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MEMORANDUM FOR: W. Minners, Technical Assistant to the Director, Division of Systems Safety

FROM: J. Kudrick, Section A Leader, Containment Systems Branch, DSS

THRU: R. Tedesco, Assistant Director for Plant Systems, DSS

G. Lainas, Chief, Containment Systems Branch, DSS

SUBJECT: REVISION TO TASK ACTION PLAN A-39

We have enclosed a revised action plan based upon our meeting on August 15, 1977 with your committee. The revisions include the following:

1. Further explanation was made concerning the load increases when the pool temperature exceeds the threshold value.

2. Evaluation of drag loads was clarified to include consideration for both SRV and LOCA loads.

3. Inclusion of the Mark III test program task was clarified.

4. Reevaluation of pool temperature limits was inserted as opposed to the interim terminology used.

John A. Kudrick, Task Manager
Containment Systems Branch
Division of Systems Safety

Enclosure:
As Stated

cc: w/o encl.
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D-67

TASK ACTION PLAN
TASK NUMBER A-39

Title - Determination of Safety Relief Valve (SRV) Pool Dynamic Loads and Temperature Limits for BWR Containment

Lead Responsibility - Division of Systems Safety/NRR

Lead Assistant Director - R. L. Tedesco (Plant Systems)

Task Manager: J. A. Kudrick (Containment Systems Branch)

1. Program Description:

Experience at several BWR plants with pressure suppression containments has shown that damage to wetwell internal structures can occur during safety/relief valve (SRV) blowdowns as a result of air clearing and steam quenching vibration phenomena.

Upon relief valve actuation, the initial air column within the SRV discharge line is accelerated by the high pressure steam flow and expands as it is released into the pool as a high pressure air bubble. The high rate of air and steam injection flow in the pool followed by expansion and contraction of the bubble as it rises to the pool surface produces pressure oscillations on the pool boundary. This effect is referred to as the air-clearing phenomenon.

In addition to the boundary loads, the air injection and subsequent bubble motion produces pressure waves and water movement within the pool that produce drag loads on components in the pool.

Following the air-clearing phase, pure steam is injected into the pool. Condensation oscillations occur during this time period. However, the amplitudes of these vibrations are relatively small at low pool temperatures. Continued blowdown into the pool will increase the pool temperature until a threshold temperature is reached. At this point, steam condensation becomes unstable. Vibrations and forces can increase by a factor of 10 or more if the SRV continues to blow down. This effect is referred to as the steam quenching vibration phenomenon. Current practice for BWR operating plants is to restrict the allowable operating temperature envelope via technical specifications such that the threshold temperature is not reached.

In response to the concern on relief valve loads, letters were sent in 1975 to all licensees of operating BWR plants requesting that they report on the potential magnitude of relief valve loads, and on the structural capability of the suppression chamber and internal structures to tolerate such loads. In addition, consideration of these loads has become an integral part of our review of CP and OL plant applications for all BWR pressure suppression containments (i.e., Mark I, II and III). As a result of the generic concerns, owner's groups were formed by both Mark I and II utilities. Through these groups, integrated generic analytical and experimental programs have been developed to address the subject of SRV loads.

2. Plan for Problem Resolution:

A. Approach

The staff will review and evaluate the results from the Mark I and II programs conducted by the owner's groups and related programs conducted by General Electric Co. (GE).

The approach taken by the owner's groups consists of a number of comprehensive experimental and analytical programs to establish and justify the SRV-related pool dynamic loads for BWR Mark I and II designs. In addition, prototypical in-plant testing is proposed to confirm Mark III SRV loads.

For both the air-clearing-induced loads and the drag loads on submerged structures, the Mark I and II programs are based on the development of analytical models which will be confirmed with test data. A series of experimental programs are underway to provide this data base for model verification. Because of differences between the Mark I. II and III designs, the composite program which will be reviewed by the staff consists of both programs common to all BWR designs and programs unique to particular SRV discharge line configurations.

With respect to drag loads on submerged structures for both SRV and LOCA events, a generic analytical model is under development by GE which will be used for all BWR designs. For loads induced by air clearing, separate analytical models are under development to describe the two different types of discharge nozzles of the relief valve discharge lines; a ramshead model and a quencher model. The ramshead is a "Tee" fitting, whereas the quencher is a multi-branch diffuser type of nozzle.

The ramshead model under development by GE is jointly sponsored by both the Mark I and Mark II owner's groups. In-plant tests at Monticello will provide the necessary confirming data base.

The basic quencher analytical model also under development by GE will be common to both Mark I and II programs. However, the confirming data bases are different. This is due to configurational differences in the SRV end device. In-plant tests to be conducted at the Caorso facility in Italy are proposed by the Mark II owner's group as the confirming data base, while, in-plant tests to be conducted at Monticello are proposed by the Mark I owner's group as the confirming data base.

The proposed program conducted by GE to address the elevated pool temperature concern for the ramshead device is based on experimental determination of the threshold temperature. Current technical specifications for operating Mark I plants restricting plant operation below this limit would be sufficient to satisfy this concern. GE plans to document these additional data to support the current temperature limit in the near future for staff review.

B. End Products

The program as outlined consists of four major tasks, described below. Upon completion of each task, a NUREG report will be issued. In some cases, this may take the form of input into a more general report (e.g., input into the overall Mark II NUREG report prepared as part of Task A-8). Each NUREG report will be generic in nature outlining the acceptable methodology to be used for computation of plant specific loads.

In addition to the final report, interim acceptance criteria may be necessary to properly interface with both the Mark I and Mark II generic programs. Reports will be issued to the appropriate task manager if such action is necessary. The enclosed detailed schedule indicates those areas where such an intermediate report may be required. The actual need will be determined when more definite schedules are established on the individual programs.

~~Upon completion~~ AS APPROPRIATE of the SRV program, revisions as required to the Standar Review Plan will be prepared to properly reflect the program results.

C. Tasks

1. Evaluation of the ramshead air clearing load methodology - This task involves the review and ev luation of the analytical model and the supporting data base. Upon completion of the review, an acceptable methodology for computation of design bases loads associated with air clearing will be ~~determined~~ DEVELOPED.

a. Evaluation of analytical model - the GE developed analytical model will be reviewed by the staff from both a theoretical and experimental viewpoint. The model will be evaluated for analytical completeness and experimental comparisons made considering the data base from both Monticello and Quad Cities in-plant tests. The actual experimental comparisons will be provided to the staff in topical reports supplied by GE.

b. Evaluation of test data - Evaluation of the Monticello test data, to be supplied by GE in a topical report, will be performed by the staff within this subtask. Areas of consideration will include;

- data scatter
- error band determination
- degree of variations of principal parameters
- fluid structure interaction effects on measured loads
- applicability of test data to plant specific conditions (i.e., applicability to other Mark I designs as well as Mark II designs).

Results of this investigation will be incorporated in the model-data comparisons evaluation conducted in Task 1.a.

c. Develop air clearing load methodology

Based on the results of tasks 1.a and 1.b, load acceptance criteria will be developed by the staff for ramshead air clearing induced loads for both Mark I and Mark II designs.

2. Evaluations of the Quencher Air Clearing Load Methodology - Evaluation and review by the staff of the analytical model with the supporting data base will be performed in this task. Currentl the various industry programs indicate that the quencher arm configuration will differ between Mark I and II designs. However, the bubble pattern associated with each arm will be the same. Therefore, it is assumed that the analytical model will remain essentially the same for both the Mark I and II designs. Upon completion of the staff's review, an acceptable methodology for computation of design basis loads will be determined. It should be noted that as part of the overall testing program, prototypical in-plant testing is planned for the Mark III quencher. This program is considered as confirmatory. The staff effort for review of this program is included in this task but will not impact on the development of the load acceptance criteria since it is confirmatory in nature.

a. Evaluation of Analytical Model -

The analytical model will be reviewed by the staff both from an analytical and empirical viewpoint. Model-to-data comparisons performed and reported by GE will form the basis of the staff's review, since the basic approach is anticipated to be similar to the methodology used in the ramshead model (see Task 1.a).

b. Evaluation of Caorso* Test Data

Caorso test data will be reviewed and evaluated by the staff to determine the adequacy of the data base for confirmation of the analytical model (Task 2.a). These data will be supplied to the staff by GE in the form of a topical report. Areas of consideration will include:

- Data scatter
- Error band determination
- Degree of variation of principal parameters
- Fluid structure interaction effects on measured loads
- Applicability of test data to Mark II designs.

Results of this task will be incorporated into task 2.a.

c. Evaluation of Mark I related test data -

The staff will review and evaluate two separate test programs; a small scale test program recently completed to determine relative performance between various quencher designs and an in-plant test program to be conducted at the Monticello plant. The results of these programs will be documented by GE in the form of topical reports. Similar considerations as outlined in task 2.b will be included in this task.

The results of this task will be integrated into Task 2.a.

*/ Caorso is a Mark II plant located in Northern Italy.

d. Develop Air Clearing Load Methodology -
Based on the results of tasks 2.a, b and c, load acceptance criteria will be developed by the staff for quencher air clearing loads for both Mark I and II designs.

e. Evaluate Confirming Mark III In-Plant Test Program and Data -
The staff will review and evaluate the test plans, instrumentation and data of the prototypical in-plant test program. This information will be supplied to the staff by GE in a topical report. Similar considerations as delineated in task 2.b will be included.

3. Evaluation of Submerged Structure Load Methodology -
This task involves the staff's review and evaluation of a generic analytical model to be developed by GE to compute the loads on submerged structures due to SRV actuation and LOCA. A portion of the review will involve the evaluation of supporting test data to be supplied to the staff in a topical report. Acceptable load criteria will be developed by the staff as a result of this effort.

a. Evaluation of Analytical Model -
The staff will review and evaluate the generic model developed by GE to compute induced loads on components located within the suppression pool. Particular attention will be directed toward the analytical considerations of the following:

- Development of transient flow fields
- Presence of components within the flow field affecting the field
- Supporting experimental data
- Applicability to LOCA induced loads

b. Evaluation of Supporting Data Base -

The staff will review and evaluate the applicability of the data provided by GE for confirmation of the analytical program. It is anticipated that the data base will consist of experimentally derived drag coefficients, recent data obtained from the 1/3 scale pressure suppression test facility tests and possible future tests which will be documented as part of the Mark I and II owner's group programs.

c. Develop Submerged Structure Load Methodology -

Based on the results of tasks 3.a and b, load acceptance criteria will be developed by the staff. These criteria will be applicable for all BWR designs.

INSERT 2

4. Determination of LOCA and ATWS Pool Temperature Limits -

This task involves the staff's review and evaluation of GE-supplied supporting test data to establish both LOCA and ATWS pool temperature limits. Based on the evaluation results, current pool temperature limits will be reevaluated by the staff for both ramshead and quencher SRV devices. In addition, minimum pool temperature monitoring requirement will be determined by the staff. Upon completion of this task, a final report will be issued by the staff summarizing our review and evaluation.

a. Evaluate Supporting Data Base -

The staff will evaluate the adequacy of the data base to be provided by GE in the form of a letter report from operating experience, Moss Landing tests and tests conducted at General Electric's San Jose facility as well as GE's licensee data (NEDE-21078). Based on the staff's review, the currently recommended pool temperature limits will be reevaluated for the ramshead device. A similar review will be conducted for the Mark I quencher device.

b. Evaluate Thermal Mixing Model -

The staff will review and evaluate the thermal mixing model with its supporting data base to be provided by GE. Based on results of this review, pool temperature limits will be reevaluated and minimum temperature monitoring requirements will be established.

3. NRR Technical Organizations Involved

A. Containment Systems Branch, Division of Systems Safety

1. Task 1

Has overall responsibility for establishing an acceptable methodology to calculate ramshead air clearing loads.

2. Task 1a

Review and evaluate the analytical model.

3. Task 1b

Review and evaluate the Monticello data excluding fluid structure interaction effects (FSI) and evaluate applicability of data to Mark II.

4. Task 1c

A generic NUREG report will be issued summarizing the acceptance criteria for the ramshead load.

Manpower Requirements -

FY 77 - .05 Man-years

FY 78 - .5 Man-years

FY 79 - .1 Man-years

Total - .70 Man-years

5. Task 2

Has overall responsibility for establishing an acceptable methodology to compute quencher air clearing loads.

6. Task 2a

Review and evaluate the analytical model.

7. Task 2b

Review and evaluate the Caorso test plan and data (excluding FSI effects).

8. Task 2c

Review and evaluate the Mark I small scale tests and the Monticello in-plant tests (excluding FSI effects) and,

9. Task 2d

Generic NUREG reports will be issued for both Mark I and Mark II designs.

10. Task 2e Review

Evaluate the Mark III confirmatory test plan and data (this effort will be part of a topical report evaluation).

Manpower Requirements -

FY 77 - 0 Man-years

FY 78 - .5 Man-years

FY 79 - .4 Man-years

Total - 0.9 Man-years

11. Task 3

Has total responsibility for establishing an acceptable methodology to compute submerged structure drag loads due to SRV actuation and LOCA.

12. Task 3a

Review and evaluate the analytical model.

13. Task 3b

Review and evaluate the supporting data.

14. Task 3c

A generic NUREG report will be issued for all BWR designs.

Manpower Requirements -

FY 77 - .05 Man-years

FY 78 - .25 Man-years

FY 79 - .10 Man-years

Total - .40 Man-years

15. Task 4, 4a, 4b

Has total responsibility for the review and evaluation of supporting information supplied by GE to confirm the current pool temperature limits for both ramshead and Mark I load mitigating devices. Input will be provided for the ATWS evaluation report. A generic NUREG STP report will be issued summarizing the minimum pool temperature monitoring requirements and the acceptable temperature limits for SRV devices. This report will in large part be based on the review of the GE thermal mixing model.

Manpower Requirements -

FY 77 - .02 Man-years

FY 78 - .23 Man-years

Total - .25 Man-years

B. Plant Systems Branch, Division of Operating Reactors

1. Task 1 through 4 - Follow the progress of the SRV Program to insure correct application of generic resolutions to specific plant applications.

2. Manpower Requirements -

FY 77 - .1 Man-years

FY 78 - .2 Man-years

FY 79 - .1 Man-years

Total - .4 Man-years

C. Engineering Branch, Division of Operating Reactors

1. Task 1b

Has responsibility for determining the fluid structure interaction effects (FSI) associated with the Monticello tests. If FSI effects are significant, methods will be developed by which the pure forcing function can be obtained. A report will be issued to the Task Manager summarizing the results of this task.

2. Task 2c

Has responsibility for determining the fluid structure interaction effects associated with the Monticello in-plant load mitigating tests. If FSI effects are significant, methods will be developed by which the pure forcing function can be obtained. A report will be provided to the Task Manager summarizing the results of this task. (Due to the similarity of this task with SEB's task associated with the Caorso test FSI evaluation, coordination between these efforts will be needed).

Manpower Requirements -

FY 77 - .04 Man-years

FY 78 - .6 Man-years

FY 79 - .3 Man-years

Total - .94 Man-years

D. Structural Engineering Branch, Division of Systems Safety

1. Task 2b

Has responsibility for determining the FSI effects associated with the Caorso test series. If the FSI effects are significant, methods will be developed by which the pure forcing function can b obtained. A report will be issued to the Task Manager summarizing the task results. (Coordination with EB will be made with respect to the FSI investigation of Monticello tests).

Manpower Requirements -

FY 77 - .1 Man-years

FY 78 - .3 Man-years

FY 79 - .2 Man-years

Total - .6 Man-years

E. Division of Project Management

1. Tasks No. 1 through 4

Provide coordination between the Division of Systems Safety, the Mark I and Mark II licensees/applicants, and the Division of Project Management project managers for the individual Mark I, II and III BWR facilities. This includes meeting coordination and

preparation of meeting minutes to document the actions of the generic SRV review when the owners are involved.

c. Manpower Requirements -

FY 1978 - .1 Man-years

FY 1979 - .1 Man-years

Total - .2 Man-years

4. Technical Assistance Requirements

A. Brookhaven National Laboratory

1. Title: BWR Pool Dynamic Technical Assistance Program

2. Responsible Division/Branch: Division of Systems Safety/ Containment Systems Branch

3. Scope .

The contractor is to provide technical expertise in the evaluation of all analytical models provided for review in all four major tasks. (Tasks 1a, 2a, 3a, 4b). In addition, he will provide an independent assessment of the available test data. (Tasks 1b, 2b, 2c, 2e, 3b, 4a). Upon the completion of each specific model or test review, a letter report will be issued to the staff for each of the above noted task items. During the course of the review, requests for additional information will also be issued, as required.

4. Funding: FY 1977 - $60,000
   FY 1978 - $60,000 (requested)
   FY 1979 - $15,000 (estimated)
   Total - $135,000

B. Lawrence Livermore Laboratory

1. Title: Structural Hydrodynamic Interactions Technical Assistance Programs

2. Responsible Division/Branch: Division of Operating Reactors/ Engineering Branch.

3. Scope

This is a program to study hydrodynamic/structure interactions in a Mark I containment system subject to hydrodynamic loading conditions. This effort should quantify the amplification, if any, of measured loads due to the structural interactions during pool swell, SRV discharge, and chugging loading conditions. This is a common technical assistance program for Mark I, Mark II and the SRV task action plans.

4. Funding: FY 1977 - 100K (NOTE: This funding represents the total program which are reflected also in Task A-7)
FY 1978 - 15K

5. Interactions with Outside Organizations:

Mark I and Mark II Owner's Groups

These groups are "ad hoc" organizations of utilities owning either Mark I or Mark II BWR facilities. They have engaged GE as their program manager for resolution of the BWR containment concerns and have designated GE as their primary contact with the NRC during the conduct of these programs.

INSERT 1 →

6. Assistance Requirements from Other NRC Offices:

Requirements for assistance are not anticipated at this time.

7. Schedule for Problem Resolution

A. Summary of schedule

1.1	Interim Ramshead Load Criteria	2/78
1.2	Report of FSI Effects	8/78
1.3	SER for Ramshead	11/78
2.1	Report of FSI Effects	9/78
2.2	SER for Quencher	2/79
3.1	Interim Submerged Structure Load Criteria	2/78
3.2	Final Submerged Structure Load Criteria	3/79
4.1	Reevaluation of Ramshead Pool Temperature Limits	2/78
4.2	Final Criteria for Pool Temperature Limits	6/78
5.0	Issue Revisions to Standard Review Plan	6/79

B. Detailed Schedule

Bar chart enclosed

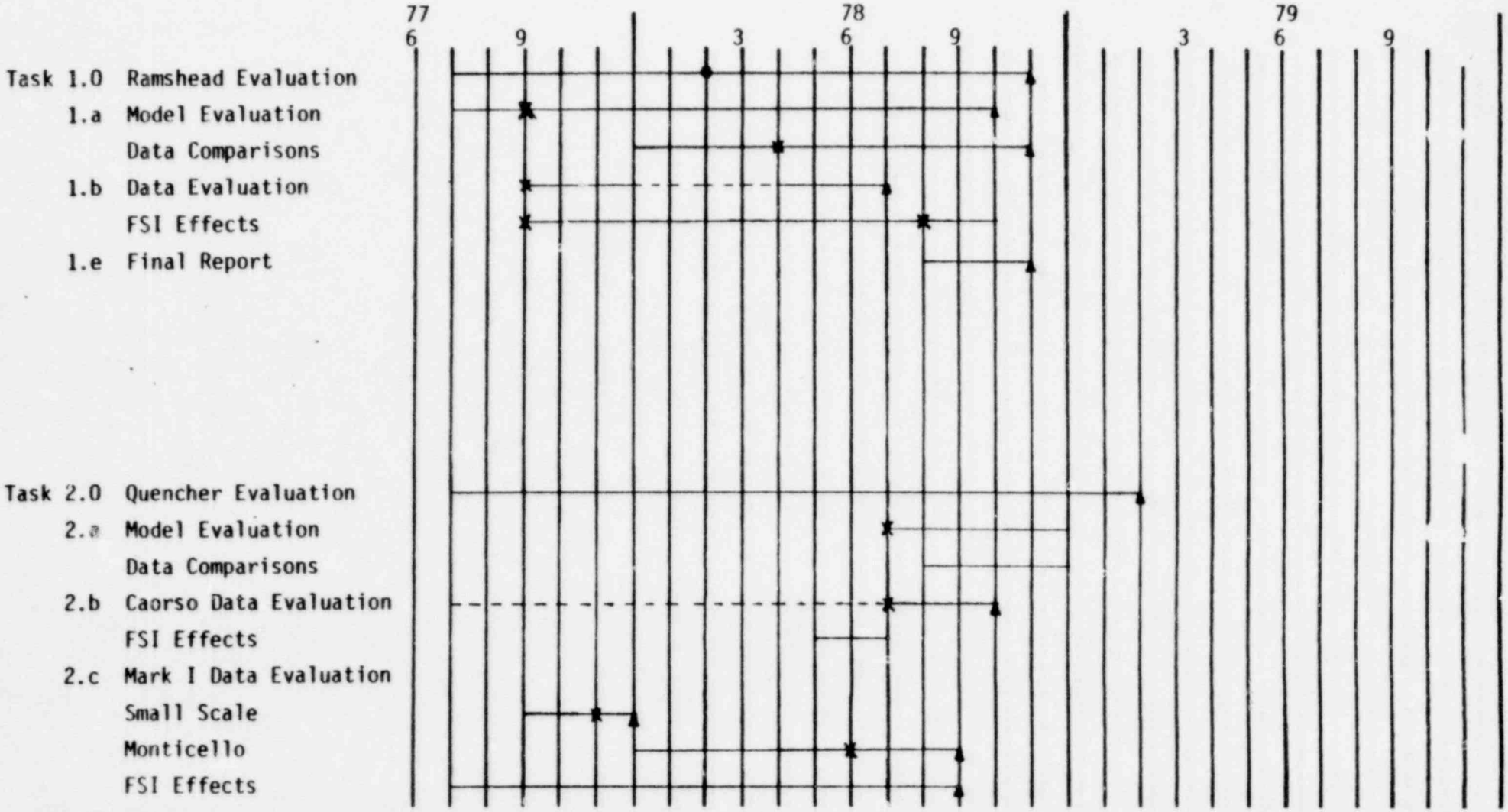
C. Technical Assignment Control Number - TAC 11.1 .

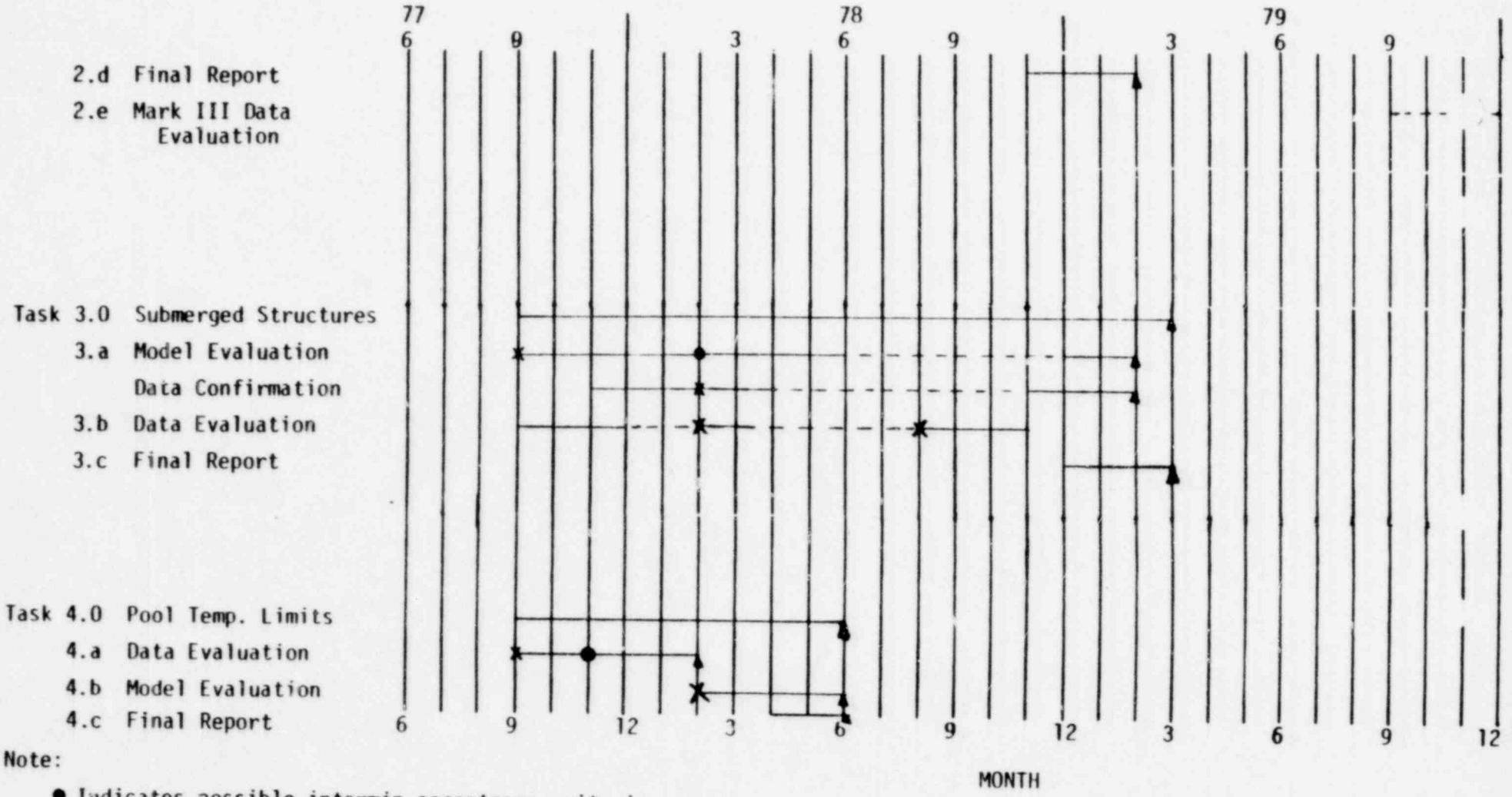
8. Potential Problems

A. The proposed schedules have been based to a large part on the current estimates of receipt of key documents from both the Mark I and Mark II owner's programs. Since there are several test programs involved, past performance would indicate a good possibility in schedule slippages in one or two tasks. This may necessitate additional in-plant testing on lead Mark II plants prior to completion of the SRV generic program.

B. Fluid structure interaction effects are an important consideration in the evaluation of both ramshead and quencher test data. A technical assistance program has been initiated for Mark I related tasks. However, efforts to develop a similar program for Mark II considerations have just begun. Early initiation of this program or incorporation into the existing program is required if successful completion of task 2 is to be realized.

SRV PROGRAM SCHEDULE





Note:

- ● Indicates possible intermin acceptance criteria
- X Indicates receipt of key documentation from either the Mark I or Mark II owner's programs or GE