TEMPORARY INSTRUCTION 2515/110 REVISION 1

PERFORMANCE OF SAFETY-RELATED CHECK VALVES

SALP CATEGORY: MAINTENANCE (SOMS)

2515/110-01 OBJECTIVE

The objective of this temporary instruction (TI) is to determine the effectiveness of the activities by licensees to provide assurance of the operability and reliability of check valves in safety-related systems. This TI is intended to provide a comprehensive evaluation of the check valve activities. The long term objective is to incorporate this TI into a comprehensive inspection procedure for addressing experience gained from conduct of check valve program activities at a nuclear power plant.

2515/110-02 BACKGROUND

The NRC regulations require that check valves be treated in a manner that assures their performance be maintained at an acceptable level. 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 Appendices A and B to 10 CFR Part 50, Section 50.55a references the ASME Boiler and Pressure Vessel Code. Paragraph (g) of Section 50.55a requires that the provisions of Section XI of the ASME Code be met for inservice testing of components covered by the ASME Code. NRC staff inspections of the Section XI program are performed in accordance with Inspection Procedure 73756, "Inservice Testing of Pumps and Valves."

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 verified their ability to perform their safety-related functions.
On April 3, 1989, the NRC staff issued Generic Letter 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. That 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 Generic Letter 89-04 is provided in the minutes of the public meetings held by the staff to discuss the generic letter. Those minutes were distributed to licensees, permit holders, and meeting attendees by a letter dated October 25, 1989, from James G. Partlow, NRC.

The Office for 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.

In 1991 the staff recognized the need for an accurate and comprehensive industry historical failure review to assess the status and subsequent trends in check valve performance and reliability. The staff reviewed the published summary report of industry's data base of check valve failures. The report was found inadequate. With the assistance of the Oak Ridge National Laboratory (ORNL), RES prepared an evaluation report of industry check valve failure rates and the factors and conditions affecting failure rates. The report correlates valve failure rates with characteristics of valve age, valve size, systems of service, valve usage, manufacturer, failure mode, discovery process and detection method, failure area and extent of degradation. The staff issued the completed RES/ORNL report September 1993, in NUREG/CR-5944, "A Characterization of Check Valve Degradation and Failure Experience in the Nuclear Power Industry."

In 1992 the staff presented concerns and the results of trial audits using TI 2515/110 regarding licensee's check valves activities during the Second NRC/ASME Symposium on Pumps and Valves in the session on Regulatory and Operability issues.

The NRC Temporary Instruction (TI) 2515/114, "Inspection Requirements for Generic Letter 89-04, Acceptable Inservice Testing Programs," dated January 15 1992 was issued to be used by inspectors to assess the effectiveness of licensees's IST Program.

2515/110-03 INSPECTION REQUIREMENTS

03.01 Verify that the licensee has a program in place to ensure the operability of check valves in safety-related systems.

a. Select a sample of safety-related check valves and verify they are addressed in the licensee's check valve program. The inspector should review the Technical Specifications, the IST Program and the Final Safety Analysis Report (FSAR) to select valves that should be addressed for this inspection verification.

b. Review the scope of the check valve program, the tests performed on check valves, preventative maintenance activities, the instrumentation used for the tests and verify that vendor supplied skid-mounted check valves are included in the program. Describe the scope of check valve activities briefly in the inspection report.

03.02 From the sample selected:

a. Verify that the check valves in the sample are included in a testing program.

b. Review maintenance activities, including maintenance history records for the sampled check valves, to determine whether a trend performance process exists to identify degradation before failure, and whether appropriate corrective actions are taken based on the maintenance results.

c. If a sampled check valve has a history of failure during service or demonstrated inability to meet test acceptance criteria, verify that, in each instance of failure or inability to meet acceptance criteria, the licensee or permit holder: (1) initiated a deficiency report, (2) follows NRC regulatory and technical specification requirements for system operability and reporting, and (3) initiated and implemented work requests to conduct trouble shooting, repairs and corrective actions, or redesign, as appropriate.

d. Review any third party or vendor reports regarding notification of cautions to observe as the result of any failures that have occurred at other sites, and evaluate the licensee's action upon receipt of this industry information.

e. Conduct a walkdown to inspect the sampled check valves to assess application of processes, material condition (including internals, when accessible through in-progress maintenance), and installed configuration to the extent possible.

f. Perform a review of the design documentation for each sampled check valve to determine whether the key attributes (valve type, installed location, orientation, sizing, and materials) were properly considered in the selection of the valve for its application.

g. Evaluate the types and extent of use of non-intrusive testing methods employed.

h. Evaluate the extent to which important check valves are reverse flow closure tested.

i. Evaluate the extent of design application review, and implementation of its results.

j. Evaluate implementation of a preventative maintenance program.

k. Record the overall check valve failure rate (failure(s) per year).

03.03 Verify that appropriate trending of check valve failures, maintenance, and test results is conducted. Review failure rate trend records and evaluate the causes of the trends. Ensure that effective action is taken to prevent repetitive failures.

03.04 Verify management involvement by the licensee in the development and implementation of a comprehensive program to provide assurance of the operability and reliability of check valves at the plant.

2515/110-04 INSPECTION GUIDANCE

Specific Guidance

04.01 Inspection Requirement 03.01. The inspector should be aware of the scope and extent of check valve activities of the plant under review. Testing requirements are contained in 10 CFR 50.55a and ASME Section XI. Plant specific application of these requirements may be derived from plant technical specifications, Final Safety Analysis Report, the applicable edition of Section XI of the ASME Code, and licensee commitments associated with staff safety evaluation reports, the licensee's Section XI IST program, Generic Letter 89-04, and the minutes of the public meetings on Generic Letter 89-04.

Further, these documents may be applicable to certain check valves and not to others. For example, the IST requirements of Section XI of the ASME Code apply to check valves within the scope of the Code. The inspector should evaluate the results of the IST Program
inspection conducted using TI 2515/114 to ensure that the safety functions of the check valve have been identified and that the check valve has been properly categorized. If an IST Program inspection using TI 2515/114 has not been performed, evaluate the licensee's IST performed on check valves selected from the sample.

In Generic Letter 89-04, the staff indicated that testing of check valves is not limited to those covered by the ASME Code. Appendix B to Part 50 describes the quality assurance program which includes testing of safety-related components. Documentation that provides assurance of operability of non-Code components through performed testing, system operation, maintenance, or some combination of these should be available at the plant site. The Code-required IST program is an example of a reasonable vehicle that a licensee may elect to use for testing of non-Code check valves. In addition to testing, the licensee should have programs in place to provide corrective and preventative maintenance and to ensure proper design applications.

04.02 Inspection Requirement 03.02. The inspector should address check valve design, maintenance and testing by evaluating a sample of the check valve population. The selection of a check valve sample can be based on different techniques. For example, if a small number of check valves is to be sampled (10 to 30), the selection of check valves should be biased toward those whose failure could challenge operating conditions or that have a marginal design for their application. The sample should include Pressure Isolation Valves (PIVs). Some of the candidates for the check valve sample can be identified by conducting a plant-specific review of failure records in the Licensee Event Reports (LERs). Check valves that have a higher incidence of failures according to industry-wide data should also be considered for selection as part of the sample. For example, as discussed in a memorandum, dated July 14, 1986, from E. Yachimiak, to E. Merschoff, a NRC staff review of industry-wide data found that certain check valves had a higher incidence of failure. These systems include main steam, nuclear service water, auxiliary feedwater (PWR), diesel air start, suppression pool support (BWR), chemical and volume control (PWR), and residual heat removal/low pressure injection. Additionally, candidates for the sample could be found from a review of a plant-specific or a generic type probabilistic risk assessment (PRA), if available, to determine those systems and check valves whose failure leads to a significant increase in core melt probability.
Another technique of check valve sampling is to select randomly a large number of check valves (50 to 100). The inspector would then review maintenance histories of the past several years for common problems and trends. If this technique is used, the inspectors should request that this, as well as other necessary information, be available at the beginning of the inspection. Based on this historical review, a smaller group of appropriate valves could then be selected for detailed evaluation.

a. Inspection Requirement 03.02.a &.h. Inspection Procedure 73756, "Inservice Testing of Pumps and Valves," provides guidance on the sources of requirements for check valve testing. NRC guidance for the testing of check valves is also outlined in Positions 1 through 4 of Generic Letter 89-04. The minutes of the public meetings on Generic Letter 89-04 provide additional guidance on the testing of check valves (such as satisfying the FSAR flow requirements during forward flow testing). The NRC issued Temporary Instruction TI 2515/114 to be used by inspectors to assess the effectiveness of licensees's IST Programs. The inspector should review the IST Program inspection results and licensee's commitments with regard to these documents.

In responding to Generic Letter 89-04, the inspector should note whether or not the licensee is performing unnecessary check valve disassembly where in situ testing could actually be performed instead. Recent improvements in technology are facilitating check valve testing so that disassembly for Code purposes can be minimized. Some of these techniques include use of new high accuracy strap-on flow meters and radiography for verifying disk position. Other non-intrusive testing, such as acoustics, ultrasonics and magnetic flux, are being qualified and appear to be promising. Licensees are expected to have a description of the basis for the acceptance criteria for the alternative testing and a description of corrective actions to be taken if the acceptance criteria are not met. Position 1 of Attachment 1 to Generic Letter 89-04 provides guidance on qualifying alternative techniques.

On March 13, 1987, the staff issued Generic Letter 87-06, "Periodic Verification of Leak Tight Integrity of Pressure Isolation Valves," which requested licensees to submit a list of all PIVs. Among these PIVs are those referred to as Event V PIVs, which are two check valves in series at an interface between the reactor coolant system and a low pressure system whose failure may result in a loss-of-coolant accident that bypasses containment. For each valve, licensees were requested to describe (1) the periodic tests or other measures performed to ensure the integrity of the valve, (2) the acceptance criteria for leakage tests, (3) operational limits, and (4) frequency of test performance. The results of this survey of PIV testing is provided in a memorandum dated October 19, 1987, to Karl Kniel from Robert L. Baer in the Office of Nuclear Regulatory Research. Based on the survey, it was concluded that PIV leak rate testing varies widely from licensee to licensee and that a number of older plants do not leak test some or all of their PIVs. Position 4 of Generic Letter 89-04 indicates that concerns persist with respect to the testing of PIVs at the plants.

At present, detailed requirements are not available for the testing of check valves that are located within systems important to safety, but are not included in the Section XI IST program. The inspector should consider the testing methods used by the licensee for acceptability. The intent of 10 CFR Part 50 Appendix A, GDC-1 and Appendix B, Criterion XI is that all components necessary for safe operation be tested to provide assurance of reliability and operability. While 10 CFR Part 50.55a delineates testing requirements for only Code components, a program similar to the Code-required IST program would provide a reasonable example of a method for inservice testing of non-Code check valves.

The inspector should determine whether quality control (QC) involvement is appropriate and whether test results are properly analyzed, necessary corrective action is taken and preventative needs are addressed.

b. Inspection Requirement 03.02.b,.g, & .j. The licensee should perform preventive maintenance on check valves in safety-related systems. Procedures should be developed to incorporate appropriate vendor recommendations with respect to preventive maintenance. Such maintenance should be performed at established intervals.

Certain licensees have incorporated into their preventive maintenance programs the use of non-intrusive techniques, such as acoustic emissions and radiography. Even where such non-intrusive techniques are used, however, the staff believes that periodic disassembly and visual inspection should be performed to assess the effectiveness of the testing to detect degradation and to determine the need for valve refurbishment. Note whether the licensee has any justification for any safety-related check valve that they do not intend to disassemble and inspect.

The licensee or permit holder should develop guidelines for periodic disassembly and visual inspections of the different types (e.g., swing, lift, duo-disk, and stop) of check valves. Frequency of the periodic inspections should be established and, ideally, should be based on service history. The guidelines should identify the type of valve and other important valve-specific information. Attributes of a good visual inspection program should, as a minimum, include checks for (1) external and internal valve body conditions, (2) disc and seat conditions, (3) the condition of the hinge, hinge pin, and other internal parts and materials, and (4) dimensions of the various items, with appropriate acceptance criteria delineated. The condition of various items should be evaluated for cracks, leaks, corrosion, foreign materials, and pitting, and also whether internal and external parts are loose, bent, misaligned, broken, or missing. Changes of dimensions should be evaluated and trended to detect the extent and rate of check valve degradation. The inspector should also verify that all disassembled check valves are post-maintenance tested by full or partial flow and reverse flow closure verification to the extent practical.

The inspector should evaluate the preventive maintenance programs established by the licensee by reviewing procedures and, as time permits, by observing these activities in progress, and reviewing their results. Along this line, the inspector should review a sample of completed work packages and, where possible, should directly observe work in progress to determine the adequacy of inspection acceptance criteria. The inspector should trace degradation trends for several valves and should attempt to correlate gross changes with the timing of performed maintenance. The inspector should also determine whether QC involvement is appropriate to the activity and whether hold points for QC signoff are incorporated in the maintenance procedures as warranted.

c. Inspection Requirement 03.02.c, & d. It is important that the licensee initiate deficiency reports on check valves that fail during service or do not pass acceptance criteria during testing. If the review of several deficiency reports on check valve failures indicates that a program or process is weak, the adequacy of the program or process should be reviewed by the inspector. If a check valve has a history of failure that has been the subject of an industry or NRC generic communication, the inspector should determine the adequacy of the licensee's action to address the generic issue. A methodical approach to root cause and corrective action determination should also exist with appropriate management oversight and involvement by the quality assurance (QA) organization. The inspector should review the adequacy of deficiency reports in determining the root cause of the problem and in directing appropriate corrective actions. The effectiveness of the process would be suspect if repeated failures for the same or related check valve have occurred since the deficiency was first observed and addressed. Possible root causes for the check valve failures could be improper design and inadequacies in testing procedures, training, engineering, maintenance, scheduling, and performance trending.

If a failed check valve is covered by plant technical specifications (such as through surveillance requirements in the Section XI IST program, the system being directly covered, the system being considered a support system, or the check valve being a PIV or containment isolation valve), the licensee should have made a determination of operability and should have taken the appropriate action required by the technical specifications. Additionally, the licensee should have assessed the valve failure pursuant to the reporting requirements of the NRC regulations (such as 10 CFR 50.72 and 50.73), and taken action as warranted.

d. Inspection Requirements 03.02.e,.f & .i. These inspection requirements are primarily to address material, part condition, and installed location/orientation of the sampled check valves. The inspection evaluation of check valve design and

application may be performed by reviewing certain characteristics. EPRI Manual NP-5479, "Application Guidelines for Check Valves in Nuclear Power Plants," may provide useful information for this evaluation. The check valve design and application should have been reviewed by the licensee for adequacy as part of its original design or a more recent design review effort. The following check valve key attributes should have been addressed in the review:

1. Valve type. Swing check, tilting disc check, and lift check valves are all suited for a particular range of service applications. Considerations for valve type selection are based on the range of flow velocities, required closing time, allowable leakage rate, allowable pressure drop across valve, and required seating/unseating pressure.

2. Location with respect to sources of turbulence. Installation of check valves close to elbows, tees, and pump discharge outlets can subject the valve to turbulent flow conditions resulting in damage due to repeated disc oscillation.

3. Size. Oversizing for a given fluid flow may result in the valve not being held in the fully open position, which may cause disc flutter. Undersizing may cause excessive fluid velocities resulting in turbulent flow and excessive disc movement, and possible cavitation- induced damage.

4. Orientation. Installed orientation should be consistent with the design orientation recommended or required by the valve manufacturer.
5. Materials. Proper selection of check valve component materials for the intended service is critical for the long term operation and availability of check valves.

e. Inspection Requirement 03.02.k. No inspection guidance provided.

04.03 Inspection Requirement 03.03. The inspector should determine whether the licensee has established a program for trending check valve failures, maintenance, and test results. Trending is the analysis of data to detect degradation of tested components in order to enable preventive maintenance to be performed before significant problems occur to challenge component operability. The inspector should determine whether the trending information is incorporated in the maintenance programs or considered in determining monitoring or inspection frequency. Based on the test and maintenance histories, the inspector should determine the adequacy of the failure analysis and corrective action for identified problems.

The inspector should attempt to perform an independent review of maintenance and test records. For example, from the review the inspector could trace trends of several valves and might correlate gross changes in trends with the performance of maintenance. The inspector might also correlate the original data for several given valves with the data recorded on trending graphs (if used by the licensee).

04.04 Inspection Requirement 03.04. The inspector should determine if (1) significant discussions are consistently being held at a level that ensures adequate management review, (2) corporate management is cognizant of work done to ensure operability of check valves, (3) safety review committees and feedback from QA/QC activities are used to improve effectiveness of check valve integrity improvement programs, and (4) management has communicated expectations to the involved organization(s) regarding the various aspects of check valve performance and all involved levels of the organization understand and are attempting to meet them. A measure of the extent of management involvement in the development and implementation of a comprehensive check valve program is the quantity and significance of the deficiencies found during the inspection. Other measures of management involvement are licensee's participation in industry

activities such as the ASME O&M Code and the Nuclear Industry Check Valve Group (NIC) aimed at improving the performance of check valves; and licensee inspection and maintenance activities and programs related to balance of plant check valves.

2515/110-05 REPORTING REQUIREMENTS

The inspector is to document the activities associated with the TI in routine inspection reports. A copy of the inspection reports should be sent to the Chief, Mechanical Engineering Branch, Division of Engineering Technology, NRR (OWFN 7-E-23).

2515/110-06 COMPLETION SCHEDULE

It is anticipated that inspections using this TI will be conducted on the basis of two persons for one week per site. The TI inspection effort should be completed when a minimum of 50% of the plants in each region are inspected. For the long term it is anticipated that this TI will be incorporated into a comprehensive inspection procedure to address all check valve activities at a nuclear plant.

2515/110-07 EXPIRATION

This TI will remain in effect to December 15, 1995.

2515/110-08 CONTACT

Questions concerning this TI should be addressed to Francis Grubelich, EMEB/DE/NRR, (301) 504-2784.

2515/110-09 STATISTICAL DATA REPORTING

Direct inspection effort for this TI should be reported against 2515/110 for RITS reporting.

The SIMS issue number for this TI is GL-89-04.

The lead LPM for this TI is James Raleigh, NRR/PD1-2.

2515/110-10 ORIGINATING ORGANIZATION INFORMATION

10.01 Organizational Responsibility. EMEB/NRR initiated this TI as part of its responsibility for coordination of NRC review of check valve activities. EMEB will assist and support inspections conducted using this TI. EMEB will review the results of inspections performed by headquarters and regional personnel. Based on that review and other information, EMEB will evaluate the need for additional regulatory action.

10.02 Resource Estimate. Inspection effort expended on this TI will be limited to two inspectors for one week per site. Initially this effort may be augmented by one contractor per week per site.

10.03 Followup Inspections. Followup inspections performed as a result of implementing this TI will be charged against IP 62702, "Maintenance Program."

10.04 Training. Training is to be provided by including one EMEB staff member in at least one inspection per region. A document containing training material will be provided to each region by EMEB.

2515/110-11 REFERENCES

Generic Letter 87-06, "Periodic Verification of Leak Tight Integrity of Pressure Isolation Valves" (NUDOCS 49208/320 - 49209/030)

Generic Letter 89-04, "Guidance on Developing Acceptable Inservice Testing Programs" (NUDOCS 49208/320 - 49209/030)

Information Notice 88-85, "Broken Retaining Block Studs on Anchor Darling Check Valves" (NUDOCS 69536/205)

Information Notice 88-70, "Check Valve Inservice Testing Program Deficiencies" (NUDOCS 46713/095)

Information Notice 86-09, "Failure of Check and Stop Check Valves Subjected to Low Flow Conditions" (NUDOCS 34535/326 - 34536/099)
Inspection Procedure 73756, "Inservice Testing of Pumps and Valves."

Letter (October 25, 1989) from J. Partlow, NRC, to all holders of nuclear power plant operating licenses and construction permits, and meeting attendees, forwarding minutes of public meetings on Generic Letter 89-04. (NUDOCS 52212/114-198)

Memorandum (July 14, 1986) from E. Yachimiak to E. Merschoff providing an evaluation of check valve failure data. Document accession no. 8607160467 (NUDOCS 68475/308)

Memorandum (October 19, 1987) from Robert L. Baer to Karl Kniel providing results of PIV testing survey. (NUDOCS 69718/309)

Title 10, Code of Federal Regulations, Part 50; Sections 50.55a, 50.72, and 50.73; and Appendices A and B.

NUREG-1352, "Action Plans For Motor-Operated Valves and Check Valves," June 1990

Memorandum (July 25, 1989) from J.W. Roe (DLPQE/NRR) to J.E. Richardson (DET/NRR), "Check Valve Issues" (NUDOCS 59240/176).

NUREG/CR-5944/ORNL-6734, "A Characterization of Check Valve Degradation and Failure Experience in the Nuclear Industry" September 1993.

Temporary Instruction (TI) 2515/114, "Inspection Requirements for Generic Letter 89-04, Acceptable Inservice Testing Programs," November 19, 1991.

NUREG/CP-0123/EGG-2676, "Proceedings of the Second NRC/ASME Symposium on Pump
and Valve Testing" July 1992.

END