary value of a/f^2 is $15 \times 10^{-17} \text{ sec}^2 \text{ cm}^{-1}$, where a is the absorption coefficient and f is the frequency.

For a comparison of preliminary attenuation data and the values derived from classical theory, $a_{\text{classical}}/f^2$ was calculated. At a temperature of 400°F, $a_{\text{classical}}/f^2$ is $13.1 \times 10^{-17} \text{ sec}^2 \text{ cm}^{-1}$, and is smaller than that obtained from preliminary attenuation data. The excess absorption is due to the bulk viscosity of liquid sodium.

k. Fermi Compilation - Atomic Power Development Associates, Inc.

In June, work was initiated on two of the ten topical reports previously selected by the Commission, bringing to eight the number of reports now in progress. Accomplishments in June on each of the eight reports are as follows:

EFFBR Primary System Development - Internal review of the detailed report outline was completed. Preparation of the first draft of the portion of the report on evolution of the design of the Fermi system also was completed.

EFFBR Nuclear Test Program - Work on the first draft of this report progressed on schedule through the month.

EFFBR Low Power Nuclear Test Results - Preparation of the first draft of the report was completed and submitted for internal review.

EFFBR Steam Generators - Work was initiated in June on preparation of a detailed outline for the portion of the report on the evolution of the design of the steam generators.

EFFBR Sodium System Level Detectors - The first draft of the report was reviewed and approved. The final draft was prepared, reviewed, approved, and released for final technical editing and preparation of the art work.

EFFBR Sodium System Flowmeters - Work was initiated in June on the preparation of the first draft of this report.

EFFBR Control and Safety Rod Drives - The first draft of this report was completed and was reviewed internally and with the consultants. Preparation of the final draft was initiated.

EFFBR Sodium Sampling Procedures - Review of the detailed report outline was completed, and the preparation of the first draft of the report was completed.

1. Heat Exchanger Evaluation - United Nuclear Corporation

Preparation of procedures was continued to provide for reducing test data from the Sodium Components Test Installation (SCTI) and for comparing the test results and predicted performance of the ALCO intermediate heat exchanger and the ALCO-Baldwin-Lima-Hamilton steam generator. The predicted performance will be based on the methods used by the component designer and will be adjusted to suit actual test conditions. Computer routines are being developed to assist in these computations.

Thermal-Hydraulic Performance

The procedure for the intermediate heat exchanger is now operational and will provide comparison of performance in the inlet, cross flow, and exit regions individually as well as the overall heat transfer performance. Overall pressure drops can also be ascertained and compared. Preliminary formats for presentation of comparisons were prepared.

Structural Performance

The procedure for predicting the stresses due to pressure and temperature gradients in the tubesheet, shell, and barrel region has been completed and checked to assure that pressure stresses will be as predicted by the component manufacturer. Temperature input for steady state operation was prepared to allow checking of stresses due to temperature gradients.

m. Development of Techniques for Measurement of Impurities in Sodium - MSA Research Corporation

The results to date of the various methods under study can be summarized as follows:

Laboratory Techniques

Surface Tension - Measurements of both clean and contaminated potassium have been made. Potassium was used initially because the surface tension apparatus had been previously filled with this metal. The results showed a measurable increase in surface tension between pure potassium and potassium that was contaminated with oxygen. The tests will be repeated using sodium.

Paramagnetic Effects of Sodium Impurities - Encapsulated samples of clean sodium, air-contaminated sodium, and carbon-contaminated sodium proved to be affected to a different degree in a magnetic field. The magnetic properties of sodium impurities have been shown to be diamagnetic in nature for both carbon and oxygen.

Organic Solvent Extraction - The difficult job of drying the necessary reagents (naphthalene and tetrahydrofuran) has been accomplished, and one completed run on pure sodium indicated an analysis of 80 ppm oxygen. The initial run is believed to be reasonable since contamination of the sample after charging was observed.

Instream Techniques

Physical Properties Changes Due to Carburization - Resistivity measurements were made of 2½ Cr 1 Mo steel, 304 stainless steel, and 316 stainless steel tabs exposed to a high-carbon sodium environment at 1200°F. Carbon concentrations ranged from approximately 400 to 10,000 ppm and exposure times up to 5400 hours. The data indicated a decrease in the resistivity of the Cr-Mo steel with increasing carbon content. Little, if any, change was noted for the 304 and 316 stainless steel materials.

Comparative magnetic measurements made on a few of the same Cr-Mo specimens indicated a decrease in relative magnetization with increasing carbon content. More complete magnetic measurements are in progress.

Electrical Sensing of Particles in Liquid Metal - The electrical detection of non-conductive particles (glass) in flowing NaK at room temperature has been achieved. Studies have been made that indicate particles with an orifice-to-diameter ratio of 3 to 1 are detectable by monitoring the

electrical resistance across the orifice. Similar tests will be conducted on sodium oxide particles in a heated sodium stream upon completion of the small test loop.

Sodium Oxide Determination by Electrical Potential Concentration -

Initial tests have been completed in which sodium oxide was concentrated at the anode of a static sodium system containing a circuit density of 400 amps/sq in. While the test results agreed with the theory, a more sophisticated apparatus is being constructed which will generate more detailed information. The apparatus will include the electrical monitoring of a niobium probe in an initial attempt to relate the oxidation of niobium to the oxygen content of the sodium.

Continuous Hydrogen Monitoring - The testing and evaluation of an aqueous cell based on a calomel electrode (Hg_2Cl_2 - Hg-KCl), HCl and a platinum electrode is in progress. Some initial difficulties were experienced when the electrode became electrostatically charged. Modifications to the system are in progress that hopefully will eliminate this trouble.

III. SODIUM COMPONENT INFORMATION FROM OPERATING REACTORS

a. EBR-II - Argonne National Laboratory

After the scheduled shutdown period for fuel-surveillance studies after nominally 0.8-a/o burnup, the reactor was started on June 10. On June 13, the reactor power was raised to 45 MWt. Operations continued at 45 MWt until 1% maximum fuel burnup had been achieved on June 25, at which time the reactor was shut down and the plant was put in standby condition preparatory to fuel handling for removal of surveillance subassemblies. Total integrated thermal power as of shutdown is approximately 2502 MWd, of which 489 MWd were accumulated during the June operation.

During the run and at various power levels and flows, measurements of power coefficient and noise were made as part of reactor kinetics studies.

b. Enrico Fermi Fast Reactor--Power Reactor Development Company

Primary Sodium Pumps

The No. 3 primary pump was taken out of service for inspection of the shaft seals following excessive leakage. The moderately scored face seals were replaced. All "O" ring seals and "U" cup seals were replaced. A thermocouple was installed on the top of the upper stationary face seal ring to monitor the seal ring temperature. Twelve of the 36 compression springs were removed from the face seal assembly to reduce the force on the face seal rings. A dam was welded around the top of the pump shaft coupling to keep the seal oil leakage from entering the pump assembly.

Sweep Mechanism

The upper drive housing of the sweep mechanism was disassembled for inspection following binding during folding of the sweep arm. The lower radial bearing of the arm actuating drive pinion was found frozen, and the shaft was badly scored. The upper radial bearing was found to be dry and difficult to turn. Several metal chips and metallic dust was found in the drive gear housing. No gears or seals were damaged. The mechanism was temporarily adapted for hand operation while the bearing problem is being investigated.

Safety Rod Extension

The No. 3 safety rod extension was found to leak argon at a brazed connection to the pressure gage. The connection was soldered but continued to leak. Further repairs are scheduled.

Offset Handling Mechanism

The gripper latch plate bearing was reset, and the latch stroke and switch settings were checked to correct erratic latching of subassemblies.

Rotating Plug Drive

A small section of the drive housing flange of the rotating plug drive was removed in order to provide clearance with the recently added leveller columns on the rotating plug.

Primary Cold Trap Room Ventilation

The freon compressor for the primary cold trap room tripped out twice due to low freon level; more coolant was added. Both cooling water regulating valves were found plugged, and they were cleaned.

c. Hallam Nuclear Power Facility - Atomics International

The reactor remained down all month for a continuation of the program for removal of failed moderator elements and stuck core components.

Moderator Element Removal

Moderator element removal work proceeded exceptionally well and five additional failed moderator elements were removed for a total of six of the seven known failed elements removed.

Removal status at the end of the month was as follows:

40 total (25 this month) moderator elements removed.

30 total (22 this month) returned to the core.

10 elements out of the core; 9 in storage, 1 in maintenance cell for examination.

Stuck Core Component Removal

Retrieval tools and methods worked well, and all but four components adjacent to failed moderator element No. 38 had been removed at the end of the month. A fuel bundle and process tube became separated during removal attempts. The assembly was borescoped on June 30, and special procedures and removal tools are being prepared. The hanger rod was sheared from this fuel assembly when it was dropped 11 inches during previous removal attempts.

Removal status at the end of the month was as follows:

17 fuel elements stuck at start of program.

16 fuel elements removed (14 this month).

1 fuel element remaining

2 of 5 process tubes removed.

2 dummy elements and 1 source thimble removed.

Moderator Element Examination

Five failed moderator elements were examined in the maintenance cell. Samples were shipped to the Atomics International Hot Cell.

The failure mode for all elements appeared to be the same as reported for the first failed element removed. All cracks are vertical, located at the same elevation, and are associated with corner fingers of the top heads except for one element which cracked in a scallop and appeared to propagate from an old galled area or scratch in the sheathing.

Written and edited by:

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IV. REPORTS

- a. MSAR Mechanical Properties of Materials - Quarterly Report, April, May, June 1965.
- b. MSAR Development of Impurity Techniques - Quarterly Report, April, May, June 1965.
- c. Sodium Technology Loop - June 1965.
- d. Continuous Oxide Meter - June 1965.
- e. Small Leak Program - June 1965.
- f. Under Sodium Scanner - June 1965.
- g. Fermi Compilation - June 1965.
- h. Heat Exchanger Evaluation - June 1965.
- i. Mass Transfer - June 1965.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT COORDINATION REPORT
JULY 1965

I. LISTING OF CURRENT PROJECTS

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a. ALCO/BLH Steam Generator	Baldwin-Lima-Hamilton Corp. Philadelphia, Pa. R. B. Abderhalden	AT(11-1)- 1213	CH
b. B&W Steam Generator	The Babcock & Wilcox Co. Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
c. Sodium Components Test Installation	Atomics International Canoga Park, California R. Cygan	AT(11-1)- GEN-8	CP
d. Mechanisms in Sodium	Atomics International Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CP
e. High Temperature Strain Measurements	Atomics International Canoga Park, California	AT(11-1)- GEN-8	CP
f. Mechanical Properties of Materials	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
g. Development of Techniques for Measurement of Impurities in Sodium	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
h. Sodium-Water Reaction - Small Leak Program	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865 P.A.-10	CH
i. Sodium Technology Loop	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865 P.A.-11	CH
j. Under Sodium Scanner	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865 P. A.-14	CH
k. Fermi Compilation	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865 P.A.-15	CH
l. Heat Exchanger Evaluation	United Nuclear Corporation White Plains, New York K. Goldmann	AT(11-1)- 1452	CH

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m. Continuous Oxide Meter	United Nuclear Corporation White Plains, New York K. Goldmann	AT(30-1)- 2877	NY
n. Mass Transfer	General Electric Company San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
o. Large Sodium Valve Design	Allis-Chalmers Bethesda, Maryland	AT(11-1)- 1357 PA-5	CH
p. Piping Flexibility Study	M. W. Kellogg Company New Market, New Jersey	AT(11-1)- 1454	CH

II. STATUS

a. ALCO/BLH Steam Generator - Baldwin-Lima-Hamilton Corporation

There was no significant progress during the month.

b. B&W Steam Generator - The Babcock & Wilcox Company

Design Analysis Work

Analysis work is proceeding on the ability of the B&W Full-Size and Prototype Steam Generator to withstand sodium-water reactions resulting from a number of simultaneous tube failures. Data supplied by APDA is being used to predict the maximum credible pressure and energy that the steam generator shell must withstand. The pressure predicted by the APDA calculations is very high at short times, (less than one millisecond), after the assumed start of the reaction and decays to much lower values at longer time intervals. At times longer than approximately five milliseconds, the static strength of the steam generator shell can withstand the maximum credible pressure on a steady-state basis. At short time intervals when the pressure is extremely high, there has not been much water injected into the steam generator through the assumed leak and, therefore, the energy released in the steam generator is limited. It appears that it will be possible to show that the Full-Size Steam Generator shell can withstand the energy released from the simultaneous failure of approximately 100 tubes in the worst location in the boiler.

Research and Development Program

Materials - Carbon Transfer and Corrosion Simulating Full-Size Plant

The destructive examination of material from the model sodium-heated steam generator has continued. Macrophotographs (3X) have been made of the sodium and water-steam sides of the specimens removed for examination.

Only a thin, rather uniform deposit is visible on the steam side of the specimens, except for those located in the transition (boiling) zone which have a somewhat heavier, non-uniform deposit making the walls of the tube appear to be rough. These heavier deposits are not typical for once-through steam generators but are associated with small test units where electrical immersion type heaters are utilized. The preliminary results of the

analysis of these deposits indicate a relationship to the failure of a heater since the major constituents are magnesium oxide and silica which are used as electrical insulation in this type of heater.

The surfaces in contact with the sodium can be generally described as quite smooth and showing little effect of the hot sodium. However, careful study of the TP 316 specimens exposed to the higher sodium temperatures does reveal fine roughening of the surface.

Corrosion Rates for Croloy 2 1/4 Steel in Products of a Sodium-Water Reaction

All experimental work on determining the corrosion rate of Croloy 2 1/4 in sodium hydroxide solutions in water and in sodium has been completed, and representative specimens from these tests are being metallurgically examined. One experimental test remains to be done - the corrosion rate of Croloy 2 1/4 in a solution of sodium hydroxide and sodium hydride at a temperature of about 500 F. The writing of a topical report on the project has started.

c. Sodium Components Test Installation - Atomics International

Rewinding of the secondary pump motor was completed in July. Testing in the Westinghouse motor repair shops was successfully performed; that is, a high potential d-c test resulted in an acceptable leakage current at 16 kv. Three full voltage starts of the motor were observed. The motor was started and after reaching operating speed, was tripped. Nine minutes after the first start, it was restarted and tripped after reaching full speed with no ill effects (this duplicates the condition under which it failed in the SCTI). The motor was then restarted and run for one hour. Following these tests, the motor was shipped to the SCTI and mounted in place.

Switch gear associated with the secondary pump was serviced and determined to be in proper operating condition by the manufacturer's service representative. Following electrical connection of the rebuilt motor, a high potential d-c test was performed to check the motor under its normal environmental conditions, i.e., with 1-2 psig of argon gas in the loop and in the motor case. At a test voltage of 4 kv, excessive leakage current occurred. A Westinghouse representative was then called to come to the SCTI; he repeated the test, verifying the fact that excessive leakage occurred at about 4 kv. Immediately after this test, the motor case was purged with nitrogen for one hour. Then an additional high potential test resulted in an increase of breakdown voltage to 11.5 kv.

Subsequently, the motor was returned to the Westinghouse repair shop, cut open, the rotor was removed, and the windings and leakout connections inspected. In this condition, a satisfactory high potential d-c test was obtained at 16 kv. However, certain hardware items, including some metallic air deflectors, were then returned to their normal position in the assembly. With these parts in place, the coil ends arced over in three different places to the deflector rings at about 13 kv. In parallel with this activity, authorities on the subject of corona were consulted. It has been determined that operating a 4000 volt machine in one to two psig argon may result in corona and the long-term life of the insulation may be affected.

d. Mechanisms in Sodium - Atomics International

The purpose of this project is to evaluate materials, configurations and surface treatments for use in high-temperature liquid sodium or sodium vapor.

Bench testing of a stroke multiplying mechanism has continued on an uninterrupted basis for approximately 7000 cycles in air. Travel of the output shaft is approximately 6 feet at a rate of 1 foot per minute. Load cell readouts have indicated an increase in load fluctuations of from 80 to 150 lbs. Visual observations of the rack and pinion gear teeth do not indicate any evidence of fretting. The pinion teeth do not have the smooth wear characteristics that were evident early in the test. This mechanism is a rough model made of standard steel pinions and gears lubricated with Moly-Koat and is undergoing room temperature tests to determine the wear pattern and alignment characteristics. The present mechanism has a motion multiplying factor of four and may find application in fast reactor control drive and fuel handling mechanisms. A future phase of the program will take the results of the gears in sodium studies, extended bellows, and shaft seal experiments to design an integral test to determine the applicability of this motion multiplying scheme operating in a high temperature sodium environment.

Number three Belmetric bellows assembly has been installed in the test vessel and cycled 1895 times in 1200°F sodium. The test has been terminated because of a shaft seizure. Preliminary inspection indicated sodium on both sides of the bellows. The apparatus is being disassembled to determine the cause of failure.

e. High Temperature Strain Measurements - Atomics International

The purpose of this project is to test commercially available gages and determine their limits, applicability and reliability as analytical instruments for use in sodium systems as sensing elements in pressure transducers and force-arm applicators.

Soaking of the Microdot Model SG420 weldable half bridge at 900°F was discontinued after 1000 hours. The gage had a drift rate of approximately 0.5 μ in./in./hr when the test was ceased. This gage will be identified as Microdot 1 for future reference. Another model SG420 gage, which will be identified as Microdot 2 was subjected to approximately 60 thermal shocks between 500 and 900°F at varying rates between 20 and 50°F/sec. The gage held up with no indication of deterioration throughout the shocks. Microdot 1 was subjected to thermal shocks in the same manner as was Microdot 2. Approximately 80 shocks were made and the gage is still responding in good fashion.

Microdot 2 has now been soaking at 900°F for 600 hours. The gage still maintains a drift rate of approximately 2.5 μ in./in./hr. The B-L-H HT-1212-5A half bridge has now been at temperature 1270 hours. During the past 150 hours the drift rate has increased to 0.6 μ in./in./hr. Monitoring continues.

f. Mechanical Properties of Materials - MSA Research Corporation

TEST 3 (316 SS in high carbon sodium) sodium operation has just been completed. The metallurgical studies and data analyses are still in progress, as well as the testing of exposed specimens by the University of Michigan. This work will not be completed until September.

TEST 5 (316 SS in High Oxygen Sodium) sodium operation was completed during this report period. The last two weeks of operation continued to be plagued with the formation of plugs in the Oxygen Control and Indication (OCI) system. These plugs have been shown to be chiefly iron. Post test examinations of the OCI system are expected to show heavy iron deposits.

The metallurgical studies of test specimens and data analyses are still in progress. The testing of exposed specimens is still in progress at the University of Michigan. This work is also scheduled for completion in September.

TEST 6 is the testing of 304 SS in 1200 F high oxygen-sodium and will be conducted in Loop 2. Upon the completion of TEST 5, Loop 2 was drained. Loop samples are being removed for examination, after which scheduled repairs and in-between-test maintenance will be performed. Some initial operation may be conducted in the next report period.

TEST 7 is the testing of 304 SS in 1200 F high carbon-sodium and will be conducted in Loop 1. The repairs of Loop 1 following TEST 6 were completed, including the installation of a new cold trap, new inlet and outlet lines to the test units, and the replacement of pipe samples and several system valves. Initial operation of the heavily carburized loop was achieved without incident. Heat-up was conducted slowly and steadily. The OCI system was put into operation and the main system piping, not including the test units, was coldtrapped to a plugging temperature of less than 300 F. Scheduled operations call for putting each test unit on stream separately, without test specimens, followed by cold trapping each time. After all the test units are on stream and the oxygen concentration is under control, then the carbon concentration will be adjusted by appropriate control of a bypass stream through the carbon bed. Specimen testing and exposure will then begin.

g. Development of Techniques for Measurement of Impurities in Sodium - MSA Research Corporation

The results to date of the various methods under study are as follows:

Laboratory Techniques

Magnetic Effects - Differences were observed in the degree of magnetic deflection between pure sodium and carbon and oxygen-contaminated sodium. Additional work is required on this approach to quantitize the degree of deflection as a function of the impurity concentration.

Surface Tension - Differences were noted between the surface tension of pure potassium versus oxygen-contaminated potassium. Additional work is required to evaluate the effect of oxygen on the surface tension of sodium and to quantitize the effect.

Organic Solvent Extraction - Sodium was separated from sodium oxide using naphthalene with THF as a solvent. Additional work is needed to determine the purity of reagents, and the reproducibility and minimum limit of detection of the method.

High Temperature Mass Spectrometry - Fabrication of the test system was completed; however, no experiments have been run.

Instream Techniques

Physical Property Change of Metals Due to Carburization

A total of 21 magnetic and resistivity measurements have now been run on 2½ Cr-1 Mo steel specimens that had been exposed for varying lengths of time in a high carbon sodium environment at 1200 F. The results are scattered, making it difficult to determine if the magnetization and/or resistivity does correlate with the carbon content. A

statistical analysis study will be made to determine what correlations and conclusions can be drawn with respect to the several variables involved (magnetism, resistivity, time, and carbon content).

Electrical Sensing of Particles in Liquid Metal (ESP)

The electrical detection of non-conductive particles (glass) in flowing NaK at room temperature has been achieved. Studies have been made that indicate particles with an orifice-to-diameter ratio of 3 to 1 are detectable by monitoring the electrical resistance across the orifice.

Sodium Oxide Determination by Electrical Potential Concentration

Initial tests have been completed in which sodium oxide was concentrated at the anode of a static sodium system containing a circuit density of 400 amps/sq. in. While the test results agreed with the theory, a more sophisticated apparatus is being constructed which will generate more detailed information. The apparatus will include the electrical monitoring of a niobium probe in an initial attempt to relate the oxidation of niobium to the oxygen content of the sodium.

Continuous Hydrogen Monitoring

The testing and evaluation of an aqueous cell based on a calomel electrode (Hg_2Cl_2 -Hg-KCl), HCl and a platinum electrode is in progress. Some initial difficulties were experienced when the electrode became electrostatically charged. Modifications to the system are in progress that hopefully will eliminate this trouble.

h. Sodium Water Reaction - Small Leak Program - Atomic Power Development Associates, Inc.

Effort on the program is being directed toward the design and construction of the test system.

Two design modifications must be made to Rig-10. From the experience gained during the sodium water tests in the static rig for The Babcock & Wilcox Company, it was evident that the trigger mechanism had to be redesigned and that provisions for extensive cleanup of the tube bundle were required.

The original trigger device incorporated an orifice in a block to inject the reaction water. A rupture diaphragm over the orifice kept the water from coming into contact with the sodium prior to triggering. When pressure was applied through the orifice to the rupture diaphragm, the diaphragm burst, allowing water-sodium contact. This device was also used in the static sodium test, and its operation proved to be too erratic to be used in Rig-10 where reproducibility is required. The new device will employ a hardened capillary tube with one end sealed shut and the other end brazed into the block. The water-sodium reaction is now triggered by mechanically breaking off the capillary tube.

Because of the extensive amount of crud formed on the tube bundle in the static tests, it is obvious that a cleanup method must be chosen, designed, and installed for the large rig. The best method is being investigated.

i. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Loop Operation

During the month of July, the sodium monoxide program was initiated. At low temperatures, consistent readings of mass balance between impurities introduced into the loop and analysis of the sodium itself are proving difficult to obtain. However, the oxygen meters and the chemical analysis were consistent with each other, both showing essentially no increase in oxide concentration. This may be due to slow dissolution of oxide at 450 F and may be fortuitous.

Rhometers

The study of automatic temperature compensation for the Mark I Rhometer for the range 205-537 C has been completed. The only practical method found for continuously and automatically compensating the instrument is a combination of gold winding (in place of the platinum originally used) and supplementary servo. Among the high-temperature metals, gold most closely approaches the resistivity characteristic of the sodium-filled toroid. The servo would provide a correctional function to "make up" the difference in the resistivity characteristic of gold relative to that of the sodium-filled toroid.

In-Line Hydrogen Meter

Final construction of the in-line hydrogen meter has been delayed by difficulties encountered in obtaining a uniform nickel plate over the palladium tubing.

Hydrogen Solubility

During the month the hydrogen solubility apparatus was checked out. Several modifications were found necessary. The modified apparatus is presently being checked out and should be ready for use sometime during the month of August.

Chemistry Support

Analysis of oxygen, total carbon, and carbonate carbon in sodium has continued at the same levels of precision and accuracy previously reported.

The final design for extending the sample line from RM-1 and RM-2 into a vacuum glove box is completed. Installation is planned for August-September, with the work furnished by an outside contractor.

j. Under Sodium Scanner - Atomic Power Development Associates, Inc.

Ultrasonic attenuation measurements in liquid sodium as a function of temperatures of the medium have been made in the temperature range from melting point of sodium to 500 F. Attenuation increases as temperature increased, which is in agreement with theory. The absorption coefficient, as measured in liquid sodium at 500 F, is low compared with that of pure water measured at room temperature.

In order to determine the temperature limitations for piezoelectric materials, lead metaniobate and quartz crystals were installed in the transducers and operated at temperatures to 600 F. Of the two types, at 600 F the lead metaniobate crystals generate stronger signals than the quartz crystals. Tentative conclusions are that the lead metaniobate crystals

will operate satisfactorily at 600 F in general-purpose scanning systems. The performance of quartz crystals at this temperature is marginal.

k. Fermi Compilation - Atomic Power Development Associates, Inc.

The status at the end of July of the reports authorized is as follows:

1. EFFBR Primary System Development

The first draft of the portion of the report dealing with the evolution of the design of the Fermi system was under intermittent internal review during the month. The preparation of the first draft of the portion of the report dealing with the actual installation and operating experience was well along by the end of the month.

2. EFFBR Fuel Handling in the Reactor Vessel

A small effort on this report was initiated by the end of the month.

3. EFFBR Nuclear Test Program

The first draft of this report was completed and submitted for internal review.

4. EFFBR Low Power Nuclear Test Results

Review of the first draft of this report was completed and the rework of the first draft was initiated.

5. EFFBR Steam Generators

Work on the preparation of the outline of the portion of the report on the evolution of the design is in progress.

6. EFFBR Sodium System Level Detectors

The final technical editing and preparation of the artwork for this report was completed and the report was ready for final printing.

7. EFFBR Sodium System Flowmeters

The final draft of this report was completed and submitted for internal review.

8. EFFBR Control and Safety Rod Drives

The author's final draft of this report was completed and was submitted for internal review and for review by outside consultants. Copies of the author's final draft were submitted to the Commission--one for forwarding to the Liquid Metals Branch.

9. EFFBR Fuel and Blanket Subassemblies

Work on this report is scheduled to begin in February, 1966.

10. EFFBR Sodium Sampling Procedures

Following completion of the first draft of this report in June, further effort on preparation of the report was suspended and is scheduled to be resumed in August.

1. Heat Exchanger Evaluation - United Nuclear Corporation

No report received.

m. Continuous Oxide Meter - United Nuclear Corporation

The major activities during July 1965 were liaison with field test sites, evaluation of field unit in-loop calibration data, and preparation of a final report covering development of the Electrochemical Oxygen Meter field test units.

The Four meters have been in operation at APDA for 2-1/2 months and have operated satisfactorily during this time. The first of two meters was installed in the Argonne National Laboratory test loop on July 8, 1965. No difficulties were encountered during installation or initial operation. The meter operated satisfactorily for about one day. The loop was then shut down for installation of the second meter. The second meter broke due to thermal shock resulting from operator error during installation.

Shortly after the loop was restarted, an emergency loop shutdown occurred. The alarm interlocks shut down the pump but a number of trace heaters remained on. When the loop was restarted ($\sim 1/2$ hour after shutdown), the cell broke as a result of thermal shock.

n. Mass Transfer - General Electric Company

No report received.

o. Large Sodium Valve Design - Allis-Chalmers

The purpose of this project is to survey existing valve types and specify those which may be adopted for large sodium systems. The work is essentially complete. The final report is in draft form.

p. Piping Flexibility Study - M. W. Kellog Company

This study had as its specific aims the determination of the problems associated with the use of thin-walled pipe expansion loops and bellows joints in large pipe diameter systems at the operating conditions of the primary coolant systems of the design studies, the review and evaluation of the applicability of present design practices to these systems and the delineation of the additional work considered necessary to enable these systems to be designed with confidence.

The report on the study has been completed.

III. SODIUM COMPONENTS INFORMATION FROM OPERATING REACTORS

a. EBR-II - Argonne National Laboratory

Preliminary examination of the fuel removed after 1.0% burnup indicated

an anomalous swelling behavior of the special surveillance samples, although the regular production fuel appear to be behaving as expected. The special samples were removed from the core for temporary storage in the storage basket, and on July 21 the reactor was started up for operation to the next 0.1% burnup increment.

b. Hallam Nuclear Power Facility - Atomics International

The reactor remained down all month. The program for removal of failed moderator elements and stuck core components was completed. The facility is being maintained in layup status until a decision is reached on the disposition of the facility.

Moderator Element Removal

The seventh and last known failed moderator element (M-38) was removed on July 5. An unfailed moderator element (M-40) was removed for destructive examination on July 8.

Moderator element status at completing the current program is:

- 42 total moderator elements removed (2 this month)
- 42 total moderator elements returned to the core
(12 this month; includes 10 new moderator elements)
- 1 moderator element was shipped to Nevada for burial
- 6 moderator elements will be subsequently buried in Nevada

Stuck Core Component Removal

The final fuel element assembly and three process tubes were removed to complete this work.

- 17 total stuck fuel elements removed (1 this month)
- 5 process tubes removed (3 this month)
- 2 dummy elements and 1 source thimble were removed previously

Core Cleanup

All moderator element chocks (24) remaining in the core were removed.

c. Enrico Fermi Fast Reactor - Power Reactor Development Company

Vacuum diffusion analyses on zirconium clad specimens of two pins removed from a proof test subassembly showed that one pin contained 330 PPM and the other pin contained 2070 PPM of hydrogen in the clad. Metallographic examination verified hydriding of the clad to the extent reported by the vacuum diffusion technique. Additional pins removed from the subassembly showed pins with and without evidence of zirconium hydride in the clad. The subassembly had seen about 7500 hours of core-A flow, and had been in primary sodium about 17,000 hours.

In order to clarify these conflicting data, a sodium worth subassembly, which had been in the primary sodium about 14,000 hours, was removed, alcohol cleaned, and examined in the manner of the proof test subassemblies. Visual examination of 35 pins revealed no significant abnormal surface conditions. The average length decrease was 0.17 per cent. Metallographic examination of six pins showed the alloy phase transformation between 15 to 35 per cent and no evidence of significant zirconium hydriding of the clad.

Equally important, spacer contact areas between pins and support structure showed no significant evidence of zirconium pull-out, and a typical area was metallographically examined which showed the dimpling depth was an insignificant maximum depth of 0.0003 inches.

Further investigation of records has revealed that pins with high zirconium hydride in the clad, contained in the proof test subassembly had been used in the APDA sodium endurance tests. These tests occurred before the pins were inserted into the subassembly wrapper tube and subsequent to installation to the reactor. Further metallographic examinations of pins used in the sodium endurance testing, and which had never been installed in the reactor, revealed comparable zirconium hydriding of the pin cladding as was observed on pins with the same history which had been in the proof test subassembly. Also, metallographic examination of similar pins which had never been installed in the sodium endurance tests but which had been in the proof test subassembly showed no significant evidence of zirconium hydride in the clad. A formal report and summary of all data is now being prepared to substantiate that little pick-up of hydrogen in the zirconium clad or significant zirconium pull-out of spacer contacts has been found on fuel pins exposed only to the reactor primary sodium.

Written and edited by:

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Reactor Engineering Division
U. S. Atomic Energy Commission
Chicago Operations Office

IV. REPORTS

- a. MSAR Mechanical Properties of Materials - July 1965.
- b. MSAR Development of Impurity Techniques - July 1965.
- c. Sodium Technology Loop - July 1965.
- d. Continuous Oxide Meter - July 1965.
- e. Small Leak Program - July 1965.
- f. Under Sodium Scanner - July 1965.
- g. Fermi Compilation - July 1965.
- h. B&W Steam Generator - July 1965.
- i. AI Sodium Component Monthly Report - June-July 1965.
- j. Large Sodium Valve Design Project - July 1965.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT COORDINATION REPORT
AUGUST 1965

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
A. Designer/Fabricator Heat Exchanger Evaluation	Baldwin-Lima-Hamilton Philadelphia, Pa. R. A. Tidball	AT(11-1)- 1501	CH
B. B&W Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
C. Sodium Components Test Installation	Atomics International Canoga Park, California J. A. Leppard	AT(11-1)- GEN-8	CP
D. Mechanisms in Sodium	Atomics International Canoga Park, California D. T. Eggen	AT(11-1)- GEN-8	CP
E. High Temperature Strain Measurements	Atomics International Canoga Park, California	AT(11-1)- GEN-8	CP
F. Mechanical Properties of Materials	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
G. Development of Techniques for Measurement of Impurities in Sodium	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
H. Sodium-Water Reaction - Small Leak Program	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865,P.A.10	CH
I. Sodium Technology Loop	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865,P.A.11	CH
J. Under Sodium Scanner	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865,P.A.14	CH
K. Fermi Compilation	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865,P.A.15	CH
L. Heat Exchanger Evaluation	United Nuclear Corporation White Plains, New York K. Goldmann	AT(11-1)- 1452	CH
M. Continuous Oxide Meter	United Nuclear Corporation K. Goldmann	AT(30-1)- 2877	NY

N. Mass Transfer	General Electric Company San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
O. Large Sodium Valve Design	Allis-Chalmers Manufacturing Bethesda, Maryland	AT(11-1)- 1357,P.A.5	CH
P. Piping Flexibility Study	M. W. Kellogg Company New Market, New Jersey	AT(11-1)- 1454	CH

II. STATUS

A. Designer/Fabricator - Heat Exchanger Evaluation - Baldwin-Lima-Hamilton Corporation (BLH)

BLH, United Nuclear Corporation, and Commission personnel met to discuss several problems concerning the evaluation of the ALCO steam generator and IHX. Additional information was requested from BLH on tube-to-tubesheet thermal stress calculations and isothermal calculation methods used by ALCO for the IHX tubesheets. Other areas of interest discussed were steam generator oversize and its effect on the test program and recommendations to reduce and/or modify the test program presented in APAE-122.

In July BLH personnel visited the Sodium Components Test Installation (SCTI) to discuss plans for evaluating the test units and data acquisition methods.

B. B&W Steam Generator - The Babcock & Wilcox Company

Prototype Fabrication

The upper head for the superheater section has arrived. The two-inch thick cylindrical shell that attaches to the upper head and also the cylindrical shell for the spool piece which the boiler bundle is attached to have been formed and the longitudinal seam has been welded utilizing the Electroslag welding process. Machining of the flange for the upper head section has been completed. Fabrication of the various light gage shrouds has been completed, and fabrication of the tube support structure is in progress.

The coiling machine has been installed along with a simplified production line to join the various lengths of straight tubing before coiling. The straight lengths of tubing will be welded end to end as required utilizing an automatic TIG welding machine. This welding machine is an existing machine that was moved into place and modified slightly for this application. Each weld will be x-rayed before coiling. The mandrel onto which the coils pass after leaving the coiling machine is being fabricated. This mandrel is a critical item in the schedule.

Engineering Support Activities

A review has been made of the procedures to be used for helium leak testing the steam generator during fabrication in an effort to make the Specifications more definitive. A modification to the Contract Specifications has been suggested that would retain the present overall maximum leak indication of .01 micron cu.ft./hr. (10^{-7} std. cc/sec.), but would specify a maximum indicated leakage of any one tube circuit of .001 micron cu.ft./hr., (10^{-8} std. cc/sec.). In the case of any indication of leakage, an investigation will be made to determine the source of the leakage and any actual leak will be repaired. Any indications that are thought to be false indications, such as off gassing of the inner surface of a tube, will be documented and reported to the Commission with an explanation of the probable cause of the false indication.

The welding machine for making the welds in the 5/8" O.D. tubes has been completed for some time and is ready to use. The welding torch and wire feeding mechanism for making welds in 7/8" and 1" O.D. tubes has been completed. The filler wire for use in these welds are being fabricated. As soon as the first tubesheet mockup with approximately 25 stub tubes welded to it is completed it will be shipped to Los Alamos Scientific Laboratory to demonstrate the ability of the x-ray tube developed by LASL to radiograph these welds. LASL has been very helpful and cooperative in finding a practical way to radiograph the tube-to-tubesheet welds on this steam generator.

Work is continuing on the design of the instrumentation that will be installed in the Prototype Steam Generator. Several types of strain gages are undergoing proof testing and calibration. Measuring of strains in an air environment on the outside of the steam generator apparently will not be a problem for any temperature that will be encountered in this steam generator. Measuring strains in a steam or sodium environment requires a sheathed strain gage such as the "Microdot" gage. These gages are presently limited to a temperature of approximately 650°F. A Microdot gage was tested in a sodium environment and the sodium dissolved the silver brazing alloy used to attach the sheath around the lead wires to the gage. It is felt that this attachment can be made with a Microbrazing material which will not be attacked by sodium. The vendor has supplied another gage with this joint unbrazed so that B&W can make up this joint with Microbrazing and try out this strain gage in sodium.

An experimental investigation of strain hardening of Croloy 2½ material at temperatures credible for the steam generator shell has been completed. Strain hardening coefficients and strain hardening exponents were determined on samples of Croloy 2½ material simulating the thickness and heat treatment that the steam generator shells will receive. The strain hardening experiments were performed at temperatures from 700°F to 1015°F which, with the previous room temperature data, spans the full range of expected vessel temperatures. These data show that there is a significant effect on strain hardening due to temperature. The strain hardening equipment increases as temperature increases up to approximately 900°F, then decreases rapidly as the temperature is increased above 900°F. These data have been factored into the steam generator analysis.

The strength of the steam generator liner and shell is being compared by both an impulse-momentum type analysis and on a work-energy analysis. Both of these methods of analysis are derived from the same equations of motion dating back to Newton. The number of tubes failing simultaneously that the steam generator can withstand differs somewhat depending on which method of analysis is used. The work-energy analysis predicts that the vessel can withstand more tubes failing than the impulse-momentum analogy. The difference in the results is due to differences in assumptions used in making the calculations. It appears that the significant difference between these two analyses is that the hydrogen bubble pressure is considered to be a fixed value determined independently of the vessel analysis itself. Atomic Power Development Associates has calculated the hydrogen bubble pressures for various time intervals after the beginning of a leak for various locations in the steam generator. In their calculations they assumed that the steam generator remained rigid. In our analysis of the steam generator liner and shell, these vessels are allowed to take deflections or strains to the point of instability. The effect of deflection outward of the steam generator shell was not factored back into the pressure predictions. In the work-energy analysis the energy released into the steam generator shell will be independent of the deflection of the shell. In the impulse-momentum

analysis an error in the conservative direction occurs at very short times after the beginning of a leak because the impulse acting on the shell is calculated from an integration of pressure and time only. Deflection of the shell will significantly lower the peak pressure developed. It appears that the impulse-momentum analysis is conservative by approximately a factor of 5.

Research and Development Programs

The destructive examination of materials removed from the model sodium-heated steam generator has continued. Tensile testing of tubular specimens from the boiler and superheater was completed. The changes in tensile properties for the Crolöy 2½ material can be attributed to the tempering which occurred during service. The yield strength increased from 40,300 psi for the as-received material to 47,800 psi at the lowest service temperature which is similar to the secondary hardening effects common in many alloy steels. The ductility of the specimens remained virtually constant at all service temperatures. For the Type 316 tubular specimens, both yield and tensile strengths after exposure (for all service temperatures) were slightly but consistently larger than the initial values. Ductility after exposure was reduced from about 55% to approximately 44% (as measured by percent elongation).

The analysis of waterside deposits in the transition zone of the boiler was completed. The deposit weight varied from 44.5 grams/ft² entering the transition zone to 20.1 grams/ft² leaving this location. The deposit was of similar chemical composition at all locations and the principal depositing material was a magnesium silicate tentatively identified by x-ray diffraction as the compound $3 \text{MgO} \cdot 2 \text{SiO}_2 \cdot 2 \text{H}_2\text{O}$ (the mineral serpentine). From preliminary analysis of the deposit, it was believed that the deposit resulted from a failure of an electrical immersion heater. However, detailed analysis revealed that these deposits resulted from contamination of the feedwater with feed-pump packing material.

C. Sodium Components Test Installation - Atomics International

Modifications were completed to the SCTI secondary pump motor intended to eliminate the electrical arcing in argon problem. After satisfactory electrical testing, the motor was reinstalled and operation began on August 20. On August 25, after a period of 36 hours, operation at fractional power, the motor coils shorted again. The motor has been removed and sent to a shop for inspection. In the meantime, parallel steps are being taken to obtain an available surplus air cooled motor, to specify and order a new air cooled motor, and to design a shaft sealing arrangement to keep argon within the pump case.

On August 25, a bellows expansion joint in the primary piping was found to be leaking. A small leak had apparently existed for some time as there was a large cake of sodium oxide around the assembly. Visual examination did not disclose either the location or the nature of the failure. This joint is being returned to the manufacturer where it will be disassembled, the nature of the failure determined, and necessary repairs performed.

Modification and relocation of the primary plugging meter was completed. The secondary system was cold trapped for about three days, but no plugging run was obtained.

Previously reported problems with the bubbler level controller for the primary pump have been corrected; that is, heater installed, gas leaks

sealed, and grounded leads repaired. This controller functioned properly during the most recent operation of the primary pump.

D. Mechanisms in Sodium - Atomics International

Bench testing of the stroke multiplying mechanism has continued on an uninterrupted basis for over 10,000 cycles. The output shaft travels approximately six feet at a rate of one foot per minute. When the gears were lubricated with a light oil coat (SAE 40), the load readout trace dropped from 200-lb. load fluctuation to approximately 80 lb. on the upstroke.

E. High Temperature Strain Measurements - Atomics International

No report was received for this period.

F. Mechanical Properties of Materials - MSA Research Corporation

Test 3 (316 stainless steel in high carbon sodium) sodium operation has just been completed. The metallurgical studies and data analyses are still in progress, as well as the testing of exposed specimens by the University of Michigan. This work will not be completed until September. The complete results of this work will be presented in a topical report scheduled for completion by October 1, 1965.

Test 5 (316 stainless steel in high oxide sodium) sodium operation was completed during this report period. The last two weeks of operation continued to be plagued with the formation of plugs in the OCI system. These plugs have been shown to be chiefly iron. Post-test examinations of the OCI system are expected to show heavy iron deposits. The metallurgical studies of test specimens and data analyses are still in progress. The testing of exposed specimens is still in progress at the University of Michigan. This work is also scheduled for completion in September. A complete analysis of Test 5 will be reported in a separate topical report, hopefully by October 1, 1965.

Test 6 is the testing of 304 stainless steel in 1200°F high oxygen-sodium and will be conducted in Loop 2. Upon the completion of Test 5, Loop 2 was drained. Loop samples are being removed for examination, after which scheduled repairs and in-between-test maintenance will be performed. Some initial operation may be conducted in the next report period.

Test 7 is the testing of 304 stainless steel in 1200°F high carbon-sodium and will be conducted in Loop 1. The repairs to Loop 1 following Test 6 were completed, including the installation of a new cold trap, new inlet and outlet lines to the test units, and the replacement of pipe samples and several system valves. Initial operation of the heavily carburized loop was achieved without incident. Heatup was conducted slowly and steadily. The OCI system was put into operation and the main system piping, not including the test units, was cold-trapped to a plugging temperature of less than 300°F. Scheduled operations call for putting each test unit on stream separately, without test specimens, followed by cold trapping each time. After all the test units are on stream and the oxygen concentration is under control, then the carbon concentration will be adjusted by appropriate control of a bypass stream through the carbon bed. Specimen testing and exposure will then begin.

G. Development of Techniques for Measurement of Impurities in Sodium - MSA Research Corporation

The investigations of the laboratory techniques are estimated as being 99%

complete, and the instream monitoring program is approximately 98% complete.

In general, the "demonstration of initial feasibility" phase of this program is complete. Data analyses, reporting and recommendations for the next phase will account for the remainder of the effort.

H. Sodium-Water Reaction - Small Leak Program - Atomic Power Development Associates, Inc.

Effort on the program is being directed toward the design and construction of the test system.

The new trigger tube or water injection device has been designed and is being fabricated. The new device employs a hardened capillary tube with one end sealed shut and the other end brazed into the water-filled tube. The sodium-water reaction is triggered by mechanically breaking off the capillary tube. The mechanical operability will be checked in ambient air and releasing 3000 psi water in 650°F sodium and releasing 2700 psi nitrogen before being used in the first test run.

A program of support effort for Rig-10 (large flowing sodium test rig) is being outlined. Screening tests in both bench scale apparatus and in Rig-33 (small stagnant sodium test rig) will be made to establish the cause of wastage and to obtain some feeling for the significance of the variables in the big test runs.

Preoperational testing of the systems is scheduled to start the first of September and the first test results should be available around the first of October.

I. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Loop Operation

An injection capsule, loaded with 31.77 grams of sodium monoxide, was inserted into the injection port. The oxygen meters, Rhometers, and the plugging meter responded as expected, all showing an increase in impurity concentration. Further, both the oxygen meters and Rhometers indicated complete solution of the sodium monoxide in approximately four hours. The injection capsule was removed from the flow-through device 24 hours after it had been inserted. Chemical analysis of the contents of the injection capsule also confirmed the fact that all of the sodium monoxide had gone into solution. A quantitative interpretation of the data will be presented as soon as the data from the loop instrumentation are reduced and the chemical analysis of the pre- and post-injection samples are completed.

Rhometers

A specification intended for prospective bidders for the task of designing an automatic temperature compensator for the Mark I Rhometer, including Rhometer compensator fabrication and delivery, has been in preparation and is expected to be complete early in September.

High-Speed Centrifuge

Work on design modifications to adapt a standard Sharples high-speed centrifuge to sodium service consisted of an investigation of electric motor equipment which might be used within an inert atmosphere glove box to drive the unit. From available equipment, units that were recommended for consideration include a 7/8-horsepower, single-phase motor operating

at 22,500 rpm on a 400-cycle supply, and a frequency converter for converting from 60 cycles to 635 cycles (which would drive the foregoing motor at 38,000 rpm). Geared speed increasers to achieve 50,000 rpm have not been found; however, belt drivers are being investigated for this purpose.

In-Line Hydrogen Meter

Obtaining a uniform nickel plating over the palladium tubing of the in-line hydrogen meter continues to hamper the progress of this project. Other possible methods of manufacturing this composite tube are being explored while continued effort is being expended to improve the quality of the nickel plating.

Hydrogen Solubility

The hydrogen solubility apparatus has been sufficiently debugged to permit measuring the length of time required to reach equilibrium and to make some preliminary equilibrium measurements to check the reproducibility.

Chemistry Support

Construction of the extension of the RM-1 and RM-2 loop sample lines into a vacuum glove box is in progress by an outside contractor. The inlet ports for these lines have been attached to the glove box, as well as the sample line extensions inside the glove box. The heaters and thermocouples are being attached, and the insulation for these interior lines has been ordered. Installation in the loop is expected in late September or early October.

J. Under Sodium Scanner - Atomic Power Development Associates, Inc.

During the month the piezoelectric material, lead zirconate titanate (PZT-5), was tested in 600°F sodium. It generated strong signals and the transducers worked satisfactorily at this temperature in sodium. Ultrasonic attenuation measurements were made with the PZT-5 disks operating at 5 mc/sec, and the results were comparable to earlier measurements.

Since the absorption coefficient of sodium is proportional to the square of the frequency, the relative intensities at various distances from the source can be calculated at various frequencies. The results provide a basis from which the frequency for different work distances in liquid sodium can be selected. If the work distance is less than ten feet, the problem of attenuation in sodium can be ignored at frequencies below 1 mc/sec. Frequencies, up to 10 mc/sec or 30 mc/sec, can be used for work distances within a few feet or a few inches, respectively. Above 50 mc/sec, ultrasonics can work only at a distance of less than one inch.

Because of recent determinations of ultrasonic attenuation in liquid sodium and the satisfactory operation of transducers at high temperatures, the development of the ultrasonic beam orientation to locate an object in liquid sodium is assured. A draft of a report, "Concepts for General-Purpose Under Sodium Scanning Systems," was prepared, in which the details of this development are discussed. The report also includes the explanations and the analyses of the single, narrow-beam transducer scanning systems and the electronic acoustic image conversion methods.

K. Fermi Compilation - Atomic Power Development Associates, Inc.

The status at the end of August of the reports authorized is as follows:

EFFBR Primary System Development

During the month the review was completed of the first draft of the portion of the report dealing with the evolution of the design of the primary system. The preparation of the first draft of the portion of the report dealing with the actual installation and operating experience also was completed and was available for review.

EFFBR Fuel Handling in the Reactor Vessel

No effort was expended on this report during the month. At this time the report still is in the detailed outline preparation stage. Effort on this report is scheduled to resume in September.

EFFBR Nuclear Test Program

The review of the first draft of this report was completed and work was started on the preparation of the author's final draft.

EFFBR Low Power Nuclear Test Results

The preparation of the author's final draft was completed during the month and the draft is ready for internal review.

EFFBR Steam Generators

The preparation of a detailed outline on the evolution of the design was completed during the month and submitted for internal review.

EFFBR Sodium System Level Detectors

Draft copies of the final report were submitted to the AEC for comment and approval prior to printing.

EFFBR Sodium System Flowmeters

The review of the author's final draft was completed during the month and the report was returned to the author for final revisions.

EFFBR Control and Safety Rod Drives

The internal review of the author's final draft was completed and returned to the author for final revisions.

EFFBR Fuel and Blanket Subassemblies

Work on this report is scheduled to begin in February 1966.

EFFBR Sodium Sampling Procedures

Review of the first draft of this report was initiated during the month.

L. Heat Exchanger Evaluation - United Nuclear Corporation

Preparation of procedures was continued to provide for reducing test data from the SCTI and for comparing the test results and predicted performance of the ALCO intermediate heat exchanger and the ALCO-BLH

steam generator. The predicted performance will be based on the methods used by the component designer and will be adjusted to suit actual test conditions. Computer routines are being developed to assist in these computations.

Full load plant performance conditions were calculated based on the as-built dimensions and corrected procedures for the ALCO-BLH steam generator, and preparation of procedures is in progress for calculating stresses in the tube sheet, shell and barrel region of the heat exchangers.

M. Continuous Oxide Meter - United Nuclear Corporation

No report was received for this period.

N. Mass Transfer - General Electric Company

No report was received for this period.

O. Large Sodium Valve Design - Allis-Chalmers Manufacturing Company

A draft final report is being prepared for AEC review.

P. Piping Flexibility Study - M. W. Kellogg Company

Phase I of this project has been completed.

III. SODIUM COMPONENTS INFORMATION FROM OPERATING REACTORS

A. EBR-II - Argonne National Laboratory

The reactor was operated at power levels to 45 MWt until August 12, 1965, when it was shut down after attainment of about 1.1 a/o maximum burnup. Thereafter, the reactor was operated at increments of power up to 45 MWt for physics measurements until August 16, 1965. During the remainder of the month, the plant was maintained in standby condition while awaiting the results of the inspection of surveillance fuel elements.

Because of malfunction of the sensing rod in control drive No. 9, the drive was removed from the primary tank. It will be examined to ascertain the cause of the sensing rod malfunction. A replacement drive which had been previously reworked and leak tested to verify bellows integrity was installed on August 25.

Investigation of the large rotating seals continued. A piece of steel tubing attached to a vacuum system was inserted into the "window hole" of the large plug dip ring and used to remove oxide from the top surface of the molten alloy. Approximately two pounds of black powdery oxide nodules, and metal were recovered by the procedure. Samples of these substances are being analyzed chemically to determine their composition.

B. Hallam Nuclear Power Facility - Atomics International

Examination of all seven failed moderator elements has been completed. Six of the elements failed by cracking in similar locations with metallography showing little or no thinning of the material or grain distortion in the region of the cracks. This long-term stress failure mechanism occurs below the yield stress in the range of creep deformation and results in intergranular separation of the material. The other element failed rapidly at the location of a gouge in the sheathing caused by a damaged process tube following core "binding" or "jamming" of moderator logs.

C. Enrico Fermi Fast Reactor - Power Reactor Development Company

Maintenance on electrical penetrations, floor seals, electrical interlocks was carried out during the month.

Examination of fuel pins removed from the sodium worth subassembly showed no significant evidence of hydrogen in the zirconium cladding, and no significant abnormal surface condition. The fuel elements were in very good condition. Pin lengths had decreased on an average of 0.1% and alloy transformed about 25%. The program to inspect fuel pins, before going to full power, has been concluded and showed all elements to be in satisfactory condition.

Written and edited by:

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IV. REPORTS

- A. MSAR Mechanical Properties of Materials - August 1965.
- B. MSAR Development of Impurity Techniques - August 1965.
- C. Sodium Technology Loop - August 1965.
- D. Small Leak Program - August 1965.
- E. Under Sodium Scanner - August 1965.
- F. Fermi Compilation - August 1965.
- G. B&W Steam Generator - August 1965.
- H. Sodium Heat Exchanger Evaluation - August 1965.

SODIUM COMPONENTS DEVELOPMENT PROGRAM
PROJECT COORDINATION REPORT
SEPTEMBER 1965

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor,Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
A. Designer/Fabricator Heat Exchanger Evaluation	Baldwin-Lima-Hamilton Philadelphia, Pa. R. A. Tidball	AT(11-1)- 1501	CH
B. B&W Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
C. Sodium Components Test Installation	Atomics International Canoga Park, California J. A. Leppard	AT(11-1)- GEN-8	CP
D. Mechanisms in Sodium	Atomics International D. T. Eggen	AT(11-1)- GEN-8	CP
E. High Temperature Strain Measurements	Atomics International Canoga Park, California	AT(11-1)- GEN-8	CP
F. Mechanical Properties of Materials	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
G. Development of Techniques for Measurement of Impurities in Sodium	MSA Research Corporation R. C. Werner	AT(11-1)- 765	CH
H. Sodium-Water Reaction - Small Leak Program	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865 P.A. 10	CH
I. Sodium Technology Loop	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865 P.A. 11	CH
J. Under Sodium Scanner	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865 P.A. 14	CH
K. Fermi Compilation	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865 P.A. 15	CH
L. Heat Exchanger Evaluation	United Nuclear Corporation White Plains, New York K. Goldmann	AT(11-1)- 1452	CH
M. Continuous Oxide Meter	United Nuclear Corp. K. Goldmann	AT(30-1)- 2877	NY

N. Mass Transfer	General Electric Company San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
O. Large Sodium Valve Design	Allis-Chalmers Mfg. Co. Bethesda, Maryland	AT(11-1)- 1357 P.A. 5	CH
P. Piping Flexibility Study	M. W. Kellogg Company New Market, New Jersey	AT(11-1)- 1454	CH

II. STATUS

A. Designer/Fabricator - Heat Exchanger Evaluation - Baldwin-Lima-Hamilton Corporation

No progress to report.

B. B&W Steam Generator - The Babcock & Wilcox Company

Prototype Fabrication

The hemispherical upper head has been machined to the correct thickness and profile. It has been ultrasonically tested, and it is ready for welding into the cylindrical portion of shell that was completed last month. The large flange that will attach to this section of shell is completed with the exception of drilling the bolt holes and final facing of the mating flange surface.

The stainless steel shrouds and tube support bars for the superheater section are complete; the superheater tubes have been welded into the proper lengths for the superheater coils. The welds have been dye checked and x-rayed. The x-rays showed zero defects to the limit of sensitivity of the x-ray film which is 2% of the wall thickness or a minimum of .010 inches. These tubes are stored with the ends capped under a plastic dust cover awaiting completion of the coiling mandrel that attaches to the coiling machine.

Work has begun on assembling the straight lengths of boiler tubes into the length required for the boiler coils. With these tubes welded to the proper length and tested, it will be possible to proceed from the coiling of superheater tubes to the coiling of boiler tubes without delay.

Model Steam Generator Test

The examination of materials removed from the model sodium-heated steam generator has continued. The electron microprobe x-ray analysis of the pipes and tube samples has begun. Hardness measurements have been made on samples from several locations within the model steam generator. Metallographic examination of specimens has progressed with approximately 20% of this work remaining.

Corrosion Rates for Croloy 2½ Steel

An experimental test which involved the determination of the corrosion rate of Croloy 2½ steel in a sodium-sodium hydroxide-sodium hydride system at 900°F under a hydrogen overpressure equal to the dissociation pressure of sodium hydride at this temperature was completed. The corrosion rate found was of the same order of magnitude as that in a sodium hydroxide-sodium system under the same conditions of sodium hydroxide concentration and temperature. A topical report has been

written for the completed experimental work on determining the corrosion rate of Croloy 2½ steel in sodium hydroxide solutions in water and in sodium and on the metallographic examination of representative samples from these tests. It is undergoing review prior to final release. The only remaining experimental work on this project is completion of the metallographic examination of a specimen exposed to the sodium hydroxide-sodium hydride-sodium system at 900°F.

C. Sodium Components Test Installation - Atomics International

Examination of the burned-out SCTI secondary pump motor revealed that a lead had shorted to one phase of the winding. A complete rewinding of the motor would have been required to make it operable again. Because of the repeated difficulty experienced with this motor, no further attempt will be made to use it.

An air-cooled motor, suitable for use as a substitute drive unit, has been obtained on a one-year loan basis from Borax V in Idaho. Examination of this motor revealed that the coupling end of the shaft had been twisted. Ultrasonic testing and magnafluxing of the shaft indicated that there were no flaws or cracks in the material. The old keyway and the shaft end will be built up by welding. A new keyway will be machined diametrically opposite the old position. With replacement of the bearings this motor can be used as the drive for the secondary pump. Bids are being requested for a new standard design air-cooled motor specified for the requirements of this application. In order to apply an air-cooled motor to the secondary pump, it is necessary to change the configuration of the pump case. A new pump case closure, jack shaft, bearing housing, and shaft seal assembly are being fabricated and assembled. Integral with this pump case closure will be a new motor mount.

Examination of the bellows of the failed expansion joint revealed that the stainless steel material was sensitized and had subsequently undergone massive intergranular corrosion. Because sodium does not cause this type of effect, it seems that the corrosion occurred prior to sodium filling. The specification for these bellows has been revised to eliminate a high-temperature, outgassing backout which probably sensitized the bellows material.

A second bellows expansion joint was cut out of the piping, cleaned, and examined. It was determined by the dye penetrant technique that no cracks or corrosion pitting existed on the interior surface of the bellows. Appearance of this second bellows was excellent and no corrosion was evident. This joint has now been reinstalled in the primary piping in place of the failed bellows.

A short of straight pipe has been welded into the primary piping system in lieu of the repositioned joint No. 6. Recalculation of piping stresses with a spool in this particular location indicates that operation of the loop below 1000°F will not impose excessive stresses on the piping. This action will permit operation of the primary loop sooner than a replacement bellows can be procured. Six spare bellows expansion joint assemblies have been ordered. Leak detectors are being installed on all of the bellows expansion joints.

Installation of a vent line between the shell side of the IHX and the primary expansion tank has been started. This vent line will contain a blocking valve as well as a fixed orifice. The use of this line will prevent the buildup of a gas bubble in the upper end of the IHX.

Modification of bellows seal valves to freeze stem valves has been nearly completed. All but three of the original 25 have been modified.

D. Mechanisms in Sodium - Atomics International

The metallographic examination of Bell-Metrics Bellows No. 3 which failed after 1895 cycles in 1200°F sodium has been completed. The examination revealed that a weld bead had a thickness of only 66% of the 0.010 inch parent metal on some of the outer welds during manufacture of the bellows. The inner welds were approximately 20% heavier than the parent metal. Improvement in welding specifications has been incorporated for manufacturing.

The testing of the second pair of orifice actuator bellows is continuing at a half cycle rate every seven hours with 170 half cycles completed. One of the test bellows is located in 1200°F sodium and the other is in a 800°F sodium vapor-helium atmosphere. Cycling will continue until 500 half cycles have been completed.

The model free floating rack and pinion 4:1 stroke multiplying mechanism operating in air has completed 13,500 cycles. The output shaft load is 100 pounds and the stroke is approximately six feet.

E. High Temperature Strain Measurements - Atomics International

A test specimen was instrumented with four strain gages fabricated from Armour D wire. These particular gages are from the first units fabricated at AI. Some testing has been completed and results indicate good quality. Ambient loads versus strain measurements are linear. Thirty thermal shocks caused one gage to fail, but instrument readings from the other three consistently repeated prior results on each shock with no sign of instability. Future experiments include mechanical load tests at elevated temperatures and thermal soak tests over a substantial period of time.

F. Mechanical Properties of Materials - MSA Research Corporation

Tests 1, 2, and 4 have been completed and the results reported in topical reports.

Test 3 (316 stainless steel in high carbon sodium) is nearing completion. The final test at the University of Michigan of an exposed specimen is well into the third stage of creep and should rupture in the near future. The final draft of a topical report is being completed and the report is expected to be issued during the next report period.

All testing for Test 5 (316 stainless steel in high oxide sodium) has been completed. Final metallographic examinations are being completed and the data is being summarized for issuance in a topical report during the next report period.

Test 6 (Type 304 stainless steel in 1200°F high oxygen sodium) is to be conducted in Loop 2. Between-test maintenance has been completed and preliminary operations of this loop are expected to begin during the next report period. A portion of the test specimens have been machined.

Test 7 (Type 304 stainless steel specimens in 1200°F high carbon sodium) is being conducted in Loop 1. Preliminary operations have been carried out to establish and confirm the operating conditions for this test.

The completion of the preliminary operations in air of the creep machine to be used in the Extensometer Development Program resulted in the

addition of a voltage stabilizer to the test unit. Creep measurements, using a standard differential transformer at room temperature, were then initiated in air at 1200 F on a Type 304 stainless steel test specimen from the same heat which will supply specimens for both the extensometer tests in sodium and the Mechanical Test Program. The specimen was placed under a stress of 8500 psi and will serve as a basis for comparing the future work with the high temperature differential transformers. The test has now been in progress for a period of 550 hours and will continue until the high temperature transformers are ready for testing and/or sufficient data is collected for comparison on future tests.

The room temperature calibration and stability testing phase of the high temperature differential transformer is nearly complete. Within the next two weeks this unit should be ready for the initial test run in air at temperature with an actual specimen. The schedule for completing the special test container and completing the above-mentioned preliminary control creep test is directed toward this goal.

G. Development of Techniques for Measurement of Impurities in Sodium--
MSA Research Corporation

The objective of this study was to evaluate feasibility of selected approaches that might lead to the development of techniques for the measurement of impurities in sodium. The performance of these limited studies was as follows:

1. Laboratory Techniques

Magnetic Effects - Differences were observed in the degree of magnetic deflection between pure sodium and carbon- and oxygen-contaminated sodium. Additional work is required on this approach to quantitize the degree of deflection as a function of the impurity concentration.

Surface Tension - Differences were noted between the surface tension of pure potassium versus oxygen-contaminated potassium. Additional work is required to evaluate the effect of oxygen on the surface tension of sodium and to quantitize the effect.

Organic Solvent Extraction - Sodium was separated from sodium oxide using naphthalene with THF as a solvent. Additional work is needed to determine the purity of reagents, and the reproducibility and minimum limit of detection of the method.

High Temperature Mass Spectrometry - Fabrication of the test system was completed, but experimentation was not possible due to deployment of funds to other selected approaches.

2. Instream Techniques

Physical Property Change of Metals Due to Carburization - Magnetic and electrical resistivity measurements were made on carburized specimens of 2½ Cr-1 Mo steel. The results indicated a correlation did exist between the carbon content and the magnetic effects and electrical resistivity.

Electrical Sensing of Particles in Liquid Metals - Bench tests indicated that studies in actual systems with sodium oxide were warranted. A small plugging indicator system was then built, but the limited operations during this phase were not successful in indicating electrical changes across an orifice during the precipitation of sodium oxygen particles.

Sodium Oxide Determination by Electrical Potential Concentration - Sodium oxide was concentrated during several tests at the anode of an electrical circuit by the passage of electrical current through the system. Material was purchased for the construction of an apparatus that would permit a more detailed evaluation of this process.

Continuous Hydrogen Monitoring - A bench type aqueous hydrogen cell was constructed and the feasibility of measuring hydrogen by this method was demonstrated.

H. Sodium-Water Reaction - Small Leak Program - Atomic Power Development Associates, Inc.

1. Fabrication and erection of Rig 10 is essentially completed.
2. After reviewing the results of the sodium-water reaction tests performed under AEC Contract No. AT(11-1)-1280, Subcontract No. 1, it was decided to change the water injection method for Rigs 10 and 33. The new trigger tube, or water injection device has been designed and fabricated. The new device employs a hardened capillary tube that has one end sealed and the other end brazed into the water injection tube. The sodium-water reaction is triggered by mechanically breaking off the capillary tube. Prior to use in the first test run, the mechanical operability will be checked in ambient air while releasing 3000 psi water, and in 650°F sodium while releasing 2700 psi nitrogen.
3. Post-test cleaning methods are being studied from the standpoint of:
 - (a) The method that will most efficiently clean the tube bundle without interfering with the wastage and reaction results.
 - (b) The safety problems involved with the various cleaning methods.

Although the work is not completed at this time, it appears that alcohol cleaning of the tube bundle within the reaction vessel is the most desirable.

4. A support program for Rig 10 involving bench scale tests is being undertaken.
5. The testing program for Rig 33 is continuing and will be broken into two categories as follows:
 - (a) Rig 33 will be used as a proof-test facility for untested and/or undeveloped equipment and components of Rig 10, such as:
 - (1) Trigger Mechanism
Test the operability in sodium at 650°F with 2650 psia water inside.
Investigate whether capillaries plug during a sodium-water reaction, and, if so, what minimum size will stay open.
 - (2) Test the durability of the fast-response thermocouples used on the Rig 10 bundle.
 - (3) Develop a method of attaching and operating the pressure detectors that will be used during large leak tests, and check out the pressure detector operation.
 - (b) Rig 33 will be used to investigate some of the Rig 10 variables including those that will be studied in the initial series of

Rig 10 tests and those that will be studied in future tests. The results of these tests will be used to establish the limits of the range over which these variables should be studied in Rig 10.

I. Sodium Technology Loop - Atomic Power Development Associates, Inc.

A meaningful interpretation of the data obtained from the sodium-monoxide injection performed last month and the injection performed early this month could not be made with regard to determining the signal output per ppm change in oxygen concentration of the Rhometer and oxygen meter. The primary reason was that the amplitude of the peak-to-peak fluctuations before, during, and after each injection, in terms of equivalent oxygen concentrations, were of the same order of magnitude as the change expected from each injection. In order to insure that these large noise-to-signal ratios from the oxygen meters and Rhometers are not due to inherent deficiencies in the loop, a shakedown of the loop is in progress. Briefly, the shakedown procedure covers:

1. An investigation of loop temperature variations with respect to both time and position, aimed at installing automatic temperature control.
2. An investigation of the effect of environmental conditions on the readout instrumentation of the Rhometers and oxygen meters.
3. An investigation of the effect of flow variations on the readout of the Rhometers and oxygen meters, aimed at installing automatic flow control.
4. An investigation of the possible sources of impurity feedback.
5. An investigation of the effect of normal loop operations such as sampling and plugging temperature determinations on loop stability.

It is also planned to replace the Rhometer's silver contact decade and temperature compensator switches with a type that is noncorrosive to atmospheric impurities, thus eliminating a continually changing contact resistance.

High-Speed Centrifuge

A standard, laboratory model super centrifuge was ordered from Sharples on September 3. Fabrication drawings of this unit were received from Sharples on September 24, 1965. Design modifications on the seal module for the outside drive and the argon purging-arrangement for the inside drive may now proceed. General arrangement drawings will be prepared for both concepts to permit a choice of concept to be made.

Investigation of electric motor equipment to drive the above-mentioned centrifuge is in progress. A high-speed belt drive was found which may eliminate the need for driving a 400-cycle motor at 635 cycles which would increase the life of the motor. The use of an electronic, direct current, high-cycle source rather than a rotary converter is also being considered.

J. Under Sodium Scanner - Atomic Power Development Associates, Inc.

Since the theoretical ultrasonic absorption coefficient of liquid sodium is related to the velocity of sound and the specific heat of the liquid, the velocity of sound in liquid sodium was measured over the temperature

range (220°F to 600°F) of attenuation measurements. The specific heat at constant volume was then calculated at 600°F from the results of the acoustic velocity measurements. No previous experimental data are available at this temperature for comparison.

An interim report on the Under Sodium Scanner Test Program was prepared in which the details of the ultrasonic attenuation measurements are discussed and a summary of the report, "Concepts for General-Purpose Under Sodium Scanning Systems," APDA-179, is presented.

K. Fermi Compilation - Atomic Power Development Associates, Inc.

The following is the status of reports being written:

1. EFFBR Primary System Development

The first draft of the report is completed and the portion on evolution of the design has been reviewed internally.

2. EFFBR Fuel Handling in the Reactor Vessel

This report is in the detailed outline preparation stage.

3. EFFBR Nuclear Test Program

The first draft of this report is written and the internal review is completed. The writing of the final draft is underway.

4. EFFBR Low Power Nuclear Test Results

The final draft of this report is written and internal review has been completed. Final revisions by the author are underway.

5. EFFBR Steam Generators

The outline of the portion of the report dealing with the evolution of the design is completed. The portion of the report dealing with the actual installation and operating experience is in the detailed outline preparation stage and researching of the APDA files for pertinent information is in progress.

6. EFFBR Sodium System Level Detectors (APDA-300)

Draft copies of the final report have been submitted to the AEC for comment and approval prior to printing.

7. EFFBR Sodium System Flowmeters

The final draft of this report is written and internal review has been completed. Final revisions by the author are underway.

8. EFFBR Control and Safety Rod Drives

The author has completed revisions to his final draft to incorporate comments resulting from the internal review. The report is now ready for final editing prior to submission of a draft to the AEC for approval.

9. EFFBR Fuel and Blanket Subassemblies

Work on this report is scheduled to begin in February 1966.

10. EFFBR Sodium Sampling Procedures

The first draft of this report has been written and the internal review is in progress.

L. Heat Exchanger Evaluation - United Nuclear Corporation

Thermal Hydraulic Performance

The computer code, which had been prepared to process test data and to calculate the predicted and observed thermal-hydraulic performance, was run with sample input data. This program also contains subroutines for calculating shell and tube metal temperature distributions which are required for structural evaluation of the sine wave tubes. Debugging is essentially complete.

Work on the procedure for predicting temperature distributions in the tube sheet area which is required for structural analysis has been suspended pending receipt of clarification of the methods and assumptions used by ALCO. Because there is considerable difference between the temperatures predicted in APAE-112 for the intermediate heat exchanger and the steam generator, a recommendation has been prepared for the installation of additional thermocouples on both heat exchangers to check the actual temperature distribution in this area.

Structural Performance

Preparation of procedures for calculating stresses in the tubesheet, shell and barrel region of the heat exchangers continued.

1. Last month it was stated that the UNC procedure for analyzing the lower tubesheet performance under thermal loads produced results which were different from those indicated in APAE-112. After further review the input for the computer code was modified to consider thermal expansion at junctions of the barrel and shell with the tubesheet rather than at the outside of the tubesheet. This now results in discontinuity loads which are comparable to those predicted in APAE-112.
2. Influence coefficients relating the discontinuity loads to deflections and rotations at the junctions of the inner core, tube section and outer ring of the upper tubesheet under pressure loading were calculated using a computer code and these checked closely with those used by ALCO. The influence coefficients relating pressure to rotation were also calculated for these elements. Those for the outer ring and inner disc do not check with those used by ALCO. Investigation is continuing.

M. Continuous Oxide Meter - United Nuclear Corporation

A final report describing development of the Electrochemical Oxygen Meter was completed. Liaison with APDA, ANL, and LASL was continued. Field tests of the oxygen meters continued during September. At APDA and LASL approximately two months of continuous operation have been completed. Approximately one month of operation has been accumulated at ANL.

APDA and LASL have observed a daily high to low cycle in meter output voltage. Preliminary tests indicate that the cyclic variation is associated with changes in ambient temperatures. However, the mechanism by which ambient temperature affects the meter output voltage has not

yet been determined. Tests have also shown that the daily fluctuations can be essentially eliminated by controlling the temperature of the meter housings.

N. Mass Transfer - General Electric Company

No report was received for this period.

O. Large Sodium Valve Design - Allis-Chalmers Manufacturing Company

A draft final report is being prepared for AEC review.

P. Piping Flexibility Study - M. W. Kellogg Company

Phase I of this project has been completed.

III. SODIUM COMPONENTS INFORMATION FROM OPERATING REACTORS

A. EBR-II - Argonne National Laboratory

Reactor operation began September 3, 1965, and continued to September 20, 1965, when 1.21 a/o burnup was achieved.

Control Rod Drives

The gripper jaw mechanism of control rod drive No. 9, which was removed from the primary tank last month, could not be examined closely because of its radioactivity (approximately 50 R/hr at 6 in.). The sensing rod of this drive was stuck in the "Up" position. Cleaning of the drive has been started.

Control rod drive No. 11 was installed earlier in the No. 9 position, but would not latch readily on the control subassembly. To determine whether the subassembly might be at fault, it was replaced by a new one. The same problem occurred.

For current operation, control rod drive No. 11 (position 9) was manually latched to the new control subassembly. After the power run, the control rod was manually unlatched.

During subsequent testing to investigate this problem, the control drive was latched to the subassembly with the reactor cover up. The same problem was encountered.

Rotating Shield Plug-Seal Troughs

By a vacuum cleaning technique approximately 21½ pounds of black powdery oxide, nodules, and metal were removed from the large plug (a total to date of 23½ pounds). Small-plug cleaning, begun this month, yielded approximately 2½ pounds of the same type of material. No attempt has been made to separate the recovered oxide from the metal.

The oxide removal seems to allow the large shield plug to rotate with somewhat less heating; the last melting time (to obtain plug rotation) was approximately 40 hours versus the 56 hours required before the cleaning operation. The small plug does not seem to present as great a problem and appears to have less black powder on the surface.

Improved Pump for Secondary System

In April 1964, prior to start of the approach to power, a leak developed in the secondary-system pump due to cracks (fatigue failures) in the pump

duct wall caused by duct vibration. The vibration resulted from deficiencies in the pump design which produced deleterious differential pressure conditions across the wall at high flow rates.

After repair and reinstallation of the pump, flow has been limited to 5500 gpm as a result of downrating of the pump by the manufacturer (from the original 6500-gpm capacity). This is adequate for reactor operation at 45-50 MW. However, use of the very high flow rates required for full reactor power (62.5 MW) presumably would unduly increase the probability of failure.

To enable future full power operation with minimal risk of extended plant shutdown due to a secondary-pump failure, a linear induction pump of 6500-gpm capacity at 53 psi head is being procured. Design improvements are expected to include a redesigned inlet transition member, to reduce pressure drop, and elimination of internal spacer supports in the duct.

B. Hallam Nuclear Power Facility - Atomics International

The reactor remained in layup status during the month. Two additional moderator elements for a total of five have been buried.

C. Enrico Fermi Fast Reactor - Power Reactor Development Company

The reactor remained shut down awaiting action of the Safety and Licensing Board with respect to the 200 MWt license.

Written and edited by:

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IV. REPORTS

- A. MSAR Mechanical Properties of Materials - September 1965.
- B. MSAR Development of Impurity Techniques - September 1965.
- C. Sodium Technology Loop - September 1965.
- D. Small Leak Program - September 1965.
- E. Under Sodium Scanner - September 1965.
- F. Fermi Compilation - September 1965.
- G. B&W Steam Generator - September 1965.
- H. Sodium Heat Exchanger Evaluation - September 1965.
- I. Continuous Oxide Meter - September 1965.

SODIUM COMPONENTS DEVELOPMENT PROGRAM

PROJECT COORDINATION REPORT

OCTOBER 1965

I. LISTING OF CURRENT PROJECTS

<u>Current Projects</u>	<u>Contractor, Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
A. Designer/Fabricator Heat Exchanger Evaluation	Baldwin-Lima-Hamilton Philadelphia, Pa. R. A. Tidball	AT(11-1)- 1501	CH
B. B&W Steam Generator	Babcock & Wilcox Barberton, Ohio P. B. Probert	AT(11-1)- 1280	CH
C. Sodium Components Test Installation	Atomics International Canoga Park, Calif. J. A. Leppard	AT(11-1)- GEN-8	CP
D. Mechanisms in Sodium	Atomics International D. T. Eggen	AT(11-1)- GEN-8	CP
E. High Temperature Strain Measurements	Atomics International	AT(11-1)- GEN-8	CP
F. Mechanical Properties of Materials	MSA Research Corporation Callery, Pennsylvania R. C. Werner	AT(11-1)- 765	CH
G. Development of Techniques for Measurement of Impurities in Sodium	MSA Research Corporation R. C. Werner	AT(11-1)- 765	CH
H. Sodium-Water Reaction Small Leak Program	Atomic Power Development Associates, Inc. Detroit, Michigan A. Amorosi	AT(11-1)- 865 P.A. 10	CH
I. Sodium Technology Loop	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865 P.A. 11	CH
J. Under Sodium Scanner	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865 P.A. 14	CH
K. Fermi Compilation	Atomic Power Development Associates, Inc. A. Amorosi	AT(11-1)- 865 P.A. 15	CH
L. Heat Exchanger Evaluation	United Nuclear Corporation White Plains, New York K. Goldmann	AT(11-1)- 1452	CH
M. Continuous Oxide Meter	United Nuclear Corporation K. Goldmann	AT(30-1)- 2877	NY

<u>Current Projects</u>	<u>Contractor,Address Person in Charge</u>	<u>Contract Number</u>	<u>Contract Administrator</u>
N. Mass Transfer	General Electric Company San Jose, California R. W. Lockhart	AT(04-3)- 189	SAN
O. Large Sodium Valve Design	Allis-Chalmers Mfg. Co. Bethesda, Maryland	AT(11-1)- 1357 P.A. 5	CH
P. Piping Flexibility Study	M. W. Kellogg Company New Market, New Jersey	AT(11-1)- 1454	CH

II. STATUS

A. Designer/Fabricator - Heat Exchanger Evaluation - Baldwin-Lima-Hamilton Corporation

There was no progress to report this period.

B. B&W Steam Generator - The Babcock & Wilcox Company

Prototype Fabrication

Coiling of the superheater tube bundle has begun. The outer row of superheater tubes has been coiled onto the coiling fixture and the tube support bars inserted. The dimensions of the tube bank have been checked, and it has been adjusted slightly to insure that the bundle is a true cylinder of the correct diameter. As soon as the tubes at the inlet and outlet end of the bank have been bent to the proper location for attaching the risers and downcomers, this coil bank will be removed from the fixture and the next diameter of coil bank will be made.

Welding of the several lengths of tube required for the boiler bundle is proceeding. Three thicknesses of tube are used in the boiler bundle. These tubes are being welded together before coiling, utilizing the same automatic welding machine that was used for the superheater tubes. These welds are ground smooth, x-rayed, and dye checked. There have been zero defects in the welds so far to the limit of sensitivity of the x-ray process which is 2% of the wall thickness with a .010" minimum. These tubes are being stored, with the ends capped, under a plastic dust cover ready for coiling.

The 1" thick Croloy 2½ plate for the lower vessel shell was purchased in accordance with Section VIII of the ASME Unfired Pressure Vessel Code. The specification for such plate is SA 387-GR.D. This specification does not require that the plate be ultrasonically tested. As a part of the receipt inspection of this plate, B&W applied an ultrasonic test and found a large zone of laminations in the center of the plate. The vendor was contacted and agreed to take back this 1" plate and replace it at no cost. The specifications to which the plate was purchased did not require ultrasonic testing.

Model Steam Generator Test

The metallographic examination of materials removed from the model sodium-heated steam generator is virtually completed. Electron microprobe x-ray analysis of the pipe and tube samples has continued, and microhardness testing of samples is nearly finished.

Corrosion Rates for Croloy 2½ Steel

The metallographic examination of the specimen from the corrosion test in which Croloy 2½ was exposed to sodium hydroxide-sodium hydride-sodium system has been completed. This examination indicated that there was no preferential attack of the steel by this system, and that the relatively low weight losses could be attributed only to a general-solution type of attack. This completes all the experimental work on this project. The topical report on this project is being modified to include the results of the sodium hydroxide-sodium hydride-sodium system test.

High Temperature Strain Gages in a Sodium Environment

Three types of high temperature gages are presently being investigated for use on the prototype steam generator. Each will be reported separately as follows:

Microdot 650° F Gage - The welding group microbrazed six gages. Two of these gages indicated complete loss of resistance to ground after brazing. A third gage was found to be highly unstable. One of the three remaining gages is now undergoing tests in sodium at 650° F.

Baldwin-Lima-Hamilton High Temperature Weldable Strain Gages - These gages are now being calibrated at temperatures up to 1100 F.

900° F Microdot Half Bridge Gage - These units have been installed for evaluation and subsequent calibration.

C. Sodium Components Test Installation - Atomics International

The availability evaluation study of the SCTI is approximately 60% complete.

Sodium was circulated in the primary loop for 25 of the last 31 days with a straight pipe spool in place of one expansion joint. Operation of the primary loop has permitted cold trapping of primary sodium, resulting in a present plugging temperature of 290° F; recalibration of the expansion tank level gage which now transmits an acceptable signal; and reactivation of the bubbler-level controller for the primary pump.

Circulating of sodium in the primary system has also made possible extensive testing of the large gas fired heater. All five main burners have been lighted and a number of checkout tests have been conducted to determine the characteristics of the natural gas control system and interaction of these with the rest of the control system. It was found that the flame detectors for the main burners did not "see" the main burner flame. The position of these detectors has been changed and they now function properly. The heat introduction to the sodium by the main burners was dissipated to the atmosphere through the sodium cooler which is located in a bypass circuit in the primary system. Operation of this cooler has been entirely satisfactory and, on the basis of the initial operation, appears to have more than the design heat transfer capability. At the time of this report, approximately 6 MW of power was being transferred with an 80 F delta T across both the heater and the cooler.

The air-cooled motor obtained from Borax-V in Idaho has been examined, repaired, and operated at a vendor's shop. The motor has been delivered to Santa Susana, and it is ready for use as the secondary pump drive upon delivery and installation of the jack-shaft assembly. The contract date for delivery of the jack-shaft assembly is November 12. An order has been placed for a new 300-hp, 4160-volt, air-cooled motor to replace the Borax-V motor.

Bids for six spare bellows expansion joint assemblies have been received and are being evaluated. On the basis of these bids it would appear that the spare bellows assemblies can be available during the month of January 1966.

D. Mechanisms in Sodium - Atomics International

The sliding seal and sliding bearing test assembly has been modified to allow a slip fit of the Wiggins Bar-X Tungsten carbide on Inconel-X in the seal housing. Sodium has been directed into the test pot and is being heated to 1200°F. At this temperature the assembly will be cycled to determine performance of Wiggins Bar-X seals as linear guide bearings.

Two gear and journal bearing test rigs have been assembled and covered with sodium. One experiment will be continuation of the Hastelloy C gear and bearing test which was initiated in FY 1963. For the first test in the second assembly, a pair of 316 stainless steel gears (coated with Microseal) and two journals of Hastelloy C will be operated in 1200°F sodium.

E. High Temperature Strain Measurements - Atomics International

Studies of ways of further improving the fatigue performance of wire filament strain gages continue. Particular emphasis is being focused on development of joining techniques which may eliminate the need for spot-welded joints and thereby improve fatigue resistance of gage with respect to thermal shock. Elements for pilot gages have been prepared to investigate the feasibility of gold-brush plating, twisted wire, and mechanically crimped joints. Metal foil gages have been fabricated having a substantially reduced "flat-plate" area and increased thickness. Flame-spray bonding and evaluation of these gages is in progress.

Evaluation continues of the first Atomics International fabricated Armour D-Platinum gages. Results from long term soak and thermal shock tests of these and other gages look promising. Eleven out of thirteen gages under evaluation are still operating after soaking for periods of up to approximately 500 hours at 1200°F.

Ambient load versus strain tests have been conducted on three Microdot specimen assemblies after stabilization at elevated temperature for 16 hours. Two of these specimen units have been subjected to 30 thermal shocks between 325 and 900°F with temperature changes being maintained at 5, 10, and 25°C/sec in groupings of ten tests at each condition. Both gages recorded in a consistent and stabilized fashion throughout the cycling and showed no signs of thermal fatigue. Ten other strain gages have been subjected to a 450-hour soak test at 1200°F, and this experiment is being continued. In the latter group, gages which had not been subjected to prior thermal shocking are producing the best results. Two gages which had been cycled indicate a high drift rate.

As a point of interest, monitoring of the Baldwin-Lima-Hamilton flame-spray bonded electric resistance strain gages and associated thermocouples on the SRE-THX continues. As of October 19, 1965, 21 out of 26 of the strain gages are still operational, after 4 months in service. Of the 21 gages still operational, only 3 gages show strains that may indicate strains significantly different from those measured on September 12, 1965.

F. Mechanical Properties of Materials - MSA Research Corporation

The initial runs of Test 7 (304 stainless steel in high-carbon sodium) have been started in Loop 1. The revisions of one of the mechanical test units for the exposure of specimens to helium and high-carbon sodium for

4000 hours were completed. This unit has been installed in Loop 1 and the 4000-hour exposure period initiated.

The preliminary operations of Loop 2 have been completed and the initial runs of Test 6 (304 stainless steel in high-oxygen sodium) initiated. During the preliminary operations the test parameter of 300 ppm oxygen was attained, and the plugging indicator saturation temperature was confirmed by chemical analysis of sodium samples removed from the in stream expansion tank.

Testing of high-oxygen and high-carbon sodium exposed specimens in air and helium at the University of Michigan for Tests 3 (316 stainless steel in high-carbon sodium) and 5 (316 stainless steel in high-oxygen sodium) has been completed, ending the mechanical testing for Tests 3 and 5. The final metallography of the specimens generated during these tests is being completed, and the data is being summarized in topical reports being issued in the near future.

Extensometer Development Program

The Extensometer Development Program was included under the MSA contract and involves the design, development, and testing of an extensometer for improving the measurement of creep rates of specimens immersed in high-temperature sodium.

During the period in which the experimental extensometer is undergoing calibration tests, background data is being generated on the creep rate of 304 stainless steel in 1200° F air using a standard dial gage and extensometer. Preliminary testing of a 304 stainless steel specimen in air at 1200° F at a stress of 8500 psi was terminated after 833 hours. The specimen was removed from the test unit, and the total over-all specimen elongation was compared with the elongations indicated by a standard extensometer and dial gage. This comparison is shown below:

<u>Total Specimen Elongation as Measured</u>	<u>Total Specimen Elongation by Extensometer</u>	<u>Total Specimen Elongation by Dial Gage</u>
0.005 in.	0.0058 in.	0.0144 in.

The measured elongation and the elongation obtained from the extensometer are in close agreement. This extensometer was attached directly to the specimen at the gage marks by extension rods which permitted the transducer to operate in room-temperature air. The dial gage reading, however, is not in good agreement. The creep data from the dial gage during testing was in good agreement with the extensometer. The dial gage was not attached directly to the specimen but was externally mounted so that any creep in the pull rods and/or the threads of the pull rod would be included as part of the specimen elongation readings. Actually this dial gage included longer structural portions than the ones on Loops 1 and 2. During testing of the sodium-immersed high-temperature differential transformer, the dial gage will be relocated to eliminate as much of this error as possible and will be more in keeping with the data from Loops 1 and 2.

G. Development of Techniques for Measurement of Impurities in Sodium - MSA Research Corporation

There was no progress to report this period.

H. Sodium-Water Reaction - Small Leak Program - Atomic Power Development Associates, Inc.

Fabrication and construction of Rig 10, the large flowing sodium test rig, is complete. Only those items on the contractors' punch lists remain, along with those which were found during systems checkout.

The new trigger device has been fabricated and shipped. Rig 33, the small stagnant sodium loop, and Rig 10 both use the same design; however, they have individual mechanisms because of the difference in required length. Mechanical operation of the Rig 33 trigger was checked in air at ambient conditions. It was found that a minor modification to the delatching system was required. The small delatching spring at the top of the mechanism was too long and had to be shortened to allow the delatching arm to rotate a full 90 degrees. If the delatching arm does not rotate far enough, the cocking spring will not release and drive the guillotine against the capillary tube. This modification is complete, and the trigger checkout is continuing.

Rig 10 should be filled with sodium around November 10, 1965, thus allowing the first test results to be available about the end of the month.

I. Sodium Technology Loop - Atomic Power Development Associates, Inc.

Loop Operation

The shakedown program is almost complete, and corrective measures are in progress. Some of the results of the shakedown program and the progress made so far in the corrective measures are given below:

Temperature Variations - A semiprecision potentiometer was used to monitor loop temperatures in order to determine variations with respect to both position and time. Temperatures along the sodium flow path were within $\pm 15^{\circ}\text{F}$ of a nominal loop temperature of 600°F . Temperature variations of specific locations were within a $\pm 2^{\circ}\text{F}$ band.

Temperatures as low as 260°F were obtained in branched lines adjacent to sodium flow lines in which there was no sodium flowing. Temperatures as low as 316°F were found on uninsulated valve stems. Such locations can act as cold traps and cause loop instability.

In order to improve the temperature control of the sodium loop, the following actions have been or will be taken: an extended range potentiometer which will allow temperatures to be read to the nearest $\pm 1^{\circ}\text{F}$ has been ordered to replace the present temperature indicator which can only be read to the nearest $\pm 15^{\circ}\text{F}$; variac control is being planned to replace on-off manual control of approximately 36 heaters now installed in the loop; and variac-controlled heaters will be used to eliminate the cold spots in the branched lines mentioned above, and insulation will be used to eliminate the cold spots on exposed valve stems.

Flow Variations - The effect of flow variations on the Rhometer readout is insignificant for small fluctuations at 7.5 gpm which is the nominal flow rate maintained in the one-inch sodium technology loop. The Rhometer readout is affected by large fluctuations, however, which occur during injection of impurities and during sampling of the loop sodium.

The oxygen meters do not appear to be influenced by variations in flow at isothermal conditions.

Flow variations do, however, upset the stability of the loop indirectly by causing subsequent temperature fluctuations affecting both the oxygen meters and Rhometers.

To correct this indirect flow effect, an automatic flow control valve will be inserted in the one-inch loop.

Source of Impurity Feedback and Hideout - No work was directed toward establishing the possibility of sources of impurity feedback this month. However, with regard to impurity hideout, significant progress has been made. As mentioned in the section covering temperature variations, temperature profiles taken along uninsulated valve stems and branched lines adjacent to sodium flow lines in which there was no sodium flow, i.e., bypass lines, etc., definitely indicated that such locations could act as cold traps. In one branched, nonflow line the temperature of the sodium dropped to 260°F.

In order to eliminate these potential cold traps, all valve stems are being insulated and all branched, nonflow lines are being equipped with separate, variac-controlled heaters.

High-Speed Centrifuge

The laboratory model Super Centrifuge, ordered from Sharples on September 3, 1965, has been delivered.

Comparative evaluation of two drive systems for this centrifuge has progressed. A conceptual layout drawing of an air turbine drive system located outside the glove box and driven through a seal module is essentially complete. Work is continuing on the design considerations of the second drive system. The primary feature of this latter system is a 400-cycle drive motor contained in a semi-leaktight secondary enclosure located in the glove box. Lubricant vapors from the motor and bowl support bearings will be purged from the semi-leaktight enclosure with argon from the glove box.

The use of an electronic direct-current, high-cycle source has been dropped in favor of a rotary converter. The use of a high-speed belt drive to increase the rotational speed of the centrifuge has also been dropped because of the radial load that must be applied to the bearings to obtain the proper belt tension. Suitable motors and frequency converters to drive the centrifuge have been found. Selection will be based on price and delivery.

Vacuum Glove Box

Fabrication of the extension of the RM-1 and RM-2 loop sample-lines into a vacuum glove box by an outside contractor has been completed. The sample lines are presently being connected into the loop. Some modifications of the original design of the sample line layout in the box will have to be made, however, before the system can be made operational. These modifications will be made at the APDA Test Site.

J. Under Sodium Scanner - Atomic Power Development Associates, Inc.

For obtaining high resolution of an image in ultrasonic scanning systems, a narrow radiation beam is highly desirable. Because of theoretical and practical limitations, the types of narrow beam transducers are different for various work distances. For relatively short distances, focusing transducers with plastic lenses provide satisfactory performance in nondestructive testing in room-temperature water. Similar focusing transducers with metal lenses are being designed for operation in 600°F sodium. Acoustic impedance matching and attenuation devices will be used

to reduce the effect of multiple reflections caused by metal lenses. For working over longer distances, both horn-type and line-and-cone transducers are being designed. It is expected that sharp radiation beams will be obtained and that the suppression of minor lobes will be achieved.

The preliminary design of the sodium facility, which will be installed under the dry box, is completed. This facility, a tank 42" x 19.25" x 20.25", is designed so that the transducer, the reflector, and the object that is to be observed can be oriented properly.

K. Fermi Compilation - Atomic Power Development Associates, Inc.

The following is the status of the ten reports being written:

1. EFFBR Primary System Development - The first draft of the report is completed, and the portion on evolution of the design has been reviewed internally.
2. EFFBR Fuel Handling in the Reactor Vessel - The preparation of the detail outline and the planning for the writing of the report are in progress.
3. EFFBR Nuclear Test Program - The first draft of this report is written, and the internal review has been completed. Final draft writing is underway.
4. EFFBR Low Power Nuclear Test Results - The final draft of this report is written, and internal review has been completed. Final revisions by the author are underway.
5. EFFBR Steam Generators - The outline of the portion of the report dealing with the evolution of the design is completed, and writing of the first draft is underway. The portion of the report dealing with the actual installation and operating experience is in the detail outline preparation stage, and researching of the APDA files for pertinent information has been completed.
6. EFFBR Sodium System Level Detectors (APDA-300) - Comments on the draft were received from the AEC, and revisions are underway.
7. EFFBR Sodium System Flowmeters - The final draft of this report is written, and internal review has been completed. Final revisions by the author are underway.
8. EFFBR Control and Safety Rod Drives - The preparation and review of this report is completed, and the report is in final editing prior to printing.
9. EFFBR Fuel and Blanket Subassemblies - Work on this report is scheduled to begin in February 1966.
10. EFFBR Sodium Sampling Procedures - The first draft of this report has been written, and the internal review is in progress.

L. Heat Exchanger Evaluation - United Nuclear Corporation

Thermal-Hydraulic Performance

The computer code was checked with sample data and is now considered operational. It will be used to process Sodium Components Test Installation data and to calculate predicted and observed thermal-hydraulic performance of the heat exchangers.

A procedure was prepared for predicting the temperature distributions in the tubesheet area which are required for stress calculations. An answer to the United Nuclear request for clarification of ALCO methods and assumptions used for their calculations was received late in October from Baldwin-Lima-Hamilton. This is now being reviewed to ascertain the reasons for the differences between the distribution shown in APAE-112 and that determined using the United Nuclear procedure.

Structural Performance

Procedures using United Nuclear computer codes have been completed and are now operational for calculating stresses in the tubesheet, shell and barrel area of the steam generator. Influence coefficients, which relate pressure to rotation for the outer ring and inner disc of the tubesheet, were calculated using a United Nuclear code. These coefficients did not agree with those used by ALCO. The difference has been found to be caused by the fact that ALCO did not consider the effect of shear and normal stresses.

The procedures for calculating principal stresses and their direction from strain gage data have been checked out and are now operational.

Formats for presenting calculated stresses in the sine wave tubes were completed and have been added to the previously described procedures.

Procedures for calculating transient thermal stresses in the upper steam generator head using bulk fluid temperature changes were completed.

M. Continuous Oxide Meter - United Nuclear Corporation

Field tests were continued during October at Atomic Power Development Associates, Inc., Argonne National Laboratory, and Los Alamos Scientific Laboratory. All of the meters have operated satisfactorily for periods from 2½ to 5½ months.

A meeting was held at APDA on October 14, 1965, to review results of the field tests. Representatives from ANL, APDA, LASL, UNC, and AEC New York Operations Office attended. In general, the test sites have reported that the meters are easily installed and operated and respond quantitatively to changes in oxygen content.

At LASL, two meters were calibrated against vacuum distillation method for determining oxygen in sodium. The calibration obtained showed excellent agreement with calibration results obtained at UNC based upon an oxygen solubility relationship.

The meters are stable over long periods but are subject to daily cyclic variations in output voltage. Tests have indicated that the cyclic variations are related to changes in ambient temperature or the temperature of the fin tube. APDA and LASL have reported that with provisions for controlling the temperature at the base of the fin tube, the daily voltage fluctuations are essentially eliminated. The cyclic variations were of the order of 15 to 25 mv. Maintaining a constant fin temperature reduces the variation to 3 to 6 mv.

Attempts were made at ANL to vary the oxygen content of the sodium by draining the loop and refilling with clean sodium. Results to date are inconclusive. However, the meters at ANL have, in the past, shown responses which could be correlated with probable changes in oxygen content.

N. Mass Transfer - General Electric Company

No report was received for this period.

O. Large Sodium Valve Design - Allis-Chalmers Manufacturing Company

A draft final report has been prepared and is being reviewed by the AEC.

P. Piping Flexibility Study - M. W. Kellogg Company

Phase I of this project has been completed.

III. SODIUM COMPONENTS INFORMATION FROM OPERATING REACTORS

A. EBR-II - Argonne National Laboratory

Operation of the reactor proceeded very satisfactorily this month. A scheduled run was started on October 13, completed on October 21, and another started on October 29. At month's end, seven experimental irradiation subassemblies and three special fuel subassemblies for measuring capture-to-fission ratios were being irradiated in the reactor.

Eleven fuel subassemblies were transferred to the Fuel Cycle Facility for surveillance measurements and reprocessing. Seven reprocessed fuel subassemblies were transferred back to the reactor. The reactor now contains 13 reprocessed subassemblies with fuel which had previously been irradiated to levels up to 1.1% burnup.

Surveillance measurements have shown that no fuel pins have exceeded set allowable limits for growth. There has been no evidence of failed elements.

B. Hallam Nuclear Power Facility - Atomics International

The reactor remained in layup status during the month. The Consumers Public Power District proposal to modify the moderator element and to resume operation of the reactor has been received by the AEC.

C. Enrico Fermi Fast Reactor - Power Reactor Development Company

The reactor remained shut down awaiting action of the Safety and Licensing Board with respect to the 200 MWt license.

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IV. REPORTS

A. MSAR Mechanical Properties of Materials - October 1965.

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- G. B&W Steam Generator - October 1965.
- H. Sodium Heat Exchanger Evaluation - October 1965.
- I. Continuous Oxide Meter - October 1965.
- J. AI Sodium Components Newsletter - October 1965.

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