~~CONFIDENTIAL~~

APCI-541102

This document consists of 37 pages.
Copy No. 67 of 125 copies. Series A.

Classification cancelled (or changed to)
memo from Declassification
by authority of *Branch, Dtd 7-27-64*
by *J.C. Ridenour* - TISOR, date *9-3-64*

UNCLASSIFIED

UNCLASSIFIED

ENERGY DEPOT CRYOGENIC FUEL
STORAGE AND DISTRIBUTION
SYSTEM
PHASE I - CONCEPTUAL DESIGN STUDY (U)
QUARTERLY PROGRESS REPORT NO. 2

OCT 23 1963

R. G. Clark, E. M. Flounders and
P. D. Stelts

October 1963

1 2802

MASTER

Air Products and Chemicals, Inc.
Research and Development Department
Allentown, Pennsylvania

AEC Contract No. AT (30-1)-3129
APCI Project No. 03-3-1415

Prepared Under the Direction of the
United States Atomic Energy Commission
New York Operations Office

"This document contains information affecting the national
defense of the United States within the meaning of the
Espionage Laws, Title 18, U. S. C. sections 793 & 794, the
transmission or revelation of which in any manner to an
unauthorized person is prohibited by law."

1 2802

~~CONFIDENTIAL~~

LA-268-C 67

UNCLASSIFIED

LEGAL NOTICE
This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission makes any warranty or representation, expressed or implied, with respect to the use of any information, apparatus, method, or process disclosed in this report, or that the use of such information, apparatus, method, or process disclosed in this report may not infringe upon privately owned rights, or that the use of such information, apparatus, method, or process disclosed in this report will not result in damages resulting from the use of any information, apparatus, method, or process disclosed in this report.
As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor has access to, any information pertains to his employment or contract with the Commission, or his employment with such contractor.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

UNCLASSIFIED

FOREWORD

This is the second of a series of written quarterly progress reports which precede the Final Technical Report. This report summarizes work performed by Air Products and Chemicals, Inc. under Phase I of the Atomic Energy Commission Contract Number AT(30-1)-3129 for the period July - September, 1963.

The authors wish to express appreciation to: E. S. Tyminski for his contributions to the materials study and to L. F. Howard and C. W. Hildebrandt for their contributions in the field of insulation technology.

This document may not be reproduced or published in any form in whole or part, without prior approval of the United States Atomic Energy Commission.

UNCLASSIFIED

UNCLASSIFIED

Air Products and Chemicals
INC

ABSTRACT

This second quarterly report, prepared under USAEC Contract AT(30-1)-3129, covers the work performed by Air Products and Chemicals, Inc. during the period July - September, 1963. The following is a brief summary of the program status.

Work Package I. - Vessel Conceptual Design Study

This effort, formerly designated Materials and Design Selection, was completed during the first quarter.

Work Package II. - Materials Study

This effort was initiated during the second quarter. Sufficient vendor and materials information was collected to allow the procurement of the outer shell aluminum-honeycomb cylindrical section, the outer shell cylinder heads, the inner shell for the light-weight 50-gallon test vessel and the multiple radiation shield insulation for the boiler-plate and light-weight 50-gallon test vessels. Tests to identify a satisfactory aluminum-to-steel welding transition piece and tests to permit the future selection of the most promising of the candidate inner vessel materials are progressing. This effort was formerly designated as Applied Research and Development Study.

Work Package III. - Boiler-Plate 50-Gallon Vessel Test

This effort was initiated during the second quarter. The test vessel was designed and is presently being fabricated. The fabrication of the instrumented test stand is nearing completion. The testing program has been established. Formerly this work package was concerned with the testing of a 5-gallon vessel.

Work Package IV. - Light-Weight 50-Gallon Vessel Test

This effort was initiated during the second quarter. The preliminary design of the test vessel has progressed to the point that the inner and outer shell materials are being ordered.

Work Package V. - Conceptual Design of the Storage and Distribution System

This effort is scheduled to start early in the third quarter.

Work Package VI. - Final Technical Report

This effort is scheduled late in the fourth quarter.

UNCLASSIFIED

TABLE OF CONTENTS

	Page No.
I. Introduction	1
II. Materials Study	3
A. Introduction	3
B. Outer Shell Study	3
C. Insulation Study	4
D. Inner Shell Study	5
E. Transition Piece Study	6
III. 50-Gallon Boiler-Plate Vessel Study	7
A. Introduction	7
B. Vessel Design	7
C. Test Stand Design	14
D. Test Program	18
IV. 50-Gallon Light-Weight Vessel Study	20

LIST OF FIGURES

Figure No.		Page No.
1 A, B, C	Assembly and Detail Drawings of 50-Gallon Boiler-Plate Test Vessel	8, 9, 10
2	Photograph of Boiler-Plate Outer Shell and Dolly	12
3	Photograph of Front End of Boiler- Plate Vessel	13
4	Photograph of Flanged Head for Boiler-Plate Outer Shell	15
5	Photograph of Boiler-Plate Support Member and Getter Container	16
6	Flow Diagram for 50-Gallon Boiler- Plate Vessel Study	17

I. INTRODUCTION

In Quarterly Technical Report Number 1 (1) Air Products and Chemicals, Inc. made general recommendations concerning revisions to the program. During this second quarter, the Atomic Energy Commission gave Air Products limited approval to proceed with the program as revised pending a detailed evaluation of the time and funds associated with the changes. Air Products has prepared and submitted a draft of the recommended Work Program document which contains a PERT chart, a description of the activities and cost estimates. Upon evaluation and approval of this document by the Atomic Energy Commission, Air Products will formally distribute it as APCI-541002. In the meantime the program is proceeding as amended.

The recommendations for program revision were based on the information that had been developed at the end of the vessel conceptual design study, Work Package I. The singular goal of the experimental portions of this program is the demonstration that the basic vessel concept is feasible. It is reasoned that the design, fabrication and test of a light-weight 5-gallon vessel will not contribute significantly to the general development of advanced tankage for the Energy Depot and therefore it was recommended that this study not be performed. It was recommended that in its place a boiler-plate 50-gallon vessel be tested as Work Package III. This test vessel would be similar in all aspects, except in shell design, to the light-weight 50-gallon vessel to be tested as Work Package IV. Therefore the boiler-plate model is considered to be a full-scale thermodynamic mock-up of the light-weight test vessel and will provide the opportunity to study the heat leak problem independently from the weight problem.

- (1) Energy Depot Cryogenic Fuel Storage and Distribution System: Phase I - Conceptual Design Study, Quarterly Progress Report Number 1. R. G. Clark, E. M. Flounders and P. D. Stelts, July, 1963. APCI-541101.

The fundamental purposes of the light-weight vessel test will be to demonstrate that the low hydrogen boil-off rates achieved during the boiler-plate tests can also be achieved with an extremely light test vessel that is designed for 10-g static loads in all directions. This demonstration of both low weight and low boil-off rate built into one ruggedly designed vessel will constitute the proof of feasibility of the basic vessel design concept. It is envisioned that in follow-on studies the design concept will be developed further and the ruggedness of vessels under thermal and mechanical shock will be demonstrated.

This second Quarterly Technical Report covers Air Products and Chemicals, Inc. activities under USAEC Contract AT(30-1)-3129 during the period, July through September, 1963.

II. MATERIALS STUDY

A. Introduction

The purpose of the materials study is to establish certain information which will allow the selected materials to be utilized for the feasibility demonstration of the selected design concept. During the outer shell study sufficient information has been collected concerning vendors and fabrication techniques to allow the procurement of an aluminum honeycomb outer shell. Similarly, vendors, quality inspection techniques, and fabrication techniques have been identified during the insulation study. The inner shell study is to provide the basis for the selection of the most promising inner vessel material. The prime candidates at this time are aluminum alloys 2219-T87, X7039 and X7006, and 18% nickel maraging steel. With the concurrence of the AEC Project Engineer, the decision was made to proceed with the designing of the light-weight 50-gallon feasibility model with 2219-T87 aluminum alloy for the inner shell. The transition piece study is to identify an aluminum-to-stainless steel welding transition piece which is satisfactory for this use. Such a piece is necessary if the inner shell will be aluminum. Stainless steel has already been selected for the piping to minimize heat leak into the vessel.

B. Outer Shell Study

Early in this quarter several fabricators of honeycomb sandwich structures were contacted verbally and in writing and were asked to supply bids on a given-sized cylinder capable of withstanding two atmospheres external load. The two vendors which responded proposed developmental-type projects which are considered to be well beyond the scope of this present program in both time and funding. Therefore

these vendors, together with some additional suppliers not previously contacted, have been asked to bid on supplying a structure of a specified design without being held responsible for engineering analysis or testing. The shell will be used to demonstrate that honeycomb sandwich structure can be used as a vacuum jacket and that it is very light. Extensive mechanical tests will not be performed on the feasibility model. Responses to this second request have been more encouraging and will provide the basis for the procurement of a test shell in the near future.

C. Insulation Study

Insulation materials from several vendors were obtained. A wide variation in the thickness of the aluminum layer was observed visually. The thinnest layer indicated a tendency to crack upon deformation of the material. Under a Company-sponsored program, an instrument to measure the electrical resistance of the aluminum layer has been assembled. Electrical measurements on the collected samples showed a high correlation with the visual evaluation of the metal thickness and continuity. On the basis of these inspections and the experience of other Air Products' groups which have used this insulation, the specifications for the material desired for the vessel tests under this contract were established. The material was procured from the only vendor which promised delivery of the required material within a time period which was consistent with the vessel test program. The material was tested upon receipt and was found to be within specifications. It has been the Company's experience that the material from this vendor performs well as an insulation. The techniques for effective handling and fabrication of the insulation are being identified.

D. Inner Shell Study

Welding procedure parameters have been established during this quarter for the experimental aluminum alloys X7006 and X7039 which are very similar to each other. At this point it is difficult to determine which is more acceptable for our application, hence both will be tested. Satisfactory results were obtained using the MIG process and 1/16-inch diameter consumable wire. In addition, the metal arc process was used to achieve satisfactory weldments for samples from one heat of 18% nickel maraging steel.

Room temperature tensile and bend tests have been conducted on the first group of X7039 weldments. ASME UPVC (Unfired Pressure Vessel Codes), Section IX criteria were employed. The test results are tabulated below.

PRELIMINARY WELD TEST RESULTS

Sample: Aluminum Alloy X7039 Plate, 0.380"
Weld Wire: X5039

	UTS	YS	ELONG
1. Base Material 7039-T6			
Longitudinal, Arg	64,300	48,000	14.7
Transverse, Arg	66,750	48,200	16.5
2. As-Welded, Naturally Aged (30 days)			
Transverse, Arg	48,025	33,925	13.2
3. As-Welded, Not Aged	47,400	36,000	18.5
4. Bend Tests			
Base Material, Longitudinal - 2T Radius 180°	acceptable		
Transverse - 2T Radius 180°	acceptable		
As Welded, Transverse - 2T Radius 135°	acceptable		
5. X-ray and Weldability	- Satisfactory		
Welding Process - MIG, 1/16-inch diameter filler			
6. Apparent Joint Efficiency	- 0.70 to 0.75		

Machining of tensile bend and impact test specimens is nearly completed for the room temperature and cryogenic tests of both the 18% nickel maraging steel and X7039 aluminum alloy weldments.

A sample of X7039 aluminum alloy has been sent to a vendor for chemical milling. After milling this sample will be checked for uniformity of metal removal, surface finish, and effect on tensile strength. Chemical milling is being considered as a means of achieving reinforced welding joints with little weight penalty.

E. Transition Piece Study

Several representative samples of commercial aluminum-to-stainless steel welding transition joints have been received and are being prepared for cryogenic testing under load. In addition, material is on order for fabricating an experimental transition piece.

III. 50-GALLON BOILER-PLATE VESSEL STUDY

A. Introduction

The purpose of the 50-gallon boiler-plate vessel study is to demonstrate the feasibility of the thermal insulation and vessel support and piping concepts selected during the preliminary design study (Work Package I). Primary attention is being focused on determining the rate at which contained liquid hydrogen is vaporized due to heat leak into the vessel.

During this quarter the test vessel was designed, construction materials were purchased, and the vessel shells were fabricated. The insulation of the inner shell was initiated at the very end of the quarter. The instrumented test stand was designed and specifications for the major components were established. Most of the test stand components have been procured and the stand is being fabricated.

B. Vessel Design

The boiler-plate vessel, represented as Figure 1, consists of three primary structural components: an outer shell, an inner shell and support members. Figure 1A is the assembly drawing of the test vessel. Figures 1B and 1C illustrate details of the design. The technical basis of this design was discussed in detail in the first quarterly progress report. Multiple-layer, reflective-type insulation will be employed. This boiler-plate vessel differs from the light-weight vessel primarily with respect to materials of construction. The boiler-plate vessel is constructed of 1/8-inch thick stainless steel whereas the light-weight vessel will be constructed of lighter materials. The ASME design upper limit on working pressure of the boiler-plate inner shell is 1200 psia. The anticipated burst pressure at -423° F is considerably higher. The ASME allowable external pressure load on the vacuum jacket is 18 psi difference.

NOTE:
END ASSEMBLIES ARE SIMILAR EXCEPT FOR
7/8" TUBING & RELATED ITEMS.

FIGURE 1A

Air Products and Chemicals
ALLENTOWN, PENNSYLVANIA, U. S. A.

50-GALLON BOILER-PLATE
TEST VESSEL ASSEMBLY

DRAFTSMAN	D. BUSS	DWG. No.	03-3-1415
CHECKER	<i>E. Shindler</i>	DATE	9/20/63
ENGINEER	<i>P. Sells</i>	SCALE	1/4" & FULL
DATE	9/20/63		
SCALE	1/4" & FULL		

51.00.03 2/0 D

FIGURE 1B

Air Products and Chemicals
ALLENTOWN, PENNSYLVANIA, U. S. A.

SUPPORT TUBE DETAILS — 50-GALLON
BOILER-PLATE VESSEL

DRAFTSMAN	D. BUSS	DWG. No.	03-3-1415
CHECKER	<i>P. Stoltz</i>	DATE	9-20-63
ENGINEER	<i>P. Stoltz</i>	SCALE	AS NOTED
DATE	9-20-63		
SCALE	AS NOTED		

51.00.03 3/0 D

Air Products and Chemicals
INC.
ALLENTOWN, PENNSYLVANIA, U. S. A.

DETAILS — 50 - GALLON
BOILER-PLATE VESSEL

DRAFTSMAN	D. BUSS	DWG. No. 03-3-1415 5,00.03 4/0 D
CHECKER	<i>E. J. Anderson</i>	
ENGINEER	<i>P. Stiller</i>	
DATE	9-20-63	
SCALE	FULL	

Original plans called for the stainless steel inner shell of the 50-gallon boiler-plate vessel to have the same thermal resistance to conductive heat transfer as the 0.045-inch thick 2219 aluminum inner shell of the light-weight vessel. The reasoning was that stratification effects for both vessels would be equal using this approach. Calculations showed that a 3/8-inch thick stainless steel shell would be required to match the thermal resistance of the aluminum. From a structural standpoint a 3/8-inch thick shell is unnecessary. Stainless steel 1/8-inch thick, was used for the inner shell in order to make the shell lighter, easier to handle, and less expensive. Because the inner shell is only 1/8-inch thick, stratification will be more severe in the 50-gallon boiler-plate vessel than in the light-weight aluminum vessel. If it can be demonstrated, therefore, that stratification does not significantly affect the boil-off rate characteristics of the boiler-plate vessel, then it is highly probable that stratification will not affect the boil-off rate characteristics of the light-weight vessel.

Fabrication of the outer shell and support member is essentially complete. Miscellaneous hardware required to complete the assembly of the boiler-plate vessel is presently available.

The outer shell, 24 inches in diameter and approximately 4 feet long with ASME flanged and dished heads at each end, is flanged at one end to facilitate access to the inner vessel. Welded to the heads at the ends of the vessel are flanged, 6-inch pipes which house support members and radiation shields. Vent and fill tubing penetrates one of these 6-inch pipes. Figure 2 shows the outer shell cradled in the dolly specially built for this experimental program. A front view of the shell, Figure 3, shows the vacuum-jacketed portion of the vent and fill lines which are welded to the 6-inch pipe. The 1-inch line extending horizontally to the left is fitted

Figure 2
BOILER-PLATE OUTER SHELL AND DOLLY

Figure 3
FRONT END OF BOILER-PLATE VESSEL

with a vacuum valve and quick-connect coupling. When the vessel is assembled the annular space containing the insulation will be evacuated through this line. Figure 4 shows the flanged head which mates with the flange on the outer shell. The 1-inch line extending vertically upward is fitted with a vacuum valve and quick-connect coupling. An ionization-type vacuum gage will be installed in this line. A four-point support spider which fits into four clips welded to the inside of the 6-inch pipe is shown installed. A similar spider is installed in the 6-inch pipe at the opposite end of the vessel. An Invar rod attached to these spiders and the center support tube provides longitudinal stability for the inner vessel. The support member, getter container, and the 4-point support spider are shown in Figure 5. The vent and fill lines are shown loosely installed in the 3-inch diameter stainless steel support tube.

C. Test Stand Design

A flow diagram for the 50-gallon, boiler-plate vessel study is shown in Figure 6. All major items of equipment, instrumentation, and piping are shown on this drawing. The primary flow stream is indicated by the heavy line. Cold hydrogen vapor generated by the vaporization of liquid in the vessel due to heat leak passes through an electric heater where it is warmed slightly above room temperature. The warm gaseous hydrogen then flows through an adjustable back-pressure regulator mounted in an instrument rack. The regulator maintains a constant pressure in the vapor space of the test vessel. The hydrogen gas next passes through a coil of copper tubing immersed in a water bath. The water bath is used to stabilize the temperature of the hydrogen gas before it passes through the flow meters shown on the instrument bench. Two flow meters, having overlapping ranges, provide a means of measuring flow rates up to 150 scfh of hydrogen. Hydrogen is vented to the atmosphere through a 2-inch exhaust stack which terminates about 10 feet above the roof of the laboratory. Fabrication of the test stand is nearing completion. All major equipment items have been designed or specified and their procurement has been initiated. Miscellaneous hardware

CONFIDENTIAL

Figure 4
FLANGED HEAD FOR BOILER-PLATE OUTER SHELL

CONFIDENTIAL

CONFIDENTIAL

Figure 5

BOILER-PLATE SUPPORT MEMBER AND GETTER CONTAINER

CONFIDENTIAL

- LEGEND
- NORMALLY OPEN
 - NORMALLY CLOSED
 - ELECTRICAL WIRING
 - VOLTMETER
 - AMMETER

FIGURE 6

Air Products and Chemicals
ALLENTOWN, PENNSYLVANIA, U. S. A.

**FLOW DIAGRAM FOR 50-GALLON
BOILER-PLATE VESSEL STUDY**

DRAFTSMAN <i>B. J. Burr</i>	DWG. 03-3-1415
CHECKER <i>P. Smith</i>	51.00.03-1/0 D
ENGINEER <i>C. M. Blouder</i>	
DATE 7/4/63	
SCALE NONE	

required to complete the assembly of the test stand is presently available.

A tension load cell with remote digital readout will be used to measure the weight of the vessel contents and also to calculate the boil-off rate of liquid hydrogen as a check on the meter system. The vessel dolly was constructed so that the vessel with accessories may be lifted from its cradle by means of a jack screw. All piping and electrical leads running between the vessel and other equipment will be flexible to minimize extraneous loads which might interfere with the weighing system readings.

The indicating and control instrumentation will be contained in an instrument rack. The rack will be purged with nitrogen while tests are being performed. A nitrogen purge is used as a safety precaution to reduce the possibility of forming an explosive hydrogen-air mixture within the rack.

D. Test Program

The present objectives of the test program for the 50-gallon boiler-plate vessel are as follows:

- . To obtain experience in applying multiple-layer, reflective-type vacuum insulation to vessels of this shape and size
- . To obtain experience in the mechanical assembly and testing of a 50-gallon vessel
- . To determine the heat leak into the vessel
- . To determine the pressure rise in the vacuum space as a function of time

- . To investigate the effect of temperature stratification on the hydrogen loss rate and
- . To provide a basis for estimation of the minimum insulation thickness required to meet the boil-off criteria.

After assembly of the vessel and leak-checking of the system, heat leak tests will be performed with liquid nitrogen. This initial testing will provide an economical means of determining equipment cool-down time and heat leak. At the same time, experimental operating procedures and check-out of instrumentation will be accomplished.

Following successful tests with liquid nitrogen, the vessel will be tested with liquid hydrogen. An effort will be made to correlate the performance data of the liquid nitrogen tests with the data of the liquid hydrogen tests. It is probable that the heat leak for the 50-gallon boiler-plate vessel will be comparable when testing with either liquid nitrogen or liquid hydrogen. Once the relationship between nitrogen and hydrogen heat leaks have been established, the majority of the testing will be done with liquid nitrogen. However, some testing would also be done with liquid hydrogen for certain selected conditions to validate the data obtained from the liquid nitrogen tests.

The effect of stratification on the boil-off rate of hydrogen will be investigated qualitatively during these tests. To evaluate stratification, the vessel containing liquid hydrogen will be allowed to sit undisturbed for an extended period of time after which the vessel will be moved in such a way to induce sloshing, and therefore complete mixing of the liquid. If the pressure after sloshing is significantly lower than the pressure before sloshing then significant temperature stratification has taken place during the "quiet" storage period.

If sufficient test time is available, an attempt will be made to determine the minimum acceptable insulation thickness required to meet design criteria. Several different insulation thicknesses will be applied to the vessel and the boil-off rate will be determined for each thicknesses.

CONFIDENTIAL

IV. 50-GALLON LIGHT-WEIGHT VESSEL STUDY

During this quarter, enough design information has been obtained to permit ordering of the long delivery hardware items - the inner and outer shells. The AEC Project Engineer has agreed that the inner shell for this test vessel shall be 2219-aluminum alloy. This material is on order. The inner vessel will be 20 inches in diameter and 45 inches long with a skin thickness of 0.045 inches. This thickness was determined by using a design stress of 58,000 psi (room temperature yield stress in T87 condition) and a joint efficiency of 0.78. The design upper limit on working pressure is 100 psi. Burst pressure at -423°F should be about 375 psi.

The vacuum jacket will be constructed of a 24-inch I.D. honeycomb sandwich cylinder welded to ASME torispherical heads, 0.090 inch thick. The honeycomb sandwich will consist of 0.020-inch thick aluminum alloy faces bonded to a 1/2-inch thick core. Panel weight will be 0.90 lb/ft² assuming a core density of 4.3 lb/ft³ and an adhesive weight of 0.14 lb/ft². This shell is designed to withstand an external load of at least two atmospheres. Procurement of this item is being initiated.

In general, vessel dimensions and methods of construction will conform very closely to those of the boiler-plate vessel shown in Figure 1. The component weights for this lighter vessel are now estimated to be:

Vacuum jacket	
cylindrical section	20.4
end closures	5.5
heads	10.0
end caps	3.3
cover plates	2.8
Inner shell	14.5
Insulation	10.0
Support discs	7.6
Spiders	1.0
Piping	1.5
Support tube	3.0
Adsorbent	1.0
	<hr/> 80.6 pounds

It should be noted that the above weight is higher than the estimate presented in the first quarterly report. The estimated inner and outer shell weights are heavier than those reported in the first quarterly. This is due to the fact that the previous estimate was made on a slender vessel, ($L/D = 4$) while the present test design is based on an L/D ratio of about 2. The larger radius of the present design requires thicker vessel walls and hence a higher weight. The weight of the supports and piping had previously been underestimated. These factors account for the higher estimated specific weight reported in this quarterly compared with that reported previously. The engineering to achieve a substantial weight reduction will be performed in subsequent contracts. It is anticipated, however, that the results of the materials studies in Work Package II will point the way to substantial weight reduction in the inner shell. A further possibility for decreasing the weight and volume would be the reduction of insulation thickness. As an example, if the insulation thickness is cut from 2 inches to 1 inch, the net contents volume may be increased about 25% with a negligible increase in weight for the same external volume of the vessel. This would constitute approximately a 25% reduction in the specific weight. The results of the heat leak on the boiler-plate vessel will be used to estimate if this reduction in specific weight is possible.

With the preliminary design activity complete and the vessel shells being ordered, the effort is being directed to the final design of the light-weight test vessel. According to the present schedule, this test vessel will be insulated and assembled after the 50-gallon boiler-plate vessel heat leak tests have been completed. This will allow limited modifications of the light-weight vessel as indicated by the boiler-plate vessel test results.

DISTRIBUTION LIST

Copy No.

**Chief of Research and Development
Department of the Army
Washington 25, D. C.**

1 - 9

**Chief, Nuclear Power Division
Department of the Army
Military Construction Command, OCE
Building T-7, Gravelly Point
Washington 25, D. C.**

10 - 11

Attention: ENCMC-NO

**Army Map Service
War Plans Division
Strategic Planning Group
6500 Brooks Lane, N. W.
Washington 25, D. C.**

12 - 14

Attention: George Orrell

**Director
Advanced Research Projects Agency
The Pentagon
Washington 25, D. C.**

15

Attention: Fred A. Koether

**Office, Chief of R&D
Department of the Army
Room 3D 442, The Pentagon
Physical Sciences Division
Washington 25, D. C.**

16

**Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois**

17

Attention: Dr. Hoylande D. Young

Mr. Harmon S. Potter Chief, New York Patent Group U. S. Atomic Energy Commission Upton, New York	18
U. S. Atomic Energy Commission Reports & Statistics Branch Division of Reactor Development Washington 25, D. C.	19
Commander Aeronautical Systems Division Wright-Patterson Air Force Base, Ohio Attention: ASNXRR-Lib.	20
General Dynamics/Fort Worth P. O. Box 748 Fort Worth, Texas Attention: Keith G. Brown	21
Martin Nuclear A Division of Martin Marietta Corporation P. O. Box 5042 Middle River 3, Maryland Attention: AEC Contract Documents Custodian	22
Chief of Naval Operations (OP-03EG) Department of the Navy Washington 25, D. C.	23 - 24
T. E. Beehan Aerojet-General Corporation P. O. Box 573 Azusa, California Attention: Evelyn Henry	25

Aerojet-General Nucleonics
P. O. Box 78
San Ramon, California

26

Attention: Barbara Probert

AiResearch Manufacturing Company of Arizona
Division of Garrett Corporation
402 South 36th Street
Phoenix, Arizona

27

Attention: Myric H. Currey

Commander
Air Force Special Weapons Center
Technical Information and Intelligence Office
Kirtland Air Force Base, New Mexico

28 - 29

Attention: Delmer J. Trester

Commander
Air Technical Intelligence Center
Wright-Patterson Air Force Base, Ohio

30

Attention: H. Holzbauer
AFCIN-4Bla

U. S. Army Chemical Research and Development
Laboratories
Building 330
Army Chemical Center, Maryland

31

Attention: Miss Alice M. Amoss, Librarian
Technical Library

U. S. Army
Engineer Research and Development
Laboratories
Fort Belvoir, Virginia

32

Attention: Chief, Nuclear Power Field Office

Commanding General 33
Army Rocket and Guided Missile Agency
Restone Arsenal, Alabama

Attention: ORDDW-MR for James E. Norman

Commanding General 34
U.S. Army Signal Research and Development
Laboratory
Fort Monmouth, New Jersey

Attention: SIGFM/EL-SXR, Dr. Ramm

U. S. Army Transportation Research Command 35
Fort Eustis, Virginia

Attention: Security Officer
Administrative Division

U. S. Atomic Energy Commission 36 - 39
Technical Library
Washington 25, D. C.

Atomics International 40
A Division of North American Aviation, Inc.
P. O. Box 309
Canoga Park, California

Attention: Dr. Chauncey Starr

Battelle Memorial Institute 41
505 King Avenue
Columbus 1, Ohio

Attention: Dr. H. W. Russell

Chief, Bureau of Naval Weapons (RRNU) 42
Department of the Navy
Washington 25, D. C.

Bureau of Ships 43
Code 1500
Navy Department
Washington 25, D. C.

Attention: Melvin L. Ball

Chief, Bureau of Yards and Docks 44
Department of the Navy
Washington 25, D. C.

Attention: Code D-440

U. S. Atomic Energy Commission 45
Chicago Patent Group
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois

Attention: George H. Lee

Director 46
Office of Special Weapons Developments
U. S. Continental Army Command
Fort Bliss, Texas

Attention: 1st Lt. Thomas W. Love

Commander 47
Field Command
Defense Atomic Support Agency
Sandia Base
Albuquerque, New Mexico

Attention: FC Technical Library
Cohee W. Merriott

Chief 48
Defense Atomic Support Agency
Washington 25, D. C.

Attention: Miss Gertrude Camp

- General Electric Company
Nuclear Materials and Propulsion Operation
P. O. Box 15132
Cincinnati 15, Ohio
49 - 50
Attention: J. W. Stephenson
- General Electric Company
P. O. Box 100
Richland, Washington
51 - 53
Attention: M. F. McHale
- General Nuclear Engineering Corporation
P. O. Box 245
Dunedin, Florida
54
Attention: William P. Bigler
- Knolls Atomic Power Laboratory
P. O. Box 1072
Schenectady, New York
55 - 56
Attention: Document Custodian
- Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico
57 - 58
Attention: Report Librarian
- National Aeronautics and Space Administration
Lewis Research Center
21000 Brookpark Road
Cleveland 35, Ohio
59 - 63
Attention: Librarian
- National Aeronautics and Space Administration
1520 H Street, N. W.
Washington 25, D. C.
64 - 65
Attention: Director of Technical Information

Office of Naval Research
Department of the Navy, Code 735
Washington 25, D. C.

66

Attention: E. E. Sullivan

U. S. Atomic Energy Commission
Division of Technical Information Extension
P. O. Box 62
Oak Ridge, Tennessee

67 - 69

Office of the Chief of Naval Operations (OP-75)
Department of the Navy
Washington 25, D. C.

70

Commanding Officer
Diamond Ordnance Fuze Laboratories
Washington 25, D. C.

71

Attention: ORDTL 012; Mrs. Elizabeth W. Channel

Office, Chief of Transportation
Department of the Army
Washington 25, D. C.

72

Attention: Chief, Concepts and Doctrine Division

Commanding General
Army Tank-Automotive Command
1501 Beard Street
Detroit 9, Michigan

73

Attention: Classified Library

U. S. Atomic Energy Commission
Office of Assistant General Counsel for Patents
Washington 25, D. C.

74

Attention: Roland A. Anderson

Pratt and Whitney Aircraft Division 75
Connecticut Operations-CANEL
P. O. Box 611
Middletown, Connecticut

Attention: Librarian

Rand Corporation 76
Los Angeles Air Procurement District
1700 Main Street
Santa Monica, California

Attention: Administrative Contracting Officer
For Frank R. Callbohm

Sandia Corporation 77
P. O. Box 5800
Albuquerque, New Mexico

Attention: Records Management and Services Department

Office of the Surgeon General 78
Special Assistant to the Surgeon General for Nuclear
Energy
Washington 25, D. C.

Attention: MEDNE

Union Carbide Nuclear Company 79 - 84
X-10 Laboratory Records Department
P. O. Box X
Oak Ridge, Tennessee

Headquarters, U. S. Air Force 85
Washington 25, D. C.

Attention: Nuclear Research Officer, AF)CE-ES

University of California 86
Lawrence Radiation Laboratory
Technical Information Division
Berkeley 4, California

Attention: Dr. R. K. Wakerling

University of California 87
Lawrence Radiation Laboratory
Technical Information Division
P. O. Box 808
Livermore, California

Attention: Clovis G. Craig

Westinghouse Electric Corporation 88
Bettis Atomic Power Laboratory
P. O. Box 1468
Pittsburgh 30, Pennsylvania

Attention: Virginia Sternberg

Office, Assistant Director (Army Reactors) 89 - 98
Division of Reactor Development
U. S. Atomic Energy Commission
Washington 25, D. C.

Allison Division, GMC 99
Indianapolis, Indiana
Master Document Control

MCR Project 100
New York Operations Office
Post Office Box 24187
Indianapolis, Indiana

National Aeronautics and Space Administration 101
Langley Research Center
Langley Field, Virginia

Attention: Associate Director

UNCLASSIFIED

Officer-in-Charge
U. S. Naval School
Civil Engineer Corps Officers
U. S. Naval Construction Battalion Center
Port Hueneme, California

102

Attention: C-44

Commanding Officer and Director
U. S. Naval Civil Engineering Laboratory
Port Hueneme, California

103

Attention: Marna R. Hendricks

Superintendent
U. S. Naval Postgraduate School
Monterey, California

104

Attention: George R. Lockett

Director
U. S. Naval Research Laboratory, Code 1572
Washington 25, D. C.

105 - 106

Attention: Classified Material Control Branch

U. S. Atomic Energy Commission
New York Operations Office
376 Hudson Street
New York 14, New York

107 - 112

Attention: Gilbert Silverman
Reactor Development Division

U. S. Atomic Energy Commission
Oak Ridge Operations Office
Main and Document Accountability Section
P. O. Box E
Oak Ridge, Tennessee

113

Attention: Document Library

UNCLASSIFIED

UNCLASSIFIED

Air Products and Chemicals
INC.

Allis-Chalmers Mfg. Company
508 Kennedy Street, N. W.
Brightwood Station
P. O. Box No. 8697
Washington 11, D. C.

114

Attention: Mr. Spottswood B. Burwell
MED Project Manager

UNCLASSIFIED