NORTHEAST UTILITIES

The Connecticut Light And Power Company
Western Massachusetts Electric Company
Holyoke Water Power Company
Northeast Utilities Service Company
Northeast Nuclear Energy Company

General Offices Selden Street, Berlin Connecticut

P.O. BOX 270
HARTFORD, CONNECTICUT 06414-0270
(203)665-5000

Re: 10CFR50.73(a)(2)(v)
January 15, 1991
MP-91-43

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Reference: Facility Operating License No. DPR-21
Docket No. 50-245
Licensee Event Report 90-014-01

Gentlemen:

This letter forwards update Licensee Event Report 90-014-01 required to be submitted pursuant to the requirements of 10CFR50.73(a)(2)(v).

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

FOR: Stephen E. Scace
Director, Millstone Station

BY: Carl H. Clement
Millstone Unit 3 Director

SES/WGN:mo

Attachment: LER 90-014-01

cc: T. T. Martin, Region I Administrator
W. J. Raymond, Senior Resident Inspector, Millstone Unit Nos. 1, 2 and 3
M. Boyle, NRC Project Manager, Millstone Unit No. 1

Cert NO P601A50920

IE22 1/1

NRC Form 366 (6-89) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED OMB NO. 3150-0104
EXPIRES: 4/30/92

Estimated burden per response to comply with this information collection request: 50.0 hrs. Forward comments regarding burden estimate to the Records and Reports Management Branch (p-530), U.S. Nuclear Regulatory Commission, Washington, DC 20555, and to the Paperwork Reduction Project (3150-0104), Office of Management and Budget, Washington, DC 20503

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Millstone Nuclear Power Station Unit 1	0 5 0 0 0 2 4 5	1 OF 0 7

TITLE (4): Low Pressure Coolant Injection Heat Exchanger Flow Rates

EVENT DATE (5) MONTH	DAY	YEAR	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	REPORT DATE (7) MONTH	DAY	YEAR	OTHER FACILITIES INVOLVED (8) FACILITY NAMES	DOCKET NUMBER(S)
0 9	0 7	9 0	9 0	0 1 4	0 1	0 1	1 5	9 1		0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9)	N
POWER LEVEL (10)	1 0 0

THIS REPORT IS BEING SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

[ ] 20.402(b)	[ ] 20.402(c)	[ ] 50.73(a)(2)(iv)	[ ] 73.71(b)
[ ] 20.405(a)(1)(i)	[ ] 50.36(c)(1)	[X] 50.73(a)(2)(v)	[ ] 73.71(c)
[ ] 20.405(a)(1)(ii)	[ ] 50.36(c)(2)	[ ] 50.73(a)(2)(vii)	[ ] OTHER (Specify in Abstract below and in Text, NRC Form 366A)
[ ] 20.405(a)(1)(iii)	[ ] 50.73(a)(2)(i)	[ ] 50.73(a)(2)(viii)(A)	
[ ] 20.405(a)(1)(iv)	[ ] 50.73(a)(2)(ii)	[ ] 50.73(a)(2)(viii)(B)	
[ ] 20.405(a)(1)(v)	[ ] 50.73(a)(2)(iii)	[ ] 50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER AREA CODE	
William G. Noll, Sr. Engineer (Ext. 4442)	2 0 3	4 4 7 - 1 7 9 1

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
[ ] YES (If yes, complete EXPECTED SUBMISSION DATE)	[X] NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On September 7, 1990, at 1845 hours, with the plant at 100% power (530 degrees Fahrenheit and 1030 psig), an inconsistency between procedural and design parameters associated with the Low Pressure Coolant Injection (LPCI) heat exchanger flow rates was identified. The inconsistency was associated with the maximum LPCI flow permitted through the heat exchanger to preclude failure due to flow-induced vibration, and the heat exchanger flow rates required by the Emergency Operating Procedures (EOP's). After review of the procedures, the design basis, and discussions with the heat exchanger manufacturer, it was determined that operability of the containment cooling system could not be assured due to potential mechanical limitations of the heat exchanger. Both containment cooling subsystems were declared inoperable and a plant shutdown to cold shutdown was immediately initiated as required by Technical Specifications. Cold shutdown was achieved on September 8, 1990 at 1705 hours. No safety systems were required to function as a result of this event and no safety consequences resulted from this event.

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Millstone Nuclear Power Station Unit 1	0 5 0 0 0 2 4 5	9 0	— 0 1 4 —	0 1	0 2 OF 0 7

TEXT (If more space is required, use additional NRC Form 366A's) (17)

I. Description of Event

On September 7, 1990, at 1845 hours, with the plant at 100% power (530 degrees Fahrenheit and 1030 psig), an inconsistency between procedural and design parameters associated with the Low Pressure Coolant Injection (LPCI) heat exchanger flow rates was identified. The inconsistency was associated with the maximum LPCI flow permitted through the heat exchanger to preclude failure due to erosion and flow-induced vibration, and the heat exchanger flow rates required by the Emergency Operating Procedures (EOP's). After review of the procedures, the design basis, and discussions with the heat exchanger manufacturer, it was determined that operability of the containment cooling system could not be assured due to potential mechanical limitations of the heat exchanger. Both containment cooling subsystems were declared inoperable and a plant shutdown to cold shutdown was immediately initiated as required by Technical Specifications. Cold shutdown was achieved on September 8, 1990 at 1705 hours. No safety systems were required to function as a result of this event and no safety consequences resulted from this event.

II. Cause of Event

A review of the original Millstone Unit One emergency procedures and the system operating procedures indicated that no precautions or limitations associated with excessive heat exchanger flow rates existed for the LPCI heat exchangers since initial plant start-up in 1970. In 1987, Northeast Utilities implemented a voluntary program for design basis reconstruction at Millstone Unit One. It was during a review of the LPCI Design Basis draft document on the LPCI system that the discrepancy between the design heat exchanger flow rates and the procedural required flow rates was identified.

The Design Basis Reconstruction program was the original source of the inconsistency between the component design limitations and the system operating procedures. Although the original discrepancy was identified in June of 1989, a preliminary engineering assessment of the discrepancy determined no safety significance based upon engineering judgement. However the design basis discrepancy associated with the LPCI heat exchanger flow rates continued to be evaluated under the resolution process implemented by the Design Basis Reconstruction process.

Implementation of Revision 2 of the BWR Owner's Group Emergency Procedure Guidelines in June 1983, required LPCI injection flow be established through the LPCI heat exchanger as soon as possible. This procedural requirement was established by General Caution #4, and was contained in an administrative section of the EOP's applicable to all EOP steps. Revision 4 of the BWR Owner's Group Emergency Procedure Guidelines and subsequent EOP's implemented in September 1989, incorporated the administrative guidance into the actual EOP procedure steps. The continuing effort to enhance the general guidance provided by the EOP's resulted in procedure changes to the Emergency Service Water (ESW) system operating procedure. The ESW operating procedure was undergoing revision to more clearly identify the required heat exchanger flow rates for containment cooling. The ESW procedure revisions prompted discussions with plant engineering, the heat exchanger manufacturer, and corporate engineering and concluded that LPCI heat exchanger flow rates in excess of 5000 gpm could jeopardize LPCI heat exchanger operability. The excessive flow rates could be experienced during a design basis accident by following the procedure guidance contained in the EOP'S. As a result of this information, the LPCI containment cooling sub-systems were declared inoperable and a plant shutdown was initiated.

The root cause of this event has been determined to be inadequate evaluation of original plant design documentation that permitted component operation such that the design limitations would have been exceeded. Therefore, operation of the LPCI system with all flow being directed through the heat exchanger did not take into consideration the potential long term damage to the heat exchanger component.

III. Analysis of Event

This event is reportable pursuant to 10CFR 50.73(a)(2)(v), any event or condition that alone could have prevented the fulfillment of the safety systems that are needed to mitigate the consequences of an accident. Immediate notifications were performed in accordance with 10CFR 50.72 (b)(1)(i)(A).

The Emergency Operating Procedures were developed with the philosophy of establishing as high a heat exchanger flow rate as possible. Therefore, the EOP's would allow the operator to perform the long term containment cooling function utilizing two 5000 gpm LPCI pumps to provide flow through each LPCI heat exchanger. This would also be the same active equipment used during the LOCA injection phase. However, as part of the Design Basis Reconstruction project, it was discovered that the LPCI heat exchanger was designed for only 5000 gpm. Thus, the Emergency Operating Procedures would have allowed the operator to exceed the design parameters for the LPCI heat exchangers.

The most limiting design basis event affected by excessive heat exchanger flow rates is as follows:

1. The initiating event is a LOCA.
2. LPCI is automatically placed in the Post LOCA Core Reflood mode and injection starts.
3. Valves LP-7A and LP-7B (LPCI heat exchanger bypass valves) are interlocked in the open position to prevent closure until one minute after initiation of the injection mode.
4. Some time after the interlock clears, the operator would close LP-7A and LP-7B to initiate cooling through the LPCI heat exchanger. The operators are directed by the Emergency Operating Procedures to perform this action as soon as practical.

Closing the LPCI heat exchanger bypass valves LP-7A and B, will direct all LPCI flow to the shell side of the heat exchanger. Therefore as much as 9,600 gpm could be passed through each heat exchanger designed for only 5000 gpm. Flow through the heat exchangers would be decreased only for the following reasons:

1. Torus water temperature decreases to a 90 - 110 degree F range and only if adequate core cooling has been assured.
2. LPCI Net Positive Suction Head (NPSH) requirements dictate that the operator decrease LPCI flow to maintain adequate NPSH, or
3. Direction is given from the Emergency Response Organization.

Based on the scenario discussed above, it is possible that the high flow condition could have been maintained for some period of time resulting in potential heat exchanger damage. Therefore, it was determined that the LPCI heat exchangers were inoperable and a shutdown was initiated as required by Technical Specifications.

Northeast Utilities contracted Holtec International to perform extensive further analysis of the potential for heat exchanger damage under postulated high flow rates. In addition, a computer modeling of the LPCI system calculated that the maximum flow through the LPCI heat exchanger that could exist with the heat exchanger bypass valve closed is 9584 gpm.

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Millstone Nuclear Power Station Unit 1	0 5 0 0 0 2 4 5	9 0	— 0 1 4	— 0 1	0 4 OF 0 7

TEXT (If more space is required, use additional NRC Form 366A's) (17)

III. Analysis of Event (Continued)

The Holtec analysis demonstrated that the threshold heat exchanger flow rate (the flow rate above which large amplitude vibrations will occur) is 6200 gpm. This analysis also demonstrated the following:

1. The LPCI heat exchanger is most vulnerable to flow induced vibration in the shell inlet region near the impingement plate, due to the high localized velocities.

2. In view of the unsupported span and type of tube material (90:10 copper-nickel), the failure mode is expected to be one due to tube-to-tube impact. That is, the tubes will not break, but will develop holes. Collision damage to the tubes is not an instantaneous phenomena, but will occur over a period of two to six hours. This failure mechanism will not decrease the heat exchanger heat transfer capability.

3. There are twelve tubes near the impingement plate vulnerable to failure. The tube-to-tube failure mechanism results in a conservative estimate that a total of 24 tubes per heat exchanger could fail. The failure of the tubes is expected to be confined to the regions of high local velocities. The failure mechanism does not suggest massive or uncontrolled progressive failure and it is not expected that the tubes would sever and become internal missiles. The central heat exchanger tubes are not expected to fail due to the low cross-flow velocities.

4. Certain tubes in the heat exchanger outlet region could exhibit large amplitude motions at approximately 9600 gpm.

Based on this judgement, it was concluded that the heat exchanger would still perform its intended safety function for a period of several weeks to a month. In addition, to date the LPCI heat exchangers have seen very little service, and eddy current testing indicates little or no degradation of the tube wall thickness.

In the event that the LPCI heat exchangers failed early in the postulated LOCA, the following sequence of events could be postulated:

1. The likely failure modes would be a failure of some of the tubes in the inlet region of the heat exchanger and a minimum reduction in heat transfer capability.

2. Since the ESW pressure is maintained higher than the LPCI pressure, tube leakage would result in emergency service water addition to the LPCI flow. This would result in an increase in Torus water level. This would alert the operators to the potential for a heat exchanger tube leak.

3. The heat exchanger heat removal capability would be slightly degraded, but would be more than offset by the addition of cold ESW flow to the torus.

4. When the torus water level reaches 26 ft., the EOP's direct the operator to terminate injection from all external sources into the containment.

5. Termination of ESW flow results in a loss of torus cooling. Very high torus water temperatures could lead to inadequate LPCI or Core Spray pump NPSH, LPCI or Core Spray pump seal failure (pumps remain operable for core cooling) or containment pressurization to the point where containment venting would be required. Containment venting is postulated to occur no sooner than two days after initiation of the event.

6. Adequate core cooling is maintained throughout the scenario and no fuel damage occurs.

Based upon the Holtec analysis of heat exchanger performance discussed previously, and the relatively long time frame involved where alternative mitigating strategies could be developed, it is judged that this scenario is of low safety significance.

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Millstone Nuclear Power Station Unit 1	0 5 0 0 0 2 4 5	9 0	0 1 4	0 1	0 5 OF 0 7

TEXT (If more space is required, use additional NRC Form 366A's) (17)

IV. Corrective Action

Amendment 18 of the original Millstone Unit One FSAR was utilized as the design analysis of record for containment cooling capability. Case study #5, Table A-11.1, of FSAR Amendment 18 shows that one LPCI pump and heat exchanger is capable of satisfying containment cooling requirements, but requires a higher containment spray interlock pressure to ensure adequate NPSH is available for the remaining ECCS pumps.

FSAR Amendment 18 Analysis was performed in 1969 with details of the analytical techniques unavailable for evaluation. On September 8, 1990, General Electric was requested to perform additional analyses with more current methodologies and provide confirmation of the conclusion on adequate NPSH in Amendment 18 of the FSAR.

Both the original FSAR Amendment 18 analysis and the more recent analysis performed by General Electric demonstrated that one LPCI pump and heat exchanger were capable of providing adequate containment cooling.

The following actions were completed to restore the containment cooling system to an operable status:

1. The Emergency Operating Procedures (EOPs) and normal operating procedures (OP's) were changed to allow only a single LPCI pump per train to supply each heat exchanger when in the containment cooling mode.

2. The containment spray interlock switch was recalibrated from 5 psig to 9 psig to ensure adequate low pressure emergency core cooling system pump net positive suction head (NPSH). This action was completed following receipt of the Emergency Technical Specification Change Request for the Containment Spray Interlock.

3. Simulator verification and validation of the EOP's were performed in accordance with the EOP program. In addition, all operating crews were trained on the EOP changes by performing scenarios that exercised the EOP changes and demonstrated the changes on the containment cooling system. This training was completed for each operating shift prior to assuming control room duties.

The discrepancy between the heat exchanger design flow limits and the system operating procedures was first identified during the Millstone Unit One Design Basis Reconstruction Program which was completed for the LPCI system in late 1989. Other design discrepancies were also identified on the LPCI system and were either directly related to the heat exchanger flow issue, or were dispositioned as not reportable and did not affect system operability. At the time of the LPCI heat exchanger event, two other Millstone Unit One systems had completed the design basis review process. To ensure other design deficiencies did not exist that could threaten system operability, a review of each design deficiency was performed for the Control Rod Drive System (CRD), and the Feedwater Coolant Injection system (FWCI). The reviews performed on the CRD and FWCI systems did not identify any additional operability concerns. A corporate procedure which was under development at the time of this incident has been implemented to specify the "initiation, tracking, handling, and disposition of design discrepancies" identified during the design basis reconstruction effort. Implementation of this program will ensure all design basis discrepancies identified during the reconstruction program receive a thorough and timely review for operability and reportability concerns.

A design review of other safety related heat exchangers was implemented to ensure similar operating design limits were not exceeded. The Turbine Building Secondary Closed Cooling Water (TBSCCW) heat exchangers were identified as having a potential for excessive flow rates during normal operation. A monitoring program has been implemented to evaluate the TBSCCW heat exchanger performance.

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Millstone Nuclear Power Station Unit 1	0 5 0 0 0 2 4 5	9 0	— 0 1 4	— 0 1	0 6 OF 0 7

TEXT (If more space is required, use additional NRC Form 366A's) (17)

IV. Corrective Action (Continued)

The Design Basis reconstruction process will be utilized to identify potential design deficiencies on Millstone Unit One safety related systems and other selected systems. This effort will also contain a dedicated review of system operating and emergency procedures to ensure components are operated within their design limitations.

The original engineering assessment of the LPCI heat exchanger by the manufacturer indicated that the heat exchanger would still perform its intended safety function for several weeks to a month. Further analysis using the Heat Transfer Research Institute (HTRI) computer model indicated that less than 2% margin existed between the design flow rates and critical flow rates. The HTRI analysis is highly conservative and cannot predict heat exchanger failure following exposure to critical flows.

Millstone Unit One commissioned an independent firm (Holtec International) to perform additional heat exchanger analysis. The results of this analysis demonstrated that the threshold for flow induced vibration damage to the LPCI heat exchanger is expected to occur at flow rates above 6200 gpm. The current LPCI system configuration permits only one LPCI pump in operation with the heat exchanger bypass valve closed. This represents a safety margin of 24% between the design flow rate and the critical flow rate. The current LPCI configuration meets all normal and emergency operating and design requirements.

V. Additional Information

The following information is being provided to identify the system and components affected by the design discrepancy associated with the LPCI heat exchangers.

EIIS Codes

System	Components	Manufacturer
Low Pressure Coolant Injection - BO	Heat Exchanger - HX	P160 - Perfex

NRC Form 366A (6-89)

U.S. NUCLEAR REGULATORY COMMISSION

APPROVED OMB NO. 3150-0104
EXPIRES: 4/30/92

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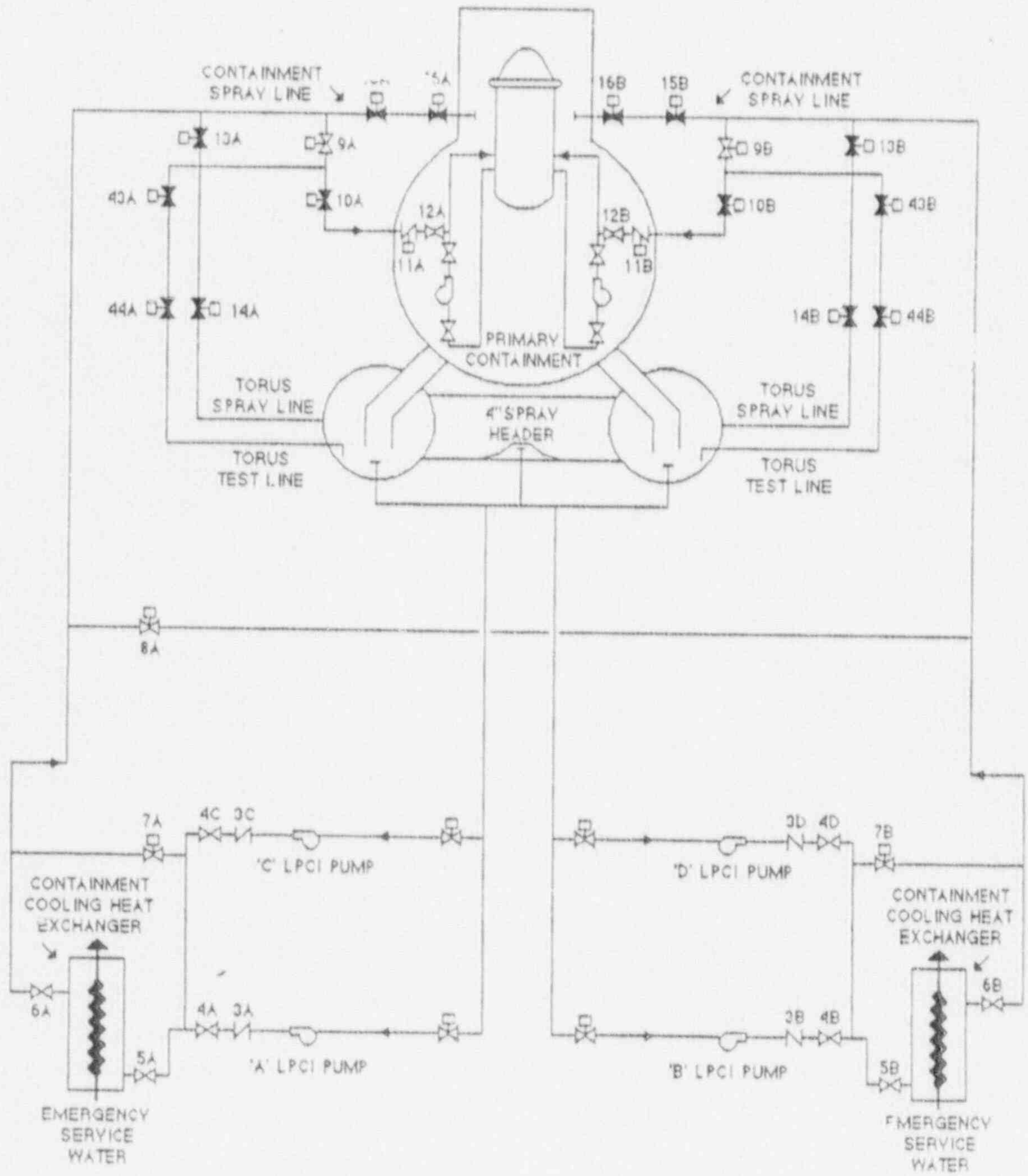
LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

FACILITY NAME (1)	DOCKET NUMBER (2)	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	PAGE (3)
Millstone Nuclear Power Station Unit 1	0 5 0 0 0 2 4 5	9 0	— 0 1 4	— 0 1	0 7 OF 0 7

TEXT (If more space is required, use additional NRC Form 366A's) (17)



LPCI SYSTEM DIAGRAM