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**PLAN FOR SUPPORT OF LARGE-PLANT (POST-CRBR) NEEDS
IN LARGE-LEAK SODIUM-WATER REACTION AREA**

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PLAN FOR SUPPORT OF LARGE-PLANT (POST-CRBR) NEEDS
IN LARGE-LEAK SODIUM-WATER REACTION AREA

1.0 INTRODUCTION

Work in the large leak test and analysis area of steam generator development has been carried out at GE-ARSD under 189a SG037 since 1973. The major elements of large leak testing, analytical methods development, relief systems development and cleanup and recovery were identified in 1972 by a survey of the Steam Generator Industry and National Laboratories "Critical Areas" which required immediate development to assure reliable LMFBR steam generation systems in future years. This effort has necessarily focused on the needs for CRBR. A complementary program has been carried out at ANL under 189a CA-059 to develop an advanced 2-D large leak analysis code termed SWAAM. Large leak testing at ETEC has been carried out under 189a SL042.

On May 2, 1979, a meeting was held at DOE-RRT to review status and future plans for the Large Leak programs at GE and ANL. Reference (1) transmitted Agreements and Commitments from this meeting along with an attachment entitled, "Additional Action Items," which provided DOE-RRT guidance to the Large Leak Program. This guidance directed ANL and GE to solicit near-term information needs in the large leak sodium-water reaction area from steam generator suppliers and CDS contractors who were engaged in design work on steam generators and plant systems beyond CRBR. GE in Reference 2 requested identification of the aforementioned information needs from the CDS contractors; in other correspondence, ANL-LCDM requested similar information from steam generator suppliers. In References 3-7, the CDS contractors responded to the GE request and in References 8 and 9, the steam generator suppliers responded to the ANL-LCDM requests. Reference 3 contained combined supplier/CDS contractor needs from AI. Reference 9 needs were subsequently clarified and focused in a working meeting among

B&W, ANL and GE and are summarized in Reference 10. In Reference 11, the CDS contractor needs were categorized and transmitted by GE to DOE-RRT for information. A draft plan for satisfying both steam generator supplier and CDS contractor needs was transmitted in Reference 12 for DOE-RRT review; comments on the plan were received from DOE-RRT in Reference 13. The plan contained herein reflects the Reference 13 DOE-RRT comments on the earlier draft plan.

2.0 DESCRIPTION OF SGO37 LARGE LEAK TEST AND ANALYSIS PROGRAM

Figure 1 shows the currently planned master schedule for the SGO37 program and the various elements contained in the program. Associated work being carried out at ANL under CA059 is also shown on this schedule. Principal activities are the large leak testing program being carried out at the Large Leak Test Rig (LLTR) at ETEC and the analysis methods development being carried out at GE and ANL. Supporting analysis support tests and Na/H₂O wastage tests have been carried out at SRI and GE, respectively.

The current large leak test program is termed Series II and employs a test article (The Large Leak Test Internals/Large Leak Test Vessel) which is prototypic of the CRBR steam generator in terms of number of tubes, tube spacing, vessel diameter, tube support spacing, etc. Three double ended guillotine (DEG) tests (two non-reactive nitrogen tests and one reactive sodium-water test) have been conducted to date. The previous Large Leak Test Program, Series I, utilized the smaller diameter AI-Modular Steam Generator (MSG) as the test article and contained 6 tests over the 1976-77 period. Test results are described in Reference 14. The final GE Series I evaluation report (Reference 15) is scheduled for issue in April 1980,

3.0 DESCRIPTION OF THE PLAN

Table 1 describes the plan for supporting the large plant (post-CRBR) needs in the large leak sodium-water reaction area. The needs of the steam generator suppliers and CDS contractors are divided into Sections I and II,

Figure 1

respectively and are categorized according to major topics (e.g., Large Leak Analytical Methods, Special Sodium-Water Reaction Tests, etc.). The individual needs are tabulated together with the organization identifying the needs and the plans for satisfying the needs.

As noted, most of the needs will be answered in the current SG037 large leak program. Disposition of the needs, not presently in the program, are contained within Table I. Major reports, produced in conjunction with the SG037 program are cited in Table I, where applicable for satisfying certain information needs.

4.0 REFERENCES

1. Letter, ET-786 (RR:EC:167), J. J. Morabito (RRT) to R. H. Bauer (CH) and J. B. LaGrone (SAN), "Transmittal of Agreements and Commitments, Large Leak Program Review of May 2, 1979 (SG037, CA059)," June 28, 1979.
2. Letter, XL-796-79109, W. V. Leeburn (GE) to CDS Contractors, "Request for Near Term Information Needs in the Large Leak Sodium/Water Reaction Area," July 20, 1979.
3. Letter, 79 ESG-7611, A. L. Lillie (AI) to W. R. Simmons (ANL) and W. V. Leeburn (GE), "AI Information Needs in the Large Leak Sodium/Water Reaction Area," August 6, 1979.
4. Letter, XL-153-90953, S. M. Davis (GE-CDS) to W. V. Leeburn (GE-SG037), "General Electric Near Term Needs in the Large Leak Sodium/Water Reaction Area," August 30, 1979.
5. Letter, W. P. Staker (CE) to W. V. Leeburn (GE), "Near Term Information Needs in the Large Leak Sodium/Water Reaction Area," September 6, 1979.
6. Letter, ARD #79-134, D. W. Montgomery (B&W) to W. V. Leeburn, "Near Term Needs in Large Leak Sodium/Water Reaction Area," September 10, 1979.

7. Letter, WDF-087, W. D. Anderson (W) to R. D. Larson (DOE-ROO) and J. R. Longenecker (DOE-RRT), "Near Term Needs in the Large Leak Sodium/Water Reaction Areas," September 18, 1979.
8. Letter, W-ANL-4177-79-948, W. D. Froman (W-TD) to D. James (ANL), "Contract No. EN-77-C-02-4177 WTD Large SWR Analyses Information Requirements," June 11, 1979.
9. Letter, DDM-79-190, D. D. Mokris (B&W) to C. C. Stone (ANL), "Detailed Plans for B&W Effort on Sodium/Water Reaction Analysis and Evaluation of Experimental Programs," July 6, 1979.
10. Letter, XL-790-79159, W. V. Leeburn (GE) to S. G. Harbison (SAN), "Recommendations for Support to Babcock & Wilcox Steam Generator Design in Sodium/Water Reaction Analysis Area," July 18, 1980.
11. Letter, XL-796-79154, W. V. Leeburn (GE) to S. G. Harbison (SAN), "Compilation of CDS Contractor Near Term Information Needs in Large Leak Sodium/Water Reaction Area," October 18, 1979.
12. Letter, XL-796-79175, W. V. Leeburn (GE) to S. G. Harbison (SAN), "Draft Plan for Support of Large Plant (Post-CRBR) Needs in SWR Area," December 7, 1979.
13. Letter, NE-50-RRT/EC-016), J. R. Hunter (RRT) to J. B. LaGrone (SAN), "Steam Generator Leak Protection Development for Large Plant LMFBR," January 16, 1980.
14. Report ETEC-78-10, "Sodium-Water Reaction Tests in LLTR, Series I Final Report," R. L. Eicheberger (ETEC), July 15, 1978.
15. Report GEFR-00420, "Evaluation of Sodium-Water Reaction Tests No. 1 Through 6 Data and Comparison with TRANSWRAP Analyses, Series I Large Leak Program," J. O. Sane, J. J. Regimbal and P. C. Brown, April 1980.

Table 1 - PLAN FOR SUPPORT OF LARGE PLANT (POST-CRBR) NEEDS IN SWR AREA

<u>CATEGORY/DESCRIPTION OF NEED</u>	<u>ORGANIZATION IDENTIFYING NEED</u>	<u>PLAN FOR SATISFYING NEEDS</u>
I. STEAM GENERATOR SUPPLIERS		
A. <u>LARGE LEAK ANALYTICAL METHODS</u>		
1. Documentation and verification of SWAAM or equivalent 2D SWR analysis code be completed by October 1, 1980.	WTD	SWAAM-I Code sent to ANL Code Center on 3/7/80. Histam type code (SWAAM-LT) will be sent to Code Center by 6/1/80 (CA-059). GE will issue a preliminary validation report on SWAAM by August 1980
2. Modification of SWAAM-I water-side leak model for application to SWAT-3 leak rate calculations. Computer tape and user description to be available to B&W by 10/15/79.	B&W	Work has been implemented by ANL under CA-059. Computer tape and user description provided to B&W on schedule.
3. Modification of SWAAM-I to include improved cover gas model. Computer tape to be available to B&W by 10/1/79 in preliminary form and in final form by 2/1/80.	B&W	Work has been implemented by ANL under CA-059. Computer tape in preliminary form provided to B&W on schedule. ANL provided final computer code on tape to B&W on 2/1/80.
4. Provide one-dimensional HISTAM-type code for calculating pressure and flow effects (to ~10 sec) with capability to accommodate specific B&W design features (i.e., coiled tube bundle, cover gas, relief nozzle from cover gas & two phase flow). Code to be operational at ANL by 2/1/80. A report, containing description of code, instructions and sample calculation, to be available to B&W by 6/1/80.	B&W	Work has been implemented by ANL under CA-059. ANL is on schedule for meeting requested code operational and code reporting dates. As of 2/1/80, code (named SWAAM-LT where LT stands for "long term") is operational at ANL and work is on schedule.

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<u>CATEGORY/DESCRIPTION OF NEED</u>	<u>ORGANIZATION IDENTIFYING NEED</u>	<u>PLAN FOR SATISFYING NEEDS</u>
I. STEAM GENERATOR SUPPLIERS (Cont'd)		
5. Need to address scalability of TRANSWRAP to large modules by comparing MSG and LLTI SWR tests.	AI	Under SG037, GE will address TRANSWRAP scalability as part of Series II Tests A-1a and A-2 evaluation. This is scheduled for completion in June 1980.
6. Need to address accuracy of TRANSWRAP or new code for further scaleup (757 tubes CRBR/LLTI to 2200 tube hockey stick unit for CDS).	AI	GE, under SG037, will determine accuracy of analysis codes (TRANSWRAP AND SWAAM) for 757 tube CRBR/LLTI as part of Series II post-test evaluation. This will allow AI extrapolation to the 2200 tube hockey stick unit.
7. Request transmittal of latest validated TRANSWRAP by 10/1/79 including:	AI	Current versions of TRANSWRAP with static rupture disc model (i.e., immediate opening when pre-set pressure is achieved) and RELAP/MOD-5 water injection model are available at ANL Code Center. Utilizing A-1b test data and SRI analysis support test data, GE plans to incorporate a dynamic rupture disc model into TRANSWRAP under SG037. This modified TRANSWRAP code will be sent to the ANL Code Center by June 1980.
o Latest code versions incorporating latest rupture disc model (with listing, sample case, cards).		Transient pressure measurements, available from both Series I and II, will allow calculation of POGO loads. AI has been provided Series I data in GEAP-00420, Sept. 1979 and will be provided Series II reports.
o Latest recommended water injection model for high pressure, once-thru steam generators.		Diameter effects assessment will be performed by GE under SG037 in FY80 in conjunction with Series II Test A-1a and A-2 evaluations.
o Data on "POGO" loads from both AI-MSG and LLTI.		
o Assessment of diameter effects based on MSG and LLTI.		

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<u>CATEGORY/DESCRIPTION OF NEED</u>	<u>ORGANIZATION IDENTIFYING NEED</u>	<u>PLAN FOR SATISFYING NEED</u>
II. CDS CONTRACTORS		
A. <u>DESIGN BASIS (DBL) SELECTION</u>		
1. Large leak program should establish guidelines from which plant designer can determine upper bound of DBL.	GE, W	Data base is being provided by existing LLTR Series II program under SG037 and SL042 for single wall, straight tube steam generators. These data are considered to be applicable to double wall steam generators. A determination of whether additional testing, beyond this program, for the double wall design will be done in 1981 after substantial completion and evaluation of the currently planned Series II tests.
2. Development of DBL is needed.	B&W	
3. Compilation of data base required for steam generator designers to propose a DBL should be made available as soon as possible.	W	
4. Need definition of a DBL that is not excessively conservative.	AI	<p>Data applicable to the helical coil steam generator are available from the Japanese SWAT tests. The Series II data and SWAT data will be evaluated in early FY81 to determine whether the data are adequate for DBL selection for the coiled tube design or whether additional testing is necessary.</p> <p>Plant designers should select DBL using data provided by LLTR Series II program and data from other large leak tests. GE, under SG037, will provide assessments of the data during the course of the LLTR program to facilitate the DBL selection and will make recommendations.</p>

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<u>CATEGORY/DESCRIPTION OF NEED</u>	<u>ORGANIZATION IDENTIFYING NEED</u>	<u>PLAN FOR SATISFYING NEED</u>
II. CDS CONTRACTORS (Cont'd)		
B. <u>LARGE LEAK ANALYTICAL METHODS</u>		
1. Need "best estimate" analytical methods with supporting test data for determining pressure, temperatures, and flow rates in IHTS and SWRPR's.	B&W	<p>Development/modification of SWR analytical methods using LLTR and SRI test data is underway under SG037 and CA059. Methodology was demonstrated in GEF-00420, dated 9/79 for TRANSWRAP/RELAP using Series I and SRI data. Following obtaining patent clearance, GE will provide CDS contractors with copies of GEF-00420, Volumes 1 and 2 (estimated April 1980). GE will issue a preliminary report on SWAAM validation by August 1980 and a final validation report on SWAAM by October 1981. GE also will issue a Design Guide on the use of TRANSWRAP and SWAAM by February 1981.</p> <p>Under CA059, in early March 1980 ANL initiated evaluation of the Japanese SWAT data from an overall systems standpoint to check out the modeling of the helical coil steam generator (with cover gas) and associated systems. This work will provide means of validating or identifying areas of improvement for the SWAAM code and is scheduled for completion in July 1980. Results will be reflected in the GE preliminary validation report on SWAAM scheduled for August 1980.</p>
2. Need assessment on degree of conservatism and limits of analytical methods.	GE	<p>Assessment of TRANSWRAP is described in GEF-00420, Vol. 2, Sept. 1979. This report will be provided to CDS Contractors (estimated April 1980). Assessment of SWAAM code conservatism and limits will be provided with preliminary SWAAM validation report in August 1980.</p>

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<u>CATEGORY/DESCRIPTION OF NEED</u>	<u>ORGANIZATION IDENTIFYING NEED</u>	<u>PLAN FOR SATISFYING NEED</u>
II. <u>CDS CONTRACTORS</u> (Cont'd)		
B. <u>LARGE LEAK ANALYTICAL METHODS</u> (Cont'd)		
3. Determine degree of conservatism in predicting relief system piping reaction loads by comparison of measured versus predicted piping reaction forces.	GE	Instrumentation has been installed on the LLTR lower relief line for Test A-1b to measure piping reaction loads. This data, along with future test data, will be compared with the predicted loads and reported in the test evaluation reports. Modifications to the design methodology, described in GEAP-00420, Sept. 1979, will be recommended as required to accurately model the relief system piping reaction loads.
*4. Determine the degree of conservatism in predicting the IHTS piping loads resulting from acoustic pressure pulses.	GE-SG037	Accelerometers are installed on the LLTR upper sodium piping to obtain piping dynamic response data. Results from the completed Test A-2 will be given in the evaluation report (scheduled for issue mid-1980).
5. Need copy of current analytical programs used to predict system pressures due to SWR.	<u>W</u>	TRANSWRAP (with static rupture disc model) and RELAP codes are available at ANL Code Center. TRANSWRAP with dynamic rupture disc model will be sent to the ANL Code Center by 6/80. SWAAM-I code sent to ANL Code Center in March 1980. SWAAM-LT code will be sent to Code Center by June 1980.

* Additional need identified from CRBR Design Experience.

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II. <u>CDS CONTRACTORS (Cont'd)</u>		
C. <u>SPECIAL SWR TESTS</u>		
1. Desirable to have by late 1980 test data on off-centered large leaks.	AI	Off-centered test is planned for Series I as Test A-6 now scheduled for June 1981.
2. Wastage and self-wastage data on proto-typical double walled tubes (with pressurized gas space between tubes) subjected to plant operating conditions, should be obtained for comparison with existing single wall tube data.	W	This work is not in present program (SG027 or SG037). Available impingement wastage data for single wall tubes as reported in GEAP-14094 (available at TIC) are believed to be applicable to duplex tubes. The need for self-wastage tests in the double-wall geometry should be assessed and a decision reached (in 1981) based on the outcome of: (1) On-going tests by WTD, as to what happens with moisture in the Third Fluid Leak Detection System (TFLDS), given a sodium side leak; and (2) testing of the effectiveness of the TFLDS planned to be done in conjunction with the forthcoming WTD Few Tube Test Model testing.
3. Consider resolving "hot tee" problem (mixing of sodium and steam in superheater inlet line following SWR) experimentally under large leak program.	GE	Transient thermal analysis is underway in the CRBR project to define temperatures and attempt to quantify problem. One possible solution to this problem appears to be to install sufficient redundancy in the steam/water isolation and blowdown system so that early termination of water supply to a large tube leak can be assured, thus preventing development of the "hot tee" condition. Further identification of engineering or design solution to the problem is required in order to determine whether an experimental approach is indeed needed or useful.

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II. <u>CDS CONTRACTORS</u> (Cont'd)		
D. <u>REACTION PRODUCT TRANSPORT/EFFECTS IN IHTS/SWRPRS</u>		
1. Need analytical methods for predicting distribution of reaction products with IHTS.	B&W	For large leaks TRANSWRAP will identify location of the sodium-water reaction product (SWRP) interface as a function of time for short time intervals (up to 1 sec), and for longer periods, a modification of SWAAM-LT (to be available in mid-1980) would be applicable. The priority (intensity of need) to assign to this work is not clear at this time, and no specific further activity beyond the work already in progress is planned at present
2. Interested in LLTR experience with reaction product transport.	GE	The LLTR does not contain a recirculating IHTS. However, the Series I experience with SWRP deposition in the MSG test article and removal of the SWRP from the MSG is documented in report ETEC-78-9, "Sodium Water Reaction Product Deposition and Post-Test Cleaning of the Modular Steam Generator," which is available from TIC, Oak Ridge, TN. Similar data will be provided by Series II.
3. Test program should establish effects of reaction products on various system components, particularly on steam/water separation boundaries.	B&W	The present Series II test program will provide information on the effects of reaction products on steam generator internals and on relief system. U-bend specimens placed in the LLTR relief system will be examined after each test. Further, selected portions of the LLTR relief system will be UT and dye penetrant examined after each test. Reports concerning these inspections will be transmitted to the CDS contractors.

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II. <u>CDS CONTRACTORS (Cont'd)</u>		
D. <u>REACTION PRODUCT TRANSPORT/EFFECTS IN IHTS/SWRPRS (Cont'd)</u>		
4. Interested in receiving information gained from LLTR test program on effects of SWR products on sodium loop and relief piping components	GE	The report on destructive post-test examination of Series I test article is available from TIC:ETEC-78-12, "Metallurgical Evaluation of Modular Steam Generator (MSG) after LLTR Cleaning," Sept. 1978. Also, GE will transmit to TIC copies of a report describing the examination of LLTR relief system piping removed after Series I and the stress corrosion cracking incident experienced at the outset of the Series II program. Issuance of this report is expected in June 1980. Similar data will be obtained in Series II and, additionally in Series II, U-bend specimens will be installed in the relief system to check for stress corrosion cracking.
E. <u>CLEANUP AND RECOVERY</u>		
1. Test program should investigate means of removing reaction products from steam generator and IHX.	B&W	The previous Series I cleaning experience with the MSG is documented in ETEC-78-9 as noted under II.D.2 above. The current Series II program will provide additional experience as the LLTI/LLTV will be cleaned each time prior to removal for instrument tube replacement or tube bundle maintenance which cannot be performed in place. Information on SWRPS removal from the LLTI will be transmitted to the CDS contractors. No data will be obtained from the INX as this component does not exist in the LLTR.

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II. CDS CONTRACTORS (Cont'd)		
E. <u>CLEANUP AND RECOVERY</u> (Cont'd)		
2. Test program should establish effects of cleaning process on various system components, particularly on sodium/water separation boundaries.	B&W	As noted in II.D.2 and II.D.4, cleaning experience with the MSG and subsequent metallurgical examination of the 2-1/4 Cr-1Mo test article is described in ETEC reports available through TIC. Information will also be obtained from Series II and transmitted to the CDS contractors as noted in II.E.1 above.
3. Interested in obtaining information from LLTR test program on degree of reaction products removal from test article upon hot draining.	GE	Information on reaction product buildup over the six-test Series I program and rapid drain operation is described in ETEC-78-9 cited in II.D.2 above. Additional information will be derived from the Series II program and transmitted to the CDS contractors.
F. <u>STEAM GENERATOR RELIEF SYSTEM</u>		
1. Provide analytical methods with supporting test data for determining composition of effluent from SWRPR tank vents.	B&W	Analytical methods for determining composition of stack effluent is not in present program. Because the methods rely strongly on steam generator geometry, plant layout, and reaction products tank design, GE does not believe that it would be cost effective for the base programs to pursue analytical methods development in this area. Experimental stack effluent data is available from Series I and forthcoming from Series II as described in II.F.2 below.

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II. <u>CDS CONTRACTORS</u> (Cont'd)		
F. <u>STEAM GENERATOR RELIEF SYSTEM</u> (Cont'd)		
2. Provide data on stack effluent levels from LLTR test program for determination of need for centrifugal separator.	GE	Experimental stack effluent data is summarized for all of Series I program in interim report LMEC-TDR-78-3, "Experimental Results of Sodium-Water Reaction Test No. 6," Feb. 1978. GE will provide copies of the appropriate sections of LMEC-TDR-78-3 by April 1980 to CDS contractors. Design description of LLTR relief system is provided in ETEC-78-10, "Sodium-Water Reaction Tests in LLTR - Series I Final Report," July 1978, which is available at TIC.
3. Provide information on maintainability, reliability and functional performance of CRBRP-type rupture discs. In particular, would like long term creep effects data.	GE	The LLTR Series II program will provide information on maintainability, reliability, and functional performance of CRBRP-type double membrane, reverse buckling discs. A report on rupture disc performance is scheduled for Sept. 1980 and will include CDS distribution. Long term creep data and aging effects to be provided by test in SGTR.
4. Investigate material behavior of large rupture disc, up to 26 inches, including aging and failure characteristics.	GE	Present SG037 program will provide aging data and failure characteristics with SGTR test and LLTR test for 18" disc. GE-SG037 believes that the disc behavior will be adequately characterized by the present program; additional work on the larger 26" disc is not recommended.