U.S. NUCLEAR REGULATORY COMMISSION
REGION I

Report No. 50-289/92-04

Docket No. 50-289

License No. DPR-50

Licensee: GPU Nuclear Corporation
P.O. Box 480
Middletown, Pennsylvania 17057

Facility Name: Three Mile Island Nuclear Station, Unit 1

Inspection At: Middletown, Pennsylvania

Inspection Conducted: February 24-28 and May 1, 1992

Inspection Members: A. Lopez-Goldberg, Reactor Engineer
D. Waters, Consultant

Lead Inspector: Harold I. Gregg — 5/12/92
Harold I. Gregg, Sr. Reactor Engineer, Systems Section, EB, DRS — Date

Approved by: P. K. Eapen — 5/12/92
Dr. P. K. Eapen, Chief, Systems Section, Engineering Branch, DRS — Date

Area Inspected: Effectiveness of licensee's activities to assure operability and reliability of check valves in safety-related systems.

Inspection Results: The licensee's management and staff were aggressive in identifying, evaluating and correcting check valve problems. Consideration of generic implication was evident and there was proactive use of non intrusive testing techniques. Findings that both the inservice testing (IST) program and the industry initiated check valve program are not controlled program documents, justification for several valves omitted from the program, and review of design application calculations were identified as unresolved items.

1.0 Background

The NRC regulations require that check valves be treated in a manner that provides assurance of their performance. Criterion 1 of Appendix A to 10 CFR Part 50, General Design Criteria for Nuclear Power Plants, states, in part, that structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. The quality assurance program (which includes testing) to be applied to safety-related components is described in Appendix B to Part 50, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.

In addition to the general requirements of Appendix A and B to Part 50, Section 50.55a of the NRC regulations references the ASME Boiler and Pressure Vessel Code. Paragraph (g) of Section 50.55a which requires that the provisions of Section XI of the ASME Code be met for inservice testing of components covered by the Code.

On August 29, 1988, the NRC staff issued Information Notice 88-70, "Check Valve Inservice Testing Program Deficiencies," as a result of inspections of check valve activities at several nuclear power plants. A common finding from those inspections was that not all safety-related check valves had been included in the Inservice Testing (IST) programs. Another finding was that some of the check valves within the IST programs were not being tested in a manner that verifies their ability to perform their safety-related functions.

On April 3, 1989, the NRC staff issued Generic Letter (GL) 89-04, "Guidance on Developing Acceptable Inservice Testing Programs," to assist licensees in correcting several weaknesses that the staff has found in IST programs. Positions 1 through 4 and 10 address the inservice testing of check valves. Position 11 indicates that certain valves have been erroneously omitted from the IST programs in the past. The position further reminds licensees and permit holders that, while 10 CFR 50.55a delineates the testing requirements for ASME Code valves, the testing of valves is not to be limited to only those components covered by 10 CFR 50.55a. Detailed information on the implementation of GL 89-04 is provided in the minutes of the public meetings held by the staff to discuss the generic letter.

The Office of Analysis and Evaluation of Operational Data (AEOD) has been performing diagnostic evaluations of check valve activities at nuclear power plants and has found numerous deficiencies in those activities. For example, certain check valves have been improperly omitted from the testing program, testing did not demonstrate all safety functions of check valves, check valve failures were not being tracked, and testing programs were not consistent between plants operated by the same licensee.

The overall NRC staff plans to organize activities aimed at identifying and resolving the concerns about testing and performance of check valves are described in NUREG-1352, "Action Plans for Motor-operated Valves and Check Valves," issued in June 1990.

The Institute of Nuclear Power Operations (INPO), a nuclear industry sponsored organization, issued the Significant Operating Experience Report (SOER) 86-03, titled "Check Valve Failures and Degradation," to address check valve concerns after the San Onofre Unit 1 incident. The importance of proper check valve operation and consequences of failures was made clear in that incident. The SOER provided check valve failure information, conclusions that major causes of failure were inadequate maintenance and misapplication, and recommended actions for licensees to improve maintenance and perform design reviews of check valve installations. SOER 86-03 was an initial industry response to improve check valve performance and remains a key guidance document in licensees' industry directed check valve programs.

The staff has developed a Temporary Instruction (TI 2515/110) that provides inspection guidance to assess the effectiveness of licensee programs regarding the performance and testing of safety-related check valves as part of an NRC action plan.

2.0 Scope

This inspection was performed to assess the effectiveness of the licensee's check valve activities using the guidance of NRC Temporary Instruction 2515/110, Performance of Safety-Related Check Valves.

3.0 Licensee's Check Valve Program

The licensee's check valve program is a two part program. One part consists of the IST to assess the operational readiness of these valves as required in the ASME Section XI Code, the licensee's IST program, and safety evaluations from NRC. The other part responds to the program industry initiated after the check valve problem at San Onofre Unit 1.

3.1 Check Valve Program Developed in Response to Industry Problems

The licensee developed and issued the TMI-1 SOER 86-03 Check Valve Program in 1989. The program was described in letter 3220-89-280, "TMI-1 SOER 86-3 Check Valve Program," JR Pearce to RR Harper, August 10, 1989. The program addressed check valves in the problem systems identified from the industry and plant specific experience. A total of 207 check valves were identified, of which 83 were excluded from any requirements for repetitive testing or inspection because their failure would have no effect on either plant operation or safe shutdown. The remaining 124 valves were

divided into two categories. The first category, consisting of 67 limited duty valves which were tested in the IST program, was determined to have adequate provisions to identify abnormal wear or degradation. No additional PM activities were prescribed for this category of valves. The second category, consisted of 57 valves which were either in the IST program or were considered as having an impact on plant reliability. Eighteen of the fifty-seven valves were not included in the IST program or any other preventive maintenance programs.

The second category of 57 check valves formed the initial TMI-1 Check Valve Program. The program was subsequently expanded to include the other category of 67 IST valves, although no additional testing or inspection requirements were proposed. The list of check valves in the program was contained in Enclosure 2 to Corrective Maintenance Procedure 1410 V 18, "Check Valve Maintenance," Revision 14. The inspector reviewed the letter referenced above; the design application review summarized in the Technical Data Report, TDR-971; applicable maintenance procedures for check valve disassembly, repair, inspection and reassembly; machinery histories and additional licensee documentation pertaining to check valve activities. The inspector expressed concerns of the administrative control effectiveness because the program was not consolidated into a controlled program document. This item is unresolved pending the licensee's actions to establish a controlled industry related check valve program document (50-289/92-04-01).

The licensee's industry related check valve program was implemented through several of the existing licensee procedures. However, the inspector observed that the licensee had effectively and proactively implemented measures to test, monitor, inspect and correct deficiencies in check valves, which reflected awareness of the importance of correctly identifying and resolving check valve concerns. Examples of the measures found were:

1. Extending valve disc backstops on CO-V17C, IC-V13A&B, and NS-V10A,B,C to minimize or eliminate valve flutter/chatter.

2. Continuing non-intrusive testing (NIT) and/or disassembly of problem valves to monitor wear or confirm the effectiveness of corrective measures.

3. Effective interface between engineers and maintenance craft to ensure proper evaluation of inspection results.

4. Modifications performed on Crane tilting disc check valves to remove lockwires and secure seat holddown bolts.

The Emergency Feedwater (EF) system pump discharge check valves (EF-V11A&B, EF-V13) and the Reactor Building Emergency Cooling - River Water (RR) system pump discharge check valves (RR-7A&B, RR-8A&B) were included in the IST program but did not have additional PM requirements specified. The licensee stated that additional monitoring was unnecessary due to the low flows experienced during surveillance testing and the standby nature of the systems, but as NIT techniques improved in the future, these valves as well as other IST valves would be considered for possible expansion of the current testing program.

3.2 Check Valves in the IST Program

The IST program is implemented through controlled procedure AP-1041, "IST Program Requirements," that is revised and updated to reflect the submittals and responses. This procedure defines the responsibilities and boundaries of the IST program and lists each valve in the program and a procedure number of the test to be performed. While procedure AP-1041 is well implemented it does not contain all the valve details in the program submittals. Similarly, the program submittals and responses are multiple documents and the assessment of program issues requires review of several documents using a manual retrieval system. Further review was made of the IST program submittals and responses, and the inspector concluded there is no single complete IST controlled program document. The program consisted of the licensee's submittals and NRC responses and safety evaluations. While there were no inspection findings of nonadherence of submittal commitments, due in part to the indepth knowledge of the IST coordinator, the inspector was concerned that over reliance on personnel instead of a controlled program document could present future problems. The inspectors assessed the multiple IST program documents as an unresolved item pending the licensee's actions to establish a consolidated and controlled IST program document (50-289/92-04-02).

A selection of 64 check valves was made from the ISI boundary and P&ID drawings and was reviewed against the IST program requirements. Six of the 64 selected check valves were not included in the program. Documented justification was provided for 3 valves not being in the program. However, for the 3 valves DH-V50 and DH-V59A/B, that are class boundary valves, there was no documented justification for these valves not being in the program. This issue is unresolved, pending the licensee's review and documented position justification (50-289/92-04-03).

The IST coordinator demonstrated in-depth knowledge of testing requirements, safety systems, TMI program submittals and responses. The coordinator also remains current and knowledgeable of ongoing check valve issues. There was evidence of good communications and coordination of testing and repairs with the operations and maintenance department and all problems are promptly resolved.

4.0 Design Application Review

The licensee performed a design review of the valves included in the SOER 86-03 program, which was summarized in TDR 971, "TMI-1 Check Valve Program Status," Revision 1, 11/28/89. Revision 0 provided a review of the 57 valves for which additional testing to meet the requirements of the SOER was needed. The design review addressed valve sizing, whether or not the proper valve type was installed, and the orientation and location of the valve. Revision 1 expanded the design review to address the additional 67 valves which were only tested or inspected to IST program requirements.

During the review of the TDR and supporting documentation and discussions with licensee representatives, the inspector observed that the calculations of valve critical velocity in accordance with the guidance found in EPRI-5479 existed in the form of notes in the engineer's working files, but had not received a formal documented review. These calculational results were used in determining if a valve required increased testing or PM. The licensee stated that a formal documented review of the calculations would be completed by September 1992. This item is unresolved pending completion of the licensee's actions to formally document these calculations (50-289/92-04-04).

The inspector did not find evidence that the design review considered additional factors affecting check valve operability, such as blockage, erosion or corrosion of internal parts, the presence of chemical stressors, or material misapplication. Consideration of a particular valve's safety significance under failed or degraded conditions or the effect of transient operating conditions were also not found. NRC INs and EPRI-5479 identified that such factors should be considered in the review of check valves. The licensee stated that some of these factors were addressed during the program development based on past experience with plant check valves, but documentation was not provided.

Prioritization of the valves with regard to inspection frequency, type of inspection or significance to operation or safety concerns was not provided in the design review, nor was grouping of the program valves for type, size or service conditions performed. However, these functions appeared to be accomplished effectively by the site technical and maintenance organizations.

In comparing the check valves tested in the IST program to the list of valves addressed by the design review, the inspector found that four valves in the Spent Fuel Cooling system (SF-V7, V8, V50, V51) and one valve in the Nuclear Services - Closed Cooling system (NS-V205) were not addressed in the design review nor were they in the expanded list of SOER 86-03 program valves contained in Procedure 1410-V-18. These systems were part of the list of systems reviewed by the licensee to establish the Check Valve Program. The licensee reviewed the status of these five valves and stated that they had been added to the IST program during or after the development of the Check Valve Program and had not been addressed in the design review process. The licensee stated that they would perform the design review for these five valves and add them to the SOER 86-03 program in the appropriate category, consistent with the other program valves. This action was satisfactory to the inspector.

5.0 Control, Evaluation and Implementation of Industry Information

The inspector reviewed the handling of the following documents to evaluate the licensee's control of NRC and vendor information:

1. NRC Information Notice 86-01, "Failure of Main Feedwater Check Valves at SONGS."

2. NRC Information Notice 86-09, "Failure of Check and Stop Check Valves Subjected to Low Flow Conditions."

3. NRC Information Notice 88-70, "Check Valve IST Program Deficiencies."

4. NRC Information Notice 88-85, "Broken Retaining Block Studs on Anchor Darling Check Valves."

5. NRC Generic Letter 89-04, "Guidance on Developing Acceptable Inservice Testing Programs."

6. Velan Service Bulletin, "Swing Check Valves - Forged Steel."

The licensing organization reviews and evaluates all NRC generated documents. The evaluations for the above Information Notices and Generic Letter were found to be very thorough and complete. In particular, evaluations for IN 88-70 and GL 89-04 provided substantial information regarding the basis for the adequacy of the present IST program or the need for program improvements, technical evaluations or relief requests.

The Vendor Document Control (VDC) organization receives, reviews, and evaluates all vendor information. TMI-1 has a system in place for contacting safety related component vendors to obtain equipment update information. However, a large number of those vendors were uncooperative in responding to letters sent. The only service bulletin that the VDC has received for check valves was the Velan service bulletin noted above. The licensee identified two check valves, MU-V-219 and MU-V-220, that are similar to those described in the service bulletin. Both of these check valves have been opened and inspected, and found to be in good condition and were already included in the TMI-1 check valve and preventative maintenance programs. The inspector concluded that the licensee's vendor information program was effectively implemented.

6.0 Check Valve Testing Program

The IST and disassembly inspections have been effective in identifying check valve problems. Site engineering and maintenance efforts in correcting problems when they are found and in evaluating generic implication of like type valves have resulted in minimal failures.

The inspector reviewed the licensee's IST procedures to determine the means utilized to assess back leakage of idle pump check valves where the discharge header communicates with a running pump. In the response to IN 88-70, "Check Valve IST Program Deficiencies," summarized in Memorandum 3310-89-0017 (May 10, 1990), the licensee added instructions to applicable procedures which verified that the idle pump was not windmilling (turning backwards). Lack of windmilling was used to confirm the closed function of the idle pump discharge check valve.

7.0 Training

The inspector reviewed the training provided to personnel involved in the maintenance, inspection, and testing of check valves at TMI-1. The lesson plan for the classroom phase of maintenance craft training appeared comprehensive and addressed the check valve types present in the plant. The On Job Training (Qualification Card) portion of the program utilized several actual check valves, and the training emphasized identification and importance to valve malfunction of valve deficiencies contrived by the instructors. Emphasis was also placed on proper check valve reassembly, especially the seal rings for Crane tilting disc check valves. The effectiveness of the training programs was evident in the low rework rates experienced by the plant and the leak-tightness of Crane valves following the disassembly and inspection of numerous valves during the 9R refueling outage. No deficiencies or weaknesses were found with the licensee's training program for maintenance craft.

8.0 Maintenance Program

Maintenance activities utilize the results of inservice testing, non-intrusive evaluations, engineering evaluations and disassembly inspection activities. The sampled maintenance records show the efforts of a continuing process to improve or maintain good check valve performance.

8.1 Preventive Maintenance

Check valve failures are relatively low in number. Extensive modification of Crane tilting disc check valves to all installed valves of this type in the 1976-81 time frame drastically reduced failures of these valves. More recently, the increased frequency disassembly and repair techniques for Walworth model 5341 swing check valves has improved the failure record of these valves. The plant's involvement with non intrusive testing and the lengthening of disc stops to eliminate flutter has shown good results.

The inspector reviewed specific check valve maintenance procedures 1410-V-18 and 1410-V-31. The first provides the instructions to disassemble, inspect, clean, repair and reassemble check valves (except for Crane tilting disc valves). The second provides similar instructions for the Crane tilting disc valves. Both procedures provide detailed instructions for an as-found inspection, documentation of data, measurement criteria, repair instructions, and post maintenance testing requirements. These procedures were enhanced with valve drawings and parts sketches.

The inspector found that, since 1987, over 75 separate disassembly or NIT activities had been performed on the group of 57 valves described in paragraph 3.1. One valve, NS-V10A, had received three NITs and two disassemblies over the period, and the valve backstop had been lengthened twice during the disassemblies. The inspector also found that 18 of the 67 IST-only category of check valves were disassembled and inspected periodically due to IST program requirements, and that the same maintenance procedures applied to the work on these valves. The inspector concluded that the licensee's program for monitoring plant check valves for abnormal wear, degradation and failures was effective.

8.2 Failures and Corrective Maintenance

The inspector reviewed the maintenance history of check valve failures and determined there have been very few failures. The review of an NPRDS report of TMI-1 check valve failures since 1987 identified only six failures. The specific job orders for three of those failures (valves MUV44A, NRV20B, and NRV20A) were reviewed in detail. For the three valves that failed, the

maintenance histories did not reveal a trend for identifying the failure. The corrective actions for all valves reviewed were found to be appropriately supported with good evaluations of the problem and an engineering directed resolution.

Earlier problems were also reviewed and it was apparent that engineering was fully involved with effective check valve corrective actions. The large scale rework and improvements of all 23 Crane tilting disc check valves with failed seat ring and internals, and fabrication inconsistencies were identified in LER 80-03. The 1986 improvements made to the Walworth swing check valve MS-V9A found without the nut and cotter pin that retains the disc on the hinge arm were also good engineering and maintenance accomplishments. Further, stop pins were installed in 4 vertically oriented valves in response to IE Circular 78-15 even though there were no indication of discs hanging open.

Most recently the IST leak test failure of MV-14A in the 9R outage (November 1991) showed good corrective actions. A wire edge on the seat of this valve was removed by a lapping tool devised in the maintenance shop and post repair leakage was non existent.

9.0 Trending

The procedure AP 1073, "Maintenance History Assessment," outlines requirements and responsibilities to implement a history assessment. This procedure defines the multi-failure criteria that initiates trending actions, quarterly reviews and graphic display of check valve failure information.

Recent check valve maintenance history shows few safety-related check valve failures. Of the six failures since 1987, none fit the multiple failure trending criteria. The inspector determined that only one check valve trend report was issued in the past several years. It was trend report 88-12 for secondary river water check valve SR-V9C, a non safety-related valve that stuck open twice. This was a Walworth model 5341 check valve that already is in a comprehensive disassembly and inspection program. However, because of the trend report, the disassembly frequency of this valve was shortened.

The inspector concluded that the testing and maintenance programs reduced failures and have diminished the need for trending.

10.0 Use of Non-Intrusive Test Methods

The inspector reviewed the licensee's use of non-intrusive testing to assess check valve conditions, and found that they had initiated extensive testing in early 1988 utilizing the MOVATS "Checkmate" ultrasonic methods. Machinery records indicated that 19

NIT measurements had been performed on 14 valves and that this testing had been effectively used to determine valve disc "flutter" on valves with low flow velocities, which subsequently led to valve disassembly and modifications to reduce or eliminate abnormal valve disc oscillations. Some measurements were performed on modified valves to confirm the effectiveness of the modifications in improving valve stability; in the case of NS-V10A, a second modification to lengthen the valve disc backstop was performed to further improve the stability.

The licensee was continuing to evaluate acoustic and magnetic monitoring equipment provided by several vendors and assess the increased capability for NIT of check valves afforded by these techniques. There presently was a preference to utilize vendor equipment and technicians for measurements rather than purchase equipment for in-house use, based on the continuing improvements in the technology.

The use of non-intrusive testing for check valve performance was proactive and effective. No deficiencies or weaknesses were found during the inspection.

11.0 Walkdown Observations

The inspectors performed walkdowns to observe condition of check valves in the plant. Observations were made of check valves NS-V10B, DH-V14A, EF-V11B, EF-V13, CO-V30 A/B/C, and MV-V73C. The inspectors noted the ultrasonic transducer attachments on several of these valves. The external valve conditions were excellent and each of these valves were noiseless.

During the walkdown, noises of the disc fluttering against its stop were heard in valve 1C-V13A, a horizontally mounted discharge check valve off the intermediate closed cooling water pump. The inlet piping was noted to have a large expansion from the pump to the valve. From the inspectors followup of this valve after the walkdown, it was determined that the disc stops were lengthened and fluttering was reduced but not eliminated, and the licensee is considering additional repair.

The walkdown observations provided confirmation of the licensee's effective check valve maintenance. The general plant housekeeping was also found to be excellent.

12.0 Management Involvement

There was confirmation of management involvement in check valve activities. A memorandum from the GPU Nuclear president, Phil Clark, on July 1, 1988 directed the staff to respond to industry check valve issues after the San Onofre check valve related event.

Management supports participation in industry activities involved in improving check valve performance such as the Nuclear Industry Check Valve (NIC) group and the ASME OM-22 codes and standards group.

Lower levels of management have recognized the need to address check valve problems and have authorized evaluations and corrective actions when required. The directors of site engineering and operations/maintenance are cognizant of the check valve program effort and the occurrences of check valve failures. IST of check valves is being implemented in accordance with the program submittals.

13.0 Unresolved Items

Unresolved items are matters about which more information is required in order to ascertain whether they are acceptable items, violations or deviations. Four unresolved items are identified in this report, one in paragraph 3.1, two in paragraph 3.2, and one in paragraph 4.0.

14.0 Conclusions

Based on the inspection findings it was concluded that the licensee's activities in addressing check valve failures is effective as evident in low failure rates. The strong performance in finding problems, correcting them, considering generic implications, training programs, and proactive use of NIT provides assurance that installed check valves will perform their function.

The engineering staff was extremely knowledgeable and technically competent in check valve issues and the IST program and testing issues. Similarly, maintenance personnel were also technically competent in check valve repairs and there is a close working relationship of engineering, operations and maintenance.

Several findings pointed to problems in not having single entity controlled programmatic descriptions of both the IST program and the industry check valve program, in review of calculations, and determinations for several valves not included in the program.

15.0 Exit Meeting

This inspectors met with the licensee's representatives denoted in Appendix A on February 28 and May 1, 1992, to summarize the findings of this inspection.

APPENDIX A

Persons Contacted

GPU Nuclear

* D. Atherholt, Operations Engineer
*+ T. Basso, Lead Mechanical Plant Engineer
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* T. Broughton, Director of TMI-1
* W. County, QA Audit Manager
*+ M. Feary, Plant Material Assessment
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* B. Knight, Licensing Engineer
* D. Laudermilch, Maintenance Training Manager
* R. Rogan, Licensing Director
+ M. Ross, Director, Operations and Maintenance
* D. Skillman, Plant Engineering Director
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* D. Beaulieu, Resident Inspector - TMI 1
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* Denotes presence at exit meeting on February 28, 1992
+ Denotes presence at exit meeting on May 1, 1992