MARCH 2 1979

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Docket No. 50-220

Mr. Donald P. Dise
Vice President - Engineering
Niagara Mohawk Power Corporation
300 Erie Boulevard West
Syracuse, New York 13202

Dear Mr. Dise:

RE: SCHEDULE FOR THE IMPLEMENTATION AND RESOLUTION OF THE MARK I CONTAINMENT LONG TERM PROGRAM

The generic aspects of the Mark I Containment Long Term Program (LTP) are nearing completion. We have concluded that it is appropriate at this time to establish specific schedules for the implementation of the plant-unique aspects of the LTP.

We have scheduled the completion of our review of the Load Definition Report (LDR) and Plant Unique Analysis Applications Guide (PUAAG) for May 1979. Upon the completion of our review of the LDR and PUAAG, we will advise the Mark I Owners' Group of any specific exceptions to these documents that must be addressed for a satisfactory LTP plant-unique analysis. Your plant-unique analysis should be submitted as soon after that time as possible. Following our review of your plant-unique analysis, we will take appropriate licensing action, including a license amendment, to assure the timely completion of the LTP.

At this point in the program, you should be in a position to know the majority of plant modifications that will be necessary to conform to the LTP acceptance criteria. Therefore, we request that, within 60 days following your receipt of this letter, you provide a bar-chart schedule showing the time periods for the installation of specific plant modifications. Your schedule should be directed toward the completion of the needed plant modifications by December 1980. Should you be unable to meet this targeted completion date for the installation of the major plant modifications, your response should include sufficient justification to demonstrate your best efforts to meet this goal.

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An issue that relates to your LTP implementation schedule is the use of "ramshead" devices for safety-relief valve discharge. The enclosed staff evaluation discusses our conclusions regarding the basis for the definition of the ramshead threshold temperature (i.e., stability limit). As discussed in this report, the quencher discharge device has been shown to significantly improve both the loading on the containment and the condensation stability. The quencher device has been shown to provide the necessary improvements in the containment loading and the condensation stability, and you have informally advised us of your intention to install quencher discharge devices in your facility. Please identify when the quencher discharge devices will be installed.

Another aspect of the resolution of the LTP concerns the licensing fees required by 10 CFR 170. The LTP constitutes a "special project" as defined by that regulation. As such, we have determined that the fee associated with the generic aspects of the LTP will be based on the manpower required to review the LDR and PUAAG. The responsibility for this fee will be shared by the Owners Group as a whole. In addition, a fee will also be imposed on each individual utility for the license amendment associated with the LTP. The fee class for the license amendment will be based on the manpower required to review the LTP plant-unique analysis and any related changes to the plant Technical Specifications.

As discussed above, your detailed schedule for modifications should be submitted within 60 days following your receipt of this letter. If you so desire, we will meet with you to discuss your specific plant modification schedules.

Sincerely,
Original Signed by
Victor Stello

V. Stello, Jr., Director
Division of Operating Reactors
Office of Nuclear Reactor Regulation

Enclosure:
As stated

cc w/enclosure:
See next page

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DATE	3/8/79	3/8/79	3/9/79	3/9/79	3/10/79	3/9/79

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EVALUATION BY THE
OFFICE OF NUCLEAR REACTOR REGULATION
OF
SUPPRESSION POOL
TEMPERATURE LIMITS
IN BWR FACILITIES

I. Introduction and Summary

Safety-relief valves (SRVs) in BWR plants are used for reactor vessel pressure relief during either anticipated plant transients or accident situations. These valves are installed on the main steam lines of the reactor system with discharge lines from the valves routed to the suppression pool. When the valves open, the steam is discharged through the piping into the pool where it is condensed. A discharge device, which is affixed to the end of the piping beneath the water level in the pool, serves to mix the discharged air and steam with the pool water. The most common discharge device in use today is the ramshead type, which consists of two 90-degree pipe elbows welded together, as shown in Figure 1.

During SRV operation, when air and steam are discharged into the suppression pool, vibratory loads (due to bubble formation and subsequent collapse) are imposed on the containment structure and components within the pool. The characteristics and magnitude of the load profile are dependent upon the type of discharge device, the temperature of the pool, and the mass and energy discharge rate.

For the ramshead device, the two most significant loads occur during vent clearing and subsequent steam condensation. When the latter loading condition occurs at elevated pool temperatures, condensation becomes unstable and significantly higher loads result. Because of this phenomenon, General Electric (GE) has proposed a pool temperature limit for all plants using ramshead devices to avoid operation in this unstable condensation zone. GE's proposed threshold for unstable condensation is 150°F for the bulk pool temperature and 160°F locally. Justification for the limit was supplied by GE to the staff in the form of topical reports (References 1 and 2). These reports contain the experimental data base used by GE to establish the temperature threshold. The initial concern arose from an event that occurred at a foreign plant, that caused damage to the containment and subsequent leakage from the wetwell.

We have recently completed our review of the GE supplied justification for the pool temperature limit. We and our consultants (from BNL and MIT) have concluded (Reference 3) that the data base alone is not sufficient to support the GE proposed temperature limit because of a lack of full-scale SRV ramshead discharge load data. First, the data base consisted of small-scale elbow and straight pipe data as well as small-scale ramshead tests, with no scaling analysis provided to show the direct applicability of such tests. Second, the results showed substantial data scatter.

Limited plant operational data were also provided, indicating that local pool temperatures of approximately 165°F have been experienced during a stuck-open SRV event without any evidence of structural damage. This experience can be considered as supporting data for the limited-mass flow-pool temperature zone that occurred. However, it cannot be considered as the operational basis for all potential events.

We have, therefore, concluded that the GE bulk suppression pool temperature threshold of 150°F cannot be adequately supported with the existing data base for the ramshead discharge device. We can, however, conclude that the actual temperature threshold is in the vicinity of the GE proposed limit (i.e., about 150°F). In light of our current understanding of the ramshead device and since actual plant pool temperatures could approach the GE-proposed limit, we believe that the ramshead device should be replaced to preclude the unstable condensation phenomena. The basis for this conclusion follows in Section II of this report.

A "quencher" type of device has been used for several years in foreign-based plants. This device was developed to improve the performance of SRV discharge at elevated pool temperatures as well as to reduce the air clearing loads. The principle behind the quencher-type device is to promote the creation of large surface areas of air and steam bubbles for rapid mixing and diffusion rather than the jet type of discharge mixing provided by the ramshead device. Thus, the quencher consists of pipe sections that contain many small holes, either uniform or graduated along the surface to promote and enhance diffusion and condensation in the pool. The quenchers are typically referred to as either the "cross" or "T" types, depending upon their geometrical configuration.

The data base for several quencher-type designs has demonstrated superior performance at elevated pool temperatures. Characteristically, a quencher-type device has not exhibited the temperature threshold phenomenon that has been observed for the ramshead device, based on the test data generated to date. Pool temperatures have approached the boiling point (i.e., greater than 90°C) without any noticeable load increases. Hydrodynamic loads on structures during vent clearing are also reduced, due to the inherently better distribution of the steam/air mixture in the pool. The use of the quencher device would therefore lead to larger safety margins.

Based on the available data, we conclude that a design basis suppression pool temperature limit has not been adequately established for the ramshead device. Furthermore, we believe that, even if full-scale ramshead testing were performed, it is likely that a temperature limit would be established so that operator action would be required during SRV discharge transients to ensure that the pool temperature limit would not be exceeded. (Note: Full-scale ramshead testing at elevated pool temperatures to establish a design basis pool temperature limit has not been proposed). Therefore, in the absence of any further information on the ramshead, we conclude that it should not be used. We also conclude that the quencher-type device provides improved safety margins and can be used in all BWR plants with water suppression containments. The comparative benefits are given in the following table:

Table 1

SRV DISCHARGE DEVICE EVALUATION SUMMARY

Device	Local Temperature Limit*	Remarks	Air Clearing Loads**
Ramshead	160°F	1. Test data do not support the proposed limit. 2. Severe vibration occurs if the limit is exceeded.	+21 psi -10 psi
Quencher	200°F	1. Test data show no severe vibration for tank water temperatures approaching boiling. 2. Steam condensation loads are about ±2.2 psi.	+6 psi -5 psi

*Minimum temperature limit for onset of condensation instability.
**Peak positive and negative torus shell loads observed in the Monticello in-plant tests.

We have considered the bases for interim operation of the Mark I plants currently using ramshead devices. The SRV loads are cyclical in nature, thereby creating the potential for fatigue degradation of the containment. For currently operating Mark I plants, we have determined that there is sufficient fatigue margin to permit continued plant operation while a new discharge device is being developed and installed. Although some damage to the torus internals has been observed due to apparent SRV operation, there has not been a loss of containment integrity or function in any case.

II. Evaluation of Supporting Data for Ramshead Device

In late 1975, GE submitted a topical report (Reference 1) to support the temperature limit for the suppression pool when using a ramshead device. The report, however, contained test data for SRVs having a straight down pipe discharge device and no test data for the ramshead device. As a result of our evaluation, we conclude that the data base did not support the proposed limit.

In response to our request, GE provided additional data (Reference 2) that contained three sources of test data: subscale test data of ramshead and elbow devices, small-scale test data of straight-down pipes, and plant operational data. Results of our evaluation of this report are discussed below.

A. Local and Bulk Temperature Differences

Local temperature is referred to as the water temperature that is in the vicinity of the discharge device but not in contact with the steam bubble. Bulk temperature, on the other hand, is a calculated temperature that assumes a uniform pool temperature. Bulk temperature is normally used for pool temperature transient analyses. Because the test facilities are confined pools, the measured temperatures are considered to be local temperatures. This has been confirmed through evaluation of the test data. Generally, the test results show less than a 2- to 3-degree variation within the test pool.

To allow proper interpretation of the test data, GE performed a test at the Quad Cities plant. The pool was instrumented with 18 thermocouples, 6 of which were located in the vicinity of the discharge device to determine local pool temperatures. The test was conducted by continuously discharging an SRV into the suppression pool for 27 minutes. Throughout the transient, the results showed that the measured local temperature did not deviate from the calculated bulk temperature by more than 10°F. Based on this result, GE has suggested that a difference of 10°F between local and bulk conditions be used. We concur with this evaluation of the test data.

Based on this temperature difference, therefore, the GE-proposed 150°F bulk temperature limit is equivalent to a 160°F local temperature. Test results then represent local temperature conditions. The following data evaluation is based on this assumption.

With respect to the quencher device, the magnitude of the difference between the local and bulk temperatures has not been established due to the lack of an adequate data base. However, recently performed in-plant tests are expected to provide the necessary data base. We will continue our review of this matter.

B. Sub-scale Ramshead and Elbow Data

Sub-scale tests were performed at Moss Landing Test Facility and in a separate test facility in San Jose, California. These consisted of seven tests using a ramshead and 37 tests using a 90-degree elbow. The mass flux ranged from 50 to 195 lbm/sq ft-sec. The local threshold temperature for steam condensation instability calculated by GE for each of these tests ranged from 152° to 176°F for the ramshead and 146° to 172°F for the elbow.

Based on the following specific concerns, we conclude that the applicability of the sub-scale test data has not been adequately demonstrated and cannot be supported without additional testing.

1. Scaling Law Application: We know from our experience with the Mark I pool swell phenomenon, and from the work that has been done by the Mark II Owners' Group on steam condensation chugging, that small-scale modeling laws are complex and must be established from fundamental principles and carefully applied in model testing. No such modeling laws have been derived for the SRV discharge phenomenon. Test facilities were not scaled to simulate an actual plant. Therefore, neither dynamic nor geometrical similarities can be established by the tests. Furthermore, GE has not justified the assumption that scaling has no effect on the temperature threshold.

2. Data Scattering: Substantial data scattering appears in the sub-scale test results. As noted previously, the temperature threshold ranges from 146^{o} to 176^{o}F. With such a wide scattering, the probability for the temperature thresold to be below the GE proposed 160^{o}F is relatively high (16% of the sub-scale data points fall below the limit).

C. Small Scale Straight Down Pipe Data

This data set was obtained from foreign tests (Reference 1). The tests used a straight-down pipe and yielded 12 data points. The threshold was defined as the pool temperature at which the peak-to-peak pressure oscillation first reached 2 bar (29 psig) outside a circular projection with twice the pipe diameter on the floor of the tank. Results of the tests show that all data points fall below the 160^{o}F limit. However, the straight-pipe discharge is phenomenologically different from that of the ramshead device and therefore this data is not applicable.

D. Plant Operatinal Data

The GE memorandum report (Reference 2) provides actual in-plant data. Five plants have experienced SRV discharge into the suppression pools where temperatures in excess of 100^{o}F were reached with no reported instabilities. Specifically, the highest pool temperature from those events ranged from 122^{o} to 165^{o}F. However, the report only provides detailed data for two plants identified as Plant A and Plant C.

Data indicate that Plant A was manually scrammed before the suppression pool temperature reached 110°F following a stuck-open event. The suppression pool temperature increased rapidly and reached 165°F when the reactor pressure was 184 psig. Plant C reached 146°F only because the reactor was scrammed at a lower pool temperature.

Figure 2 shows the loci of the Plant A and C events on a plot of pool temperature versus SRV steam mass flux during blowdown. It also shows the GE-proposed pool temperature limit. It is clear that the plants experience SRV discharges far below the GE proposed pool temperature limit at virtually all mass fluxes except the lowest. Thus, their experience does not provide support for the higher mass flux at the GE-proposed limit of 160°F.

III. Discussion of SRV Quencher Discharge Device Designs

In 1972, a foreign BWR plant with water pressure suppression containment experienced severe vibratory loads on the containment structure during extended SRV operation at high pool temperatures. The loads were severe enough to cause damage to the containment shell and components and to result in water leakage from the suppression pool.

Following this incident, extensive experiments were conducted to investigate various alternate discharge configurations. The objective of the investigation was to develop a device that would reduce the hydrodynamic loads during SRV air clearing and provide stable steam condensation. Varied configurations of the discharge device considering more than 20 design parameters were investigated. Results of the investigation concluded that the quencher-type device yielded superior performance. Some of the test results are provided in a GE topical report (Reference 1).

Figure 1 shows the configuration of a typical cross quencher, which is currently used by all Mark III containments. The cross quencher has four arms with each arm perforated by several rows of small holes. The tip of each arm is plugged and the device measures approximately 10 feet long from tip to tip. Steam flows through the hub, is distributed among the four arms, and is discharged into the pool. The T-quencher device presently being developed for the Mark I plants is similar to the cross quencher except that it has only two arms that are approximately 20 feet long from tip to tip. The quencher device produces a cloud of air or steam mist, whereas the ramshead produces large bubbles.

Because of the quencher configuration, the magnitude of the quencher air clearing load is reduced by a factor of two to four. In addition, steam condensation instability does not occur although the pool temperature approaches boiling point.

Figure 3 shows the comparison of structural loading functions for quencher and ramshead devices for a 238 GESSAR Mark III plant. Although these loading functions are not applicable for the Mark I design, they demonstrate that the quencher device, in general, substantially reduces the loads on the containment structure with the magnitude of the load reduction being dependent on the quencher configuration and its relative location to the adjacent stuctures.

Foreign large-scale testing and in-plant tests from the United States (Monticello) have verified the reduction in hydrodynamic loads when using the quencher-type discharge device. Additional testing on a small scale has also shown the temperature threshold for unstable condensation to increase to about 200°F using the quencher-type device. GE is presently conducting full-scale confirmatory testing of the cross-type quencher device at the Caroso plant in Italy. Additional testing on a full-scale plant has been performed in Japan at the Tokai 2 facility.

IV. Conclusion

The suppression pool temperature limit proposed by GE to preclude unstable condensation during SRV discharge through a ramshead device has not been adequately demonstrated. Furthermore, we believe that, even if sufficient full-scale testing of the ramshead device were to be performed to adequately define the suppression pool temperature limit, it is likely that the resulting limit would require several operator actions and perhaps an additional margin in the allowable pool temperature during normal plant operation to preclude unstable condensation.

The test data that has been generated to date for the quencher devices have not exhibited the unstable condensation observed in the ramshead tests at elevated pool temperatures. These data also demonsrate that the quencher air clearing loads on the containment are substantially lower than the loads resulting from discharge through a ramshead device. Furthermore, based on the limited number of suppression pool temperature transient analyses that we have received for Mark I plants, it appears that a lesser amount of operator action would be required.

Based on the improved performance demonstrated for the quencher discharge devices and the uncertainty associated with the definition of the pool temperature limits for ramshead discharge devices, we conclude that the use of ramshead devices in BWR water suppression containment systems is not acceptable for long-term operation. We also conclude that the quencher-type devices provide a satisfactory resolution to the condensation stability concerns and is, therefore, an acceptable replacement.

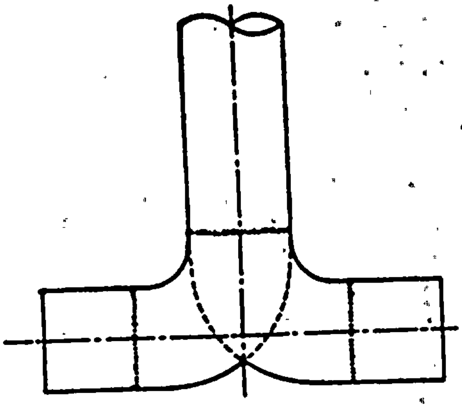
References

1. General Electric Company, "Test Results Employed by GE for BWR Containment and Vertical Vent Loads," GE Topical Report NEDE-21078-P, October 1975.

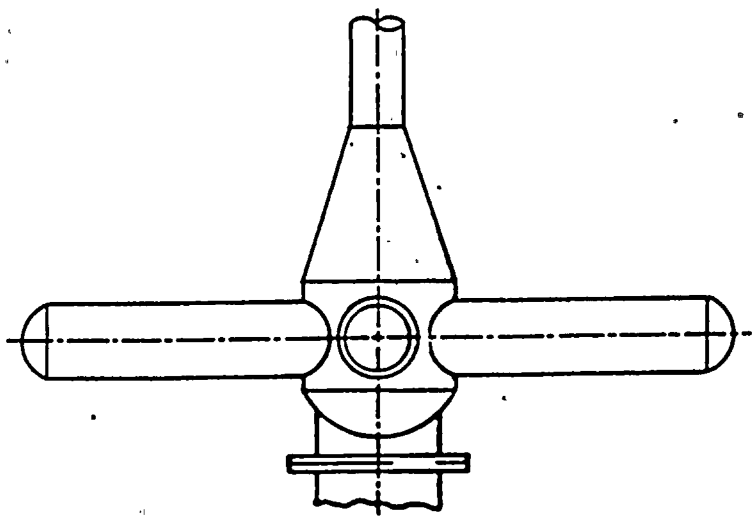
2. General Electric Company Memorandum Report, "170°F Pool Temperature Limit for SRV Ramshead Condensation Stability," September 1977.

3. Ain A. Sonin and C. Tung, "Comments on the Pool Temperature Limit for Avoiding Pulsating Condensation with Ramshead SRVs," Brookhaven National Laboratory, February 1978.

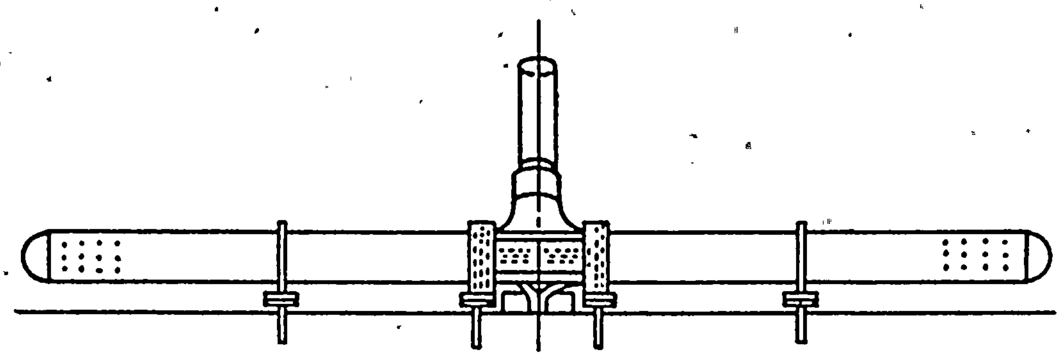
4. General Electric Company, "Information Report Mark III Containment Dynamic Loading Conditions (Final)," GE Topical Report NEDO-11314-08, July 1975.



RAMSHEAD



CROSS-QUENCHER



T-QUENCHER

Figure 1 TYPICAL SRV DISCHARGE DEVICES

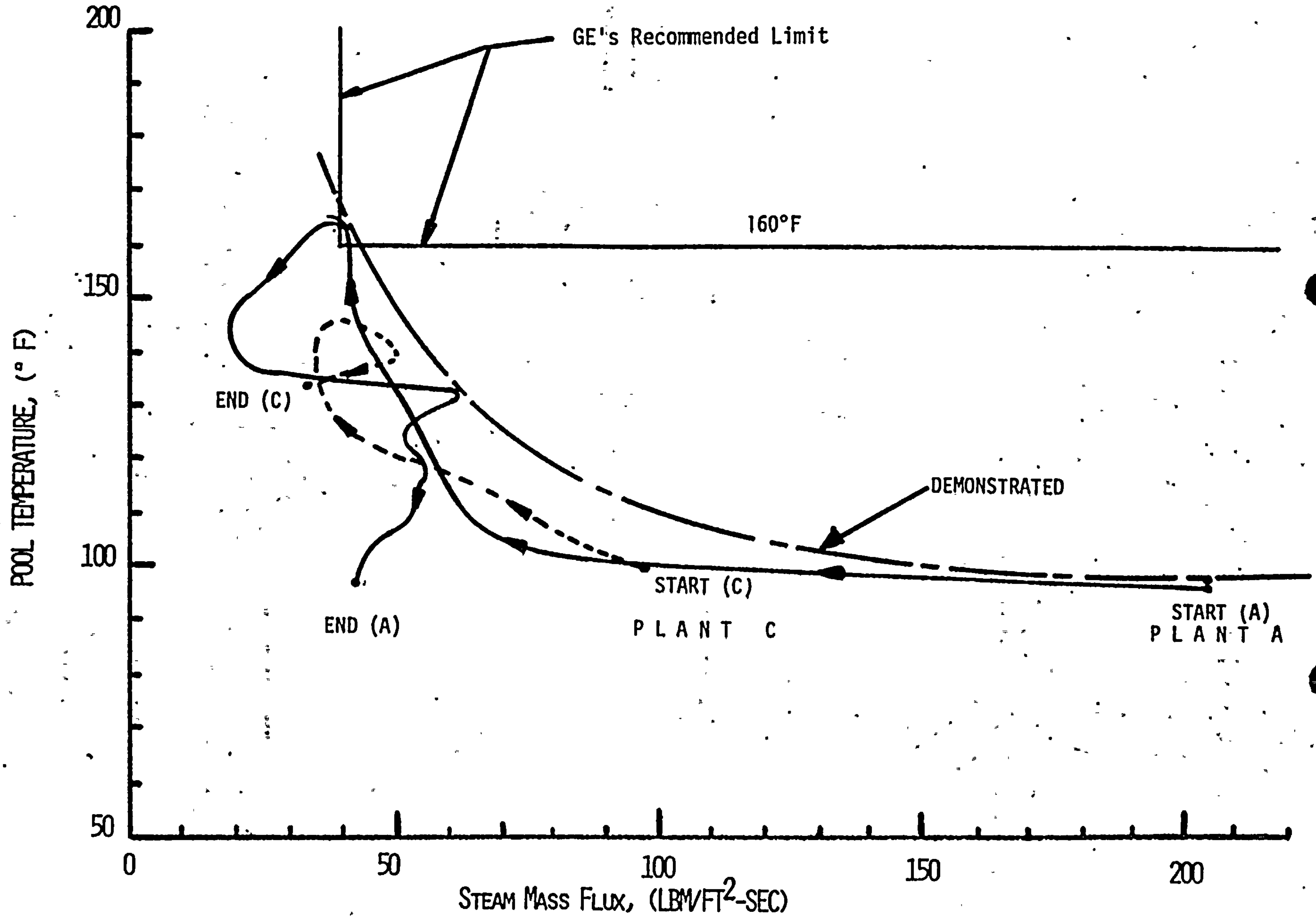


Figure 2 PLANT OPERATIONAL EXPERIENCE

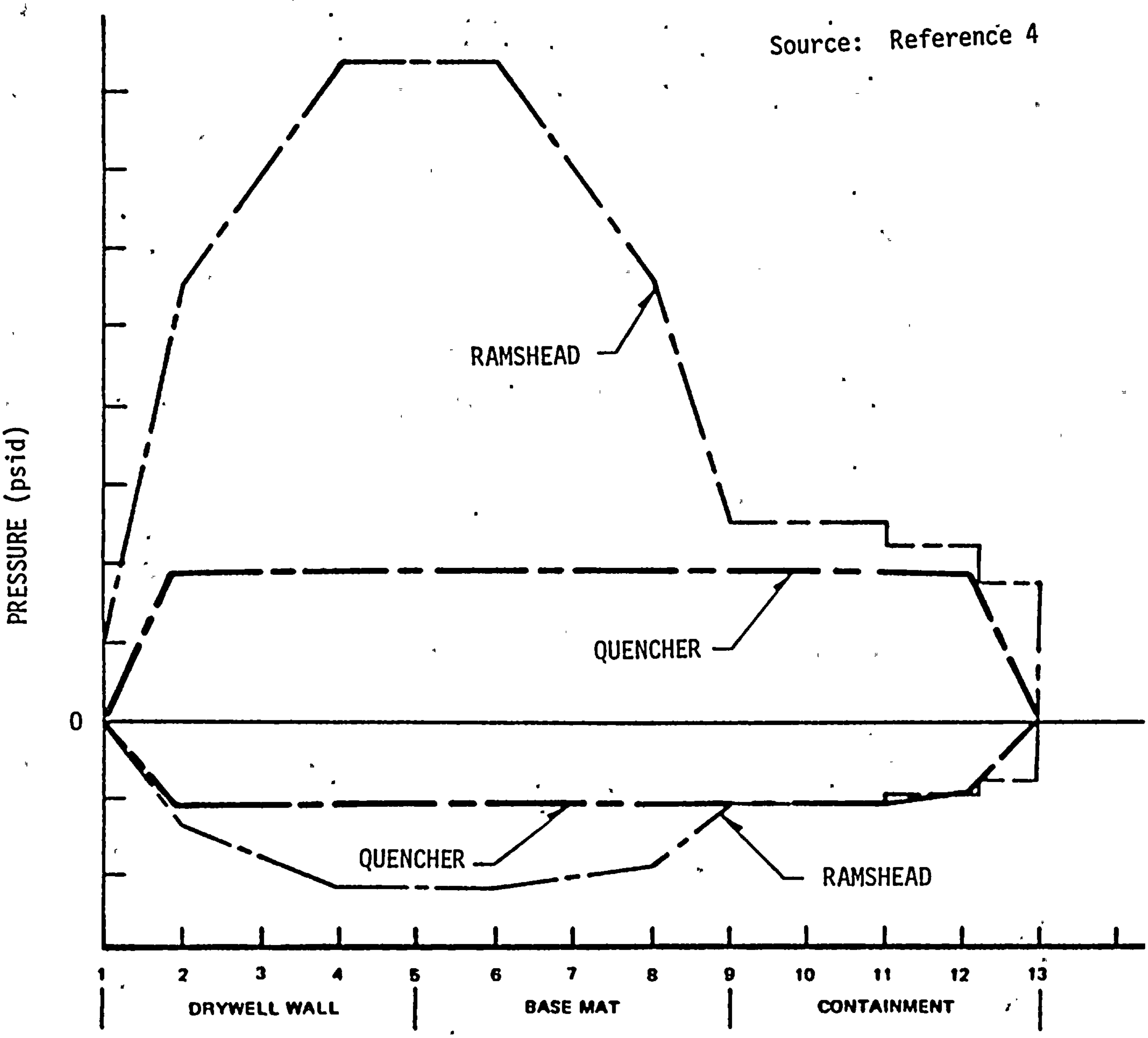


Figure 3 MARK III STANDARD PLANT SRV WALL PRESSURES