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Examples, Clarifications, and Guidance on Preparing Requests for Relief from Pump and Valve Inservice Testing Requirements

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Prepared for
U.S. Nuclear Regulatory Commission

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ABSTRACT

In this report, the Idaho National Engineering Laboratory reviewers discuss issues related to requests for relief from the American Society of Mechanical Engineers Code requirements for inservice testing (IST) of safety-related pumps and valves at commercial nuclear power plants. This report compiles information and examples that may be useful to licensees in developing relief requests and implementing IST programs. The report includes numerous examples of relief requests submitted to U.S. Nuclear Regulatory Commission (NRC) for their consideration and provides insights and recommendations on related IST issues. The report also gives specific guidance on relief requests acceptable and not acceptable to the NRC and advises licensees in the use of this information for application at their facilities.

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ABBREVIATIONS

ADS	automatic depressurization system
AFW	auxiliary feedwater
ALARA	as-low-as-reasonably-achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BWR	boiling water reactor
CFR	*Code of Federal Regulations*
CIV	containment isolation valve
CRD	control rod drive
CS	containment spray
CSD	cold shutdown
DHR	decay heat removal
ECCS	emergency core cooling system
EDG	emergency diesel generator
EFW	emergency feedwater system
ESG	engineered safeguard
ESW	emergency service water
EPRI	Electric Power Research Institute
FMEA	failure modes and effects analysis
FST	full-stroke exercise test
GE	General Electric Company
GL	NRC Generic Letter
HCU	hydraulic control unit
HHSI	high head safety injection
HPCI	high-pressure coolant injection
HPCS	high pressure core spray
HVAC	heating, ventilating, and air conditioning
INEL	Idaho National Engineering Laboratory
INPO	Institute for Nuclear Power Operations
IST	inservice testing
LCO	limiting condition for operation
LHSI	low head safety injection
LLRT	local leak rate test
LOCA	loss-of-coolant accident
LOOP	loss-of-offsite-power
LPCS	low pressure core spray
LPSW	low pressure service water
MHA	maximum hypothetical accident
MOV	motor-operated valve
MSIV	main steam isolation valve
NIE	non-intrusive examination
NPRDS	Nuclear Plant Reliability Data System
NRC	U.S. Nuclear Regulatory Commission
NUMARC	Nuclear Management and Resources Council
OM	Operations and Maintenance
PIV	pressure isolation valve
PTC	Performance Test Code
PUAR	plant unique analysis report
PWR	pressurized water reactor

RBCCW	reactor building closed loop cooling water
RCM	reliability centered maintenance
RCS	reactor coolant system
RCIC	reactor core isolation cooling
RFO	refueling outage
RHR	residual heat removal
RMS	root-mean-square
RWCU	reactor water cleanup
RWST	refueling water storage tank
SBLC	standby liquid control
SLC	standby liquid control
SIT	safety injection tank
SOER	Significant Operational Event Report
SOV	solenoid-operated valve
SRV	safety/relief valve
SW	service water
TS	technical specification
VCT	volume control tank

EXECUTIVE SUMMARY

The Idaho National Engineering Laboratory (INEL) prepared this report as part of its support to the U.S. Nuclear Regulatory Commission (NRC) to assist the industry in improving and standardizing requests for relief from the requirements of the industry Codes and standards. These Codes and standards are in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code and the ASME/American National Standards Institute (ANSI) Operations and Maintenance (OM) *Standards*, Part 6 (ASME 1988a), "Inservice Testing of Pumps in Light-Water Reactor Power Plants," (OM-6) and Part 10 (ASME 1988b), "Inservice Testing of Valves in Light-Water Reactor Power Plants" (OM-10). The guidance in this report may be used to assist the user in preparing relief requests and improve the quality and consistency of the requests. Implementation of the guidance is strictly voluntary.

This document was developed to accomplish the following purposes:

(1) To give examples of relief requests submitted by many licensees for a multitude of pumps and valves for diverse reasons.

(2) To give guidance on information that needs to be included in relief requests for prompt staff approval.

(3) To clarify a number of issues that have been identified in reviews of relief requests and through participation on the OM committees.

(4) To clarify certain ASME Code issues.

FOREWORD

The information provided in this report is not intended to convey any new requirements or positions on inservice testing (IST). Where the requirements of NRC regulations or the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (the Code), as incorporated into the regulations, are discussed, the terms *shall, must, requires,* or *requirements* are used consistently to indicate their mandatory nature.

Only guidance on preparing relief requests is intended, the depiction of example relief requests that have been determined by the staff to be acceptable does not indicate that the same request would be determined to be acceptable in other situations (e.g., different components or different facility configurations). Where a recommendation is made, the licensee may choose whether or not to follow the guidance. The discussion of previous guidance issued in Generic Letter (GL) 89-04, NUREG 1482, or other NRC documents does not convey new requirements.

1 INTRODUCTION

Section 50.55a of Title 10 of the *Code of Federal Regulations* (10 CFR 50.55a) defines the requirements for applying industry codes and standards to boiling or pressurized water-cooled nuclear power facilities. The American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* (the Code), Section XI, Subsections IWP (ASME 1986a) and IWV (ASME 1986b), specify the inservice testing (IST) requirements for pumps and valves. The 1989 Edition of Section XI was incorporated by reference into paragraph 50.55a(b) by the rulemaking effective September 8, 1992. The 1989 Edition specifies that the rules for the IST of pumps and valves are stated in the ASME/American National Standards Institute (ANSI) *Operations and Maintenance* (OM) *Standards*, Part 6 (ASME 1988a), "Inservice Testing of Pumps in Light-Water Reactor Power Plants," and Part 10 (ASME 1988b), "Inservice Testing of Valves in Light-Water Reactor Power Plants."

Licensees are required to test certain safety-related pumps and valves in accordance with the Code. The regulations allow that where a test requirement of the Code is determined to be impractical for a facility, the licensee may submit requests for relief from the Code with information to support the determination. Relief requests generally detail the reasons for deviating from the Code requirements and describe proposed alternate testing. The U.S. Nuclear Regulatory Commission (NRC) is authorized to evaluate the relief requests and may grant relief or impose alternative requirements, considering the burden upon the licensee that could result if the requirements were imposed on the facility. The Director of the Office of Nuclear Reactor Regulation may also authorize alternatives to the requirements of 10 CFR 50.55a, including Code requirements, pursuant to 10 CFR 50.55a (a)(3)(i) and (a)(3)(ii) if the alternatives ensure an acceptable level of quality and safety or the requirements present a hardship without a compensating increase in the level of quality and safety. Finally, when licensees find special circumstances, specific exemptions from the regulations may be requested in accord with 10 CFR 50.12 (e.g., a request to implement a risk-based IST program).

Paragraph (f)(4)(iv) in 10 CFR 50.55a specifies that inservice tests of pumps and valves may meet the requirements in subsequent editions and addenda that are incorporated by reference in paragraph 50.55a(b), subject to the limitations and modifications listed in paragraph 50.55a(b), and subject to Commission approval. Portions of editions or addenda may be used if all related requirements are met. NRC approval may be indicated in generic communications or may be through specific requests from licensees. The discussions in this report are for information only and do not represent NRC staff positions.

Synopsis of Report

Section 1 provides an introduction. Section 2 addresses valve relief request issues and includes Subsections on power operated valves, check valves, relief valves, and general valve issues such as leak rate testing. Each Subsection identifies existing IST requirements and guidelines for that component type. The Subsections are further divided based on specific issues that formed the bases for relief requests reviewed as part of this project. Each of these areas contained a discussion of the requirements and one or more examples of the relief requests submitted by commercial licensees that dealt with the issue. After the examples, a summary and additional comment paragraph is provided to summarize the salient points brought out in the examples. Section 3 addresses pump relief request issues and includes Subsections on test frequency, flow measurement, differential pressure, use of pump curves for establishing acceptance criteria, vibration measurements, instrumentation, and temperature measurement. These Subsections contain similar information as the valve subsections.

Throughout Sections 2 and 3, issues are discussed for which plants have requested relief. The enclosed examples and suggestions provide indication of the type of information that would typically

2 VALVE RELIEF REQUESTS

The following sections of this report address issues that have resulted in the submission of relief requests from the inservice testing (IST) Code requirements for various types of valves in safety-related systems of nuclear power plants. These valve-related issues have been divided into the following five major sections; 2.1) power-operated valves, 2.2) check valves, 2.3) relief valves, 2.4) containment isolation valve (CIVs), and 2.5) pressure isolation valves.

2.1 Power-Operated Valves

This section addresses relief request issues for power-operated valves. This section is divided into the following subsections: 2.1.1, test frequency; 2.1.2, stroke timing of power-operated valves; 2.1.3, stroke timing rapid-acting valves; 2.1.4, fail-safe testing; and 2.1.5, valve remote position verification. Each of these subsections begins with an introduction to the issue and a summary table of applicable requirements and related guidance. In most of the following sections, a brief summary is included to characterize the disposition of relief requests that were reviewed to develop that section. Following the introduction and requirements summary, in most cases, we provide examples of relief requests that have been submitted and reviewed by the U.S. Nuclear Regulatory Commission (NRC). For some issues, Code changes or other provisions have resolved the issue negating the need to submit relief requests. For example, changes to OM-10 (ASME 1988b) allow deferring tests to refueling outages (RFOs) without requesting relief have been approved on a generic basis in Generic Letter 89-04, Supplement 1. In these sections, examples may be provided only if they would be helpful in related areas, such as preparation of cold shutdown or RFO justifications. Following most of the examples is a section summarizing the important issues or providing additional commentary or information relative to the topic. Some examples are provided for information only and no summary is included.

2.1.1 Test Frequency

The Code specifies frequencies for the various tests that apply to power-operated valves. Plant operational considerations, design limitations, and other factors can make it impractical to comply with these Code specified frequencies. Several requests have been submitted for various reasons regarding test frequency. These requests have been granted for a variety of reasons.

Requirements

Section XI (ASME 1986a), Subsections IWV-3300, -3411, -3412, -3414, -3415, -3416, and -3422 address test frequencies for power-operated valves.

OM-10, Paragraphs 4.1, 4.2.1.1, 4.2.1.2, 4.2.1.5, 4.2.1.7, and 4.2.2.3(a) also address test frequencies for power-operated valves.

Table 2-1. Summary Table of Key Requirements and Guidance for Valve Test Frequency

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3300/ Paragraph 4.1	These sections require verification of valve position indication at least once every two years.

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3411/ Paragraph 4.2.1.1	These sections require quarterly exercising except as modified by sections IWV-3412(a), -3415, and -3416 or for OM-10, Subsections 4.2.1.2, 4.2.1.5, and 4.2.1.7.
Section XI/ OM-10	IWV-3412(a)/ Paragraph 4.2.1.2(a) through (f)	These sections specify a hierarchy of exercise test frequencies beginning at quarterly. The longest interval allowed by IWV is cold shutdown (CSD), OM-10 allows deferral to once each RFO.
Section XI/ OM-10	IWV-3414/ Paragraph 4.2.1.5	These sections address testing frequency for valves in regular use.
Section XI	IWV-3415	This section requires testing fail-safe valves every three months or during CSDs. (OM-10 defers the frequency determination to Paragraph 4.2.1.1)
Section XI/ OM-10	IWV-3416/ Paragraph 4.2.1.7	These sections address testing frequency for valves in systems out of service.
NUREG 1482 (NRC 1995)	3.1	This section of the NUREG addresses inservice test frequencies and extensions for valve testing.
NUREG 1482	3.1.1	This section discusses deferring valve testing to each CSD or RFO.

There were 53 requests regarding test frequency issues for valves other than check valves. Sixteen of the requests involved cooling water systems, nine involved automatic depressurization system (ADS) valves, and the remainder addressed a wide spectrum of test frequency related issues. The issues illustrated with the following examples no longer involve requests for relief, but are now issues for CSD or RFO justifications. This is because changes to the test frequency requirements as contained in OM-10, Paragraph 4.2.1.2, permit deferral of full-stroke exercising until RFOs when exercising is not practicable during plant operation or CSDs. Rulemaking to 10 CFR 50.55a allows the use of portions of OM-10, provided that all related requirements are met. For many cases, relief from the test frequency requirements is no longer needed based on the rulemaking effective September 8, 1992, pursuant to 50.55a(f)(4)(iv), provided the licensee implement all related requirements of OM-10 as allowed by GL 89-04, Supplement 1, (NRC 1989) for certain portions of OM-6 and OM-10. The following examples may help plants in developing bases for extending test frequencies. Since there is little likelihood that licensees will need to request relief to extend testing to RFOs, there is no summary and additional discussion at the end of this section. The last example in this section illustrates a test frequency extension denial. In the request, the proposed frequency was not shown to be justified according to the provisions of 10 CFR 50.55a.

Example from Peach Bottom Units 2 and 3

In the following example, the licensee requested relief from exercising and stroke timing the control rod drive (CRD) scram inlet and outlet valves, in accordance with the requirements of Section XI, Paragraphs IWV-3411 and -3413(b), and proposed to verify proper valve operation during the

performance of individual control rod scram testing in accordance with plant Technical Specifications (TS).

Licensee's Basis for Requesting Relief

These valves are located on the hydraulic control units (HCU) whose function is to rapidly insert the control rods on a signal from the reactor protection system. The proper functioning of these valves as a unit is most practically verified by performing an actual scram test and measuring control rod insertion times.

Alternate Testing

The control rod scram insertion time testing required by TS 4.3.C will be performed in lieu of the Section XI testing.

a. After each RFO, and prior to synchronizing the main turbine generator initially following restart of the plant, all operable fully withdrawn in sequence rods shall be scram time tested during start-up from the fully withdrawn position with the nuclear system pressure above 800 psig.
b. After exceeding 30% power, all previously untested operable control rods shall be tested, as described above, prior to exceeding 40% power.
c. Whenever such scram time measurements are made (such as when a scram occurs and the scram insertion time recorders are operable) an evaluation shall be made to provide reasonable assurance that proper CRD performance is being maintained.

Evaluation

The reviewer stated that the NRC staff position on exercising these valves and measuring their full-stroke times is contained in GL 89-04 (NRC 1989), Attachment 1, Item 7. The GL states: "... for those CRD system valves where testing could result in the rapid insertion of one or more control rods, the rod scram test frequency identified in the facility TS may be used as the valve testing frequency to minimize rapid reactivity transients and wear of the CRD mechanisms." The GL further states: "The scram inlet and outlet valves are power-operated valves that full-stroke in milliseconds and are not equipped with indication for both positions, therefore, measuring their full-stroke time as required by the Code may be impractical. Verifying that the associated control rod meets the scram insertion time limits defined in the plant TS can be an acceptable alternate method of detecting degradation of these valves. Also, trending the stroke times of these valves may be impractical and unnecessary since they are indirectly stroke timed and no meaningful correlation between the scram time and valve stroke time may be obtained, and furthermore, conservative limits are placed on the control rod scram insertion times. If the above test is used to verify the operability of scram inlet and outlet valves, it should be specifically documented in the IST program."

Relief was recommended by the reviewer to be granted. This recommendation was based on the determination that the licensee's proposed testing was according to GL 89-04, Attachment 1, Item 7, and would provide reasonable assurance of operational readiness. The request also stated that requiring the licensee to scram all control rods quarterly during power operations would be a hardship without a compensating increase in safety.

Example from Perry Nuclear Power Plant

In this example, the licensee requested relief from the test frequency requirements of Section XI, Paragraphs IWV-3411 and -3521, for the drywell and containment airlock accumulator supply check and equalizing ball valves listed in the request. The licensee proposed to exercise the containment airlock valves at least once every six months and the drywell airlock valves during CSD if they have not been tested within the previous six months.

> Licensee's Basis for Requesting Relief: These valves open to charge the seal accumulators following seal pressurization. The valves shall be exercised during the opening and closing of the airlock doors: at least once every six months per TS for each containment airlock, during verifications that only one door can be opened at a time, or during CSD per TS for the drywell airlock if not performed within the previous six months during verifications that only one door of the drywell airlock can be opened at a time. Failure of the check valve to open after using the air lock door would be identified by a limit switch indication that one or both doors are open (i.e. the unsafe condition) and ball valve failure would be detected by the inability to equalize pressure across the airlock door during cycling. The surveillance requirement frequency of testing (i.e. six months or CSD) assures the necessary quality of the system and components is maintained, that facility operation will be within the safety limits and the limiting condition for operation (LCO) will be met. Therefore, exercising of the doors at a more frequent interval would result in an unusual difficulty with scheduling and wear of sealing parts without a compensating increase in the level of quality and safety.
>
> Alternate Testing: Exercise valves by seal pressurization and equalizing pressure across both containment airlock doors during normal door cycling at least once every six months and drywell airlock door during normal door cycling during CSD if not performed within the previous six months.

Evaluation

The reviewer pointed out that the Code requires valves to be exercised quarterly, or if that is impractical, during CSDs. The licensee proposed to exercise the valves associated with the containment airlock open and closed at least once every six months. The drywell is located inside primary containment. Exercising the valves associated with the drywell airlock requires entry into the primary containment. Entry into the drywell is restricted due to the high radiation levels and other personnel safety hazards. The licensee proposed to exercise those valves each CSD unless they have been tested during the last six months. The proposed test frequencies are consistent with plant TS. Testing any of these valves presents several hardships to the licensee. Testing most of the equalizing ball valves and all of these check valves requires entry into the containment airlocks (and into primary containment for the drywell airlock valves). Conduct of the test makes the airlocks inoperable per plant TS and exposes personnel to increased levels of radiological exposure. Additionally, the tests are time-consuming and cause increased wear on the door components and seals.

The licensee proposed a slight deviation from the Code test frequency requirements; that is, to test the valves associated with the primary airlock at least once every six months, rather than quarterly, and the drywell airlock valves at the frequency discussed above. The proposed test frequencies provide an acceptable level of quality and safety. The reviewer concluded that the proposed alternative should be authorized pursuant to 10 CFR 50.55a(a)(3)(i), based on the determination that the proposed alternative provides an acceptable level of quality and safety.

Example from Beaver Valley 2

In the next request, the licensee sought relief from the valve exercising and stroke timing frequency requirements of Section XI, Paragraphs IWV-3411 and -3413, for the reactor vessel head vent valves and proposed full-stroke exercising and stroke timing these valves during RFOs.

<u>Licensee's Basis for Requesting Relief:</u>

These valves are normally closed and are only required to be opened during accident conditions. Westinghouse does not recommend these valves be tested at temperatures above 200°F or pressures exceeding 300 psia. (Reference PSE-SSA-4743, dated February 8, 1985, "Reactor Head Vent/CSD System Testing"). Degradation of the system can result from repeated strokes at greater than these temperatures/pressures. Full-stroking may not be performed during CSD because the reduced pressure which is required to perform this test may not be obtainable. In addition, stroke testing if attempted at CSD could extend the length of a plant shutdown due to extensive preparatory work in establishing the proper reactor coolant system (RCS) conditions.

<u>Alternate Test:</u>

Full-stroke and time at refueling.

<u>Evaluation</u>

The reviewer's evaluation of this request stated that exercising these valves at temperatures or pressures above 200°F or 300 psia could result in their degradation. RCS pressure is not reduced below 300 psia each CSD, therefore, it is not practical to exercise these valves every CSD.

These valves could only be exercised quarterly during power operation at elevated temperatures and pressures after significant redesign of the system. Depressurizing the RCS every CSD to exercise these valves with the current system design would cause delays in the return to power. These modifications and delays would be burdensome for the licensee due to the costs involved. The licensee's proposed alternative, to full-stroke exercise and stroke time these valves during RFOs, would provide reasonable assurance of operational readiness.

The reviewer concluded that licensee's proposed alternative would provide reasonable assurance of operational readiness and recommended that relief be granted as requested. This was based on the determination that compliance with the Code requirements is impractical, considering the burden on the licensee if the Code requirements were imposed.

Example from Farley Units 1 & 2

The licensee requested relief from exercising auxiliary feedwater (AFW) pump service water (SW) supply valves, in accordance with the requirements of Section XI, Paragraph IWV-3412, and proposed to full-stroke exercise them during RFOs.

<u>Licensee's Basis for Requesting Relief:</u>

Exercising these valves open during normal operation or CSD would introduce chlorides and fluorides into the AFW system and subsequently into the steam generators. The presence of chlorides and fluorides in the secondary water chemistry have been proven to contribute to steam generator degradation. Initiation of the AFW during testing would inject a large quantity of SW directly into the steam generators. The only way to isolate the SW system from the AFW system to perform testing is by closing in line manual block valves QV015E, QV016A, and QV016B. If an AFW initiation occurred during testing, one train of AFW would be disabled.

In addition, there is no way to verify that subsequent flushing of the affected lines has removed all of the SW contaminates.

Alternate Testing:

These valves will be exercised and timed at refueling when the SW system can be isolated from the AFW system and extensive flushing of any residual SW can be performed.

Evaluation

The reviewer suggested granting relief as follows. It is impractical to exercise these valves during power operation because this could introduce SW into the AFW system and into the steam generators. Any injection of SW would result in severe chemistry control problems and possible steam generator chemical stress damage. Additionally, manually isolating one SW header for testing the associated valve renders one train of AFW inoperable which, in turn, requires entering a TS LCO. While entering an LCO is not, by itself, sufficient justification for not performing required testing, the time required to flush the affected piping could exceed the time allowed by the appropriate TS Action Statement and could result in a forced plant shutdown. It is impractical to exercise these valves during CSDs because all AFW trains are required to be operable prior to startup. An AFW train cannot be made operable while flushing the suction piping of that train, therefore, testing these SW cross connections could delay reactor startup. The Code required testing could be performed only if this system were substantially redesigned. It would be burdensome to require the licensee to perform these modifications due to the expense involved and possible reduction is system reliability because of the increased number of system penetrations and welds.

The reviewer concluded that relief should be granted from the requirements of Section XI as requested. This recommendation was based on the impracticality of exercising these valves during power operation and CSDs, the burden on the licensee if these Code requirements were imposed, and considering that the proposed alternate testing should provide reasonable assurance of operational readiness.

Example from Oyster Creek

In the next example, the licensee requested relief from the valve fail-safe actuator testing requirements of Section XI, Paragraph IWV-3415, for the main steam isolation valves (MSIVs) and proposed to fail-safe test them during CSDs when drywell access is available and during RFOs.

Licensee's Basis for Requesting Relief:

These valves are air operated and have fail-safe operators that are required to close the valves with no air assist. These valves currently cannot be tested every 3 months or during CSD unless drywell access is available due to the configuration. Drywell entry is required to observe the operators function properly per IWV-3410(e).

Alternate Testing:

These valves will be fail-safe tested during CSDs when drywell access is available and during RFOs.

Evaluation

In this case, the drywell atmosphere is maintained oxygen deficient with a high concentration of inert gas during power operation. It is impractical to fail-safe test these valves quarterly during power operation because it would require entry into the drywell which would be hazardous to test personnel.

The drywell atmosphere is also kept inerted during most CSDs. It would be burdensome for the licensee to de-inert the containment each CSD solely to perform valve testing because this process is time consuming and could result in a delay in the return to power. The licensee's proposed alternative, to fail-safe test these valves during CSDs when drywell access is available and during each RFO, would provide reasonable assurance of operational readiness.

The reviewer recommended that relief should be granted as requested. This conclusion was based on the determination that compliance with the Code requirements is impractical, that the licensee's proposed alternative would provide reasonable assurance of operational readiness, and considering the burden on the licensee if the Code requirements were imposed.

Example from Perry Nuclear Plant

The following example illustrates a request for relief from the test frequency, stroke time, and valve position indication accuracy requirements of Section XI, Paragraphs IWV-3411, -3413, -3415, and -3300, for the supply air solenoid-operated valves (SOVs) to the air operators for the ADS and safety/relief valves (SRVs) listed in the relief request. The licensee proposed to exercise, fail-safe test, and verify position indication of these valves once every other RFO.

<u>Licensee's Basis for Requesting Relief:</u>

These solenoid operated valves are proven operable during testing of the nuclear boiler ADS and SRVs. Also, in a recent study (boiling water reactor [BWR] Owners Group Evaluation NUREG-0737, Item II.K.3.16) (NRC 1980) the number of ADS and SRV openings should be reduced as much as possible to minimize loss-of-coolant-accident (LOCA) risk. The design of PNPP (Perry Nuclear Power Plant) provides divisional separation of the solenoid valves for each SRV such that SRV exercise would only exercise one of the two solenoid valves. Based on this study, and the potential for causing a LOCA condition, exercising these valves is delayed to refueling. The SRV solenoid energization shall be by exercising the SRV's between the "A" solenoid and "B" solenoid trains on alternating RFO basis per TS surveillance requirements. This surveillance requirement frequency (alternating RFO) assures the necessary quality of the system and components is maintained, that facility operation will be within the safety limits, and the LCO will be met. Therefore, the alternate testing will provide an acceptable level of quality and safety.

<u>Alternate Testing:</u>

Exercising, stroke time, fail safe, and position indication testing shall be accomplished on an alternating RFO basis as identified in PNPP TS.

<u>Evaluation</u>

The reviewer stated that these solenoid valves function to open the ADS and SRVs. It is impractical to exercise them quarterly during power operations because that would cause operation of the ADS and SRVs. Operation of those valves at power would cause reactor pressure and power transients, which could trip the reactor and challenge safety systems. It would be burdensome to require the licensee to exercise these valves during each CSD as that causes cycling of the associated ADS and SRV valves. Frequent cycling of the ADS or SRVs damages the valves and increases the chance that they will fail to close. Further, the BWR Owner's Group Evaluation of NUREG-0737, recommends that the number of challenges to these valves be kept to a minimum. The ADS and SRVs should be operated when there is reactor steam available to warm the valve seating surfaces and not when the reactor is at low temperature and pressure during CSDs. The licensee proposed to exercise these valves during testing of the ADS and SRVs each RFO. Testing during RFOs is appropriate.

There are 2 of these SOVs for each main valve. Operation of either will result in operation of the ADS/SRV. The electrical supply to these SOVs is separated into two trains. There is one solenoid

valve per train. Testing both solenoid valves would require two main valve cycles. The licensee proposed to test one train of solenoid valves each RFO. This would help to minimize ADS and SRV cycles and consequent damage to those valves, which is consistent with the NUREG. However, the licensee has not shown that the extended test frequency is appropriate for these valves. If these valves are prone to frequent failure, an extended test frequency would not be appropriate. But, assuming that these solenoid valves are all of the same type and service, a sampling approach, such as that used for safety and relief valve tests might be proper. The licensee would test half of the valves (one train) each RFO, and if any of the valves failed, the licensee would test the remaining solenoid valves during the same outage. This provides a reasonable alternative to the Code test frequency. Other approaches to testing these solenoid valves might also yield adequate assurance of operational readiness. The licensee may be able to devise a method of testing all these solenoid valves during RFO low temperature operations without causing operation of the main valve.

The reviewer concluded that relief should be granted as requested pursuant to 10 CFR 50.55a(f)(6)(i) provided the licensee employs a sampling program such that if one of the tested solenoid valves fails during RFO testing the remaining solenoid valves are tested during that outage. The recommendation was based on the determination that compliance with the Code requirements is impractical and burdensome, and considering the licensee's proposal.

Example from Oconee, Units 1, 2 and 3

In this request, the licensee asked relief from full-stroke exercising the low pressure SW "A" line to turbine building header motor-operated valve (MOV), quarterly or during CSDs as required by Section XI, Paragraph IWV-3412.

<u>Licensee's Basis for Requesting Relief</u>:

This valve is a single isolation forming the Seismic/non-Seismic boundary between the LPSW Header and both Unit 1 and Unit 2 Turbine Building non-Seismic loads.

Loads Include:

Main Turbine Oil Tank Coolers, Alterrex (Generator exciter) Coolers, Chiller "A" and "B" for Control Room Cooling, Battery Room HVAC, Main Vacuum Pumps A, B, C, Moisture Separator Reheater Drain pump cooling, Various Air Handling Units, Seal Water to Polishing Demineralizer Air Compressor, Make-up water for reaction tank supplying Demineralized and Drinking water, and Continuous Vacuum Priming Pumps.

During the stroke test these loads would be without any cooling. The most "time" critical items during operation are the Main Turbine Oil Tank Coolers, the Alterrex Coolers and slightly later the Chillers used for Control Room Cooling. In the case of the Main Turbine Oil Tank Coolers and the Alterrex, it has been evaluated that equipment damage would occur if the valve failed to reopen. Without reestablishing this cooling the main turbine and Alterrex could not be shutdown before bearing failure would occur. Several testing configurations were explored in addition to stroking the valves on-line as discussed above. The alternative of a bypass line has been considered and rejected as unfeasible. The pipe routing and Support/Restraint configuration for such a bypass is restrictive due to existing space constraints. A two unit outage (both Units 1 & 2) would be required for installation of the tie-ins for the bypass. Approximate replacement power costs for 14 days at $226,400/unit/day is $6,339,200. This cost is in addition to the costs of piping, valves, design and installation labor. The alternative of relocation of the Seismic/non-Seismic boundary was also evaluated. The piping changes would only slightly be more feasible physically to install and economically than the bypass.

Alternate Testing:

This valve will be manually partial stroked during an RFO on either Unit 1 or Unit 2. The valve will be full stroked exercised during concurrent Unit 1 and Unit 2 CSDs.

Evaluation

The evaluation addressed the issue that this is a 24 in. motor-operated butterfly valve which isolates Units 1 and 2 Turbine Building (non-seismic) LPSW Loads from the "A" LPSW (seismic) header. Isolation is required to assure adequate flow to required LPSW loads in the case of a LOCA/ loss-of-offsite-power (LOOP) event in concurrence with a seismic event.

The evaluation of this request referred to the July 23, 1993 SE, in which it was noted that although there is the potential burden of having to shut two plants down if the valve failed closed, the licensee had not discussed the safety function of the valve. It was further noted that as proposed by the licensee, the valve may not be full-stroke exercised for years, depending on the two units' outage frequency. Therefore, the licensee was advised to evaluate the amount of time required to perform the test and the consequences. It was also noted that based on the plants' vulnerability with regard to this valve, the licensee should consider installing a bypass line in order to perform testing and increase the plants' reliability. Relief could not be recommended at that time because the request contained insufficient information. The licensee was advised to revise the request and provide additional information and justification. In the current relief request, the licensee has responded adequately to all of the concerns identified in the July 23, 1993 SE. If the code requirements were imposed, the system would have to be redesigned or the units would have to be shut down. The alternate testing should provide reasonable assurance of the valve's operational readiness.

The evaluation concluded with the recommendation that relief be granted in accordance with 10 CFR 50.55a(f)(6)(i) to manually partial stroke this valve during RFOs on either Unit 1 or Unit 2, and to full stroked exercise it during concurrent Unit 1 and Unit 2 CSDs. This was based on the impracticality of full-stroke exercising it quarterly or during CSDs as required by Section XI, IWV-3412.

Example from Pilgrim Nuclear Power Station

In the next example, the licensee requested relief from the test frequency requirements of Section XI, IWV-3411, for the reactor building closed loop cooling water (RBCCW) drywell isolation valves and proposed to exercise them during CSDs when the recirculation pumps and drywell coolers are not required to remain inservice and during RFOs.

Licensee's Basis for Requesting Relief:

The testing of these valves requires isolation of the following components: drywell area coolers, reactor recirculation pump seal coolers, reactor recirculation pump lube oil coolers. Additionally for testing the 4009A and 4009B the reactor water cleanup (RWCU) non-regenerative heat exchanger, B fuel pool cooling heat exchanger, RWCU pump cooling system coolers, CRD pump area cooling, and CRD pump thrust bearing coolers must also be isolated. The listed components supply numerous plant systems required for safe plant operation. The recirculation pumps and drywell coolers may be required to support the plant during CSD conditions to prevent water stratification in the vicinity of reactor vessel lower head and overheating of drywell components. Exercising these valves quarterly during power operation is impractical because the resulting flow interruption could cause equipment damage. It also is impractical to exercise these valves during CSD when drywell cooling loads are high or when a reactor recirculation pump is operating. Stopping of reactor recirculation pumps during each CSD to allow exercising these valves could result in extending the CSD which would be costly and burdensome to the plant. Therefore compliance to the code test frequency is impractical. The proposed alternate testing provides a reasonable alternative.

Alternate Testing:

Exercise valves during CSD when recirculation pumps and drywell coolers are not required but not to exceed a refueling interval.

Evaluation

The reviewer stated that Section XI, Paragraph IWV-3411, requires that Category A and B valves be exercised quarterly or during CSDs if quarterly exercising is impractical. This testing is to demonstrate that the valves are capable of moving to their safety function position(s) to assess their operational readiness.

OM-10, Paragraph 4.2.1.2, permits deferral of full-stroke exercising until RFOs when this exercising is not practicable during plant operation or CSDs. These valves provide cooling flow to various important components in the drywell. It is impractical to exercise them quarterly during power operation as this would interrupt flow to and could result in damage to these components. It is also impractical to exercise these valves during CSDs when a reactor recirculation pump is operating or when drywell cooling loads are high. Stopping the recirculation pumps during each CSD to allow exercising these valves could result in extending the shutdown which would be burdensome to the licensee. The licensee's proposal to exercise these valves during certain CSDs (when the reactor recirculation pumps are off and drywell cooling loads permit) and during RFOs should allow an adequate assessment of valve operational readiness.

Rulemaking to 10 CFR 50.55a allows the use of portions of OM-10, provided that all related requirements are met. The staff imposed no limitations to OM-10 associated with the test frequency requirements for valves. The licensee's proposal is consistent with the provisions of OM-10 for test frequency.

The reviewer's conclusion for this request was that relief is no longer required, related to valve exercising during RFOs. This conclusion was based on the rulemaking effective September 8, 1992, pursuant to 10 CFR 50.55a(f)(4)(iv), and provided the licensee implement all related requirements of OM-10. Whether all related requirements are met is subject to NRC inspection.

Example from Plant Hatch, Units 1 and 2

In this request the licensee sought relief from the exercise procedure requirements of ASME Section XI, Paragraph IWV-3412, for the residual heat removal (RHR) SW pressure regulator valves. The licensee proposed to partial exercise them quarterly during RHRSW pump testing and stroke time these valves open and closed every RFO.

Licensee's Basis for Requesting Relief:

These valves operate as pressure control valves modulating to ensure that RHRSW pressure is always maintained greater than RHR pressure across the RHR heat exchanges. Valves are required to close in the unlikely event that accident conditions require injecting RHRSW into the reactor vessel via the RHRSW/RHR inner tie. Valve logic and operating controls prevent the valves from being fully exercised independent of valve controller response time without defeating the logic circuity. The valves cannot be opened unless the associated RHRSW pump is running. However, if the valve is fully opened with the pump operating, the pump would then run out and cause potential damage to the pump.

RHRSW is required during plant shutdown for cooldown of the RCS. Attempting to defeat valve operating logic to perform an exercise test at CSD could extend the shutdown. Performing such testing at CSD imposes undue requirements on operations personnel involved with other shutdown activities.

Alternate Testing:

Quarterly RHRSW pump testing demonstrates that the valve is operating properly to control RHRSW pressure and also ensures that the valve is capable of closure. Thus partial exercising of the valve occurs quarterly.

Each RFO the valve operating logic will be defeated and the valve will be exercised and stroke timed in both the open and closed directions. Comparison time testing per IWV-3417(a) will be applied to detect valve degradation.

Evaluation

The reviewer stated that the Code requires these valves to be exercised to their safety position once every three months to monitor for degradation. These are pressure regulator valves which have a safety function to close during an accident in the event that RHRSW is injected into the reactor vessel via the RHRSW/RHR inner tie line. They cannot be stroke timed during power operation because the valves can only be exercised closed by defeating the control logic which will interfere with the operation of the associated RHRSW pump. Testing these valves during CSDs is impractical because the RHRSW system is used for cooldown of the RCS during CSDs and testing may extend the CSD outage.

The licensee proposed to conduct stroke-time testing of these valves every RFO by defeating the valve control logic and measuring individual valve stroke time in accordance with the Code requirements. In addition, these valves are required to perform their intended function during the quarterly RHRSW pump test which results in a partial-stroke exercise of the valves.

In rulemaking to 10 CFR 50.55a effective September 8, 1992, (See 57 *Federal Register* 34666), the 1989 Edition of ASME Section XI was incorporated in 10 CFR 50.55a(b). The 1989 Edition provides that the rules for IST of valves may meet the requirements set forth in OM-10. Pursuant to (f)(4)(iv), portions of editions or addenda may be used provided that all related requirements of the respective editions or addenda are met, and subject to Commission approval, and therefore, relief is not required for those inservice tests that are conducted in accordance with OM-10 or portions thereof. Paragraph 4.2.1.2(e) of OM-10 states that if valve exercising is not practicable during plant operation or CSDs, it may be limited to full-stroke during RFOs. In addition, paragraph 6.2(d) of OM-10 requires that the justification for deferral of valve stroke testing be documented in the inservice test plan. The licensee's proposed alternative is in accordance with paragraphs 4.2.1.2(e) of OM-10. The submission of this relief request meets the documentation requirements of paragraph 6.2(d).

The reviewer concluded that stroke-time testing the RHR SW pressure regulator valves at an RFO frequency is approved pursuant to 10 CFR 50.55a(f)(4)(iv) provided that all the related requirements of OM-10 are meet which include paragraphs 4.2.1.2(e) and 6.2(d). Implementation of related requirements is subject to NRC inspection.

Example (Denial) from Waterford Generating Station, Unit 3

In the following example, the licensee requested relief from the test frequency requirements of Section XI, Paragraph IWV-3411, for the MSIVs and proposed to part-stroke the valves quarterly and full-stroke them each RFO.

Licensee's Basis for Requesting Relief:

The operability testing (full-stroke) of these normally open valves would cause a plant shutdown. In addition, it is desirable to limit the number of normal full-stroke actuations to extend the life of the valve stem. Valve stroking has been identified as one factor which led to a fatigue failure

of one MSIV stem. Analysis (reference 2.12) indicates that minimizing the number of normal full-stroke actuations can extend the life of the replacement valve stems.

Alternate Testing:

These valves will be partial-stroke tested (10% stroke) for operability quarterly, and full-stroke tested during each RFO.

Evaluation

The reviewer pointed out that the licensee's TS surveillance requirements for the MSIV's state the valves shall be operable if full closure is verified within 3.0 seconds when tested pursuant to specification 4.0.5. The licensee requested relief from the Code frequency testing requirements. The reviewer agreed that these valves cannot be full-stroke tested during power operations because this would cause a plant shutdown which would be a burden on the licensee. However, the licensee did not provided adequate justification for not conducting full-stroke testing the valves during CSDs. Generally, MSIV's in pressurized water reactors (PWR's) are tested on a CSD frequency. The licensee's justification does not demonstrate a specific problem that must be uniquely addressed.

The reviewer concluded that the preceding request should be denied and the test frequency requirements of the Code must be met.

2.1.2 STROKE TIME MEASUREMENTS

The Code requires quarterly measurement and evaluation of power-operated valve stroke times as part of their operational readiness assessment. These measurements are compared to the previous stroke times as required by Section XI, Subsection IWV, or to reference stroke times as specified in OM-10.. The comparison of stroke times can provide information indicating a change in the condition of the valve. Several requests have been submitted regarding measurement of stroke time. Relief from the stroke timing requirements has been requested for valves, such as enclosed solenoid-operated valves, steam SRVs, ADS valves, and various others. The majority of these relief requests involved valves without provisions for measuring stroke time. As described in the following, licensees have submitted many requests related to stroke timing that have been granted for a variety of reasons. In many cases, where stroke timing using traditional techniques was impractical, licensees were asked to investigate alternate means of assessing valve operational readiness.

Requirements

Section XI, Subsection IWV-3100, requires quarterly measurement of valve stroke time. Acceptance criteria and corrective actions for deviations are specified in IWV-3417.

OM-10, Paragraph 4.2, also requires measurement of stroke times and specifies acceptance criteria and corrective action requirements.

Table 2-2. Summary Table of Key Requirements and Guidance for Stroke Time Measurements

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3411/ Paragraph 4.2	These sections require quarterly exercising of power-operated valves, with certain exceptions.
Section XI/ OM-10	IWV-3413(a)/ Paragraph 4.2.1.4(a)	These sections require that the Owner specify the limiting value of full-stroke time of each power-operated valve.

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3413(b)/ Paragraph 4.2.1.4(b)	These sections require measurement of stroke times for power-operated valves when they are exercised. They require that the stroke time be measured to the nearest second.
Section XI/ OM-10	IWV-3417/ Paragraph 4.2.1.8	These sections specify stroke time acceptance criteria.
Section XI/ OM-10	IWV-3417/ Paragraph 4.2.1.9	These sections specify the corrective actions that must be taken when the limiting values are exceeded.
GL 89-04	Position 5/ Questions 29-38	These discussions address the NRC staff's position regarding limiting values for full stroke times of power-operated valves. The GL position states, in brief, that the valve stroke time limit should be based on a reasonable reference stroke time determined when the valve is in good condition. The limit should be set such that corrective action would be taken for a valve that may not perform its intended function. The section also discusses the relationship between the Code limits and limits based on the plant TS or final safety analysis report.
GL 89-04	Position 6/ Questions 39-41	This addresses the NRC staff's position regarding stroke time measurements issues for rapid-acting valves.
NUREG 1482	4.2.2	This section of the NUREG addresses issues related to stroke time measurements for rapid-acting valves.
NUREG 1482	4.2.3	This section discusses the measurement of stroke times.
NUREG 1482	4.2.7	This section addresses issues related to stroke time measurements using reference values.

Relief Request Issues

There were several issues related to the requirements to measure stroke time in the requests we reviewed. They included the following list of major issues.

Major Issues:

a) proposals to use stroke time reference values instead of previous stroke times (see Item 1)
b) steam safety/relief and ADS valves without provisions for measuring stroke times (see Item 2)
c) CRD valves without provisions for individual stroke timing (see Item 3)
d) other power-operated valves without provisions for stroke timing (see Item 4)
e) diesel generator (DG) air start system valves without provisions for individual stroke timing (see Item 5)

Each of these issues is discussed separately in the following sections of this report.

(1) Proposals to Use Reference Stroke Times in Lieu of Previous Measurements

We considered 13 requests to use reference stroke times in lieu of previous stroke time measurements as required by IWV-3417. All of these requests were granted. Code changes made during the

transition from Section XI to OM-10 for stroke timing have essentially resolved the issue. Therefore, no relief requests are provided with this discussion on the issue of using reference stroke times. OM-10, Subsection 4.2.1.8, allows that stroke times measured during testing to be compared to reference values. The staff determined that it is acceptable for a licensee to implement this method in accordance with 10 CFR 50.55a(f)(4)(iv) for use of portions of later editions of the Code approved in 10 CFR 50.55a(b) if all related requirements are implemented. When a licensee elects to compare measured stroke times to reference values the requirements of paragraph 4.2.1.8, "Stroke Time Acceptance Criteria," of OM-10 and all related requirements, such as testing requirements and corrective action apply. The related requirements include paragraphs 3.3, 3.4, 3.5, 4.2.1.1 - 4.2.1.9, 5, and 6. No additional limitations were imposed by the NRC staff regarding the use of OM-10 stroke time measurement requirements for power-operated valves.

The NRC staff's recommendation in NUREG 1482, Section 4.2.7, allows the use of OM-10 requirements in lieu of IWV-3413 for power-operated valves. The discussion in that section refers to the use of reference values. It says that GL 89-04, Position 6, did not discuss details of using reference values, but the guidance on establishing "limiting" values of stroke times given in GL 89-04, Position 5, is acceptable when using OM-10. Position 5 states in part, "The limiting value of full-stroke time should be based on the valve reference or average stroke time of a valve when it is known to be in good condition and operating properly." Paragraph 4.2.1.4 of OM-10 says that the limiting value(s) of full-stroke time be specified by the Owner.

The NUREG also offers the following suggestion. The suggestion is consistent with the Code guidance for obtaining reference values for pumps and will help licensees to obtain appropriate stroke time reference values:

> Paragraph 3.5 of OM-10 gives the requirements for establishing additional reference values. It appears that different reference values may exist for a single valve if there is justification. For example, test conditions could impact the reference stroke time depending on pressure or flow in the system. It may be necessary to have more than one test condition, such as dynamic versus static, which would necessitate different reference values. The licensee should ensure that the monitoring of the stroke time takes such differences into account.

Only one example relief request is provided. That example shows the approach that one plant proposed for establishing their reference value.

Example from Zion Station, Units 1 and 2

In this example, the licensee requested relief from the corrective action requirements of ASME Section XI, IWV-3417(a) for most of their power-operated valves.

<u>Licensee's Basis for Requesting Relief:</u>

The Code requires power-operated valves to be trended from test to test by calculating the percent increase from the previous test. Zion believes that comparing to a reference value rather than the previous test is a better method to detect a meaningful trend. Using a mean for trending reduces the potential for a floating or increasing alert limit by delineating a specific fixed value. Zion is also conscious of the "step ladder" effect of raising the mean periodically and administratively controls any changes. Zion has been able to detect valve degradation with the proposed trending method resulting in repairs and increased preventive maintenance for the affected valves.

<u>Alternate Testing:</u>

The reference mean stroke time would be established by summing the current stroke times of at least three consecutive tests, divided by the number of tests. The mean would be established only for valves in good operating condition. The mean will be re-established after maintenance

has been performed on the valve which may alter the stroke time. With the exception of using a mean instead of a previous test value for trending, the requirements of IWV-3417 will be followed.

Evaluation

The reviewer stated that the NRC has indicated the acceptability of using a reference value for trending stroke times of valves in GL 89-04, Attachment 1, Position 6, and in response to Question 40 of the Minutes of the Public Meetings on GL 89-04. The GL provides the vehicle for approval of this alternative for valves with stroke times of less than 10 seconds (fast-acting valves). The licensee has not limited the relief request to valves with stroke times of less than 10 seconds; therefore, further evaluation is required for valves with stroke times of greater than 10 seconds.

Also, for valves with stroke times of greater than 10 seconds, there may be more variance in the stroke time from test to test while still not requiring corrective action per IWV-3417, therefore making it less advantageous to the licensee to utilize a reference value. The longer stroke times result in less variance in the measurements due to operator reaction time when using a stop watch, for instance. However, by establishing a reference value based on a mean of three or more tests, the stroke time measurements can be more meaningful for monitoring any changes in the condition of the valves. The licensee states that the requirements of IWV-3417 will be met except that the stroke time test results will be compared to the reference value rather than to the previous test value. Therefore, for valves which stroke in greater than 10 seconds, an increase of 25% over the reference valve will require an increased test frequency. For valves which stroke in less than 10 seconds, the increase is 50%. The limiting values should be established using the guidance of GL 89-04, Attachment 1, Position 5, "Limiting Values of Full-Stroke Times for Power Operated Valves."

Use of reference values does eliminate the possibility of a valve stroke time slowly increasing over an extended period of time without exceeding a value which would require corrective action. Therefore, the proposed alternative provides an acceptable level of quality and safety for valve stroke time measurements and comparison of test results for determining corrective actions.

The reviewer concluded that relief should be granted for establishing a reference value for comparison of test results, alternatively to the requirements of IWV-3417, pursuant to 10 CFR 50.55a(a)(3)(i) based on the alternative providing an acceptable level of quality and safety for stroke time measurements and corrective action of power-operated valves.

(2) Steam Safety/Relief and ADS Valves Without Provisions for Measuring Stroke Times

We considered 8 requests involving steam safety/relief and ADS valves without provisions for measuring stroke times.

Example from Oyster Creek

Oyster Creek requested relief from the exercising frequency and stroke timing requirements of Section XI, Paragraphs IWV-3411 and -3413(b), for main steam SRVs. The licensee proposed to full-stroke exercise them during startup from RFOs but not to measure their stroke times.

Licensee's Basis for Requesting Relief:

Exercising these valves during power operation simulates a small-break transient, subjecting the RCS and related piping to unnecessary transients. These valves cannot be exercised at CSD because reactor pressure is necessary to stroke the valves. No direct position indication exists, therefore, timing the stroke of these valves is impractical.

Alternate Testing:

These valves will be full-stroke exercised during startup following an RFO, i.e., on an RFO frequency.

Evaluation

The evaluation of this request pointed out that these valves act both as relief valves, in response to a manual or automatic control signal, and as safety valves to prevent system over-pressurization. Reactor steam provides the motive force for opening these SRVs. Upon actuation, these valves direct reactor steam to the suppression pool, which results in pressure and temperature transients in the pool.

Exercising these valves quarterly during power operation was deemed impractical as it could result in a plant trip due to exceeding the TS suppression pool temperature limit. NUREG-0626, "Generic Evaluation of Feedwater Transients and Small Break Loss-of-Coolant Accidents in GE-Designed Operating Plants and Near Term Operating License Applications," and NUREG-0737, Section II.K.3.16, "Reduction of Challenges and Failures of Relief Valves," recommend the reduction of challenges to relief valves to lessen the risk of valve damage and small break LOCAs. Therefore, the reduced frequency was considered appropriate. The valves would have to be replaced with valves of another design to make quarterly or CSD testing practical. Therefore, the licensee's proposal to exercise these valves at an RFO frequency was deemed an acceptable alternative to the Code test frequency.

Regarding the test technique, the evaluation determined that these valves are not equipped with direct sensing position indication and have short stroke times that are dependent on steam pressure. Trending stroke times may not be meaningful since response times and test pressure variations could mask changes in valve condition. However, not monitoring for degradation of these valves is unacceptable. The licensee was asked to develop a method to obtain repeatable stroke times for these valves or to propose some other method to monitor for valve degradation. If stroke time measurements are used to monitor for valve degradation, the licensee should assign a maximum stroke time limit to these valves that is based on test data and verify that they stroke within that limit during testing. The measured stroke times need not be trended or compared to previous values, but if the maximum limit is exceeded, the valve should be declared inoperable and corrective action taken in accordance with IWV-3417(b). The reviewer concluded that immediate compliance with the Code requirements would be a hardship without a commensurate increase in the level of quality and safety. An interim period was provided to allow the licensee time to develop a method to monitor for valve degradation. The proposed exercise test would provide reasonable assurance of operational readiness during the interim period.

In this case, interim relief was granted based on the determination that immediate compliance with the Code requirements would be a hardship without a commensurate increase in the level of quality and safety, and considering the adequacy of the licensee's proposed alternative during the interim period. At the end of the interim period, the licensee was requested to implement a method of stroke timing these valves as discussed above or propose some other method to monitor for valve degradation.

The licensee's action at the end of the interim period was to propose a long-term alternative to full-stroke exercise and stroke time the valves during startup following a refueling outage. The discharge piping acoustic monitors were to be used to obtain stroke-time measurements. The NRC evaluation discussed NUREG-0626 for the extension of the test interval. The use of acoustic monitors for measuring stroke time was accepted provided a limiting stroke time was established for the valves in accord with Generic Letter 89-04, Position 5 or Position 6.

Example from Quad Cities

Quad Cities requested relief from the test frequency and stroke time testing requirements of Section XI, Paragraphs IWV-3411 and -3417(a), for the dual-function Target Rock SRVs, and the electromatic relief valves. The licensee proposed to exercise them once every six months during plant operation without measuring and evaluating their stroke times.

Note: Valves 0203-003A-SO are the solenoid valves that control the air supply to the Target Rock valve's diaphragm operator. These valves were included in the relief request, but are non-Code Class, and therefore were not evaluated with the relief request.

<u>Licensee's Basis for Requesting Relief:</u>

These valves can only be tested with primary system pressure greater than 150 psig. The test sequence requires an operator to:

a. Open at least one turbine bypass valve and discharge main steam directly to the condenser,
b. Actuate the relief valve and observe the corresponding closure of the turbine bypass valve (pressure control on the turbine bypass valve is fairly quick to respond, 1-1/2 seconds),
c. Close the relief valve and observe the corresponding opening of the turbine bypass valve.

Each relief valve actuation produces hydrodynamic loads which are transmitted to the Suppression pool (torus). The Quad Cities Mark I Containment, Plant Unique Analysis Report fatigue evaluation is based on 300 relief valve actuations with normal operating conditions (i.e., 300 actuations for testing purposes). Quarterly testing of the subject valves would result in 4 (quarters) x 40 (years) x 5 (valves) = 800 test actuations, which would exceed the approved design basis.

Finally, the failure of any relief valve to close would cause an uncontrolled rapid depressurization of the primary system (stuck open relief valve transient). The resulting severe thermal gradients in the reactor vessel are not desirable, and should be minimized. These valves cannot be tested at CSD or reactor refueling since the primary system pressure must be greater than 150 psig to actuate these valves. The subject valves are fast acting valves (normally exercise in less than 2 seconds) and they do not have stem/disk position indicators. Stroke timing of these valves is performed indirectly via turbine bypass valve position and relief valve discharge line temperature and acoustic alarms.

<u>Alternate Testing:</u>

The subject valves will be exercised (open and closed) once every six (6) months during plant operation. Relief request RV-OOF contains additional alternate testing information for 0203-003A-SO. Relief request RV-00C contains additional alternate testing information for 0203-003A through -003E. Stroke times will not be measured, and increased test frequency based on change in stroke time will not be implemented. As described in the basis for relief, Quad Cities will verify the operability of the subject valves.

<u>Evaluation</u>

The review of this request stated that the Target Rock ADS valves act both as power-operated valves, in response to an automatic control signal and as safety relief valves. As a result, they should be tested to both the Category B and C requirements. The electromatic ADS valves act only as power-operated relief valves. They are connected to the main steam lines upstream of the MSIVs and discharge to the torus. Full-stroke exercising them quarterly during power operations is inadvisable

as this may result in a LOCA and an increase in suppression pool temperature. Quarterly testing over the life of the plant would also result in exceeding the allowed number of valve opening cycles on the torus. Reactor steam pressure is necessary to full-stroke exercise these valves, therefore, exercising is not practical during CSDs or RFOs when the reactor pressure is low. NUREG-0626 "Generic Evaluation of Feedwater Transients and Small Break Loss-of-Coolant Accidents in GE-Designed Operating Plants and Near Term Operating License Applications" recommends reduction of challenges to relief valves to lessen the risk of a small break LOCA (see also NUREG-0737, Section II.K.3.16).

Valve or system redesign would be necessary to permit testing these valves at the Code specified frequency. Making these modifications would be difficult for the licensee. The licensee proposed to exercise these valves once every six months with the reactor at power, by passing reactor steam through them. The valves will be verified to open by monitoring the turbine bypass valve position and relief valve discharge line temperature and acoustic alarms. ASME/ANSI OMa-1988, Part 10, Paragraph 4.3.2.2, permits deferral of full-stroke exercising until RFOs when this exercising is not practicable during power operation or CSDs. Therefore, this frequency is appropriate and we recommend that the alternative be approved pursuant to 10 CFR 50.55a(f)(4)(iv), provided the licensee implements all related requirements. Whether all related requirements are met is subject to NRC inspection.

Regarding the proposed test method; these SRVs operate rapidly, on the order of 100 milliseconds, and are not equipped with direct sensing position indication. Further, their stroke times vary with changes in system operational parameters, such as steam pressure. Therefore, trending the stroke times for these valves may not be meaningful since test-personnel response times and variations in system parameters can change the measured stroke times and could mask changes in valve condition. However, not monitoring for degradation of these valves is unacceptable.

The licensee should develop a method to obtain repeatable stroke times for these valves or propose some other method to adequately monitor for valve degradation. It may be possible to demonstrate that enhanced maintenance procedures during the periodic refurbishment of these valves provides adequate assurance that the valves are not degraded. If stroke time measurements are used to monitor for valve degradation, the licensee should assign a maximum stroke time limit to these valves that is based on test data and verify that they stroke within that limit during testing. The measured stroke times need not be trended or compared to previous values, but if the maximum limit is exceeded, the valve should be declared inoperable and corrective action taken in accordance with Paragraph IWV-3417(b). An interim period of one year or until the next RFO, whichever is longer, should be provided to allow the licensee time to develop a method to monitor for valve degradation. The licensee's proposed exercise test should provide an acceptable level of quality and safety during this interim period.

The reviewer recommend that the proposed alternative be authorized pursuant to 10 CFR 50.55a(a)(3)(i) for one year or until the next RFO, whichever was longer. The recommendation was based on the determination that the proposed testing method provides an acceptable level of quality and safety during the interim period as described in the preceding paragraph. At the end of the interim period, the licensee was asked to implement a method of stroke timing these valves, as discussed in the preceding paragraph, or propose some other method to adequately monitor for valve degradation.

Example from Brown's Ferry, Units 1, 2, and 3

The licensee requested relief from the test frequency and stroke time measurement requirements of Section XI, Paragraphs IWV-3411, -3412, and -3413, for the main steam ADS valves. The licensee proposed to exercise them during RFOs and to verify valve operation by observing an indication of steam flow through each valve. Valve stroke times will not be measured.

Licensee's Basis for Requesting Relief:

The six safety relief valves assigned to the ADS system perform an essential safety function when operated by the pneumatic actuator with gas supplied through the ADS solenoid valves. Operation of these valves is not practical during power operations because this action will vent main steam to the suppression pool, inducing a transient condition and increasing the potentiality for an open failure of a safety relief valve. Also, no stroke timing is practical as these are pneumatic assisted SRVs. Since "position indication" of the SRVs is provided by acoustic monitors attached to the valve discharge piping, exercising during CSD cannot be accomplished because of lack of steam flow (and attendant noise).

Alternate Testing:

The ADS valves will be exercised once each operating cycle in accordance with TS 4.6.D.2 which provides manual opening of each ADS valve observing an indication of steam flow through each valve.

Evaluation

The reviewer pointed out that these valves are connected to the main steam lines upstream of the MSIVs and discharge to the suppression pool. Full-stroke exercising them quarterly during power operations is impractical as this may result in a loss-of-coolant accident and an increase in suppression pool temperature. Reactor steam pressure is necessary to full-stroke exercise these valves, therefore, exercising is not practical during CSDs when the reactor pressure is low. NUREG-0626 "Generic Evaluation of Feedwater Transients and Small Break Loss-of-Coolant Accidents in GE-Designed Operating Plants and Near Term Operating License Applications" recommends reduction of challenges to relief valves to lessen the risk of a small break LOCA (see also NUREG-0737, Section II.K.3.16).

Valve or system redesign would be necessary to permit testing these valves at the Code specified frequency. Making these modification would be burdensome for the licensee. The licensee proposed to exercise these valves once each operating cycle with the reactor at power by passing reactor steam through the valves and to verify the valve opens by monitoring steam flow through each valve. ASME/ANSI OMa-1988, Part 10, Subsection 4.3.2.2, permits deferral of full-stroke exercising until RFOs when this exercising is not practicable during plant operation or CSDs, therefore, this frequency is appropriate.

These SRVs operate rapidly, on the order of 100 milliseconds, and are not equipped with direct sensing position indication. Further, their stroke times are dependent on system parameters such as steam pressure. Therefore, trending the stroke times for these valves may not be meaningful since test-personnel response times and variations in system parameters could mask changes in valve condition. However, the intent of stroke time measurements is to monitor for degradation and not monitoring for degradation of these valves is unacceptable.

The reviewer suggested that the licensee should develop a method to obtain repeatable stroke times for these valves or propose some other method to adequately monitor for valve degradation. It may be possible to demonstrate that following enhanced maintenance procedures during the periodic refurbishment of these valves provides adequate assurance that the valves are not degraded. If stroke time measurements are used to monitor for valve degradation, the licensee should assign a maximum stroke time limit to these valves that is based on test data and verify that they stroke within that limit during testing. The measured stroke times need not be trended or compared to previous values, but if the maximum limit is exceeded, the valve should be declared inoperable and corrective action taken in accordance with Paragraph IWV-3417(b). An interim period of one year or until the next RFO, whichever is longer, should be provided to allow the licensee time to develop a method to monitor for valve degradation. The licensee's proposed exercise test should provide an acceptable level of quality and safety during this interim period.

The reviewer recommended the granting of interim relief, based on the determination that the combination of the proposed exercise test of these valves and the periodic maintenance and refurbishment should provide an acceptable level of quality and safety during the interim period, the reviewers recommended that the proposed alternative be authorized pursuant to 10 CFR 50.55a(a)(3)(i) for one year or until the next RFO, whichever is longer. At the end of the interim period, the licensee was requested to implement a method of stroke timing these valves as discussed in the preceding or to propose some other method to adequately monitor for valve degradation.

Example from Plant Hatch, Units 1 and 2

The licensee requested relief from the stroke time frequency and method requirements of ASME Section XI, Paragraphs IWV-3411 and IWV-3413, for their main steam safety and relief valves. The licensee proposed to monitor valve degradation by a combination of exercise testing and maintenance activities.

Licensee's Basis for Requesting Relief:

Failure of these valves to close while being stroke tested during power operation would cause a loss of the primary reactor coolant. These valves cannot be exercised at pressure below 100 psig and the position of the main stage of this 2 stage relief valve can only be determined by indirect means.

Alternate Testing:

For Unit 1, once during the operating cycle at a reactor pressure greater than 100 psig, each relief valve shall be manually opened until thermocouples downstream of the valve indicate steam flow.

For Unit 2, at least once per 18 months, when the reactor steam dome pressure is greater than 100 psig, these valves shall be manually opened and observed to ensure that either;

1. The control valve or bypass position responds accordingly, or
2. There is a corresponding change in measured steam flow.

Additionally for both units, all pilot operating assemblies and at least one valve body are removed and sent to an independent testing laboratory each RFO. These components are inspected and tested to determine their operating condition. Each pilot assembly is repaired/adjusted to ensure its operability prior to reinstallation. Therefore, due to the maintenance, testing and adjustments performed each RFO, additional testing methods which might detect valve degradation are unwarranted.

Evaluation

The evaluation of this request stated that relief from the test frequency requirements of IWV-3411 was granted in the December 10, 1991, SE, for the main steam safety and relief valves. In the evaluation, it was noted that the licensee did not request relief from Code requirements to measure the stroke times of these power-operated valves. The licensee has revised Relief Request RR-V-29 in their submittal dated November 17, 1992, to include a request for relief from the power-operated valve stroke-time testing requirements for the main steam safety and relief valves. Each main steam safety and relief valve consists of a main stage and a pilot stage. The body of the main stage contains the main steam inlet and discharge ports. The main disc is seated in the discharge port and is attached to the main piston. The pilot stage or "top works" is a separate component. The bonnet of the pilot stage is flanged to the main stage body over the main piston. The pilot stage functions to vent the area over the main piston when the inlet pressure reaches the setpoint pressure. Venting this

volume actuates the piston and unseats the disc, thereby allowing steam to flow through the main stage discharge port. The pilot valves are totally enclosed with no visible moving parts. There are no position indication devices installed on either the pilot or main stage valves.

As discussed in the December 10, 1991, SE, stroke timing the main steam safety and relief valves by normal means is impractical because their typically fast stroke times could yield results with a high degree of uncertainty due to the variations in the response times of the individuals performing the testing. In addition, variations in steam pressure and other system variables which may not be precisely duplicated from test to test could produce variations in valve stroke times that may mask changes in valve condition. It would be a burden for the licensee to install instrumentation to facilitate stroke timing the valves because the results may not accurately reflect the valve condition.

The licensee proposed to exercise the valves on a reduced frequency. In addition, the licensee has included in their relief request an inspection plan for the main steam safety and relief valves which includes removing all the pilot valves on both units and inspecting and testing them every RFO. Finally, the licensee stated that one main stage from each unit's main steam safety and relief valves is removed every RFO and inspected and tested. Although the licensee did not specify the types of inspection and testing activities to be performed, these generally include bench setpoint testing of the pilot valve, inspection of the pilot valve internals, and replacement of any worn elastomeric components on the pilot valves. The main stage valves are usually inspected and bench tested in the same manner. Exercise testing of the main steam safety valves should be performed once the valves are reinstalled during startup from the RFO. The proposed testing provides reasonable assurance of operational readiness because the inspection and maintenance activities monitor the valves for degradation. Exercising the valves during startup would confirm that they have been properly reinstalled. Additionally, the licensee may consider the categorization of these valves in light of ongoing actions of the OM Committee (reference Paragraph 4.3.4 of NUREG 1482).

The reviewer concluded that relief from the Code stroke time measurement requirements for the main steam safety and relief valves should be granted pursuant to 10 CFR 50.55a(f)(6)(i). This conclusion was based on the impracticality of performing testing in accordance with the Code requirements, and in consideration of the burden on the licensee if the Code requirements were imposed on the facility. The relief was granted with the provision that exercising of the main steam safety valves be conducted during the initial startup after RFO to ensure that the valves have been properly reassembled. In addition, the licensee was asked to update this relief request to include the inspection and testing activities to be performed on the pilot and main stage valves.

Example from Duane Arnold

In the following example the licensee requested relief from the valve exercising and stroke time trending requirements of Section XI, Paragraphs IWV-3411 and -3417(a), respectively, for several of their ADS, safety relief, and solenoid valves. The licensee proposed removing, testing, disassembling, inspecting, and rebuilding at least half of these valves every cycle, having the solenoid actuators stroke timed by Wyle Labs, and exercising these valves in situ once every RFO during plant startup.

<u>Licensee's Basis for Requesting Relief:</u>

These valves can only be tested at very low reactor power levels with primary system pressure greater than 50 psig. The test sequence requires an operator to:

a. Open at least one turbine bypass valve and discharge main steam directly to the condenser,
b. Actuate the relief valve and observe the corresponding closure of the turbine bypass valve (pressure control on the turbine bypass valve is fairly quick to respond, ~1-1/2 seconds), and the response of pressure switches and thermocouples downstream of the relief valve.

c. Close the relief valve and observe the corresponding opening of the turbine bypass valve and the response of pressure switches and thermocouples downstream of the relief valves.

Each relief valve actuation produces hydrodynamic loads which are transmitted to the suppression pool (torus). The Duane Arnold Mark I Containment, Plant Unique Analysis Report (PUAR) fatigue evaluation is based on 740 relief valve actuations with normal operating conditions (i.e., 740 actuations for testing purposes). Quarterly testing of the subject valves would result in 4 (quarters) x 40 (years) x 6 (valves) = 960 test actuations, which would exceed the approved design basis.

Finally, the failure of any relief valve to close would cause an uncontrolled rapid depressurization of the primary system (stuck open relief valve transient). The resulting severe thermal gradients in the reactor vessel are not desirable, and should be minimized. These valves should not be tested during CSDs in order to reduce the number of challenges to SRVs as recommended by NUREG-0737 Item II.K.3.16, Reduction of Challenges and Failures of Relief Valves. The subject valves are fast acting valves (normally exercise in less than 2 seconds) and they do not have stem/disk position indicators.

At least half of these valves will be removed, tested, disassembled, inspected and rebuilt every cycle in accordance with TS 4.6.D.1. Stroke timing of the solenoid actuators is performed by Wyle Labs. Comparison to previously measured stroke time will not be performed. The subject valves will be exercised once every RFO during plant startup.

Evaluation

The evaluation of this request stated that reactor steam provides the motive force for opening these valves which act both as pneumatic-operated relief valves, in response to a manual or automatic control signal, and as safety valves. As a result, these valves should be tested to both the Category B and C requirements.

Upon actuation, the safety relief valves direct reactor steam to the torus resulting in pressure and temperature stresses. The fatigue evaluation for the Duane Arnold containment is based on 740 relief valve actuations under normal operating conditions. Additionally, the failure of any of these relief valves to close while testing, if performed during power operation, would create a LOCA resulting in large thermal stresses in the reactor vessel. NUREG-0626, "Generic Evaluation of Feedwater Transients and Small Break LOCAs in GE-Designed Operating Plants and Near Term Operating License Applications," and NUREG-0737, Section II.K.3.16, "Reduction of Challenges and Failures of Relief Valves," recommend the reduction of challenges to relief valves to lessen the risk of small break LOCAs. Therefore, a reduced frequency of testing is appropriate.

These valves are not equipped with direct sensing position indication, therefore, precise stroke time measurement is difficult and trending the stroke times is not meaningful. Since these valves are rapid-acting (normally stroke in less than 2 seconds), the application of Position 6 of GL No. 89-04 to these valves would provide a reasonable alternative to the Code stroke time trending and corrective action requirements.

The reviewer recommended that relief be granted as requested. The recommendation was based on consideration that the licensee's proposed alternative, to remove, test, disassemble, inspect, and rebuild at least half of these valves every cycle, combined with exercise tests and stroke time measurement in accordance with GL No. 89-04, Position 6 of all valves each RFO would provide an acceptable level of quality and safety.

Summary and Additional Comments

The following are key issues related to these types of requests.

1) These are dual function valves.
2) When actuated, these valves direct steam to the suppression pool. The resulting pool heating can result in a plant shutdown if a TS or other limit is exceeded.
3) Two NUREGs recommend reductions in challenges to these valves citing safety concerns, therefore, the RFO test frequency is appropriate.
4) The proposed testing was often not judged to be adequate to assess operational readiness; therefore, the licensee was requested to identify or develop a method for assessing operational readiness.
5) The NRC has accepted alternatives to stroke timing of these valves including the use of acoustic monitors, indirect measurement of stroke time, and performance of enhanced maintenance (such as that described in the last two preceding examples).

(3) Control Rod Drive (CRD) Valves Without Provisions for Individual Stroke Timing

Three requests addressed issues related to CRD control system valves without provisions for individual stroke timing. An example of these requests follows.

Example from Pilgrim Power Station

The licensee requested relief from the test frequency and stroke time measurement requirements of Section XI, Paragraph IWV-3411 and -3413, for the CRD insert and withdrawal control SOVs and proposed weekly verification of proper valve operation by observing CRD movement during rod notching.

<u>Licensee's Basis for Requesting Relief:</u>

The insertion and withdrawal of control rods is accomplished via positioning of these valves. The CRD Units are integrally constructed components. Notching of control rods causes rapid position changes to these valves. The recording of stroke time (e.g., less than tenth of a second) would only be indication of electrical circuitry delay and human response errors. Proper insertion/withdrawal by notching shall verify valve operability.

<u>Alternate Testing:</u>

Verify control rod movement by notching weekly.

<u>Evaluation</u>

The reviewer stated that IWV-3413 requires measurement of the full-stroke times of power-operated valves to monitor for changes that could be indicative of valve degradation. This results in more frequent testing of degraded valves and corrective action to repair seriously degraded valves prior to their reaching the point where they are incapable of performing their function. The licensee proposed to verify operational readiness of these SOVs by observing control rod notching during weekly rod testing.

These are rapid-acting solenoid valves which position to cause insertion or withdrawal of the control rods. There are four valves for each HCU. It is impractical to accurately stroke time these valves because they do not have position indication and stroke so rapidly that large variations could be introduced by the response times of test personnel. Obtaining accurate stroke times for each of these valves might require significant system redesign or installation of special test equipment, which would be burdensome to the licensee. These valves are exercised weekly during notching of the control rods

and must operate in a timely fashion to move the rods. Failure or significant degradation of these valves should be evident during this weekly testing. The licensee's proposal to verify operation of these valves each week during rod movement should give adequate assurance of valve operational readiness.

The reviewer concluded that relief should be granted as requested pursuant to 10 CFR 50.55a(f)(6)(i). This was based on the determination that compliance with the Code requirements was impractical and burdensome, and considering the proposed alternate testing.

Summary and Additional Comments

Relief may be granted for cases where secondary indications such as observing the proper functioning of a dependant component can (e.g. a control rod) be used as an alternative to identify degradation or failure and satisfy the Code tests method requirements. In the preceding case, compliance with the Code was impractical, failure or significant degradation of the SOVs should be evident from observation of proper control rod motion, and the valves were being exercised weekly (much more frequently than required by the Code).

(4) Other Power-Operated Valves Without Provisions for Measuring Stroke Times

The following examples are typical of requests proposing not to measure stroke times of valves which are not equipped with provisions for measuring stroke times. In general, these requests have been granted for an interim period of one year or until the next RFO to allow development of appropriate assessment techniques. We reviewed 26 requests of this nature. Nearly half (12) of the requests involved solenoid-operated valves (SOVs). The remaining 14 involved other power-operated valves, such as pneumatically operated valves. Only two requests were denied, one denial is provided as an example. Examples are also provided for one request involving SOVs and one for other power-operated valves.

Example from Waterford Generating Station

The licensee requested relief from the stroke time measurement requirements of ASME Section XI, Paragraph IWV-3413, for the component cooling to diesel solenoid valves and proposed to verify that they are exercised by monitoring changes in the DG standpipe level during quarterly testing and after the valves are reassembled.

Licensee's Basis for Requesting Relief:

No means exists to measure the stroke times of these SOVs. These valves have no position indicators, and no external parts which can be used to detect valve movement. Non-intrusive testing using ultrasonic or magnetic detection of disk position does reveal disk motion, but due to the small size of the disk, and the small disk travel, this cannot be correlated to full stroke time with the required accuracy and repeatability to be useful for stroke time trending. Acoustic emission of the disk against the seat can be used to detect the completion of the valve stroke, but the only indication of the beginning of the valve stroke is a computer point indication of power to the valve. However, the computer samples this point only once per second, and indicates only in the control room. This information would then be relayed to the diesel room to start timing, and the operator would then detect an acoustic emission and stop timing. However, due to the long computer sampling rate, delays in relaying information to the diesel room, and the short stroke time of the valve, this method would lack the required accuracy and repeatability, and would not provide any useful information about the valve stroke time.

Additionally, these valves are not designed for routine disassembly and inspection. The valves are sealed with a very small weld. Valve disassembly requires that the weld be removed, and subsequently rewelded. Due to the small size of the weld, this is a painstaking, tedious operation.

Alternate Testing:

Demonstration of valve exercising will be performed by monitoring changes in the DG standpipe quarterly and after valve reassembly. Valve stroke time will not be measured.

Evaluation

The reviewer noted that the component cooling makeup to diesel valves are 1 inch solenoid operated butterfly valves. The Code requires that the stroke times of these valves be measured quarterly. These valves are not equipped with any type of position indication apparatus that could be used to aid in stroke timing the valves. The licensee proposed to exercise these valves quarterly and monitor the water level in the DG standpipe to ensure that they are stroking to their closed safety position. The licensee did not propose any method to monitor the valves for degradation in their relief request.

The licensee stated in their basis for relief that they have investigated a number of non-intrusive methods in an attempt to stroke time these valves and monitor them for degradation. None of the methods investigated by the licensee provide the accuracy and repeatability to justify using a non-intrusive test method to meet the Code requirements. The licensee has also investigated disassembly and inspection of these valves to satisfy the Code requirements. However, these valves are welded into the component cooling piping and must be removed before they can be inspected. Imposition of the Code requirements would be a burden because the licensee would have to replace the installed solenoid operated valves with valves capable of stroke time measurement.

The proposed testing does not directly monitor the solenoid valves for degradation. However, the valves are exercised at a quarterly frequency and system parameters are monitored which should provide indication that these valves have actuated to their closed safety position. The licensee should develop some type of acceptance criteria based on the proposed testing for the quarterly stroke test of these valves. In addition, corrective action should be specified, such as valve replacement, if the valves fail the quarterly testing. Finally, the licensee should take advantage of any future technologies that are developed to measure the stroke time of these valves. With the addition of acceptance criteria and corrective action for these valves, the proposed testing provides a reasonable assurance of operational readiness.

The reviewer concluded that relief for stroke timing the component cooling makeup to diesel solenoid valves should be granted with provisions pursuant to 10 CFR 50.55a(f)(6)(i). This conclusion was based on the impracticality of performing testing in accordance with the Code requirements, and in consideration of the burden on the licensee if the Code requirements were imposed on the facility. The relief was granted provided the licensee develop acceptance criteria for the proposed alternate testing and appropriate corrective action if the valves fail the quarterly testing.

Example of Denied Request from Zion Station, Units 1 and 2

The licensee requested relief from the requirements of OM Part 10, Subsection 4.2.1.2, which requires quarterly measurement of valve stroke times for the CS pumps' cooling water SOVs.

Licensee's Basis for Relief:

1(2)SOV-SW0153 is a SOV which is required to open upon starting of the 1(2) C Diesel-Driven Containment Spray (CS) pump to provide cooling to the engine and to the CS room coolers. The valve opens automatically on starting of the pump. This valve is an integral

component of the CS Diesel-Driven pump skid and, as such, does not have control circuit or indication independent of the pump engine. This lack of remote position indication coupled with the fact that position of solenoid valves cannot be determined by observation makes it impossible to perform stroke time testing on this valve.

Alternate Testing:

Zion Station tests the 1(2) C Diesel Driven CS Pumps on a quarterly frequency. During this test, the flow rate of cooling water through 1(2)SOV-SW0153 is recorded and verified to be within a certain range. The verification of flow through the valve during operation of the diesel-driven CS pump is considered sufficient to ensure that the valve is capable of opening on demand to meet its safety function.

Evaluation

The reviewer stated that OM Part 10, Subsection 4.2.1.3 requires the necessary valve obturator movement be determined by exercising the valve while observing an appropriate indicator or by observing other evidence such as changes in system flow rate which reflect change of obturator position. Simply verifying the flowrate is within a range can substantiate that the valve moves to the required position, however, this alternative does not provide a means for detecting valve degradation. Measuring the length of time between pump start and the detection of flow rate through 1(2)FISW84 can provide an adequate means of measuring the stroke time in accordance with the Code.

Based on the review, the evaluator recommended that relief be denied. The reviewer suggested that the licensee should perform stroke time testing in accordance with the Code as described above. Alternatively, the licensee could consider using nonintrusive methods to determine valve stroke time.

Summary and Additional Comments

As discussed in the previous section on CRD valves, relief may be granted for cases where secondary indications are used to verify the proper functioning of a dependant component. As illustrated by the immediately preceding (denied) request the proposed method should be capable of detecting a change in the valve's condition if it is to be used as an alternative to stroke timing as specified in the Code. Provisional relief was granted for the Waterford example, to develop suitable acceptance criteria for their proposed testing. For some components where system indications are not adequate, non-intrusive methods should be considered.

(5) Diesel Generator Air Start System Valves Without Provisions for Individual Stroke Timing

We considered thirteen requests for DG air start system valves. The requests involved two types of diesels; emergency DGs (EDGs) and high pressure core spray (HPCS) diesels at BWRs. All but one of the diesels were EDGs. All of the requests were granted and most were granted outright. However, some were granted either provisionally or on an interim status, while the licensee developed an improved method for assessing operational readiness, such as isolating a bank of starting air. The following examples are typical of these relief requests.

Example from McGuire, Units 1 and 2

The following request sought relief from the requirements of ASME Section XI, 1980 Edition through winter 1980 Addenda, Article IWV-3413(b) and IWV-3414 for measuring the stroke time of diesel control air header valves.

Licensee's Basis for Requesting Relief:

Since the valves in question are solenoid valves, direct observation of valve disk movement is not practical. Further, due to limitations of available acoustic emission monitoring equipment, this means of verifying disk movement is not readily available at this time. Furthermore, during the upcoming RFOs for both units (EOC-8 RFOs), the valves in question will be modified such that they would not fall within the scope of IWV-1100. As such, no adverse trends can be developed from the quarterly full stroke exercise test. In addition, a diesel start test is performed every month. If any one of these valves fail to perform its intended function, it would result in a failure of the diesel to start. Conversely, if the diesel does successfully start, this would indicate that the valves in question performed their intended safety function. By this indirect means, the proper performance of the valves are verified on at least a monthly basis.

Accordingly, since there is no short term practical way of monitoring the valve disk movement; that in the near future the valves will be modified in such a manner that they no longer fall within the IST program; and that the operation of the valves is verified (indirectly) via the monthly diesel start test, relief from the timing requirements of IWV-3413(b) and the recording requirements of IWV-3414 is requested.

Alternate Testing:

As stated above the valves are indirectly tested during the monthly diesel start test. Any failures of one of the valves in question would result in the diesel failing to start. The monthly diesel start test will continue to be performed and during the EOC-8 RFOs for both units, the function of these valves will be modified such that they are no longer subject to the requirements of IWV-3400. The EOC-8 RFO for Unit 1 is scheduled to begin in March 1993 and for Unit 2 to begin June 1993.

Evaluation

The reviewer stated that the Code requirements for measuring the stroke times of power-operated valves were established to provide a method of monitoring for potential degradation of the tested valve. The diesel control air header solenoid valves are enclosed and have no position indication. There are no design provisions that allow for measuring stroke time of these valves by conventional methods. The licensee states that acoustic emission monitoring equipment is limited and not readily available for stroke timing these valves, though no details describing the limitations or availability are provided. The licensee further states that modifications are to be made such that these valves will no longer fall within the scope of the IST Program with no details on the type of modifications. Imposition of the Code requirements would require plant shutdown prior to the RFOs to allow for completion of the modifications or require the licensee to shutdown and implement a testing method which has not yet been developed. In either case, immediate imposition of the Code requirements would be a hardship on the licensee and directly impact the operation of the plant.

With the schedule of the upcoming RFOs, stroke timing of these valves would be required three times for Unit 1 valves and four times for Unit 2 valves. Identification of trends indicating degrading conditions in these three to four tests would be unlikely. The current condition of the valves is an unknown other than as indicated by the diesel monthly testing which provides a level of assurance of the operational readiness of these valves. Beginning stroke timing to complete a total of only three to four tests would not provide sufficient data to make a determination of the condition of the valves, particularly with no past data to use for comparison. Therefore, requiring the licensee to comply with the Code requirements would not increase the quality and safety of the plant.

The reviewer concluded that relief should be granted from the stroke time measurement requirements of ASME Section XI for the diesel control air header valves for the interim period until the next RFO for each unit pursuant to 10 CFR 50.55a(a)(3)(ii). That conclusion was based on the determination

that immediate imposition of the Code requirements would result in a hardship without a compensating increase in the quality and safety of the plant.

RFOs were scheduled for March 1993 (Unit 1) and June 1993 (Unit 2) and the reviewer stated that in the event modifications were not effected in the 1993 RFOs, the licensee must determine if continued relief is required and submit a revised relief request prior to startup from the RFO. The proposed alternative was not considered adequate for long-term relief.

Example from Perry Nuclear Plant

The next request was from Perry Nuclear Plant and requested relief from the stroke timing and fail-safe testing requirements of Section XI, IWV-3413, and -3415 for the HPCS standby DG air start supply valves. The licensee proposed to verify valve operational readiness by recording the start time for the HPCS diesel and comparing that to the starting time requirements.

Note: The request also addressed several valves in the starting air supply lines for the Division 1 and 2 DGs. Those valves are non-ASME Code Class, therefore, were not considered in the evaluation.

<u>Licensee's Basis for Requesting Relief:</u>

It is impractical to measure the stroke times of these valves because they are totally enclosed solenoid/air operated valves which have no externally visible indication of valve position. Failure of a valve to perform the required function will result in an increase in the starting time of the DG or failure to secure starting air. Division 3 HPCS requires both air start solenoids to open to satisfy its starting time for operability, thus normal monthly timing verifies operability. Therefore, the proposed alternative provides an equal level of quality and safety.

<u>Alternate Testing:</u>

Diesel starting air valves shall be verified operable during monthly DG surveillance testing. The operability of HPCS starting air valves shall be determined by monitoring HPCS diesel starting time.

<u>Evaluation</u>

The evaluation pointed out that the subject valves are completely enclosed. They have no externally visible means to determine valve position. It is impractical to measure their stroke times due to their fast action and because there are no installed provisions for determining when a valve receives a signal to open or when it reaches the open position. These valves are rapid-acting, normally stroking almost instantly. When they do not operate promptly, they most commonly fail to operate at all.

These valves function to admit air to the HPCS diesel air starting system, which in turn operates air-operated valves to roll and start the diesel. Because of the rapid stroke time of these solenoid valves and the manner in which they receive a open signal, timing them is difficult. These valves must stroke promptly to start the HPCS diesel quickly. The start time limit for the HPCS diesel is specified in TS. Failure or significant degradation of these valves would be evidenced by failure to meet the start time limit specified in TS. Direct stroke time measurement cannot be made without system redesign and modifications. Those modifications, such as replacing these valves with valves with disk position indication, would be burdensome to the licensee. Note that the licensee also proposed to perform the test monthly.

The evaluation concluded that compliance with the Code requirements was impractical and burdensome and considering the licensee's proposal relief was recommended to be granted as requested pursuant to 50.55a(f)(6)(i).

Summary and Additional Comments

Relief may be granted for cases where the proper functioning of another (dependant) component indicates operational readiness of the subject valves. The following should be considered when developing relief requests for these cases:

(1) These valves are generally enclosed and sealed without provisions for external position indication.
(2) Usually these valves stroke very rapidly, often in 2 seconds or less (rapid acting).
(3) Failure or significant degradation of the valves would be indicated by sluggish or improper starting of the associated diesel.
(4) Reasonable, objective acceptance criteria should be assigned to an observable parameter, such as a start time of the diesel.

2.1.3 Stroke Timing Rapid-Acting Valves

The Code requires quarterly measurement and evaluation of power-operated valve stroke times as part of their operational readiness assessment. These measurements are compared to the previous stroke times as required by Section XI, Subsection IWV, or to reference stroke times as specified in OM-10. The comparison of stroke times can provide information indicating a change in the condition of the valve. The Code requirements for power-operated valves have been difficult to apply to rapid-acting valves, or those that stroke in less than two seconds. A practical approach was developed to apply a maximum limiting stroke time value of 2 seconds to these valves.

Requirements

Section XI, Subsection IWV-3410, requires quarterly measurement of valve stroke time. Acceptance criteria and corrective actions for deviations are specified in IWV-3417.

OM-10, Paragraph 4.2.1, also requires measurement of stroke times and specifies acceptance criteria and corrective action requirements.

Table 2-3. Summary Table of Key Requirements and Guidance for Stroke Timing Rapid-Acting Valves

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3411/ Paragraph 4.2	These sections require quarterly exercising of power-operated valves, with certain exceptions.
Section XI/ OM-10	IWV-3413(a)/ Paragraph 4.2.1.4(a)	These sections require that the Owner specify the limiting value of full-stroke time of each power-operated valve.
Section XI/ OM-10	IWV-3413(b)/ Paragraph 4.2.1.4(b)	These sections require measurement of stroke times for power-operated valves when they are exercised. They require that the stroke time be measured to the nearest second.
Section XI/ OM-10	IWV-3417/ Paragraph 4.2.1.8	These sections specify stroke time acceptance criteria. Paragraph 4.2.1.8(e) exempts valves that stroke in two seconds or less from comparing the stroke times of rapid-acting valves to reference stroke times.

Document	Section	Requirement/Guidance
GL 89-04	Position 6/ Question groups 39-41	These discussions address the NRC staff's position regarding stroke time measurements for rapid-acting valves. The GL position states, in brief, that a maximum limiting stroke time value of 2 seconds may be used for these valves.
NUREG 1482	4.2.2	This section of the NUREG addresses issues related to stroke time measurements for rapid-acting valves.

We considered 9 requests regarding stroke timing of rapid-acting valves. All were submitted prior to 1992 and were approved based on the fact that the proposals were in accordance with the provisions of GL 89-04, Attachment 1, Item 6. Changes in OM-10 have negated the need for relief requests in this area. OM-10, Paragraph 4.2.1.8 (e), specifically exempts valves that stroke in less than 2 seconds from the requirement to compare their stroke time measurements to reference values. A maximum limiting value of 2 seconds shall be applied to these valves. The following request is typical of requests regarding rapid acting valves.

Example from Farley

The licensee requested relief from measuring and trending the stroke time of all rapid-acting power-operated valves in the IST program in accordance with the requirements of Section XI, Paragraphs IWV-3413 and -3417, and proposed to assign a maximum stroke time limit of 2 seconds to these valves.

Licensee's Basis for Requesting Relief:

For rapid-actuating power-operated valves, the application of the above criteria could result in requiring corrective action when the valves are functioning normally. These valves are generally small air and SOVs which, because of their size and actuator types, stroke very quickly. Operating history on this type of valve indicates that they generally either operate immediately or fail to operate in a reasonable length of time. The intent of the referenced Code sections is to track valve stroke time as means of detecting valve degradation. This type of valve does not lend itself to this tracking technique.

Alternate Testing:

A maximum stroke time of 2 seconds will be specified for each rapid-actuating valve. If the measured valve stroke time is 2 seconds or less, it will be considered as acceptable and no corrective action will be required. If the measured valve stroke time exceeds 2 seconds, it will be considered inoperable and appropriate corrective action will be taken.

Evaluation

The review of this request pointed out that rapid-acting valves are defined as those valves which stroke in 2 seconds or less. Industry experience has shown that these valves are difficult to stroke time using presently available methods of measurement and the results are subject to variation due to influences other than valve condition. Variations in the response time of the personnel performing the tests will result in slight variations in the stroke times and a very small increase in stroke time would result in a large percentage change which could easily exceed the limits of Section XI thus requiring corrective action whether necessary due to valve degradation or not. Considering the design of these valves, assigning a maximum stroke time limit of 2 seconds to them and taking corrective action upon exceeding that limit is a reasonable alternative to the Code requirements.

The reviewer concluded that based on the preceding considerations relief should be granted as requested. The reviewer stated that the licensee's proposal is in accordance with the guidance

presented in GL 89-04, Attachment 1, Item 6, and that the proposed alternative should provide an acceptable level of quality and safety.

Summary and Additional Remarks

The preceding example shows the difficulty of assessing the condition of rapid-acting valves with traditional techniques. The historical problem with stroke timing of rapid-acting valves has been the limited ability to detect changes in the condition of the subject "rapid-acting" valve using traditional stroke timing techniques. The historical practice was to observe a light and time the stroke using a verbal signal while observing the indication. That technique was too crude in practice to effectively detect changes in the valve's stroke time that could indicate degradation. However, as mentioned in NUREG 1482, Section 4.2.2, Stroke Time Measurements for Rapid Acting Valves, improvements in measurement technology have made accurate measurement of stroke times for these valves much more practical. Licensees now have alternate methods available to accurately measure the stroke times of many "rapid-acting" valves.

2.1.4 Fail-Safe Testing

The Code requires fail-safe testing of valves with fail-safe actuators quarterly or at CSDs. This testing is accomplished by observing the valve's operation upon loss of actuator power.

Requirements

Section XI, Subsection IWV-3415, requires fail-safe testing once every three months or during CSDs.

OM-10, Paragraph 4.2.1.6, also requires fail-safe testing valves with fail-safe actuators according to the frequency specified in 4.2.1.1.

Table 2-4. Summary Table of Key Requirements and Guidance for Fail-Safe Testing

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3415/ Paragraph 4.2.1.6	These sections require quarterly or CSD (OM-10 also allows RFO testing, based on practicality) fail-safe testing of valves with fail-safe actuators.

We considered 9 requests regarding fail-safe testing of valves. Three examples typical of the issues involving these requirements are provided in the following.

Example from Oconee

In this example, the licensee requested relief from the requirements of Section XI, Paragraph IWV-3415, which requires fail-safe valves to be tested by observing the operation of the valves upon loss of actuator power.

<u>Licensee's Basis for Requesting Relief:</u>

Testing by loss of actuator power is not practical. First, loss of actuator power generally involves maintenance action to interrupt power, which must subsequently be restored and verified. This greatly increases the manpower requirements for testing and increases possibility for human error in returning component to service. Second, by IWV-3200, a subsequent post-maintenance test is required to verify return to acceptable operation. Third, some components, especially pneumatic valves, have two modes of "loss of actuator power": they can lose pneumatic power by loss of instrument air or they can lose electrical power to control solenoids. Therefore, to test all modes of failure, at least three tests would be required

on some valves. The net result is a significant increase in manpower and time to perform the tests, an increase in radiation exposure for valves in radiation areas, and an increase in the possibility of improper return to service.

Alternate Testing:

Fail-safe valves will be tested using normal controls. Where both normal controls and engineered safeguard (ESG) control switches exist, the ESG switches will be used. The action of the switch is the same as if the actuator power is removed. Fail/Safe valves installed have pneumatic or mechanical devices to fail the valve in the safe direction. Response to Generic Letter 88-14 and recent analysis has shown all valves installed to fail in the safe direction and/or mechanical means have been provided and incorporated into procedures to reposition the valve.

Evaluation

The reviewer stated that in the July 23, 1993 SE, generic relief was denied pending an evaluation by the licensee of the testing for each valve to determine if the safety-related fail-safe function can be monitored by the proposed testing, i.e., that testing the valves using the normal or ESG control switches has the same effect as a loss of electric power supply or loss of air supply.

The licensee revised the relief request with a statement that, for all fail-safe valves, "The action of the switch is the same as if actuator power is removed. Fail-Safe valves installed have pneumatic or mechanical devices to fail the valve in the safe direction." The licensee further states that the "response to Generic Letter 88-14 and recent analysis has shown all valves installed to fail in the safe direction and /or mechanical means have been provided and incorporated into procedures to reposition the valve." The licensee should ensure that this test method will verify the safety related function for each valve and failure mode.

The reviewer recommended that the licensee's request be approved in accordance with 10 CFR 50.55a(f)(6)(i). This recommendation was based on the impracticality of physically disconnecting the actuator power, which may result in an increased radiation exposure to the personnel performing the test, and that the proposed alternate testing adequately assures that the valve will return to the fail-safe position.

Example from Dresden Station, Units 2 and 3

In this example the licensee requested relief from the requirements of IWV-3410 and IWV-3415 for valve exercising and fail-safe testing for the high pressure coolant injection (HPCI) drain pot solenoid valves. These are 1", Class 2, Category B valves.

Licensee's Basis for Requesting Relief:

These valves are in-line SOVs which open to drain the turbine exhaust drain pot when a high level alarm in the drain pot is received. The only way to receive a high level alarm is if the normal drain path to the Torus is blocked or isolated. To test the valve in the open direction would require isolating the drain path to the Torus during quarterly HPCI IST testing and verifying that the alarm comes up and clears. This is not practical during HPCI runs. These valves close when the alarm is cleared.

These SOVs are totally enclosed with no evidence of position indication available. No other direct or indirect method is available for verifying valve disk position.

These valves can be opened by a hand switch, but verification that the valves open or close is not achievable. There are no valve position indicating lights available. Although the valve

does open on high drain pot level, this type of verification cannot be repeated during operations or CSDs.

Alternate Testing:

Since there is no practical method of verifying these valves open or close, during refuel outages the drain pot will be filled with water until the high level alarm is received. The water will then be turned off and it will be verified that the alarm clears.

Evaluation

The reviewer stated that for power-operated valves, the Code requires valve stroke time and fail-safe testing quarterly, or during CSDs, to identify degrading conditions before unacceptable operation of the valve occurs. The valves cannot be tested in accordance with the Code requirements during power operations or at CSD conditions. Exercising and fail-safe testing the HPCI drain pot solenoid valves with verification of disc movement quarterly or during CSD is not practical; however, the basis does not discuss the impracticality of exercising the valves quarterly or during CSD conditions, even though verification that the valve strokes cannot be performed at conditions other than during RFOs, using current test methods. Because exercising solenoid valves periodically can contribute to prevention of internal binding or sticking failure modes (NRC 1991), exercising quarterly or during CSD, though not verifying position, should continue unless the licensee has specific reasons why this is not practical. The relief request indicates the valves can be exercised by means other than a high level signal. Exercising the valves quarterly or during CSD is consistent with the Code requirements, also, even though the stroke cannot be timed or verified by this testing.

The proposed test frequency for performing verification that the valves open and close by filling the drain pot with water until the high level alarm is received is a reasonable alternative to the Code frequency, in that it is impractical to perform the test by any other method which meets the Code requirements within the limitations of the design of the system. Imposition of the Code requirements would result in design modifications which would be a burden to the licensee. The proposed alternative testing will meet the intent of the Code to verify the valves stroke by verify position of the valve using an alternate parameter (water level alarm). However, the valves should be exercised quarterly or during CSD conditions using the hand switch.

Relative to monitoring the SOVs for degradation, because the alternative test method does not allow for measuring stroke time in accordance with IWV-3413, the licensee must determine a method which will provide a means of assessing the condition of the valves. Methods which might provide acceptable alternatives to IWV-3413 could be measurement of the coil impedance or resistance, acoustics, or a regular preventative maintenance which assesses the internal condition of the valves and ensures proper operation of the valves electrically.

The reviewer concluded that relief should be granted to test the HPCI drain pot solenoid valves at an RFO frequency pursuant to 10 CFR 50.55a(g)(6)(i). That conclusion was based on (1) the impracticality of performing the Code required testing quarterly or during CSD conditions, (2) consideration that imposition of the Code requirements would result in design modifications, and (3) the proposed alternative testing providing an acceptable level of assurance of the operational readiness of the valves. The licensee was encouraged to exercise these valves quarterly or during CSD, as practical, as an additional measure to prevent binding.

The reviewer concluded that interim relief should be granted for the method of assessing the valves for degradation. That conclusion was based on the determination that the proposed test method does not allow for measurement of stroke times. The interim relief for a period of one year, or until the end of the next RFO (whichever is later for each unit) was granted pursuant to 10 CFR 50.55a(g)(6)(i) based on the (1) impracticality of performing stroke time testing in accordance with Code requirements within the limitations of design, (2) consideration that immediate imposition would require a design modification, and (3) the proposed alternative testing providing an acceptable level of

assurance of the operational readiness of the valves for an interim period. During the interim period, the licensee should determine and implement a method for assessing the condition of these valves and submit relief requests as applicable.

In the revised relief request following the interim period, the licensee proposed the following:

> These valves will be exercised quarterly using the handswitch. They will also be functionally tested each refueling outage by filling the drain pot and verifying that valve 2301-32 actuates as indicated by the high level alarm clearing. Because exercising of these valves without stroke timing provides no measure of valve degradation, maintenance activities were instituted to compensate for testing deficiencies. Following discussions with the manufacturer regarding valve design and application, it was decided to disassemble, inspect, and repair these valves every third cycle in addition to the above testing.

The revised relief request had not been evaluated prior to completion of this NUREG.

Example from Duane Arnold

In this example, the licensee requested relief from the Section XI, Paragraph IWV-3415, requirement that valves with fail-safe actuators be verified to stroke to their fail-safe positions upon the loss of actuator power. The licensee has proposed that normal stroking to the fail-safe position be considered a fail-safe test for most valves.

> <u>Licensee's Basis for Requesting Relief:</u>
>
> Solenoid valves which control the air supply to air-operated valves and direct SOVs must stroke to their fail-safe position upon interruption of their electric power or air supply. De-energizing the SOV has the same effect as loss of electrical power or loss of control air. Therefore, stroking the valve from the control room to its fail-safe position constitutes a fail-safe test for most valves.
>
> For most configurations, normal stroking to the fail-safe position of valves equipped to fail open or closed constitutes an FST. No additional testing of these valves is necessary. Where complicated fail-safe configurations exist, or where test solenoids are provided, a separate fail-safe test, utilizing the proper solenoids and/or methods are used to verify true fail-safe operation. The following valves are tested to their fail-safe position by means other than normal stroking:

MSIVs -	CV-4412, CV-4413, CV-4415, CV-4416, CV-4418, CV-4419, CV-4420, CV-4421
CRD -	CV-1849, CV-1850
SW -	CV-4909, CV-4914, CV-4915

> Note: A modification is planned to install necessary controls for the individual fail-safe testing of these valves. This modification will be complete by July 5, 1991.

Evaluation

The reviewer stated that the Code specifies that valves with required fail-safe positions be tested quarterly by verifying that they move to their fail-safe positions when the actuator power is removed. If normal stroking to the fail-safe position is not accomplished by use of a valve's fail-safe actuator then a normal stroke would not constitute a fail-safe test. However, if normal stroking of a valve to its fail-safe position has the same effect as the loss of actuator power (e.g. - the control switch denergizes an electrically operated valve or, operates a solenoid valve which isolates and vents the

motive gas from a pneumatic operated valve) then a normal exercise test to the fail-safe position would be equivalent to the requirement of IWV-3415.

The licensee's basis for relief lists main steam, CRD, and SW valves that are fail-safe tested by means other than normal stroking. The licensee's fail-safe test method and frequency are not specified, therefore, evaluation is not possible and no relief is granted for these valves.

The licensee's proposed testing would provide an acceptable level of quality and safety for those valves for which normal exercising has the same effect as the loss of actuator power and relief may be granted as requested for those valves only.

2.1.5 Verification of Remote Position Indication Accuracy

The Code requires verification of position indication accuracy for valves with remote position indicators. This verification is to be performed at least once every two years. This testing is accomplished by observing that the valve's operation is accurately indicated. Generally this is done by observing the valve while timing its stroke.

Requirements

Section XI, Subsection IWV-3300, requires verification of valve position indicator accuracy once every two years.

OM-10, Paragraph 4.1, also requires verification of valve position indicator accuracy once every two years, but is less prescriptive regarding how to perform the verification than Section XI.

Table 2-5. Summary Table of Key Requirements and Guidance for Verification of Remote Position Indication Accuracy

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3300/ Paragraph 4.1	These sections require verification of valve position indicator accuracy once every two years.

We reviewed 18 requested regarding the requirement to verify remote position indication accuracy. Of those requests, 9 were granted based on the information presented in the requests, 8 were granted either with provision or for an interim period, and only one request was denied. The following examples illustrate several issues associated with this topic.

Example from Perry Nuclear Plant

The following request sought relief from locally verifying valve position indication accuracy according to the requirements of Section XI, Paragraph IWV-3300, for the rapid-acting, short stroke valves listed in the relief request. The licensee proposed to use system parameters and/or leak tests in conjunction with open/closed position indication to verify valve position.

> Licensee's Basis for Requesting Relief:
>
> These valves require disassembly of the actuator components to verify operation. Additionally, each valve has minimal stroke time (less than 2 seconds) and stem travel (approximately 0.075 inch), which makes accurate visual verification of valve operation very difficult due to the minimal stem travel and short stroke period. This visual observation would not contribute significantly to the assurance of safe and proper valve operation.

Therefore, the proposed alternative provides an equal to or better than acceptable level of quality and safety.

Alternate Testing:

The valve open indication/position is verified by normal system parameters during operation. The valve shut indication/position is verified by 10 CFR 50, Appendix J testing, and ASME Code Section XI seat leakage testing during RFOs or by normal system operating parameters.

Evaluation

The reviewer stated that Section XI, Paragraph IWV-3300, requires periodic verification of valve remote position indication accuracy. This helps to ensure that valve position is accurately indicated, which is important for safe plant operation and valve stroke timing. Local observation of these valves to verify their indication accuracy is very difficult because of their short stroke time and small stem travel. The results of direct observation are subjective. The licensee would have to modify or replace these valves to get meaningful results from direct observation. The licensee proposes to observe operational parameters such as leakage, pressure, flow, etc., to verify indication accuracy in both the open and closed positions. That proposal should allow an adequate assessment of position indication accuracy. Therefore, the licensee's proposal provides an acceptable level of quality and safety that is essentially equivalent to that provided by the Code for these valves.

The reviewer concluded that the proposed alternative should be authorized pursuant to 10 CFR 50.55a(a)(3)(i). The conclusion was based on the determination that the licensee's testing was essentially equivalent to the Code and provides an acceptable level of quality and safety.

Example from Kewanee Plant

In this request the licensee requested relief from the requirements of Paragraph 4.1 of OM-10 to observe and verify the remove position indication for the pressurizer and reactor vessel head vent valves and the RCS hot leg sample line isolation valves.

Licensee's Basis for Requesting Relief:

These valves are the pressurizer and reactor vessel head vent valves and the RCS [reactor coolant system] hot leg sample line isolation valves. All the affected valves are fast-acting solenoid operated valves and are designed with completely enclosed movable plug/valve stem assemblies and position indicating reed switches. This design precludes observation of valve and switch operation for the purpose of verifying remote indication.

Alternate Testing:

The two RCS hot leg sample line isolation valves are leak tested during each RFO in accordance with 10 CFR 50, Appendix J, and are used routinely for obtaining reactor coolant samples; unexpected results in either case would identify potential problems with the remote position indication. Likewise, the pressurizer and reactor head vent valves are tested to verify open flow paths during each performance of the RCS fill and vent procedure and leak tightness is observed routinely within the scope of RCS leakage monitoring required by TS. Problems with the remote position indication for these valves would be identified.

Evaluation

Observation of valve position indication during valve operation when performing plant fill and vent on a refueling will indirectly indicate proper remote position for the reactor vessel and pressurizer vent

valves. Observation of valve position indication during routine sampling and RFO leak testing will indirectly indicate proper remote position for the RCS hot leg sample isolation valves. The design of these valves make it impractical to observe actual stem motion locally as required by the Code. Paragraph 4.1 of OM-10 states that "where local observation is not possible, other indications shall be used for verification of valve operation." Indirect verification meets the intent for monitoring that the position indication provides the correct indication on the control panels. Therefore, the proposed method will provide assurance of the operational readiness of the indication of valve plug position for these valves. Imposition of direct indication would be a burden on the licensee in that design changes would be necessary.

The reviewer concluded that relief should be granted for indirect position indication verification pursuant to 10 CFR 50.55a(f)(6)(i). This conclusion was based on (1) the impracticality of direct verification because of limitations in the design, (2) the burden if the Code requirements were imposed, and (3) in consideration that the alternative testing provides assurance of the operational readiness of the position indication.

Example from Arkansas Nuclear One, Unit 1

In this example the licensee requested relief from the position indication requirements of ASME Section XI, Paragraph IWV-3300, for various SOVs and proposed to use other means of indication to verify valve position in accordance with OM-10, Section 4.1.

<u>Licensee's Basis for Requesting Relief:</u>

These solenoid valves have enclosed stems and no external means of determining valve position locally. Therefore these valves cannot be directly observed to verify the accuracy of the remote position indicators associated with them.

<u>Alternate Testing:</u>

Valve position verification shall be performed on the subject valves by compliance with the 1988a Edition of OM-10, Section 4.1, Valve Position Verification; specifically, "Where local observation is not possible, other indications shall be used for verification of valve operation." These verifications employ system parameter indications and testing results to provide assurance that valve position is accurately indicated.

<u>Evaluation</u>

The reviewer stated that ASME Section XI, Paragraph IWV-3300, requires that the position of valves with remote position indicators be verified to be accurate at least once every two years. The valves listed in this relief request are SOVs which do not have any means of position indication by direct observation because the valve stem is totally enclosed. It would be a burden on the licensee to verify the position of these SOVs if there were other means to verify valve position.

The licensee proposed to use the valve position verification requirement of OM-10, Paragraph 4.1, which allows position indication to be verified by either direct means or employ the use of other indicators. The licensee's relief request lists a number of SOVs in different systems, however, the licensee has not described the "other indicators" that it intends to use to verify the valve remote position indication.

In rulemaking to 10 CFR 50.55a effective September 8, 1992, (See 57 *Federal Register* 34666) the 1989 edition of ASME Section XI was incorporated in 10 CFR 50.55a(b). The 1989 edition provides that the rules for IST of valves may meet the requirements set forth in OM-10. Pursuant to (f)(4)(iv) portions of editions or addenda may be used provided that all related requirements of the respective editions or addenda are met, and subject to Commission approval, and therefore, relief is not required

for those inservice tests that are conducted in accordance with OM-10 or portions thereof. Paragraph 4.1 of OM-10 states that when local observation of valve position indication is not possible, other indications shall be used for verification of valve operation. The licensee's proposed alternative does not describe the other indicators that will be used to verify valve position for each valve or group of valves listed in this relief request. The licensee should update this relief request to include the alternate indications of valve position indication for each valve or each group of valves. The revised relief request may be subject to review during a future NRC inspection.

The reviewer concluded that verifying position indication of the listed solenoid valves by using other indications of position indication should be approved pursuant to 10 CFR 50.55a(f)(4)(iv) provided that all the related requirements of OM-10 are met, which includes paragraph 4.1. The licensee was asked to update the relief request to include the alternate indicators used to verify valve position indication for each valve or group of valves and advised that implementation of related requirements is subject to NRC inspection.

2.2 CHECK VALVES

Check valves are required to be exercised quarterly to verify their operational readiness. Most check valves are not controlled by actuators (except stop and testable check valves), they rely on system flow or reverse differential pressure to position the valve disk or obturator. In addition, check valves do not generally have position indication, which makes it difficult to verify them in any particular position. Therefore, there are a disproportionate number of relief requests related to check valves. There were 504 relief requests for check valves that were considered during the preparation of this report. Nearly 300 of these requests relate mainly with the testing frequency. One-hundred and forty-five involve the use of disassembly and inspection as an alternate testing technique to verifying the valve open or closed using system flow or reverse differential pressure. Twenty-five requests deal with the use of non-intrusive testing techniques to verify check valves in their safety position. Twenty-one involve testing series check valve pairs as a unit. The remainder of the requests are for various other issues.

2.2.1 Check Valves Test Frequency

As discussed above, the positioning of a check valve is generally dependant on system conditions and they seldom have position indication. It is often difficult or impractical to establish the necessary system conditions to test these valves quarterly during power operations or during CSDs (i.e., establish sufficient flow to full stroke the valve open or a reverse differential pressure to seat the valve closed). Even if conditions exist that would allow stroking a check valve to a position, verifying the required position may involve gaining access to the valve and the setup and use of test equipment, which may be impractical or an unusual hardship during power operations or CSDs. Almost 300 of the 504 check valve relief requests sought relief from the Code testing frequency.

Requirements

Section XI, Paragraph IWV-3522(a) states in part: "Valves that are normally open during plant operation and whose function is to prevent reversed flow shall be tested in a manner that proves that the disk travels to the seat promptly on cessation or reversal of flow." Paragraph IWV-3522(b) states: "Valves that are normally closed during plant operation and whose function is to open on reversal of pressure differential shall be tested by proving that the disk moves promptly away from the seat...." These Code testing requirements are somewhat ambiguous in that it is not clear if a valve is required to be verified in its normal position prior to exercising. The common practice has been to assume, rather than verify, that a valve is in its normal position immediately prior to exercising it to the other position. Section XI, Paragraph IWV-3522 states: "Check valves shall be exercised to the position required to fulfill their function...." This Code requirement implies that a check valve's function should determine the required testing and not solely its normal position. ASME OM Code-1990, Subsection ISTC, Paragraph ISTC 4.5.2(a) requires each check valve to be

exercised or examined in a manner that verifies obturator travel to the closed, full-open, or partially open position required to fulfill its function. The NRC indicated its position on this issue in GL 89-04, "Guidance on Developing Acceptable Inservice Testing Programs" (GL 89-04), which states that check valves are to be exercised to the positions in which they perform their safety functions. However, the NRC is reexamining this position (Position 1) as to the adequacy of testing for valves which have only an "open" safety function.

GL 89-04 clarifies that a check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve and that any flow rate less than this will be considered a partial-stroke exercise. The GL further states that a valid full-stroke exercise by flow requires that the flow through the valve be known. Knowledge of only the total flow through multiple parallel lines does not provide verification of flow rates through the individual valves and is not a valid full-stroke exercise. Additionally, if only a flow test is conducted with no closing test, the test may be inadequate for monitoring the condition (i.e., degradation) of the valve.

Full flow testing of a check valve as described above may be impractical to perform for certain valves. It may be possible to qualify other techniques to confirm that the valve is exercised to the position required to perform its safety function. In GL 89-04, the NRC provided guidelines to substantiate the acceptability of alternative techniques for meeting the ASME Code requirements. The GL states: "...licensees must as a minimum address and document the following items in the IST program:

1. The impracticality of performing a full flow test,
2. A description of the alternative technique used and a summary of the procedures being followed,
3. A description of the method and results of the program to qualify the alternative technique for meeting the ASME Code,
4. A description of the instrumentation used and the maintenance and calibration of the instrumentation,
5. A description of the basis used to verify that the baseline data has been generated when the valve is known to be in good working order, such as recent inspection and maintenance of the valve internals, and
6. 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."

Table 2-6. Summary Table of Key Requirements and Guidance for Check Valves Test Frequency

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3521/ Para.4.3.2.1	Exercise check valves quarterly, with the exceptions listed below.
Section XI/ OM-10	IWV-3522/ Paragraphs 4.3.2.2(a) through (c)	Exercise to safety function position quarterly if practical, **or** If full-stroke exercising is impractical during power operations, part-stroke quarterly and full-stroke at CSDs, **or** If any exercising is impractical during power operations, full-stroke exercise at CSDs.
OM-10	Paragraph 4.3.2.2(d) and (e)	If full-stroke exercising is impractical during power operations and CSDs, part-stroke at CSDs and full-stroke during RFOs, **or** If any exercising is impractical during power operations and at CSDs, full-stroke exercise during RFOs.

Document	Section	Requirement/Guidance
Section XI/ OM-10	IWV-3522/ Paragraph 4.3.2.4(a)	Verify the valve exercises to the required position(s) by observing a direct indicator such as a position-indicating device or by other indicator(s) such as changes in system pressure, flow rate, level, temperature, seat leakage testing or other positive means.
Section XI	IWV-3522(b)	A mechanical exerciser can be used to move the valve disk. The force or torque used to exercise the valve must be limited to a specified amount.
OM-10	Paragraph 4.3.2.4(b)	A mechanical exerciser may be used to move the valve disk. The force or torque required to initiate movement must be measured, recorded, and compared to a reference value.
OM-10	Paragraph 4.3.2.4(c)	As an alternative to exercising with pressure/flow or using a mechanical operator, disassembly may be used every refueling.
GL 89-04	Position 1/ Questions 1-8	A check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve. A flow rate less than this will be considered a partial-stroke exercise. A valid full-stroke exercise by flow requires that the flow through the valve be known.
GL 89-04	Position 2/ Questions 9-20	Disassembly and inspection can be used as a positive means of determining that a check valve's disk will full-stroke exercise open or of verifying closure capability. A sample disassembly and inspection plan for groups of identical valves in similar applications may be employed. The guidelines for this plan are explained. If possible, partial valve stroking after reassembly must be performed.
NUREG 1482	3.1.1	The licensee may implement the portions of OM-10 which allow deferral of valve testing to RFOs in accordance with 10 CFR 50.55a(f)(4)(iv) if the related requirements are met.
NUREG 1482	4.1.1	If there is no practical means of verifying the ability of two series check valves to close, and only one of the two valves is credited in the safety analysis, then verification that the pair is capable of closing is acceptable. Testing is required at an interval in accord with the Code. If the testing indicates that the closure capability of the pair is questionable, both valves must be declared inoperable and corrective actions taken for both valves.
NUREG 1482	4.1.2	Nonintrusive techniques may be used to verify a check valve's capability to open, close, and fully stroke in accord with quality assurance program requirements. Relief is not required to use this method except as would be necessary for the testing frequency if the interval extends beyond each RFO.
NUREG 1482	4.1.4	If no other practical means is available, it is acceptable to verify that check valves are capable of closing by performing leak-rate testing, such as local leak rate testing in accord with Appendix J to 10 CFR Part 50, at each reactor RFO.

Relief Request Issues

There were several issues related to the requirements to exercise check valves in the requests we reviewed. They included the following list of major issues.

Major Issues:

a) Proposals to exercise check valves at an RFO frequency (see Item 1)
b) Proposals to verify closure of check valves at an RFO frequency (see Item 2)
c) Proposals to defer testing that requires de-inerting the containment of a BWR (see Item 3)
d) Proposals to test excess flow check valves at an RFO frequency (see Item 4)

Each of these issues is discussed separately in the following sections of this report.

(1) Proposals to Exercise Check Valves at a Refueling Outage Frequency

We considered 135 requests that involved exercising the valves at an RFO frequency in lieu of the quarterly or CSD frequencies prescribed by Section XI. Requests to exercise check valves at RFOs are common because it is often impractical or an unusual hardship to establish or confirm the conditions necessary to verify these valves in their safety position(s). Code changes made during the transition from Section XI to OM-10 have essentially resolved the exercising frequency issue. OM-10, Paragraphs 4.3.2.2(d) and (e) allow check valve exercising at RFOs if full-stroke exercising is impractical during power operations and CSDs. The staff determined that it is acceptable for a licensee to implement this method in accordance with 10 CFR 50.55a (f)(4)(iv) for use of portions of later editions of the Code approved in 10 CFR 50.55a(b) if all related requirements are implemented. NUREG 1482 provides guidance to licensees on implementing the portions of OM-10 which allow deferral of valve exercising to RFOs in accordance with 10 CFR 50.55a(f)(4)(iv) if the following related requirements are met:

Category A and B Valves: OM-10, Paragraph 4.2.1, including a partial-stroke exercise quarterly or during CSD outages, if practical.

Category C Valves: OM-10, Paragraph 4.3.2, including a partial-stroke exercise quarterly or during CSD outages, if practical.

Test Plans: OM-10, Paragraph 6.2, for documenting the basis of the deferral.

Therefore, although relief is no longer required to defer check valve exercising until RFOs when it is impractical quarterly and during CSDs, the conditions of NUREG 1482, Section 3.1.1, must be referenced and met in the IST program if a plant has not already updated to OM-10. In these cases, the RFO justifications should meet the guidelines of NUREG 1482 as depicted in Examples 3-3 and 3-4 in the NUREG. Since relief is no longer needed for these cases, the following examples are provided to give sample bases for RFO justifications. Examples are included for different systems and plant types (e.g., PWR or BWR).

Example for AFW System from Indian Point Unit 3

The components involved in this request example are the turbine-driven AFW pump individual discharge check valves and the common discharge check valve.

<u>Licensee's Basis for Requesting Relief:</u>

During power operation, exercising these valves would require operating the steam-driven AFW pump and injection of cold water into the steam generators. This could result in thermal shock to the feedwater supply piping and the steam generator nozzles which is highly undesirable. During

a normal CSD period steam is not available for operation of the steam-driven AFW pump. Thus, since operation of this pump is the only practical way of exercising these valves, CSD testing is impractical. Verifying closure of these valves requires the operation of at least one of the motor-driven AFW pumps with injection to the steam generators. As discussed above, this is not practical during normal plant operation at power. Furthermore, it may not be practical during CSD when steam generator metal temperatures are elevated and thermal shock remains a concern.

Alternate Testing:

During CSD periods, valves BFD 47-1 through BFD 47-4 will be verified to be closed if operation of the motor-driven AFW pumps is permitted by the temperature conditions of the steam generators. During each reactor RFO these valves will be full-stroke exercised in the open and closed directions, as required.

Example for Charging and Volume Control System from North Anna Unit 1

The components in this request are the refueling water storage tank (RWST) supply to charging pump suction header check valves.

Licensee's Basis for Requesting Relief:

Full or part-stroke exercising this valve during power operation would require charging pump suctions be aligned with the RWST. This alignment would cause a sudden increase in RCS boron inventory. Full flow for the charging system can only be established during reactor refueling when the RCS is depressurized. To verify valve closure, the RWST must be isolated which is a violation of TS 3.1.2.1.b during normal operation. The only method to verify closure other than disassembly and inspection is to perform a leak rate/back pressure test. This valve is also subject to leak testing, which is performed every reactor refueling. Verification of closure will be performed during the leak test every reactor refueling instead of every CSD because the small increase in safety gained by testing during CSD does not justify the burden of draining the lines and performing a leak rate test.

Alternate Testing:

Exercise to the partially open position during CSD, exercise to the full open and closed positions every reactor refueling.

Example for Containment Spray System from Farley Units 1 and 2

This next example addresses CS header check valves and the CS pump RWST suction check valve.

Licensee's Basis for Requesting Relief:

The only way to verify forward flow operability during normal operation or CSD would be by using the pumps and injecting a large quality of water into the containment. Spraying the containment would result in extensive damage to safety-related equipment located inside the containment.

Alternate Testing:

The system has been modified such that spool pieces can be installed downstream of these check valves. During refueling, these spool pieces will be installed and a full forward flow test performed by pumping water through these full flow test lines to the containment refueling cavity. Because of the time involved in installing the spool pieces and the large quantity of water necessary, this test can only be performed at refueling. In addition, QV014 will be partial forward flow verified during quarterly pump testing.

Example for Control Rod Drive System from Clinton

The licensee requested relief for the CRD water header check valve.

<u>Licensee's Basis for Requesting Relief:</u>

This check valve is a CIV which provides drive water to the HCUs and seal flow to the reactor recirculation pumps. This is a normally open valve and cannot be tested during normal plant operation or CSDs since testing this valve requires that the CRD system be shutdown causing the control rods' motion to be prevented and stopping seal flow to the reactor recirculation pumps. Although the reactor recirculation pumps are not required for safe shutdown of the plant, these pumps are used to assure uniform temperatures are maintained in the vessel during CSDs. Exercising this valve would also allow air to enter the CRDs which would require substantial venting of the system to remove the entrapped air.

<u>Alternate Testing:</u>

Illinois Power Company will exercise this valve during RFOs.

Example for Core Spray System from Pilgrim

The components for which relief was requested were the core spray injection check valves.

<u>Licensee's Basis for Requesting Relief:</u>

Testing these valves during normal operation would require injecting cold water into the reactor vessel using the core spray system. This would result in both a reactivity excursion and thermal shock to the reactor vessel and spray sparger. Testing these valves during CSD could cause a thermal shock to the reactor vessel when the vessel metal temperature is greater than 212°F. The suppression pool is the core spray system's water source. Injection of suppression pool water into the reactor vessel during CSD results in exceeding the Electric Power Research Institute (EPRI) Water Chemistry Guidelines which PNPS has adopted to preclude the initiation and propagation of intergranular stress corrosion cracking in reactor coolant stainless steel components. The chemistry of the suppression pool water (typical conductivity of 4-5 umho/cm) does not meet the chemical requirements of the reactor coolant (typical conductivity of 0.15-0.3 umho/cm). Restart of the reactor is not permitted until the reactor coolant water chemistry is within the EPRI guidelines. In addition, the amount of water that is injected into the vessel during the test of only one of the core spray injection check valve results in significant vessel level increase and may cause a vessel isolation. This would extend the length of a shutdown since the only means of water removal from the reactor is via the RWCU system line to the condenser. The forward flow exercise of the injection check valves will require reactor vessel level control out of the normal parameter and a bleed and feed of the core spray system to improve water quality prior to testing.

<u>Alternate Testing:</u>

Exercise valves each refueling interval.

Example for Feedwater System from Dresden Units 2 and 3

The components involved in this request example are the inboard and outboard feedwater injection header check valves.

<u>Licensee's Basis for Requesting Relief:</u>

These valves are normally open and cannot be exercised closed during normal operation because the feedwater system is required to be operable to maintain reactor coolant inventory. To

exercise these valves closed during CSDs would require isolating the feedwater system, deinerting the drywell and back pressurizing the check valves individually to verify closure. This testing is impractical to perform during CSDs due to the RWCU path and feedwater being required (means of maintaining reactor coolant inventory) during CSDs. Additionally, approximately 2,200 gallons of feedwater would need to be drained from the feedwater system headers prior to performing the necessary backflow test. This added operational and testing burden would invariably delay unit restart.

Alternate Testing:

These valves will be exercised closed each reactor refueling.

Example for High Pressure Coolant Injection System from Dresden Station, Units 2 and 3

The components involved in this request example are the HPCI system injection check valves.

Licensee's Basis for Requesting Relief:

The HPCI check valves have both an open and closed safety function. These valves are required to be closed during normal power operation to prevent flow diversion of reactor coolant (feedwater). These valves are also required to open upon a HPCI initiation to provide the injection path for HPCI. To full-stroke exercise these valves open quarterly or during CSDs requires injecting approximately 5,000 gpm of condensate storage tank water at 70°F into the reactor vessel at 540°F. This type of test is impractical because repeating this test will eventually fatigue and crack the injection nozzles due to the induced thermal shock. In addition to the nozzle cracking concerns, a cold water transient in the vessel will cause a reactor trip.

A reverse flow test (back pressurizing) is required to verify the closed position of the HPCI injection check valves. To accurately perform a reverse flow test on these valves during normal power operation (quarterly) requires entering the X-area, mounting a temporary gauge and monitoring the pressure upstream of the injection valve. This test is impractical because of the extremely high dose rates in the area coupled with the amount of time necessary to determine valve operability. The average dose rate in the X-area during normal reactor operation is approximately 1.5 rem per hour. Two technicians will be required to perform the test. The test would take approximately 30 minutes barring any operational problems. The estimated radiation exposure of 1.5 ManRem to perform this test each quarter is considered extremely impractical.

To verify closure of the HPCI injection check valve during CSD periods requires isolating the feedwater and RWCU systems, draining and venting the respective test volume and leak rate testing the HPCI injection valve. This test is impractical to conduct during CSD because of the RWCU flow path and feedwater being required (means of maintaining reactor coolant inventory) during CSD. Additionally, the added operational and testing burden would delay unit startup.

Alternate Testing:

The 2301-7 valves will be full-stroke exercised open and closed each reactor refueling. Additionally, these valves will be full-stroke exercised open during CSDs and the torque measured as required by IWV-3522.

Example for Instrument Air System from Braidwood Station, Units 1 and 2

This next example addresses the check valves in the supply air lines to valves which are isolation valves in the instrument air supply to containment.

Licensee's Basis for Requesting Relief:

The 1(2)IA066 valves are air-operated CIVs for the instrument air line to containment; they fail closed on loss of air supply/power. The 1(2)IA091 check valves are in the supply air line to the 1(2)IA066 valves, which taps off the line between the two isolation valves. These check valves also perform a containment isolation function in the closed position. Stroke testing of these valves during plant operation or CSD would, by design, isolate the air operated instruments and valves inside the containment building. The loss of instrument air to containment creates a very serious situation and should be avoided for testing purposes. This situation involves loss of pressure control via the sprays, letdown isolation, and loss of charging flow. Additionally, loss of air would leave the pressurizer PORVs with only their accumulators as an air supply, limiting the number of operations available.

The full-stroke exercising of the instrument air CIVs during unit power operations or CSDs introduces the possibility of causing major operating perturbations and/or personnel safety concerns during the test. Additionally, should these valves fail to re-open during testing activities, the transient would be exacerbated. The failure of these valves in the closed position, as a result of testing activities during plant operation or CSD, would subsequently isolate the air operated instruments and valves inside the containment building thus resulting in one or more of the following scenarios:

Loss of Pressurizer Pressure Control - The pressurizer spray valves 1(2)RY455B & C and the pressurizer auxiliary spray valve 1(2)CV8145 would fail closed and not be available for pressurizer pressure control.

Loss of Chemical Volume Control System letdown flow (both normal and excess) and charging flow - The loss of instrument air would cause a disruption in the unit letdown flow paths resulting in pressurizer level increases. Such valves as the letdown orifice containment outlet header isolation valve 1(2)CV8160, the letdown line isolation valves 1(2)CV459 and 1(2)CV460, the letdown orifice outlet isolation valves 1(2)CV8149 A, B and C, the excess letdown heat exchanger inlet isolation valves 1(2)CV8153A and B, and the regenerative heat exchanger letdown inlet isolation valves 1(2)CV8389A and B would go to their fail closed positions. Additionally, the ability to normally make up reactor coolant inventory and adjust the reactor chemical shim (i.e. normal boration/dilution) would also be lost as the regenerative heat exchanger inlet isolation valves 1(2)CV8324A and B would fail to their respective closed positions. An additional detrimental effect would be the thermal cycle imposed on the reactor vessel nozzle upon restoration of system operation.

Loss of Component Cooling to Containment Penetrations - The loss of instrument air supply would cause the penetration cooling supply flow control valve 1(2)CC053 to go to its fail closed position. The loss of penetration cooling would result in elevated temperatures being imposed on the penetrations being supported by the CC system.

Loss of Personnel Breathing Air - The loss of instrument air supply to the service air downstream isolation valve 1(2)SA033 would cause this valve to go to its fail closed position. This loss of service air in the containment building would eliminate the normal source of supplied breathing air needed to support numerous maintenance and component inspection activities in a contaminated radiological environment.

Alternate Testing:

These valves will be exercised during RFOs. The back flow test for the 1(2)IA091 check valves will be done in conjunction with the Appendix J seat leakage test. This testing period will be each RFO as a minimum, but no more frequently than once per quarter.

Example for Reactor Building Closed Cooling Water System from Nine Mile Point Unit 1

The components involved in this request example are the check valves in RBCCW supply lines to the drywell air coolers and the reactor recirculation pumps.

<u>Licensee's Basis for Requesting Relief:</u>

Testing these valves during normal operation or CSD requires interruption of the cooling water to the drywell air coolers and reactor recirculation pump motor coolers for a long time period. Loss of the drywell air coolers could result in a reactor scram due to higher drywell temperature causing higher drywell pressure. Loss of cooling water to the recirculation pump water coolers for more than a few minutes could cause damage to the recirculation pumps. Testing the reactor recirculation pump motor cooler valve during CSDs would also require intrusion into the system in order to verify reverse flow closure. Testing during these periods is not feasible, as the reactor building closed loop cooling is a common line for the reactor recirculation pumps.

The test provisions are inside the drywell which is inaccessible during power operations due to the inerted atmosphere, the increased temperature/radiation levels for test personnel, etc. Thus it is impractical to test these valves during quarterly or CSD intervals.

<u>Alternate Testing:</u>

Reverse flow closure of these valves shall be verified at scheduled RFOs.

Example for RHR System from Clinton

The component involved is the check valve that serves as a thermal relief on the RHR line from the reactor recirculation loop between normally closed valves.

<u>Licensee's Basis for Requesting Relief:</u>

This valve is installed in the piping of the shutdown cooling mode of operation of the RHR System and is located inside the drywell. During normal operation, this line is pressurized by the reactor recirculation system. The valve is not designed to open against this pressure. Therefore, this valve cannot be exercised quarterly. This valve cannot be exercised during CSDs since the shutdown cooling mode of the RHR System will be in service. As this line is pressurized at all times during the CSDs, an exercise test is not feasible. In RFOs, the shutdown cooling and reactor recirculation can be isolated prior to reactor startup to facilitate the operating of this valve.

<u>Alternate Testing:</u>

Illinois Power Company will exercise this valve during RFOs.

Example for RHR System from Farley Units 1 and 2

This next example addresses the RHR return header checks valves.

<u>Licensee's Basis for Requesting Relief:</u>

Verification of forward flow operability of these normally closed check valves can only be performed by injecting RHR water into the RCS. During normal operation the low-pressure LHSI/RHR pumps cannot overcome the higher RCS operating pressure. Verification of full design flow rate operability cannot be done at CSD due to back pressure from the RCS. Verification of full flow operability can only be done at refueling with the RCS depressurized, the reactor vessel head removed, upper internals in place, and the refueling cavity at refueling level.

Alternate Testing:

Valves will be forward flow verified when the SI/LOSP test is being performed.

Example for Safety Injection System from Millstone Unit 2

The components involved in this request example are the high pressure safety injection system check valves.

Licensee's Basis for Requesting Relief:

These valves cannot be full stroke exercised during reactor operations since the only full flow path is into the RCS. HPSI pumps do not have sufficient discharge pressure (1,200 psi) to overcome reactor coolant pressure (2,250 psi). Valves cannot be full stroke exercised during CSD, since full HPSI flow into the reactor could result in RCS over pressurization.

Alternate Testing:

Design flow tests will be conducted during reactor refueling with the reactor head removed. These tests are conducted while filling the reactor pool cavity and effectively demonstrate that these check valves do operate properly. Partial stroke exercising will be done quarterly.

Example for Standby Liquid Control (SLC) System from Peach Bottom Units 2 and 3

The component involved is valve SLC injection check.

Licensee's Basis for Requesting Relief:

Verifying forward flow operability requires firing a squib valve and injecting water into the RCS using the SLC pumps. Injection of borated water during operation will result in a reduction in power. Additionally, introduction of relatively colder water into the RCS will cause a thermal cycle (shock) which can result in the premature failure of system components (piping). Since the firing of squib valves requires valve disassembly to replace valve internals, firing should be minimized. Therefore, forward flow testing of this check valve will be performed during SLC injection testing as required by TS 4.4.A. Reverse flow closure of CHK-2(3)-11-016 can be accomplished only by leak testing which must be performed when a squib valve has been fired (opened) to provide a leak test flowpath. Because firing squib valves should be minimized as mentioned above, and replacing squib valve internals at CSD could delay plant start-up, reverse flow closure will be verified at refueling.

Alternate Testing:

Forward flow operability for CHK-2(3)-11-016 will be verified at refueling during SLC injection testing. Reverse flow closure for CHK-2(3)-11-016 will be verified at refueling during Appendix J, Type C, testing.

Example for SW System from Pilgrim

This next example addresses the SW pump discharge check valves,.

Licensee's Basis for Requesting Relief:

During plant operation these normally open check valves are exercised closed during quarterly pump testing. Because of each system's large cooling loads and lack of installed instrumentation individual pump flow rates can not be obtained. This deviation is identified by pump relief requests with an alternate testing criteria of measuring flow rate during a CSD, if practical, but on

a not to exceed a refueling interval basis. Therefore verifying these check valves full open quarterly or during CSD is impractical and would place an undue hardship on the facility.

<u>Alternate Testing:</u>

Perform open normal position verification in conjunction with its respective pump's flow rate measurement.

Example for Containment Isolation Valves from Perry

The components involved in this request example are drywell and containment vacuum relief check valves.

<u>Licensee's Basis for Requesting Relief:</u>

These vacuum breakers have a unique design which allows remote exercising using a testable pneumatic actuator. Their design includes a position indicator and annunciator circuitry to remotely verify that the disk moves freely off the seat, thus minimizing the need for personnel access to the containment reducing that amount of radiation exposure as low as reasonably acheivable (ALARA). Exercising by use of the testable (pneumatic) mechanism shall comply with IWV-3521 test frequency requirements as a part-stroke exercise. The measurement of actual force (full-stroke exercise) to verify that the torque or force for opening is equivalent to the desired functional pressure differential force shall be performed as a channel calibration per the TS surveillance requirement. The surveillance requirement frequency of testing (i.e., measuring of torque) assures the necessary quality of the system and component is maintained, that facility operation will be within the safety limits and the LCO will be met. Therefore, measurement of torque at a more frequent interval would result in a hardship by increasing the radiation exposure without a compensating increase in the level of quality and safety.

<u>Alternate Testing:</u>

Part-stroke exercise these valves once every 3 months using the testable feature and full-stroke exercise (channel calibration) each RFO.

Example for Containment Monitoring System from Clinton

This next example addresses excess flow check valves on containment monitoring lines from the suppression pool.

<u>Licensee's Basis for Requesting Relief:</u>

These valves cannot be tested every three months because they are 8 feet below the normal suppression pool level. To perform these tests during CSDs would require the pool level to be lowered by 8 feet to gain access for installing test connections. Lowering 8 feet of water in the suppression pool (which is approximately equivalent to 62,000 ft^3 or 460,000 gallons) and processing the radioactive waste would delay the plant startup and generate more radwaste.

<u>Alternate Testing:</u>

Illinois Power Company will exercise these valves during RFOs.

(2) Proposals to Verify Closure of Check Valves at a Refueling Outage Frequency

We considered 94 requests that involved verifying the reverse flow closure of check valves at an RFO frequency in lieu of the quarterly or CSD frequencies prescribed by Section XI. Requests to verify

closure of check valves at RFOs are common because they generally do not have position indication or other means to verify that the disk is closed other than by leak testing, and it is often impractical or an unusual hardship to establish the conditions necessary to leak test these valves quarterly during power operations or during CSDs. Code changes made during the transition from Section XI to OM-10 have essentially resolved the testing frequency issue. OM-10, Paragraphs 4.3.2.2(d) and (e) allow check valve exercising at RFOs if full-stroke exercising is impractical during power operations and CSDs. The staff determined that it is acceptable for a licensee to employ this method in accordance with 10 CFR 50.55a (f)(4)(iv) for use of portions of later editions of the Code approved in 10 CFR 50.55a(b) if all related requirements are implemented.

The guidance in NUREG 1482, Section 4.1.4, indicates that licensees may defer verification of valve closure by leak rate testing until RFOs. This section states in part: "If no other practical means is available, it is acceptable to verify that check valves are capable of closing by performing leak-rate testing, such as local leak rate testing in accord with Appendix J to 10 CFR Part 50, at each reactor RFO. Recognizing that the setup and performance limitations may render leak testing impractical during power operation and CSD outages, the staff has determined that implementation of an extension of the test frequency for such valves is acceptable in accord with 10 CFR 50.55a(f)(4)(iv)." The NUREG further states: "To use this position, the licensee must include an RFO justification describing the impracticality of performing testing at the Code frequency and referencing this position in the IST program."

Although relief is no longer required to defer verifying the closed safety-function of check valves until RFOs when it is impractical quarterly and during CSDs, the conditions of NUREG 1482, Section 4.1.4, should be referenced and met in the IST program if the licensee has not already updated the program to OM-10. In these cases, the RFO justifications should meet the guidelines of NUREG 1482. Since relief is no longer needed for these cases, the following examples are provided to give sample bases for RFO justifications. Examples are included for different systems and plant types (e.g., PWR or BWR).

Example for Chemical and Volume Control System from Robinson Unit 2

The component involved is the chemical and volume control normal makeup check valve.

Licensee's Basis for Requesting Relief:

Due to the system design, the only method available to verify reverse flow and perform a leak test is to isolate the entire charging line to allow pressurizing the space downstream of the check valve. Isolating charging flow during power operation would cause level perturbation and could result in a unit trip. Due to the special equipment and system configuration required to perform this test, it has been determined to be impractical to perform at CSD intervals.

Alternate Testing:

Reverse flow closure and leak test will be performed every RFO, utilizing a separate, removable test rig.

Example for Containment Air Monitoring System from Zion Units 1 and 2

The component involved is the containment air sampling return check valve.

Licensee's Basis for Requesting Relief:

Relief is requested from the quarterly exercising requirement for the air sampling system return check valve PR0029 to the closed position. To test PR0029 quarterly would mean sending a person into containment while the reactor is operating. Also testing PR0029 to the closed position requires disassembling the air sample system in order to provide a vent path. Additionally the

System Particulate, Iodine and Noble Gas Monitor is in continuous operation and returns air back to containment through check valve PR0029. Closing RP0029 would require that the System Particulate, Iodine and Noble Gas Monitor be secured and thus air samples of containment would have to be taken at a greater frequency and analyzed manually.

Alternate Testing:

Zion Station proposed to verify closure of check valve PR0029 by leak testing at RFOs. This alternative will provide adequate assurance of the required level of safety that operational readiness is maintained.

Example for Control Rod Drive System from Browns Ferry Units 1, 2, and 3

The components involved in this request example are the CRD supply to reactor recirculation pump seal injection inboard and outboard containment isolation check valves.

Licensee's Basis for Requesting Relief:

These check valves serve as inboard and outboard CIVs. The valves are not equipped with remote indication, and there is no pressure indication downstream of the valves. For these valves, closure testing is only practical through pressurization downstream of the valve, with the upstream piping vented and verification of the absence of flow upstream. Interruption of the CRD flow (seal injection) is required to perform this testing, and during reactor recirculation pump operation, could result in seal damage. This type of testing can only be performed during a period when the containment is accessible. The deinerting of the containment will only be performed during major outages. Based on the impact of having to install temporary test equipment, the required testing will be performed during Category A leak rate testing.

Alternate Testing:

Proper valve closure will be verified by completion of local leak rate testing performed in accordance with 10 CFR 50.

Example for Core Spray System from Fitzpatrick

The components involved in this request example are the core spray check valves. These valves open to provide minimum flow required for the core spray holding pump and close to prevent reverse flow from the Torus.

Licensee's Basis for Requesting Relief:

There are no position indicators or other means to verify closure of these valves; thus, the only practical method of verifying closure is by means of back-leakage tests. Due to the lack of appropriate isolation and test connections, these valves cannot be verified to close by means of a reverse flow test. Any system modification performed to provide a means by which these valves can be backflow tested will result in an arrangement that requires set-up and connection of a hydrostatic pump in a high radiation area. System line-up changes and effort involved with testing would constitute an unreasonable burden on the plant staff.

Alternate Testing:

During the next reactor RFO, the system will be modified to provide an appropriate means of reverse flow testing these valves to verify closure. Following the modification, during each refuel outage, these valves will be verified to close via a hydrostatic leak rate test

Example for Emergency SW System from Fitzpatrick

This example addresses the emergency SW to drywell cooler check valves.

<u>Licensee's Basis for Requesting Relief:</u>

These are simple check valves with no means of determining disc position without performing a back-leakage test. Performing such a test, would require securing cooling water flow to the drywell coolers for an extended period of time. During plant operation this could cause a spike in drywell pressure with a potential for a reactor scram and plant shutdown. Initiation of the ESW system to "exercise" these valves would introduce untreated lake water into the treated RBC water system where the water is maintained at a high level of purity. A loss of chemistry would require extensive "bleed-and-feed" operations to restore the RBC system water purity, and could result in unacceptable metallurgical effects. During CSD, the system lineup changes and effort involved with testing would constitute an unreasonable burden on the plant staff.

<u>Alternate Testing:</u>

During each refuel outage these valves will be verified to be closed during leak rate testing performed per 10 CFR 50, Appendix J.

Example for the Feedwater System from Browns Ferry Units 1, 2, and 3

This example addresses the feedwater header check valves.

<u>Licensee's Basis for Requesting Relief:</u>

All four check valves remain open, maintaining the flow path to the reactor vessel whenever the feedwater/condensate systems are supplying feedwater to the reactor vessel. When RCIC or RWCU system are returning flow to the reactor vessel, check valve 3-572 remains open. When HPCI is injecting to the vessel, check valve 3-558 remains open. Due to the necessity of maintaining this flow path in virtually all modes of operation, closure testing is only practical during extended outages such as refueling during which these systems are shutdown. Also, plant design does not provide a practical means of demonstrating closure other than by upstream pressurization performed during leak rate testing in accordance with Appendix J, 10 CFR 50. This testing involves significant effort for installation of temporary equipment, and requires entry into an inerted reactor containment. Such entry into containment poses a hazard to personnel safety or requires deinerting.

<u>Alternate Testing:</u>

Valve closure will be verified by completion of local leak rate testing performed in accordance with 10 CFR 50, Appendix J, at each RFO.

Example for High Pressure Coolant Injection System from Browns Ferry Units 1, 2, and 3

The components involved in this request example are the HPCI and RCIC turbine exhaust line check valves.

<u>Licensee's Basis for Requesting Relief:</u>

These check valves are not equipped with position indication, and system design does not provide any practical method of verifying closure other than pressurization similar to leak rate testing. Such testing requires installation of temporary equipment which is impractical on a quarterly basis, and it would render the system inoperable during the testing period. Additionally, the valve location (top of torus) could present a personnel safety hazard during operation. Normally,

testing of this type is accomplished by required containment local leak rate testing in accordance with Appendix J.

Alternate Testing:

Proper valve closure will be verified by completion of local leak rate testing performed in accordance with 10 CFR 50, Appendix J.

Example for Instrument Nitrogen System from Peach Bottom Units 2 and 3

The components involved in this request example are the drywell/torus vacuum breakers nitrogen supply checks.

Licensee's Basis for Requesting Relief:

The only method to verify reverse flow closure of these valves is by leak testing. Since these valves have a primary function of containment isolation, they are leak tested during Appendix J, Type C, testing at refueling. In order to leak test the valves, a manual valve located inside the torus must be closed. During power operation and CSD, the containment atmosphere is normally inerted with nitrogen, limiting access to emergencies only. Because testing cannot be accomplished at power and leak testing at CSD could delay plant start-up, these valves will be leak tested during refueling.

Alternate Testing:

Reverse flow closure will be verified during Appendix J, Type C, testing during refueling.

Example for Reactor Water Cleanup System from Browns Ferry Units 1, 2, and 3

This example addresses the RWCU return line check valves.

Licensee's Basis for Requesting Relief:

This check valve remains open to return water to the reactor vessel whenever the RWCU system is operating. This valve is not testable whenever the RWCU, feedwater/condensate, or RCIC system is returning flow to the reactor vessel. Testing requires entry into primary containment and the disruption of system flow (RWCU, feedwater/condensate or RCIC). For these reasons, closure testing is only practical during extended outages such as refuelings during which these systems are shutdown. Also, plant design does not provide a practical means of demonstrating closure other than by upstream pressurization performed during leak rate testing conducted in accordance with 10 CFR 50 Appendix J. This testing involves significant effort for installation of temporary equipment. This would require valve lineups to abnormal positions, installation of pressurizing equipment and associated test lines as well as deinerting the drywell for safe entry.

Alternate Testing:

Proper valve closure will be verified by completion of local leak rate testing performed in accordance with 10 CFR 50, Appendix J.

Example for SLC System from Nine Mile Point Unit 1

The components involved in this request example are the liquid poison injection line check valves.

Licensee's Basis for Requesting Relief:

These valves are normally closed and are only opened during RFOs when the simulated injection test of liquid poison is performed. The valves are then verified closed by performing an Appendix J, Type C leak test. A containment entry is required to perform this leak test. Since the containment is normally inerted, it is not feasible to perform the test during normal operation or CSDs.

Alternate Testing:

Verify the reverse flow closure of these valves by performing the Appendix J, Type C, leak rate testing during RFOs.

Example for Torus Check Valves from Fitzpatrick

This example addresses the check valves in the torus lines.

Licensee's Basis for Requesting Relief:

These are simple check valves with no means of determining disk position without performing a back leakage test. Performing such a test, would require setting up a hydrostatic pump in a high radiation area. During CSD, the lineup changes and effort involved with testing would constitute an unreasonable burden on the plant staff.

Alternate Testing:

During each refuel outage these valves will be verified to close during a hydrostatic leak rate test.

(3) Proposals to Defer Testing that Requires De-inerting the Containment of a BWR

We considered several hundred requests that involved de-inerting the containment of BWRs to perform testing of check valves. These requests generally involved deferring the testing to RFOs in lieu of performing them quarterly or during CSDs because access is necessary to test the simple check valves involved and access is unavailable due to the containment atmosphere being maintained with high levels of an inert gas (nitrogen) to limit the oxygen concentration to levels that will not support combustion.

The guidance in NUREG 1482, Section 3.1.1.3, indicates that licensees may defer testing valves until RFOs if the valves would otherwise be tested during CSD outages and it would be necessary to de-inert the containment atmosphere in order to perform the testing during CSDs. This section states in part: "The NRC staff does not consider that containment de-inerting solely for the purpose of valve testing is warranted and approves the test deferral pursuant to 10 CFR 50.55a (f)(4)(iv) provided the licensee meets all requirements of Paragraphs 4.2.1, 4.3.2, and 6.2 of OM-10 and describes this section in the IST program." To use this position, the guidance in NUREG 1482 states that the licensee should include an RFO justification describing the impracticality of performing testing at the Code frequency and referencing this position in the IST program if the licensee has not already updated the program to OM-10.

Although relief is no longer required to defer testing of check valves until RFOs when it is impractical to test them quarterly and testing them at CSDs necessitates de-inerting containment, the conditions of NUREG 1482, Section 3.1.1.3, should be referenced and met in the IST program if not using OM-10. In these cases, the RFO justifications should meet the guidelines of NUREG 1482. Since relief is no longer needed for these cases, the following examples are provided to give sample bases for RFO justifications.

Example for Main Steam Check Valves from Cooper

The components involved in this request example are the check valves required for vacuum relief of the main steam lines to the suppression pool.

<u>Licensee's Basis for Requesting Relief:</u>

These vacuum breaker check valves are located inside containment and are not equipped with actuators or position indicators. Manual exercising requires drywell access. The drywell is not accessible during normal station operations and therefore the valve cannot be full-stroked or partial-stroked exercised during normal station operation. These valves can only be exercised during CSD when the drywell is de-inerted. These valves are located in the drywell and, therefore, are only accessible when the plant is shutdown and the drywell is de-inerted. The drywell is not normally de-inerted when reaching the CSD condition and doing so is undesirable because of the burden and the time required. Except for RFOs, CSDs are usually unnecessary and if a shutdown occurs, down time is kept to a minimum. De-inerting containment for check valve testing is considered to be a unreasonable burden.

<u>Alternate Testing:</u>

These valves will be mechanically exercised during CSD periods when the drywell is de-inerted.

Example for Emergency Core Cooling System Check Valves from Washington Nuclear Unit 2

The component involved are the emergency core cooling system testable check valves.

<u>Licensee's Basis for Requesting Relief:</u>

The Velan operation and maintenance manual for the testable check valves used in the RCIC, LPCS, HPCS, and RHR systems specifies that the valves are not to be operated with greater than 5 psi differential pressure across the valve disk. To achieve this condition during shutdown with any substantial level in the vessel will require that the manual isolation valve downstream be operated and pressure equalized across the disc prior to valve stroking. It is not possible to perform this task with the containment inerted. These valves are normally closed and while in the closed position function as 1) CIVs and 2) high-low pressure interface valves between the reactor coolant and portions of the emergency core cooling system. These valves must open to facilitate operation of part of the emergency core cooling system. The valves will normally only be operated in the event of an emergency during normal power operations. Lengthening the interval between tests as recommended will not preclude the timely evaluation of valve operability and thus provides adequate assurance of material quality and public safety.

<u>Alternate Testing:</u>

These check valves will be exercised with the reactor at CSD and the containment de-inerted.

(4) Proposals to Test Excess Flow Check Valves at a Refueling Outage Frequency

We considered 7 requests that involved testing excess flow check valves at an RFO frequency in lieu of the quarterly or CSD frequencies prescribed by Section XI. Excess flow check valves are located on instrument sensing lines that penetrate the primary containment. They perform a containment isolation safety function to close when excessive flow occurs through the sensing lines. It is generally impractical to exercise these valves during power operation because testing involves isolating the instrument and venting the sensing line downstream of the excess flow check valve. The instruments supplied by these sensing lines would be removed from service during this testing. Removal of certain instrumentation that provides reactor protection and control signals during power operation

could result in spurious safety system actuation and a reactor trip. Additionally, it is impractical to exercise these valves during CSD because some of the affected instruments are required to be in operation during that mode and removal of the associated instruments from service could prevent operation of systems required for decay heat removal (DHR).

Code changes made during the transition from Section XI to OM-10 have essentially resolved the testing frequency issue. OM-10, Paragraphs 4.3.2.2(d) and (e) allow check valve exercising at RFOs if full-stroke exercising is impractical during power operations and CSDs. The staff determined that it is acceptable for a licensee to implement this method in accordance with 10 CFR 50.55a (f)(4)(iv) for use of portions of later editions of the Code approved in 10 CFR 50.55a(b) if all related requirements are implemented.

Although relief is no longer required to defer testing of excess flow check valves until RFOs when it is impractical quarterly and during CSDs, the conditions of NUREG 1482, Section 3.1.1, should be met unless the program has been updated to OM-10. The following examples are provided to give sample bases for RFO justifications.

Example for Excess Flow Check Valves from Peach Bottom Units 2 and 3

Licensee's Basis for Requesting Relief:

Excess flow check valves are installed on instrument lines penetrating containment to minimize leakage in the event of an instrument line failure outside the containment in accordance with Regulatory Guide 1.11. The excess flow check valve is basically a spring loaded ball check valve. Since the system is normally in a static condition, the valve ball is held open by the spring. Any sudden increase in flow through the valve (i.e., line break) will result in a differential pressure across the valve which will overcome the spring and close the valve. Functional testing of valve closure is accomplished by venting the instrument side of the valve while the process side is under pressure and verifying the absence of leakage through the vent.

The testing described above requires the removal of the associated instrument or instruments from service. Since these instruments are in use during plant operation and CSD, removal of any of these instruments from service may cause a spurious signal which could result in a plant trip, an inadvertent initiation of a safety system, loss of DHR and/or the defeating of safety interlocks. In addition to the plant safety concerns, personnel safety concerns must be considered since the process side of these valves is normally high pressure (>500 psig) and/or high temperature (>200°F) and highly contaminated reactor coolant. In summary, due to the plant and personnel safety concerns and plant operating conditions that prohibit the testing of these valves quarterly or at CSD, testing will be performed at refueling when decay heat loads are at a minimum and safety systems can be removed from service to prevent inadvertent initiation.

Alternate Testing:

Functional testing will be performed at refueling

Example for Excess Flow Check Valves from Pilgrim

Licensee's Basis for Requesting Relief:

These excess flow check valves are the primary CIV for systems considered inservice during plant operation. These normally open instrument isolation check valves require a reverse flow exercise. Leak testing (per ASME Code) performs valve exercising in the closed direction each refueling interval. Following the leak test a normal open position verification is performed to each valve. The leak rate testing of excess flow check valves requires the reactor coolant pressure boundary (Class 1) to be at a pressure of at least 600 psig. Testing requires valving out instruments which have a high probability of causing a safety system function initiation and/or isolation. Therefore,

the plant should be shutdown for testing. During plant shutdowns, the reactor coolant pressure boundary is not pressurized except when performing the once-per-RFO ASME Boiler and Pressure Vessel Code, Section XI System Leakage Pressure Test. The excess flow check valve leak testing is conducted during this system leakage pressure test.

<u>Alternate Testing:</u>

Perform exercise, leakage test and open normal position verification to these valves during each refueling interval.

2.2.2 Check Valves Disassembly and Inspection

The most common method to exercise a check valve open is to pass flow through the valve. For this flow test to be a full-stroke exercise it must meet the criteria specified in GL 89-04, Position 1. For some normally closed check valves it is impractical to establish or verify sufficient flow to meet the GL full-stroke exercise criteria. Flow testing performed at flow rates less than the maximum accident condition flow rate can be considered a full-stroke exercise only if some other method (such as non-intrusive diagnostics) is used to demonstrate that the valve disk has moved to its required safety position. It is often impractical to establish conditions or verify certain normally open check valves in the closed position. Many do not have a means to establish the necessary reverse differential pressure while others require stopping flow in a system that is necessary during both power operation and CSDs. Where it is impractical to full-stroke exercise check valves open with flow or verify their reverse flow closure, the most common method to satisfy the full-stroke exercise requirement has been the use of check valve disassembly and inspection.

Requirements

Section XI, Paragraph IWV-3522 states: "Check valves shall be exercised to the position required to fulfill their function...." ASME OM Code-1990, Subsection ISTC, Paragraph ISTC 4.5.2(a) requires each check valve to be exercised or examined in a manner that verifies obturator travel to the closed, full-open, or partially open position required to fulfill its function. GL 89-04 states that a check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve and that any flow rate less than this will be considered a partial-stroke exercise. The GL further states that a valid full-stroke exercise by flow requires that the flow through the valve be known. Knowledge of only the total flow through multiple parallel lines does not provide verification of flow rates through the individual valves and is not a valid full-stroke exercise.

In GL 89-04, the NRC staff stated: "...valve disassembly and inspection can be used as a positive means of determining that a valve's disk will full-stroke exercise open or of verifying closure capability...." GL 89-04 established the position that during valve testing by disassembly, the valve internals should be visually inspected for worn or corroded parts, and the valve disk should be manually exercised. The GL further stated that valve disassembly and inspection may be performed during reactor RFOs. The GL also provided for a sample disassembly and inspection plan for groups of identical valves in similar applications for cases where the licensee determines that it is burdensome to disassemble and inspect all applicable valves each RFO.

OM-10 also permitted the use of disassembly and inspection of check valves as an alternative to verifying the required valve obturator movement by positive indication (e.g., flow measurement, pressure measurement) or by using a mechanical exerciser. The ASME OMc Code-1994 specified that disassembly and inspection should be used only when the other two methods of verifying the required obturator movement are impractical. OMc also included provisions for the use of a sampling plan for disassembly and inspection of check valves that is similar to the plan specified in GL 89-04.

Table 2-7. Summary Table of Key Requirements and Guidance for Check Valves Disassembly and Inspection

Document	Section	Requirement/Guidance
Section XI	IWV-3522	Verify the valve exercises to the required position(s) by observing a direct indicator such as a position-indicating device or by other indicator(s) such as changes in system pressure, flow rate, level, temperature, seat leakage testing or other positive means; <u>or</u> a mechanical exerciser can be used to move the valve disk.
OM-10	Paragraph 4.3.2.4	Verify the valve exercises to the required position(s) by observing a direct indicator such as a position-indicating device or by other indicator(s) such as changes in system pressure, flow rate, level, temperature, seat leakage testing or other positive means; <u>or</u> a mechanical exerciser can be used to move the valve disk; or disassembly may be used every refueling.
GL 89-04	Position 1/ Questions 1-8	A check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve. A flow rate less than this will be considered a partial-stroke exercise. A valid full-stroke exercise by flow requires that the flow through the valve be known.
GL 89-04	Position 2/ Questions 9-20	Disassembly and inspection can be used as a positive means of determining that a check valve's disk will full-stroke exercise open or of verifying closure capability. A sample disassembly and inspection plan for groups of identical valves in similar applications may be employed. The guidelines for this plan are explained. If possible, partial valve stroking after reassembly must be performed.
OMc-1994	ISTC 4.5.4	Same as OM-10 except that disassembly and inspection can be used only when the two other methods are impractical. Also, establishes a sampling plan similar to the plan in GL 89-04. Nonintrusive techniques are specifically identified as acceptable positive means of verifying the required valve position(s).
NUREG 1482	4.1.2	Nonintrusive techniques may be used to verify a check valve's capability to open, close, and fully stroke in accord with quality assurance program requirements. Relief is not required to use this method except as would be necessary for the testing frequency if the interval extends beyond each RFO.
NUREG 1482	4.1.4	If no other practical means is available, it is acceptable to verify that check valves are capable of closing by performing leak-rate testing, such as local leak rate testing in accord with Appendix J to 10 CFR Part 50, at each reactor RFO.

Relief Request Issues

There were several issues in the reviewed relief requests that are related to verifying a full-stroke exercise of a check valve using disassembly and inspection. They include the following major issues.

Major Issues:

a) Proposals to disassemble and inspect check valves each RFO (see Item 1)
b) Proposals to disassembie and inspect check valves on a sampling basis (see Item 2)

c) Proposals to extend the sampling interval for check valve disassembly (see Item 3)

Each of these issues is discussed separately in the following sections of this report.

(1) Proposals to Disassemble and Inspect Check Valves each Refueling Outage

We considered 17 requests that involved the use of disassembly and inspection each RFO to verify a full-stroke exercise of check valves. Requests were submitted because disassembly is not an approved method in Section XI. In addition the disassembly is performed during RFOs in lieu of the quarterly or CSD frequencies prescribed by Section XI. Code changes made during the transition from Section XI to OM-10 have addressed both the test method and the testing frequency issues for check valve disassembly. OM-10, Paragraph 4.3.2.4(c) allows check valve disassembly every RFO as an alternative to the other testing methods. GL 89-04, Position 2, grants relief for check valve disassembly and inspection when it is impractical to verify a full-stroke exercise or the closure of a check valve using flow. Position 2 also allows the use of a sample disassembly and inspection program for groups of check valves. To obtain this relief, the licensee must comply with all of the provisions of the GL position.

Although relief is granted by GL 89-04 to use disassembly and inspection during RFOs as an alternative to verifying a full-stroke exercise using flow or some other positive means, it must be performed in accordance with the GL and be referenced in the IST program. The following examples of bases are provided for using this method to verify the full-stroke exercise of check valves

Example for Diesel Generator Starting Air System from LaSalle Units 1 and 2

This example addresses the DG starting air system compressor discharge check valves.

<u>Licensee's Basis for Requesting Relief:</u>

The DG starting air compressor discharge check valves close to isolate safety-related (SR) downstream piping from the non-SR upstream piping and compressors. These check valves as well as the entire upstream portion of the system are under continuous monitoring by installed pressure instrumentation and frequent running of the compressors is also indicative of air losses in the system. There is no other alternative method to practically verify the closure capability of these valves on a quarterly basis. Therefore the alternate method of disassembly and inspection will be performed to verify the closure capability of these valves. A study conducted by Sargent and Lundy of the DG air start check valves (CQD-040256) found that the root cause of approximately 70% of the Nuclear Plant Reliability Data System (NPRDS) reported failures were caused by the valves wearing out. Disassembly of these valves on a refueling basis will provide direct results as to the valves condition and if abnormal wear is occurring. Prior inspections on several compressor discharge check valves for the Institute for Nuclear Power Operations (INPO) significant operating experience report (SOER) 86-03 concerns did not reveal any sizing or misapplication problems with the valves installed at LaSalle Station.

<u>Alternate Testing:</u>

Disassemble and inspect each DG compressor discharge check valve once every RFO per the RV-46 requirements.

Example for Reactor Core Isolation Cooling System from Brunswick Units 1 and 2

The component involved is the RCIC system to RWCU System isolation check valve.

Licensee's Basis for Requesting Relief:

This valve has to close upon RCIC system injection to ensure water is not directed into the RWCU system. There is no external/remote means to verify the check valve's position during normal operation, nor is there an external means to cycle the valve while the system is shut down. To verify the valve's ability to close requires pressurizing downstream of the valve and observing the pressure upstream. There are no test connections that will allow this pressurization. Pressurizing the pipe will require initiating the RCIC system and injecting into the reactor vessel. In order to initiate the RCIC system, the plant is required to be operating (producing steam). Introducing non-preheated water into the reactor during operation could reduce power and cause reactor vessel nozzle cracking due to thermal shock. During CSD, the shell temperature does not normally fall below 200°F, which is the upper temperature limit to avoid thermal shock when introducing non-preheated water.

Alternate Testing:

The valve will be incorporated into a disassembly program which meets the guidance of NRC GL 89-04. Upon disassembly the valve will be visually examined and manually cycled.

Example for the Service Water System from D. C. Cook Units 1 and 2

The components involved in this request example are the check valves that prevent reverse flow into the header of the opposite emergency SW (ESW) train.

Licensee's Basis for Requesting Relief:

These check valves open to provide cooling water flow to various EDG loads. In addition, these valves close to prevent back flow into the opposite ESW train header. The open safety function will be tested in accordance with IWV-3520. The closed safety function cannot be tested in accordance with IWV-3520 for the following reasons: There are no external position indicators associated with the valves, and no instrumentation or taps available at the valve to determine positive closure. In order to determine valve closure, an entire ESW header and safety train, including both EDGs, must be removed from service. These valves cannot be tested at CSD frequency since, with fuel loaded, the ESW is at its highest load demand (RHR operating) at this time and cannot be removed from service. Temporary Code relief has been granted to allow evaluation of non-intrusive examination (NIE) methods for these valves. Permanent relief is requested at this time on the basis that these valves are 'duo disc' (two center shafted crescent-shaped disc halves) check valves, and NIE is not expected to yield meaningful results.

Alternate Testing:

The licensee proposes to verify the closed safety function of these valves by disassembly and inspection during each RFO.

(2) Proposals to Disassemble and Inspect Check Valves on a Sampling Basis

We considered 120 requests that involved the use of disassembly and inspection during RFOs on a sampling basis to verify a full-stroke exercise of check valves. Requests were submitted for sample disassembly rather than disassembly each RFO as permitted by OM-10, Paragraph 4.3.2.4(c), because of the degree of involvement and problems associated with check valve disassembly and inspection. Some of the problems of this method are the time required to establish the necessary system conditions, the time needed to perform the testing, the radiation exposure to the personnel performing the examinations, the time to restore the valve and system to normal, and the time to perform the post maintenance testing. GL 89-04, Position 2, grants relief for check valve sample disassembly and inspection when it is impractical to verify a full-stroke exercise or the closure of a check valve using

flow. Position 2 also allows the use of a sample disassembly and inspection program for groups of check valves. To obtain this relief, the licensee must comply with all of the provisions of the GL position.

Although relief is granted by GL 89-04 to use sample disassembly and inspection during RFOs as an alternative to verifying a full-stroke exercise using flow or some other positive means, it must be performed in accordance with the GL and be referenced in the IST program. The following examples of bases are provided for using this method to verify the full-stroke exercise of check valves

Example for AFW System from Indian Point Unit 3

This example addresses the AFW pump turbine stop check valves.

Licensee's Basis for Requesting Relief:

The only practical method of verifying proper full-stroke operation of these valves in the open direction is to operate the turbine-driven AFW pump at full rated flow with one of the valves manually closed. During power operation, full-stroke exercising these valves as stated would require injection of cold water into the steam generators. This could result in thermal shock to the feedwater supply piping or the steam generator nozzles which is highly undesirable. Partial-stroke exercising can be performed by operation of the pump in the recirculation mode. During CSD, steam is not available for operating AFW Pump #32, thus CSD testing is impractical. Since there are no position indicating devices on these stop check valves for determining disc position, there is no practical method of verifying full closure without operation of the valve handwheel.

Alternate Testing:

During normal plant operation, on a quarterly frequency, these valves will be partial-stroke exercised to the open position and exercised closed using the installed handwheel. Every 2 years both the MS-41 and MS-42 valves will be full- stroked exercised open during TS 4.8.1.a., AFW Pump #32 full flow testing. During each reactor RFO, at least one of these valves will be disassembled, inspected, and manually exercised to "verify operability" in the closed direction. The schedule will be rotated such that valves are inspected during successive outages. During these inspections, should a disassembled valve prove to be inoperable (i.e., incapable of performing its safety function), then, during the same outage, the other valve will be disassembled, inspected, and exercised to verify operability.

Example for AFW System from Farley Units 1 and 2

The components involved in this request example are the AFW pump suction check valves.

Licensee's Basis for Requesting Relief:

There are no system design provisions for verification of reverse flow closure. The only possible test method would involve isolating the condensate storage tank, draining a large section of piping, and injecting SW into the AFW system. The SW is of poor quality and would contaminate the AFW piping. It cannot be guaranteed that flushing will remove all contamination after testing. Any contaminants which remain in the piping may be injected into the steam generators which could adversely affect secondary water chemistry and contribute to steam generator degradation.

Alternate Testing:

One of the QV007A, B valves will be disassembled and manually full-stroke tested at each refueling on a staggered test basis. The valve internals will be verified as structurally sound (no

loose or corroded parts) and the disk manually exercised to verify full-stroke capability. If the disassembled valve is not capable of being full-stroke exercised or there is binding or failure of valve internals, the remaining valve must also be disassembled, inspected, and manually full-stroke exercised during the same outage. Valve QV006 will be disassembled and manually full-stroke tested at each refueling. The valve internals will be verified as structurally sound (no loose or corroded parts) and the disk manually exercised to verify full-stroke capability.

Example for Containment Spray System from Turkey Point Units 3 and 4

This example addresses the CS header check valves.

Licensee's Basis for Requesting Relief:

Full-stroke exercising these valves to the open position would require operating each CS pump at nominal accident flow rate. Since no recirculation flow path exists downstream of these valves, the only flow path available for such a test would result in injecting radioactive-contaminated borated water into the CS headers and thence into the containment building via the spray nozzles. Dousing personnel and equipment in this manner is obviously undesirable. Partial stroking of the valves can be achieved by pressurizing the upstream piping with air or nitrogen via the air test connection. Performing partial flow exercising by this method during any mode of plant operation (at power or CSD), however, has the potential of creating an airborne contamination personnel hazard in the auxiliary building or containment.

Since these are simple-acting check valves with no provision for determining disc position, the only practical means of verifying closure involves performing a leak test. Performance of such a test would require considerable effort, including isolation and draining of the CS piping, system reconfiguration, hooking up and disconnecting leak testing equipment, and pressurizing the downstream piping with air or nitrogen while venting the upstream piping. Such a test is not practical during plant operation and could result in delays in the return to power operation during CSD periods to the extent that it would be an undesirable burden on the plant staff. These valves remain closed at all times except during an MHA in which the CS system operates for containment cooling and de-pressurization. The performance of these valves with respect to their capability to close and satisfactorily isolate the containment is adequately verified by the CIVs testing program performed in accordance with Appendix J.

Alternate Testing:

During each reactor RFO at least one of these valves will be disassembled, inspected, and manually exercised on a sequential and rotating schedule. If, in the course of this inspection a valve is found to be inoperable with respect to its function to fully open, then the other valve will be inspected during the same outage. During activities associated with valve disassembly and inspection and prior to system closure, appropriate precautions will be applied and inspections performed to ensure internal cleanliness standards are maintained and foreign materials are excluded from valve and system internals. These measures may include creating controlled work areas, maintaining a tool and equipment accounting system, installation of covers during non-work periods, and final close-out inspections.

Following valve disassembly, the subject valve will be partial-stroked in the open direction followed by a seat leakage test. These functional testing activities will ensure that the subject valve has been re-assembled and aligned properly. Each of these valves will be verified to be closed at least once every two (2) years in conjunction with Appendix J leak testing activities.

Example for the Core Spray System from Nine Mile Point Unit 1

The components involved in this request example are the check valves in the inter-tie between the core spray and CS raw water systems.

Licensee's Basis for Requesting Relief:

Forward flow exercising these valves would require introducing raw water into the Core Spray System piping. These valves also have no provisions for obtaining torque measurements. Reverse flow closure would also require introducing water within the valve boundary. These valves are also normally laid up dry due to corrosion concerns.

Alternate Testing:

Full flow exercising shall be verified individually for each valve by disassembly and inspection on a staggered basis over a 6 year period and reverse flow closure verified during Appendix J, Type C testing at each RFO interval. There are four valves in the group: 93-58, 93-60, 93-62 and 93-64. Disassembly and inspection shall be on a staggered basis with at least one valve from the group inspected each outage. No single valve shall have its inspection frequency exceed a six year period.

Example for the Emergency Core Cooling System from Waterford Unit 3

This example addresses the refueling water storage pool discharge check valves.

Licensee's Basis for Requesting Relief:

These valves are in the outlet of the refueling water storage pool (RWSP) and provide a suction source for the safety injection and CS pumps in the open direction. These valves perform a safety function in the closed direction as a backup to the RWSP outlet valves (air-operated valves) after the pumps suction is shifted to the containment sump. These valves prevent flow from the containment sump to the RWSP should the RWSP outlet valves fail to close on a recirculation actuation signal.

These valves are installed in a vertical section of piping and are normally held open by gravity. Therefore, the valves do not close upon the cessation of flow. The valves are in the suction path of the safety injection and CS pumps and no flow path exists which could establish reverse flow through these valves. An attempt was made to direct a temporary source flow through a piping vent; however, the flow achieved through the 1 inch vent was not sufficient to overcome the gravity acting on the 24 inch check valve to stroke it closed. The valves have no external operators and cannot be accessed without valve disassembly.

Alternate Testing:

One check valve from the group will be disassembled, manually exercised to its full closed position, and have accessible internals visually inspected for worn or corroded parts during each refueling [outage] on a staggered basis. The valves are partial-stroke exercised open quarterly and after reassembly. In the event the disassembled valve is not capable of being full-stroke exercised, or there is binding or failure of the valve internals, the remaining valves in that group will also be disassembled, inspected, and manually full-stroke exercised during the same outage.

Example for the Emergency Cooling System from Nine Mile Point Units 1

The components involved in this request example are the check valves in the emergency cooling header to the recirculation loops.

Licensee's Basis for Requesting Relief:

To verify forward flow operability would require placing the Emergency Cooling System into operation. These valves are normally maintained closed by Reactor Recirculation System operating pressure and to initiate flow through the valves requires initiation of the Emergency Cooling System. The Emergency Cooling System is not initiated unless the plant is being shut down under emergency conditions and initiation during normal operation would result in shutting the plant down. The Emergency Cooling System is only placed in service for testing once every five years. The test frequency is limited to once every five years in an attempt to limit the fatigue (thermal and hydraulic) on the system which is experienced during these tests. These valves are located in the drywell which is inaccessible during normal operations (inerted atmosphere, radiation exposure concerns, elevated temperature/heat stress for personnel, etc.). Opening tests connections to use as a telltale for reverse flow verification is impractical as it breeches the reactor coolant pressure boundary, violates containment integrity, and is considered a safety hazard to test personnel.

Alternate Testing:

Disassembly of these valves will be performed on a rotating basis except when full flow testing is performed. Reverse flow closure shall be verified individually for each valve during each RFO (either by performing on Appendix J, 10 CFR 50 Type C test, or by other means).

Example for the Feedwater System from Duane Arnold

This example addresses the reactor feedwater supply inboard isolation valves.

Licensee's Basis for Requesting Relief:

The valves cannot be exercised during power operation. During plant operation at power, reactor feedwater is supplied through both valves to maintain reactor coolant inventory in the reactor vessel and maintain reactor vessel water level. Closing either of these valves will isolate two of the four supplies of feedwater into the reactor vessel. This action could result in thermal shock to the reactor vessel feedwater nozzles and spargers upon resumption of flow and a plant trip due to the potential severe reactor vessel water level transients.

These valves cannot normally be tested during CSD because the containment is inerted with nitrogen. Personnel would be required to access the drywell to perform a mechanical exercise of these valves. The nitrogen must be vented (normally a 16 - 24 hour operation). The containment must be re-inerted before the plant is restarted (another 16 - 24 hour operation). Inerting and de-inerting the drywell solely for the purpose of testing is excessively burdensome. In addition, the LLRT is done with air, therefore, the line between the check valves and upstream isolation valve must be drained. This is a time consuming process resulting in lengthened shutdown times and unnecessary hours of exposure.

Alternate Testing:

The valves will be assumed to be in the open position if the feedwater system operates properly during normal plant operation. The valves will be exercised to the fully closed position each RFO and verified by local leak rate testing. In addition, during each RFO, one of these valves will be disassembled and inspected for full stroke operability in accordance with requirements of USNRC GL 89-04. Thus, both valves will be disassembled and inspected once every two RFOs. The normal operation of the feedwater system and plant will fulfill the partial flow test of these valves.

Example for the Main Steam System from LaSalle Units 1 and 2

The components involved in this request example are the MSIV leakage control system manifold drain check valves.

Licensee's Basis for Requesting Relief:

The MSIV-LCS is designed to control the leakage from the MSIV's consistent with containment leakage limits imposed for the conditions associated with a postulated design-basis LOCA. There is no design basis flow for these check valves. The valves simply must open sufficiently to drain condensate from the lines and close to prevent excessive air from being drawn back into the system, which could possibly result in a system isolation. There is no functional means available to prove the open and close capability of these valves.

Based on a study performed in response to SOER 86-03, check valves two (2) inches and smaller do not experience failure due to misapplication concerns with respect to sizing and hydrodynamic effects. The predominant failure mode of check valves in this size range is due to seat leakage caused by dirt build-up, corrosion and chemical deposits. The MSIV-LCS is normally exposed to air, which would not lead to the type of failure concluded from the study discussed above. These check valves are designed with a seal welded bonnet and require cutting/grinding off the seal weld to open the check valve up for inspection, and then welding upon installation of the bonnet. This is considered to be burdensome and not practical, therefore, the sample disassembly and inspection plan described in RV-46 will be used.

Note: Request RV-46 referenced in the above basis for requesting relief describes a sample disassembly and inspection plan that is consistent with GL 89-04, Position 2

Alternate Testing:

Disassemble and inspect the check valves using the sample disassembly and inspection plan described in RV-46 on a refueling basis.

Example for the Residual Heat Removal (RHR) System from Fitzpatrick

This example addresses check valves in the RHR system minimum flow lines.

Licensee's Basis for Requesting Relief:

These valves are demonstrated to be operable in the closed direction by successful completion of the quarterly RHR operability surveillance test. There is no means to demonstrate, by flow measurement or valve indication, that a valve has fully opened.

Alternate Testing:

The valves will be exercised during quarterly RHR pump operability testing without determination of full flow. In accordance with GL 89-04, Position 2, at least once each operating cycle (normally a refuel outage) at least 1 valve will be disassembled, inspected, and verified operable. If any valve is found to be inoperable, the remaining valves will be inspected prior to startup. The inspection schedule will be such that all valves in the group are inspected at least once every 6 years.

Example for the Safety Injection System from Waterford Unit 3

The components involved in this request example are the safety injection tank discharge check valves.

Licensee's Basis for Requesting Relief:

These valves perform a safety function in both the open and closed position. As previously discussed in the Basis for Relief for Relief Request 3.1.16, the operability testing of these normally closed check valves during normal operation or CSD is not practical. During normal operation, these valves cannot be full stroke exercised because the safety injection tanks (SITs) cannot overcome RCS pressure. The valves cannot be partial stroke exercised during normal operation without making the SITs inoperable, thus placing the plant in an unsafe condition. During CSD, these valves cannot be fully stroked without over pressurizing the RCS. During RFOs, these valves cannot be full stroke exercised at SIT operating pressure without possibly causing internal core damage due to excessive flow rates. No other flow path exists with sufficient capacity to full stroke exercise these valves. These valves are disassembled and manually exercised to the full open position during each RFO on a sampling basis.

Proving that the disk travels to the seat promptly upon cessation or reversal of flow can only be accomplished after the valve is exercised open. Since these valves are exercised to the full open position only during RFOs on a sampling basis, then they can only be exercised closed during RFOs on a sampling basis.

Alternate Testing:

The SITs have four discharge check valves. Three are spring-loaded and will be treated as one group. The other one is non-spring-loaded and will be treated as another group. One check valve from each group will be disassembled and manually exercised to its full open and full closed position during each RFO on a staggered sampling basis. The two groups of check valves are as follows:

Group 1 (Spring-Loaded)	Group 2 (Non-Spring-Loaded)
SI-329A	SI-330A
SI-329B	
SI-330B	

These valves will be partial stroke exercised open and closed after reassembly, and during CSD.

Example for the SW System from McGuire Units 1 and 2

This example addresses the nuclear SW system makeup supply to the spent fuel pool check valves.

Licensee's Basis for Requesting Relief:

These valves function to prevent backflow of potentially contaminated water from the spent fuel pool makeup header to the nuclear SW system when the manual isolation valves are opened. The safety function is to open to supply assured makeup from the nuclear SW system to the spent fuel pool. These valves cannot be full-stroked at any time without putting raw SW into the spent fuel pool.

Alternate Testing:

These valves will be partially-stroked quarterly and full-stroke exercised during refueling by sample disassembly.

(3) Proposals to Extend the Sampling Interval for Check Valve Disassembly

We considered 24 requests that involved extension of the GL 89-04, Position 2, disassembly and inspection interval. Requests were submitted for interval extension because following the proposed interval would be a hardship. In some cases the GL interval was a hardship because the reactor had to be defueled and/or be at the mid loop level to perform the testing. In other cases performing the testing either resulted in extremely high radiation exposures to personnel or resulted in the generation of large quantities of radioactive liquid waste. GL 89-04, Position 2, provides for the extension of the disassembly and inspection interval in cases of extreme hardship if the licensee meets certain provisions. To obtain the extension the licensee must:

a. Disassemble and inspect each valve in the valve grouping and document in detail the condition of each valve and the valve's capability to be full-stroked.

b. A review of industry experience, for example, as documented in NPRDS, regarding the same type of valve used in similar service.

c. A review of the installation of each valve addressing the "EPRI Applications Guidelines for Check Valves in Nuclear Power Plants" for problematic locations."

GL 89-04 grants relief to use sample disassembly and inspection performed in accordance with Position 2 as an alternative to verifying a full-stroke exercise using flow or some other positive means. However, if the frequency for examining one valve from the group is extended to once every other RFO or if the interval between examining any particular valve is longer than 6 years, the GL requires that documentation supporting an <u>extreme</u> hardship be available on site for inspection. Relief must be requested if the proposed inspection frequency is greater than every other RFO. The following examples are provided that deal with extension of the GL 89-04 sample disassembly interval.

Example for Chemical and Volume Control System from Maine Yankee

Maine Yankee requests relief from the exercising frequency requirements of Section XI, Paragraph IWV-3521, for the normal charging line containment isolation check valve. The licensee proposes to disassemble and inspect this valve once every other RFO.

<u>Licensee's Basis for Requesting Relief:</u>

This valve must be open during normal plant operation and CSDs to provide volume control to the RCS. The safety function of this valve is closed for containment isolation. Because of the physical arrangement of the system, back pressure testing of this check valve is not possible. To provide reverse flow would require testing through the vent of the regenerative heat exchanger. This vent valve is located in a high radiation area (~ 10R/hr). Performing this test utilizing this vent path would result in high levels of radiation exposure. CH-40 has been previously disassembled and inspected after 17 years of plant operation. No significant damage or degradation has been observed. A review of the maintenance history of this valve indicates no failures during plant operation. Minor pin cover leakage of this valve has been identified and corrected. An NPRDS search of this valve based on manufacturer, type and size revealed minor problems such as hinge pin cover leakage. No major failures were characterized. This valve has been reviewed in accordance with INPO SOER 86-3 and EPRI's Application Guideline for Check Valves in Nuclear Power Plants. Although this valve does not meet all the recommendations of the review, e.g., 5 to 10 pipe diameters from a major flow disturbance, specific plant history does not reveal a history of repeat failures.

Alternate Testing:

Maine Yankee will disassemble this valve to verify its safety function every other reactor refueling. This valve has previously been exempted from leakage testing by NRC Letter to MYAPCO Docket no. 50-309, dated 05-23-86. This Relief Request has used GL-89-04 Position 2 as guidance.

Evaluation

This relief was not granted as requested. GL 89-04 provides a mechanism for extending the valve disassembly interval based on the valve failure history at this plant and in the nuclear industry, however, this extension is permitted only in cases of extreme hardship. The licensee's basis supports extending the disassembly interval based on the low failure rate of this specific valve and similar valves in the nuclear industry. However, the licensee has not adequately demonstrated that disassembly of this valve each RFO would constitute an unusual hardship. It was determined that the disassembly interval not be extended unless all of the provisions of GL 89-04, Position 2, are met. It was also recommended that the licensee consider methods such as using non-intrusive techniques (e.g., acoustics, ultrasonics, magnetics, radiography, and thermography) to verify closure of this check valve

Example for the Safety Injection System from Fort Calhoun

Requests relief from the exercising frequency requirements of OM-10, Subsection 4.2.1.2, for the safety injection refueling water tank discharge check valves. The licensee proposes to disassemble and inspect these valves once every other RFO.

Licensee's Basis for Requesting Relief:

These check valves function to prevent backflow to the Safety Injection and Refueling Water Tank. These check valves are located in the lines leading from the SIRWT to the suctions of the CS pumps, the Low Pressure Safety Injection (LPSI) pumps and the High Pressure Safety Injection (HPSI) Pumps. The check valves under certain accident conditions must open sufficiently to provide design basis flow to all of these pumps. Because of this requirement the system design full-stroke exercising of these check valves Quarterly or during CSDs cannot be performed. During power operation, no full flow path exists for the combination of pumps because the HPSI and LPSI pumps cannot overcome the RCS pressure, and the CS system cannot be permitted to spray down the Containment. No full flow path is available during CSDs because operating the HPSI pumps could create a low-temperature over pressurization condition in the RCS. CS cannot be used because the Containment would be sprayed down. Additionally it is not possible to achieve the maximum design accident flow through the check valves during full flow exercising.

The corrective maintenance history of these two check valves has been limited to gasket/bolt/nut replacements since installation. In addition, the check valves are 20 inch stainless steel Mission-Duochek type valves which see very little flow during normal operations. OPPD has previously disassembled and inspected each of these check valves once with the results being that the check valves were "like new". The industry has experienced no failures with these type of check valves in similar applications at other facilities. The disassembly and subsequent inspection of these valves requires unnecessary radiation exposure as well as creating significant (i.e., greater than 50 gallons) liquid radwaste requiring disposal. Also, frequent disassembly and reassembly of the valves (i.e., every RFO) introduces unnecessary potential for valve failure due to damage caused by maintenance without providing a commensurate increase in plant safety or check valve reliability.

Alternate Testing:

OPPD will require check valves SI-139 and SI-140 to be alternately disassembled and inspected every other RFO. This sample disassembly of these check valves is in accordance with the NRC guidelines established in GL 89-04, Attachment 1, Position 2. This method of sample disassembly and inspection will ensure that each check valve is disassembled and inspected at least once every six years and will help to maintain personnel exposure ALARA, while at the same time providing reasonable assurance that integrity, quality and the ability to detect component degradation are maintained.

Evaluation

It was determined that the disassembly interval could be extended for these valves if all of the provisions of GL 89-04, Position 2, are met. The licensee's basis supports extending the disassembly interval based on the low failure rate of this specific valve and similar valves in the nuclear industry. However, the criteria for extending the interval in GL 89-04 requires the licensee to disassemble and inspect each valve in the group and to document in detail the valve condition and its capability of being full-stroke exercised. The request indicated that each valve had been disassembled and found to be "like new." Stating that a valve is "like new" may be a subjective evaluation unless supported by a quantitative assessment such as taking critical dimension measurements and comparing them with new valve baseline measurement data. The GL 89-04 interval extension criteria do not provide specific evaluation requirements (e.g., trending critical dimension measurements), however, the licensee's evaluation should be adequate to provide reasonable assurance that degradation is not occurring in the group of valves at a rate that could result in a valve becoming incapable of performing its function prior to the next examination. The GL 89-04 interval extension criteria also require a review of the installation of each valve addressing the "EPRI Applications Guidelines for Check Valves in Nuclear Power Plants." It is not clear from the relief request that this review has been performed and that the installation of these valves is satisfactory from that respect.

Example for Containment Spray System from Farley Unit 2

Requests relief from exercising the CS pump RWST suction check valve in accordance with the requirements of Section XI, Paragraph IWV-3522, and proposes to verify operational readiness by sample disassembly and inspection every third RFO.

Licensee's Basis for Requesting Relief:

The only way to verify forward flow operability using flow would be by using the pumps and injecting a large quantity of water into the containment. Spraying the containment would result in extensive damage to safety-related equipment located inside the containment. There are no valves between QV014 and the RWST to shut off flow during valve disassembly. The valve has been disassembled, inspected, and manually full-stroke exercised three times since 1985 by freeze plugging the 12 in. line just upstream of the valve. This has been done at RFOs with the RWST drained to minimum level. In each case the valve was found to be in excellent condition, with no visible signs of degradation. With the RWST at minimum level, there is a 66 foot head of water on the freeze plug. If the plug does not hold during disassembly, a minimum of 30,000 gallons of water will flood the auxiliary building with potential severe damage to safety-related equipment.

Alternate Testing:

The valve will be disassembled and manually full-stroke exercised once every three RFOs using the freeze plug method described above. The valve internals will be verified as structurally sound (no loose or corroded parts) and the disk manually exercised to verify full-stroke capability.

Evaluation

The licensee's proposal to decrease the inspection frequency from each RFO to every third RFO is acceptable provided that the guidelines in GL 89-04, Attachment 1, Item 2, are followed and the basis for extending the disassembly and inspection interval are justified and documented. The licensee's basis supports extending the disassembly interval based on the low failure rate of these specific valves and their condition during prior inspections. The GL 89-04 interval extension criteria also require a review of industry experience and a review of the installation of each valve addressing the "EPRI Applications Guidelines for Check Valves in Nuclear Power Plants." It is not clear from the relief request that these reviews have been performed and that the installation of these valves is satisfactory from that respect. The licensee's proposed alternative should provide reasonable assurance of operational readiness and provide an acceptable level of quality and safety provided they part-stroke exercise the affected valve prior to returning it to service following valve disassembly and inspection.

Summary and Additional Comments

None of the examined requests to extend the sample disassembly and inspection interval were unconditionally approved. They either did not adequately demonstrate the extreme hardship of meeting the interval specified in GL 89-04 or they did not clearly demonstrate that they were in compliance with the extension criteria of GL 89-04, Position 2. In very few cases was relief denied. However, the licensee had the burden of ensuring that they were in compliance with all of the provisions of GL 89-04, Position 2 and that they were performing post maintenance testing.

In cases of extreme hardship, relief may be granted for extending the sample disassembly and inspection interval from at least one valve from each group examined every RFO with the interval between examining any particular valve no longer than 6 years. The following should be considered when developing relief requests for these cases:

(1) Demonstrate the impracticality of full-stroke exercising the valves with flow or other positive means during power operations, CSDs, and RFOs.
(2) Demonstrate the extreme hardship of examining the valves at the GL 89-04 interval.
(3) Document in the request that the all of the examinations and reviews required for extension by GL 89-04, Position 2, have been satisfactorily completed.
(4) Demonstrate that the longer examination interval should provide adequate assurance of continued valve operational readiness.

Requests that meet the items listed above should be approved. Where all of the above items are not met, a request for relief may still be found to be acceptable. However, in these cases the licensee must clearly demonstrate that the proposed alternative provides an adequate assessment of valve operational readiness.

2.2.3 Exercising Check Valves with Flow and Nonintrusive Techniques

The most common method to exercise a check valve open is to pass flow through the valve. For this flow test to be a full-stroke exercise it must meet the criteria specified in GL 89-04, Position 1. For some normally closed check valves it is impractical to establish or verify sufficient flow to meet the GL full-stroke exercise criteria. Flow testing performed at flow rates less than the maximum accident condition flow rate can be considered a full-stroke exercise only if some other method (such as nonintrusive diagnostics) is used to demonstrate that the valve disk has moved to its required safety position. It is often impractical to establish conditions or verify certain normally open check valves in the closed position. Many do not have a means to establish or verify the necessary reverse differential pressure across the valve. Where it is impractical to full-stroke exercise check valves open with flow or verify their reverse flow closure, the use of nonintrusive techniques can verify a check valve in its required open or closed positions.

Requirements

Section XI, Paragraph IWV-3522 states: "Check valves shall be exercised to the position required to fulfill their function...." ASME OM Code-1990, Subsection ISTC, Paragraph ISTC 4.5.2(a) requires each check valve to be exercised or examined in a manner that verifies obturator travel to the closed, full-open, or partially open position required to fulfill its function. GL 89-04 states that a check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve and that any flow rate less than this will be considered a partial-stroke exercise. The GL further states that a valid full-stroke exercise by flow requires that the flow through the valve be known. Knowledge of only the total flow through multiple parallel lines does not provide verification of flow rates through the individual valves and is not a valid full-stroke exercise.

In GL 89-04, the NRC staff stated: "It may be possible to qualify other techniques to confirm that the valve is exercised to the position required to perform its safety function. To substantiate the acceptability of any alternative technique for meeting the ASME Code requirements, licensees must as a minimum address and document the following items in the IST program: 1) The impracticality of performing a full flow test, 2) A description of the alternative technique used and a summary of the procedures being followed, 3) A description of the method and results of the program to qualify the alternative technique for meeting the ASME Code, 4) A description of the instrumentation used and the maintenance and calibration of the instrumentation, 5) A description of the basis used to verify that the baseline data has been generated when the valve is known to be in good working order, such as recent inspection and maintenance of the valve internals, and 6) 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."

OM-10, Paragraph 4.3.2.4(a), states: "Observations may be by observing a direct indicator such as a position indicating device, or by other indicator(s) such as changes in system pressure, flow rate, level, temperature, seat leakage testing or other positive means." The ASME OMc Code-1994 added a definition for nonintrusive testing and in Paragraph ISTC 4.5.4(a) specifically included nonintrusive testing results as one of the acceptable "other positive means" of verifying the necessary valve obturator movement.

NUREG 1482, Section 4.1.2, provides guidance for using nonintrusive techniques to verify check valve full-stroke exercising.

Table 2-8. Summary Table of Key Requirements and Guidance for Exercising Check Valves with Flow and Nonintrusive Techniques

Document	Section	Requirement/Guidance
Section XI	IWV-3522	Verify the valve exercises to the required position(s) by observing a direct indicator such as a position-indicating device or by other indicator(s) such as changes in system pressure, flow rate, level, temperature, seat leakage testing or other positive means; <u>or</u> a mechanical exerciser can be used to move the valve disk.
OM-10	Paragraph 4.3.2.4	Verify the valve exercises to the required position(s) by observing a direct indicator such as a position-indicating device or by other indicator(s) such as changes in system pressure, flow rate, level, temperature, seat leakage testing or other positive means; <u>or</u> a mechanical exerciser can be used to move the valve disk; or disassembly may be used every refueling.

Document	Section	Requirement/Guidance
GL 89-04	Position 1/ Questions 1-8	A check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve. A flow rate less than this will be considered a partial-stroke exercise. A valid full-stroke exercise by flow requires that the flow through the valve be known.
GL 89-04	Position 2/ Questions 9-20	Disassembly and inspection can be used as a positive means of determining that a check valve's disk will full-stroke exercise open or of verifying closure capability. A sample disassembly and inspection plan for groups of identical valves in similar applications may be employed. The guidelines for this plan are explained. If possible, partial valve stroking after reassembly must be performed.
OMc-1994	ISTC 4.5.4	Same as OM-10 except that disassembly and inspection can be used only when the two other methods are impractical. Also, establishes a sampling plan similar to the plan in GL 89-04. Nonintrusive techniques are specifically identified as acceptable positive means of verifying the required valve position(s).
NUREG 1482	4.1.2	Nonintrusive techniques may be used to verify a check valve's capability to open, close, and fully stroke in accord with quality assurance program requirements. Relief is not required to use this method except as would be necessary for the testing frequency if the interval extends beyond each RFO.
NUREG 1482	4.1.4	If no other practical means is available, it is acceptable to verify that check valves are capable of closing by performing leak-rate testing, such as local leak rate testing in accord with Appendix J to 10 CFR Part 50, at each reactor RFO.

Relief Request Issues

The relief requests for nonintrusive techniques are basically similar and are not divided into sub-issues.

(1) Use of Nonintrusive Techniques to Verify a Full-Stroke Exercise of Check Valves

We considered 24 requests that involved the use of nonintrusive techniques to verify a full-stroke exercise of check valves. Requests were submitted because it was not apparent that use of nonintrusive techniques was an approved method under Section XI. In addition, the majority of nonintrusive requests specify test frequencies different than the quarterly or CSD frequencies prescribed by Section XI. Code changes made during the transition from Section XI to OM-10 have addressed the RFO test frequency issue and clarified the nonintrusive test method issue for check valves.

Section 4.1.2 of NUREG 1482 states: "... the NRC determined that the use of nonintrusive techniques is acceptable to verify the full stroke of a check valve. The licensee may use nonintrusive techniques to verify the capability to open, close, and fully stroke in accord with quality assurance program requirements. These techniques are considered "other positive means" in accordance with Paragraph IWV-3522 of Section XI (Paragraph 4.3.2.4(a) of OM-10), and relief is not required except as would be necessary for the testing frequency if the test interval extends beyond each RFO as allowed by OM-10."

The guidance in NUREG 1482 also establishes provisions for using nonintrusive testing techniques in a sampling plan. The sampling plan is similar to the plan established in GL 89-04, Position 2. During the initial test of each valve under the nonintrusive sampling plan, the licensee should use nonintrusive techniques to verify that the pressure and flow conditions specified in the test procedures cause the valves to fully stroke. During subsequent testing, each valve would typically be fully stroked with flow and the nonintrusive verification would be performed for one valve of the group on a rotating schedule each time testing is performed. If problems are found with the sample valve that are determined to affect the operational readiness of the valve, all valves in the group must be tested using nonintrusive techniques during the same outage.

Although relief is not required to use nonintrusive testing as a means of verifying a full-stroke exercise of check valves, the testing should be performed in accordance with the NUREG 1482 guidance and be noted in the IST program. The following examples are provided of bases for using this method to verify the full-stroke exercise of check valves.

Example for the AFW System from Braidwood Units 1 and 2

The components involved in this request example are the AFW pump suction check valves.

Licensee's Basis for Requesting Relief:

The 1(2)AF001A and B valves are the suction check valves to the AFW pumps from the condensate storage tanks, and function to prevent backflow of essential SW if that suction source is required. It is undesirable to full-stroke open these valves quarterly due to the transients placed on the feedwater system and the thermal stresses imposed on the S/G nozzles.

With respect to acoustically testing these valves to prove closure, versus disassembly, the operating surveillance procedure used for the AFW check valve CSD full-stroke test is written to test a single train of AFW at a time. With an AFW pump running on mini-flow recirculation, flow is initiated to each S/G on a gradual basis, while simultaneously reducing feedwater flow. As soon as the required flow data is obtained, AFW flow is gradually reduced, while simultaneously increasing feedwater flow, to minimize feedwater flow perturbations to the S/Gs. Due to this gradual change in flow, the open and close acoustical impacts cannot be observed from that of the flow noise.

However, the acoustic data taken during the 18 month dual pump injection test, has provided sufficient data to determine valve disk closure (refer to SMAD Report M-6479-91, dated 10-28-91). This test is scheduled during the shutdown process, preceding reactor refueling, due to the large transient placed on feedwater flow and the thermal stresses imposed on the S/Gs.

The application of Reliability Centered Maintenance (RCM) to the AFW system has both concluded and recommended that performing acoustic monitoring on a 3 year frequency is sufficient to detect if the check valves fail to close. The failure analysis process required that the functional failures identified be evaluated using the failure modes and effects analysis (FMEA). The FMEA provides a format for identifying the dominant failure modes of component failures leading to a functional failure and the impact of each component failure locally at the component, on the system, and on the plant.

Additionally, the closure capability of these valves cannot be verified adequately by performing a back pressure test due to the multiple boundary isolation points. The system configuration makes it impossible to assign any observed leakage to any individual valve or component using standard mass make-up or pressure decay techniques. Performing a pressure test to verify closure is impractical due to the system configuration. To perform this test it would be necessary to attach a pump or some other type of pressure source to a test connection and pressurize the line containing the valve. However, this line also contains many potential leakage paths (valves, pump seals, and

instruments). It is not possible to assign a leakage value to any specific path using available methods of seat leakage testing.

Maintenance history and previous inspections of these valves at both Byron and Braidwood Stations has shown no evidence of degradation or physical impairments. Industry experience, as documented in NPRDS, has shown no history of problems with these valves. A company wide check valve evaluation addressing the "EPRI Application Guidelines for Check Valves in Nuclear Power Plants" revealed that the location, orientation and application of these valves are not conducive to the type of wear or degradation correlated with SOER 86-03 type problems.

Acoustic testing provides ample information relative to valve condition, without physically taking the valve apart for visual inspection to prove valve closure. These valves are of the same design (manufacturer, size, model, and materials of construction) and have the same service conditions, including orientation. Upon abnormal or questionable acoustic test results, the valve will be scheduled for disassembly and internal visual inspection. The results of this inspection will be used to further evaluate the standby train valve as well, for possible action. This type of alternate testing provides more than adequate assurance of both valve functional and operational requirements.

Alternate Testing:

The 1(2)AF001A and B suction check valves will be acoustically tested for closure on an alternating refuel frequency in conjunction with the AFW full flow test and equipment response time of the AFW pumps. The "A" train valve will be tested during one refuel outage, the "B" train valve will be tested at the next, on a bi-RFO frequency. The open stroke test will be tested during CSDs, or at least once during each refueling cycle (approximately 18 months).

Evaluation

Based on the determination that more information is needed to support extending the exercising frequency for these valves from once each RFO in accordance with, relief should not be granted to extend this test frequency as requested. Performing this testing on a sampling basis, one valve every RFO, as proposed by the licensee, is a departure from the Code testing frequencies that may not be justified. The licensee has not provided an adequate justification for not exercising both of these valves each RFO. The use of a sampling program is approved by GL 89-04 for check valves when disassembly and inspection is used in lieu of testing and when all of the prescribed conditions of Position 2 are met. These allowances are made for disassembly and inspection partly due to the difficulty and hazards associated with this method. Another consideration is that disassembly and inspection can provide an accurate indication of valve condition and permit detection of essentially all check valve degradation mechanisms (e.g., erosion, corrosion, binding, fouling, wear, loose parts, fatigue failure). Check valve exercising with flow does not provide diagnostic capability unless it is accompanied by test measurements (e.g., flow and differential pressure measurements, non-intrusive diagnostic measurements) and evaluated against high quality baseline data using appropriate acceptance criteria.

Example for the Chemical and Volume Control System from Zion Units 1 and 2

This example addresses charging pump recirculation flow check valves.

Licensee's Basis for Requesting Relief:

Zion Station utilizes an indirect method of testing check valves VC8542A and B since these lines are not instrumented with flow or differential pressure indicators. Total charging pump flow is calculated using measured pump differential pressure and the manufacturer's pump curve. Total pump flow includes flow through the pump discharge header and the mini-flow line. The flow rate

through the mini-flow line is equal to the calculated flow from the pump curve minus the measured flow in the discharge header.

A review of pump performance data obtained over the last two years shows that, on average, all the charging pumps perform within ±2% of the manufacturer's pump curve. At the time this check valve test is performed, a correction factor is determined accounting for the actual difference in performance of the pump from the pump curve. Since the flow required through the mini-flow line is small (50 gpm), only a small portion of the pump curve is utilized for this test. Therefore, the correction factor is accurate over this small range of the pump curve and accurate testing results are obtained.

Due to an insufficient length of straight piping in the mini-flow line, temporary ultrasonic flow instrumentation is not effective. Results obtained during previous attempts to use this type of flow instrumentation on this system for trouble shooting have been questionable. However, as stated in the relief request, Zion did attempt a best effort validation of this testing method with temporary ultrasonic flow meters.

This method described above was verified to be accurate by installing temporary ultrasonic flow meters on the mini-flow line and comparing this to the calculated flow. This alternative will provide adequate assurance that operational readiness is maintained.

<u>Alternate Testing:</u>

Verify a full-stroke of these valves with flow by comparing the difference between the measured pump discharge header flow and the calculated pump discharge flow rates. The pump discharge flow rates are calculated by measuring the differential pressure across the pump and obtaining the flow rate from the pump curves.

<u>Evaluation</u>

The licensee's proposed alternative was authorized pursuant to 10 CFR 50.55a (a)(3)(i) because it was determined that the alternative provides an acceptable level of quality and safety in meeting the intent of the Code requirements. By using the measured pump differential pressure and the manufacturer's pump curve, a calculated pump discharge flow upstream of the recirculation line can be obtained. Subtracting the actual measured flow, downstream of the recirculation line, from the calculated pump discharge flow yields the flow rate through these check valves. The licensee's proposed method is sufficiently accurate to verify the full-stroke capability of these check valves.

Example for the Chemical and Volume Control System from D. C. Cook Units 1 and 2

The components involved in this request example are the check valves located in the volume control tank (VCT) discharge to charging pump suction header.

<u>Licensee's Basis for Requesting Relief:</u>

This normally open check valve is located in the VCT discharge to charging pump suction header and is downstream of the Reactor Coolant Pump (RCP) seal water return branch connection. Under certain conditions, this valve performs a safety related function during the recirculation phase of a LOCA by closing to prevent leakage of significant amounts of containment sump water back through the seal water heat exchanger circuit, ultimately preventing a leakage path outside of containment. Exercising the valve closed during normal plant operation would require securing the charging pumps which would interrupt charging/letdown flows as well as RCP seal injection. Loss of charging could result in loss of pressurizer level followed by a reactor trip. Testing this valve would require termination of seal injection flow. Seal injection flow is maintained continuously to cool and lubricate the RCP seals, and to prevent contaminants from the RCS from coming into contact with (and

potentially damaging) the RCP seals and pump bearing. This valve has been disassembled and inspected under the SOER 86-03 Check Valve PM Program with no degradation found.

This valve cannot be tested during CSDs with RCPs secured since seal injection is provided at all times when the RCS is full. The conservative operating philosophy of maintaining seal injection when the RCS is full prevents contaminants from entering the seal cavity, and minimizes the possibility of seal or pump bearing damage.

Alternate Testing:

The licensee proposes that this valve will be exercised in accordance with IWV-3522(a), but on an RFO frequency, and the closed position verified by radiography or other NIE means. If NIE does not yield conclusive results, the valve will be disassembled and inspected on an RFO frequency.

Evaluation

The alternate testing is approved pursuant to 10 CFR 50.55a (f)(4)(iv). The licensee's proposed alternative is in accordance with paragraph 4.3.2 of OM-10. The inclusion of the note in the IST program meets the documentation requirements of paragraph 6.2(d).

Example for the Main Steam System from Arkansas Nuclear One Unit 1

This example addresses the emergency feedwater (EFW) pump steam supply check valves.

Licensee's Basis for Requesting Relief:

These valves are normally closed during power operation except for testing of the steam turbine driven EFW pump. The only means available to operationally verify the valves as being closed while at power or under steaming conditions would be to establish a differential pressure between the steam generators. If a pressure differential were established, an imbalance in reactor cold leg temperatures as well as other undesirable plant conditions would be created. During CSD conditions no steam pressure is present to provide an opening force in order to verify valve closure when the steam flow is secured in that line.

Alternate Testing:

Non-intrusive techniques will be utilized at least once each refueling cycle to confirm the reverse flow closure capability of each of these check valves when the upstream isolation valves are closed.

Evaluation

The proposed alternative was approved pursuant to 10 CFR 50.55a (f)(4)(iv). The licensee's proposed alternative is in accordance with paragraphs 4.3.2.2(e) of OM-10. The submission of this relief request meets the documentation requirements of paragraph 6.2(d).

Example for the Reactor Coolant System from Millstone Unit 1

The components involved in this request example are the Code Class 2 reactor recirculation CIVs.

Licensee's Basis for Requesting Relief:

Each reactor recirculation pump seal flush line consists of inboard containment check valve 1-RR-111A(B) and check valve 1-RR-111A(B). Currently, there are no test connections available to implement an Appendix J test and verify leak tightness or valve closure.

Alternate Testing:

Perform a standing water reverse flow leak test or a non-intrusive test at refuel to demonstrate the closure function of the valves. An exemption request from the requirement of Appendix J is being provided to the NRC staff under separate correspondence.

Evaluation

The licensee proposes to verify closure by a reverse flow leak test or a non-intrusive test to meet the requirements of OM-10. Paragraph 4.3.2.4, "Valve Obturator Movement," allows that observation of closure may be direct indication or by changes in system pressure, flow rate, level, temperature, seat leakage testing, or other positive means. A reverse flow leak test and a non-intrusive test both meet the provisions of paragraph 4.3.2.4. Therefore, relief to verify closure by the methods proposed is not required.

Relief Request V-12 should remain in the IST program until the Appendix J exemption is approved or denied. If an exemption is received which eliminates the local leak rate testing requirements of Appendix J, the valves need not be leak tested per OM-10 unless a leak-tight function other than containment isolation is performed. Therefore, unless the licensee determines that these valves have another leak-tight function, the disposition of the IST program leak testing requirements will be dependent on the exemption to Appendix J. No further evaluation is required for the IST program requirements at this time. Upon a determination of the NRC actions regarding the requirements for local leak rate testing, the relief request should be deleted or modified as necessary.

Example for the RHR System from Pilgrim

This example addresses the RHR injection to the recirculation loop check valves.

Licensee's Basis for Requesting Relief:

These check valves are the PIVs for the low pressure coolant injection (LPCI) systems and remain closed during normal plant operation. Each valve is an integral part of its respective RHR shutdown cooling loop flowpath. One loop of RHR shutdown cooling is necessary for DHR during a CSD. PNPS practice is to select an RHR shutdown cooling loop on a staggered basis each shutdown and remain exclusively in the selected loop for shutdown duration, unless changing plant conditions or maintenance activities necessitates shifting to the other loop. Swapping from one RHR loop to another creates a "higher risk evolution" because of; 1) excessive manpower loading, 2) deviations from normal system configurations, 3) complexity of this task (i.e., high susceptibility to events causing the loss of key safety functions), and 4) large dose accumulations.

This method of devoting one loop to shutdown cooling for the shutdown duration is supported by the conclusions of NUMARC 91-06, "Guidelines For Industry Actions to Assess Shutdown Management." This document references numerous NRC IENs and IEBs in which a loss of "key safety functions" (i.e., DHR capability and inventory control) has occurred during "higher risk evolutions." Because of task complexity, shifting RHR shutdown cooling loops for the purpose of exercising these injection check valves, creates a high risk evolution and should be avoided. For the case of mid cycle and RFOs, plant conditions/activities usually require swapping from one RHR loop to the other. For these extended outages, both LPCI injection check valves will be exercised.

Exercising an injection check valve at the maximum required accident flow rate is only obtainable by operating four RHR pumps. Normal plant limitations do not allow the operation of more than two RHR pumps within a loop. A full flow exercise can be verified by performing diagnostic testing while two pumps pass flow through a shutdown cooling loop. This special testing requires entry into primary containment (drywell) and operation of test

equipment in a high radiation area. Verifying LPCI flow during two pump operation will full flow exercise the injection check valves. Performing diagnostic monitoring of these valves on a refueling interval basis will ensure operational adequacy and satisfy the maximum required accident flow verification.

Alternate Testing:

Exercise valves on a staggered basis during shutdown cooling operation, not to exceed a refueling interval. Perform diagnostic testing each refueling interval and verify that the RHR CSD flow rate (two pumps running) fully opens these valves.

Evaluation

It was determined that this relief was no longer required. OM-10, Paragraph 4.3.2.2, permits deferral of full-stroke exercising until RFOs when this exercising is not practicable during plant operation or CSDs. The licensee proposed to part-stroke exercise one of these check valves on an alternating basis during shutdown cooling operation at CSDs and to verify a full-stroke exercise of both valves using diagnostic testing each RFO.

Example for the Safety Injection System from North Anna Units 1 and 2

The components involved in this request example are the accumulator discharge and cold leg injection check valves.

Licensee's Basis for Requesting Relief:

These valves cannot be partial or full flow tested during normal operation because the accumulator pressure (600 to 650 psig) is below RCS pressure and the injection of borated water would upset the reactor coolant chemistry. During CSD, the RCS pressure may still prevent full flow testing. Also, discharging the accumulators would challenge the Low Temperature Over pressure Protection System. A partial flow test is not practical during CSDs. The flow from the accumulator is dependent on the pressure differential between the accumulator and the RCS. The pressure differential cannot be controlled to the fine degree necessary to preclude dumping too much water into the pressurizer, thus making it difficult to control pressurizer level while pressure is being reduced during cooldown. Also, the RCS temperature is high during short CSDs. Dumping cold accumulator water into the RCS could thermally shock the system.

The accumulators must be isolated to verify closure using back flow for valves 1-SI-127, -144 and -161 (2-SI-153, -170, and -187). The small increase in safety gained by performing the back seat check valve tests every CSD versus every reactor refueling does not justify the added burden of the increased test frequency. The use of non-intrusive monitoring techniques are being evaluated for confirming full disk movement. If non-intrusive techniques can provide a "positive means" for verifying obturator movement, a sampling program will be used as described below due to the burden of applying these techniques in the field.

Alternate Testing:

During the first RFO where non-intrusive techniques are used, all valves in the group will be tested to verify that the techniques verify valve obturator movement. During subsequent RFOs, flow testing will be performed on all valves in the group, but the non-intrusive techniques need be applied only to one valve in each group, on a rotating basis, unless indications of problems are identified. In this case, all valves in the group will be subjected to the non-intrusive techniques. Valves 1-SI-125, -127, -142 and -159 (2-SI-151, -153, -168, and -185) will be in one group, and valves 1-SI-144 and -161 (2-SI-170 and -187) will be in the other group. Because valves 1-SI-144 and -161 (2-SI-170 and -187) are downstream from

where RHR connects to the SI line, they experience different service conditions than the other valves. The test frequency is in accordance with GL 89-04, Position 2.

The flow test will consist of discharging the accumulator from an initial pressure that is less than 600 psig. Discharging the accumulator at a lower initial pressure reduces the severity of the transient and the risk of adverse effects on the RCS. The low pressure test should provide enough flow to force the disk to the full open position. If full disk movement cannot be confirmed using nonintrusive monitoring, these valves will be placed into two groups and one valve from each group will be disassembled and inspected every other reactor refueling. The justification for the extended disassembly and inspection schedule is available at the station. Valves 1-SI-127, -144 and -161 (2-SI-153, -170, and -187) will be confirmed closed every reactor refueling.

Evaluation

Relief was granted pursuant with 10 CFR 50.55a (f)(6)(i) with the following provision. To use nonintrusive testing techniques in a sampling plan during RFOs, all of the following guidelines should be satisfied:

a. Part-stroke exercise the valves quarterly or during CSDs if practical.
b. The valves in the group should meet the grouping criteria of GL 89-04, Position 2.
c. The test pressures and flow conditions should cause the valves to fully stroke.
d. During the initial test, verify a full-stroke of all group valves using nonintrusives.
e. During subsequent tests, exercise each valve with flow at the prescribed test conditions.
f. At each test, perform nonintrusive verification on one group valve on a rotating schedule.
g. If problems are found with the sampled valve, test the other group valves using nonintrusive techniques during the same outage.

The licensee's proposed alternate testing appears to comply with most of the above conditions, however, it is unclear from the submittal if all of these conditions are met. The licensee should verify that the testing of the subject valves complies with all of these guidelines. The proposed grouping in this request does not appear to comply with the GL 89-04 requirement that group valves have the same service conditions. Valve 1-SI-127 (2-SI-153) is the second check valve (closer to the RCS) in the injection line from the accumulator to the RCS while the other three group valves are the first check valves (closer to the accumulators). Valve 1-SI-127 (2-SI-153) is normally subjected to RCS pressure, water chemistry, and possibly elevated temperatures while the other group valves do not normally experience these conditions. These and other possible differences may affect the corrosion, erosion, wear, etc. for this valve such that it is not representative of the other valves in the proposed group. The licensee also indicated that these valves will be disassembled and inspected in accordance with GL 89-04, Position 2, if they cannot be verified to full-stroke exercise using nonintrusive techniques. If disassembly and inspection is used, the licensee should ensure that the valves are grouped for disassembly in accordance with Position 2 as discussed above and that all of the Position 2 criteria for extending the disassembly interval are met and documented.

By performing nonintrusive testing initially on all valves in the group, the licensee demonstrates that the partial flow fully opens all of the valves and that the nonintrusive method is capable of verifying a full-stroke. By repeating the flow test for all valves each RFO under the same conditions, the licensee passes the same flow rate through the valves that has been shown to full-stroke them when they are in good condition. The nonintrusive verification of one of the group valves, verifies that the sampled valve is capable of a full-stroke, which provides assurance that it is not significantly degraded. Since the sampled valve is representative of all group valves, this testing provides assurance of the operational readiness of all group valves. If the licensee finds a problem with the sampled valve, the remaining group valves would be checked with the nonintrusive technique during that outage. When the system has not been modified and the flow and pressure conditions are repeated, no phenomena should invalidate the testing as verified initially that would not be indicated

by a problem in one of the group valves. If the licensee modifies the system or performs the testing with different test conditions, the initial verifications should be repeated.

Summary and Additional Comments

The staff has determined that relief is not required to use nonintrusive techniques to meet the Code requirements for verifying disk movement for the full-stroke exercising of check valves because this test method is considered an acceptable "other positive means," even if used on a rotating basis. If the recommended alternative methods of this section are implemented, the licensee must describe the implementation of this section in the IST program document. Relief would be required for the testing frequency if the test interval extends beyond each RFO as allowed by OM-10.

Many of the requests did not meet all of the provisions listed in NUREG 1482, Section 4.1.2. Future testing using this method should seriously consider the guidance of this NUREG.

2.2.4 MISCELLANEOUS CHECK VALVES ISSUES

There were several miscellaneous issues related to the testing of check valves. Some system configurations make conventional testing impractical. In these cases, unique testing solutions may be necessary to test these valves in a manner that indicates their operational readiness while not being an undue hardship on the licensee.

Requirements

Section XI, Paragraph IWV-3522 states: "Check valves shall be exercised to the position required to fulfill their function...." ASME OM Code-1990, Subsection ISTC, Paragraph ISTC 4.5.2(a) requires each check valve to be exercised or examined in a manner that verifies obturator travel to the closed, full-open, or partially open position required to fulfill its function. GL 89-04 states that a check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve and that any flow rate less than this will be considered a partial-stroke exercise. The GL further states that a valid full-stroke exercise by flow requires that the flow through the valve be known. Knowledge of only the total flow through multiple parallel lines does not provide verification of flow rates through the individual valves and is not a valid full-stroke exercise.

Table 2-9. Summary Table of Key Requirements and Guidance for Miscellaneous Check Valve Issues

Document	Section	Requirement/Guidance
Section XI	IWV-3522	Verify the valve exercises to the required position(s) by observing a direct indicator such as a position-indicating device or by other indicator(s) such as changes in system pressure, flow rate, level, temperature, seat leakage testing or other positive means; or a mechanical exerciser can be used to move the valve disk.
OM-10	Paragraph 4.3.2.4	Verify the valve exercises to the required position(s) by observing a direct indicator such as a position-indicating device or by other indicator(s) such as changes in system pressure, flow rate, level, temperature, seat leakage testing or other positive means; or a mechanical exerciser can be used to move the valve disk; or disassembly may be used every refueling.

Document	Section	Requirement/Guidance
GL 89-04	Position 1/ Questions 1-8	A check valve's full-stroke to the open position may be verified by passing the maximum required accident condition flow through the valve. A flow rate less than this will be considered a partial-stroke exercise. A valid full-stroke exercise by flow requires that the flow through the valve be known.
GL 89-04	Position 2/ Questions 9-20	Disassembly and inspection can be used as a positive means of determining that a check valve's disk will full-stroke exercise open or of verifying closure capability. A sample disassembly and inspection plan for groups of identical valves in similar applications may be employed. The guidelines for this plan are explained. If possible, partial valve stroking after reassembly must be performed.
OMc-1994	ISTC 4.5.4	Same as OM-10 except that disassembly and inspection can be used only when the two other methods are impractical. Also, establishes a sampling plan similar to the plan in GL 89-04. Nonintrusive techniques are specifically identified as acceptable positive means of verifying the required valve position(s).
NUREG 1482	4.1.1	If there is no practical means for verifying the ability of each valve in a series to close and if only one of the two valves is credited in the safety analysis, then verification that the pair of valves is capable of closing is acceptable for IST.
NUREG 1482	4.1.2	Nonintrusive techniques may be used to verify a check valve's capability to open, close, and fully stroke in accord with quality assurance program requirements. Relief is not required to use this method except as would be necessary for the testing frequency if the interval extends beyond each RFO.
NUREG 1482	4.1.4	If no other practical means is available, it is acceptable to verify that check valves are capable of closing by performing leak-rate testing, such as local leak rate testing in accord with Appendix J to 10 CFR Part 50, at each reactor RFO.

Relief Request Issues

The following miscellaneous issues had sufficient relief requests to warrant inclusion in this report.

Major Issues:

a) closure verification for series check valves without intermediate test taps (see Item 1)
b) testing multiple check valves as a group (see Item 2)
c) using system functional testing to exercise check valves (see Item 3)

Each of these issues is discussed separately in the following sections of this report.

(1) Closure Verification for Series Check Valves Without Intermediate Test Taps

Many plants have piping configurations which include two check valves in series with no provision (such as intermediate test taps) for verifying that each valve can close. These valves may perform a safety function in the closed position to prevent the gross diversion of flow. The Code requires valves performing safety functions to be stroked to the position(s) required for the valves to perform

those functions. Systems containing these valves may have provisions for verifying that at least one of the two valves in a pair is closed. The provisions would enable the licensee to measure or observe an operational parameter such as leakage, pressure, or flow for the pair of valves. We considered 24 requests that involved testing series check valve pairs without intermediate test taps as units. Ten of these requests involved the keep fill or system pressure maintenance check valves in the emergency core cooling systems of BWRs.

The NRC addressed this issue in NUREG 1482, Section 4.1.1. This Section states in part: "If the licensee has no practical means for verifying the ability of each valve in a series to close, it may review the plant safety analysis to determine if both valves are required to function. If only one of the two valves is credited in the safety analysis (that is, if one valve could be removed without creating an unreviewed safety question or creating a conflict with regulatory or license requirements), then verification that the pair of valves is capable of closing is acceptable for IST. If relief is requested on this basis, both series check valves must be included in the IST program and be subject to equivalent quality assurance criteria. Testing (such as the use of pressure indication to verify the closure of one of the check valves) is required during each quarter or at an extended interval in accord with the Code. No additional testing need be performed unless the licensee finds indication that the closure capability of the pair of valves is questionable. If so, both valves must be declared inoperable and corrective actions taken for both valves, as necessary, before being returned to service."

There are several restrictions and limitations for IST of series valves as a pair. Both valves in a series pair must be verified to function if the plant safety analysis credits or otherwise requires both valves. IST of series valves as a pair cannot be used as an alternate means of verifying leak-tightness (Category A/C valves). IST to verify the closure of series check valves as a pair does not enable the licensee to verify the operational readiness of each component as intended in the Code, because this testing method would not detect if one valve of the pair failed open.

The guidance in NUREG 1482, Section 4.1.1, further states: "To perform testing of the pair of valves as described above, the licensee must obtain relief because the Code requirements for individual valves are not met. The relief requests typically include information on the safety analysis, quality assurance requirements, the acceptance criteria, and the corrective actions that would be taken if excessive leakage is identified."

The following examples are provided of requests to test series check valves as a pair.

Example for Instrument Air/Nitrogen Supply System from Comanche Peak Units 1 and 2

Relief is requested from the exercising requirements of OM-10, Paragraph 4.3.2, for the nonsafety instrument air or nitrogen supply systems and the safety-related accumulator and receiver tanks for certain safety-related components. These check valves are required to close upon failure of the air or nitrogen supply system to contain the compressed gas in the tanks.

Licensee's Basis for Requesting Relief:

Each valve listed is one of two check valves in series at the inlet to a safety-grade accumulator or receiver tank. In each case, only one check valve is required in order to meet the safety class interface criteria of ANSI N18.2a-1975. However, two check valves are provided for added reliability, not for redundancy. The safety-related components served by the accumulator and receiver tanks are redundant to other similar components which have their own dedicated safety-grade air supplies. As long as one of the check valves in the pair is capable of closure, then the safety analysis assumptions for the check valves are met. Some of the check valve pairs do not have provisions for testing each valve individually. However, the closure capability of each pair of check valves can be verified.

Alternate Testing:

Each pair of series check valves will be exercise tested at the required frequency by some positive means to verify the closure capability of at least one of the valves. No additional exercise testing will be performed unless there is an indication that the closure capability of the pair of valves is questionable. In that case, both valves will be declared inoperable and not returned to service until they are either repaired or replaced.

Evaluation

The licensee's proposed alternative was authorized pursuant to 10 CFR 50.55a (a)(3)(i) because it was determined that the alternative provides an acceptable level of quality and safety in meeting the intent of the Code requirements. The relief request relates to the exercising of these series check valves, not to leakage testing. For series check valves when only one of a pair is required to meet safety analysis assumptions, the staff has determined that the intent of Code requirements is met and that it is acceptable to test the pair of valves as a single valve with the following provisions: (1) both valves must be subject to comparable quality assurance requirements, (2) acceptance criteria for the pair of valves must be established appropriate to the verification method, and (3) if the acceptance criteria are not met, both valves shall be declared inoperable and corrective actions initiated for both valves, including a retest prior to returning the pair of valves to service.

Example for Chemical and Volume Control System from Zion Units 1 and 2

Relief is requested from OM Part 10 Paragraph 4.3.2.4 (a), which requires verification of individual check valve closure capability quarterly, for the RCP seal injection check valves. The licensee proposes to back flow test these series check valves as a unit.

Licensee's Basis for Requesting Relief:

These valves are physically located in series with no test connection located between them. To test each valve individually would require a modification to install a test connection between them. A modification to install a test connection on all eight seal injection lines would be an excessive cost burden to the Station. These valves can be tested in series with the current piping configuration. To perform the check valve closure test, the flow to the Reactor Coolant Pump seals needs to be isolated. Since seal injection is required during normal operation to prevent potentially damaging the seals, it is not practical to isolate seal injection during normal operations. Therefore, this test is impractical to perform during normal operations.

The methodology used in testing these valves would require the RCPs and Charging Seal Injection to be secured. A blank flange would be installed on the inlet to the seals to provide a test boundary as well as to prevent any test water leakage into the seals. Test equipment would need to be installed on the system to perform the leakage test. To set up and perform this test as required by the Code would be burdensome to perform at CSD due to the costs involved in remaining shutdown even if the RCPs were secured. Therefore, taking the above mentioned items into account, these check valves will be tested at reactor refueling.

Alternate Testing:

Zion Station will back leakage test these valves in series. Leakage identified will be attributable to both valves. This testing will ensure the integrity of the ASME Class 1 to Class 2 transition.

Evaluation

The licensee's justification for testing the valves during RFOs in accordance with OM-10, Paragraph 4.3.2.2(e) is acceptable. NUREG-1482, Section 4.1.1, provides guidance for preparing relief requests for situations where there are two check valves in series with no provisions for verifying that each can close. As discussed in the NUREG guidance, the licensee must ensure that the safety analysis does not require both of these Class 1 valves to function, i.e., one valve could be removed without creating an unreviewed safety question or creating a conflict with regulatory or license requirements. The licensee's basis does not discuss the function of these valves. Provided the licensee verifies that only one of the two Class 1 valves is required, relief can be recommended pursuant to 10 CFR 50.55A (f)(6)(i). If however, the series valves are required by the plant safety analysis assumptions, verification of the capability of each of the valves is required and relief cannot be granted. GL 89-04, Position 2 provides an acceptable alternative for demonstrating the capability of both valves to close by disassembly and inspection.

Example for Emergency Core Cooling System Stay-Fill Valves from Peach Bottom Units 2 and 3

Requests relief from full-stroke exercising the following series stay-fill check valves in accordance with the requirements of Section XI, Paragraph IWV-3521, and proposed to verify closure during RFOs.

Licensee's Basis for Requesting Relief:

The above stay-fill check valves are installed in pairs (series arrangement) with no provisions for individual valve testing. The valves function, in series as a pair, to prevent loss of RHR inventory to the stay-fill system in the event of a stay-fill system failure. Because testing these valves as a pair is preferable to valve disassembly and inspection, relief from testing individual valves is requested. In addition, TS 3.5.G requires that the discharge piping of the LPCI system be filled to prevent water hammer upon system initiation. Testing these valves during power would make the stay-fill system inoperable, requiring entry into the associated LCO. For this reason, testing of the above pairs of valves will be performed at CSDs.

Alternate Testing:

Valves will be tested as a pair in the reverse direction at CSD. Both valves in the pair will be considered inoperable if testing indicates the valves do not close on reverse flow.

Evaluation

Relief was granted pursuant to 10 CFR 50.55A (f)(6)(i). It was determined that leak testing these stay-fill series check valves as a pair should provide reasonable indication that the pair is capable of performing its safety function in the closed position. These valves perform a safety function in the closed position to prevent diversion of injection flow away from the reactor vessel. They can be exercised closed during quarterly RHR pump testing, however, the system design makes it impractical to verify closure by leak testing or observing a differential pressure across each valve. Only one valve in each of these stay-fill series check valve pairs is required to perform the closed safety function. The proposed testing does not provide indication of the condition of each valve, however, it does provide positive indication that at least one valve in the pair is capable of performing the closed safety function. If there is an indication that the closure capability of the pair of valves is questionable, both valves must be declared inoperable and repaired or replaced before being returned to service.

Example for Emergency Core Cooling System Keep-Fill Valves from Perry

Relief is requested from the test frequency requirements of Section XI, IWV-3521, and the test method of IWV-3522 for the Code Class 2, Category C, keep-fill system check valves, which function as keep-fill pump discharge check valves.

<u>Licensee's Basis for Requesting Relief:</u>

These simple check valves are the outboard check of a series pair for the safety-related keep-fill pump discharge. They provide the high-to-low pressure interface to prevent over pressurization of the low pressure portion of the system. Both the associated inboard and involved outboard check valves are in close proximity to each other. At CSD these valves are exercised open by verifying proper keep-fill system flow. The associated inboard stop check valves can be verified closed using the manual handwheel (in accordance with the guidance provided in the September 26, 1991, Supplement to the public meetings on GL 89-04). The system configuration does not include test connections between the involved outboard valves and their associated inboard stop check valves. Hence, the closure of the outboard check valves cannot be individually verified. The system would have to be redesigned and modified to perform the Code required testing. Disassembly and inspection of these valves on a sampling basis to assess their closure capability provides a reasonable alternative to the Code test method.

The NRC staff previously accepted valve disassembly and inspection on a sampling basis as an alternative to full flow testing in GL 89-04, Attachment 1, Position 2. Due to the scope of the activity, the personnel hazards involved and system operating restrictions, this valve disassembly will be performed during reactor RFOs. This deviation from the Code frequency is specifically permitted in the GL position.

<u>Alternate Testing:</u>

A sample disassembly and inspection plan which is consistent with GL 89-04, Attachment 1, Position 2, will be utilized. This plan which selects one valve in each group to be disassembled every RFO will be utilized. Sample groups may consist of more than 4 valves; however, all valves within each group must be disassembled within a maximum of 4 RFOs. These valves are exercised open following their assembly by verifying proper keep-fill pump flow.

<u>Evaluation</u>

The licensee's proposal is in accordance with guidance delineated in Position 2 of GL 89-04; therefore, the relief request was approved by GL 89-04 pursuant to 10 CFR 50.55a (g)(6)(i). These valves perform a safety function in the closed position to prevent diversion of injection flow away from the reactor vessel. They can be exercised closed during quarterly ECCS pump testing, however, the system design makes it impractical to verify closure by leak testing or observing a differential pressure across each valve.

Example for the SW System from D. C. Cook Units 1 and 2

Relief is requested from the Category A leak rate test requirements of Section XI, IWV-3420, for high head safety injection (HHSI) line check valves. The licensee proposes to leak test the valves in pairs with the resulting leak rate evaluated as if a single valve were tested. These valves provide a flow path for the HHSI system to the reactor coolant loops and prevent over pressurization of the safety injection system piping and components.

Evaluation

The licensee's justification for testing the valves during RFOs in accordance with OM-10, Paragraph 4.3.2.2(e) is acceptable. NUREG-1482, Section 4.1.1, provides guidance for preparing relief requests for situations where there are two check valves in series with no provisions for verifying that each can close. As discussed in the NUREG guidance, the licensee must ensure that the safety analysis does not require both of these Class 1 valves to function, i.e., one valve could be removed without creating an unreviewed safety question or creating a conflict with regulatory or license requirements. The licensee's basis does not discuss the function of these valves. Provided the licensee verifies that only one of the two Class 1 valves is required, relief can be recommended pursuant to 10 CFR 50.55A (f)(6)(i). If however, the series valves are required by the plant safety analysis assumptions, verification of the capability of each of the valves is required and relief cannot be granted. GL 89-04, Position 2 provides an acceptable alternative for demonstrating the capability of both valves to close by disassembly and inspection.

Example for Emergency Core Cooling System Stay-Fill Valves from Peach Bottom Units 2 and 3

Requests relief from full-stroke exercising the following series stay-fill check valves in accordance with the requirements of Section XI, Paragraph IWV-3521, and proposed to verify closure during RFOs.

Licensee's Basis for Requesting Relief:

The above stay-fill check valves are installed in pairs (series arrangement) with no provisions for individual valve testing. The valves function, in series as a pair, to prevent loss of RHR inventory to the stay-fill system in the event of a stay-fill system failure. Because testing these valves as a pair is preferable to valve disassembly and inspection, relief from testing individual valves is requested. In addition, TS 3.5.G requires that the discharge piping of the LPCI system be filled to prevent water hammer upon system initiation. Testing these valves during power would make the stay-fill system inoperable, requiring entry into the associated LCO. For this reason, testing of the above pairs of valves will be performed at CSDs.

Alternate Testing:

Valves will be tested as a pair in the reverse direction at CSD. Both valves in the pair will be considered inoperable if testing indicates the valves do not close on reverse flow.

Evaluation

Relief was granted pursuant to 10 CFR 50.55A (f)(6)(i). It was determined that leak testing these stay-fill series check valves as a pair should provide reasonable indication that the pair is capable of performing its safety function in the closed position. These valves perform a safety function in the closed position to prevent diversion of injection flow away from the reactor vessel. They can be exercised closed during quarterly RHR pump testing, however, the system design makes it impractical to verify closure by leak testing or observing a differential pressure across each valve. Only one valve in each of these stay-fill series check valve pairs is required to perform the closed safety function. The proposed testing does not provide indication of the condition of each valve, however, it does provide positive indication that at least one valve in the pair is capable of performing the closed safety function. If there is an indication that the closure capability of the pair of valves is questionable, both valves must be declared inoperable and repaired or replaced before being returned to service.

Licensee's Basis for Requesting Relief:

The Indian Point 3 TS, Section 4.5.B.2.C, requires leak testing of these valves because of the potential for over pressurization of the safety injection system (Event V scenario). To insure that this does not occur, and in accordance with NRC letter dated February 1980, (Subject: Event V Scenario) only two valves in series require testing. Because of the difficulties in testing a single valve in these cases, it has been decided to test the inner valve individually and the outer two valve as a pair (considering the inner valve as a barrier and the outer two as a barrier). This relief applies only to the outer two valves which will be tested as a pair because of the man rem exposure levels associated with performing the test. The valves, which are in a high heat and radiation environment, require a difficult series of making and breaking connections to "jumper" high pressure over the inner check valve(s). The two barriers (one inner check valve and two outer check valves) are to be provided with individual leak tests.

Alternate Testing:

These valve pairs (i.e., the two outer check valves) will be leak tested as a pair with the resulting leak rate evaluated as if a single valve were tested. The inner check valves in each of the four flow paths from the RCS (897A-D) will be individually leak tested.

Evaluation

The proposed alternative was authorized pursuant to 10 CFR 50.55a (a)(3)(i). The licensee proposed to verify the Category A seat leak tightness by testing these check valves in pairs, one test for each series set, and evaluate the leakage rate as that of a single valve. The design basis requirement concerning two barriers for the prevention of intersystem LOCA will be met by individually leak testing additional check valves for each of the four HHSI flow paths. The alternate testing is equivalent to the design basis requirement regarding individually leak testing two pressure boundary isolation valves in series provided that no credit is taken for leak tight integrity of an individual valve that is tested as a pair. Therefore, the testing provides an acceptable level of safety for the leak testing of the pressure boundary isolation valves identified in this relief request.

Summary and Additional Comments

In very few cases was relief denied to test series check valves without intermediate test taps as a unit. However, many of the requests did not meet all of the guidelines listed in NUREG 1482, Section 4.1.1. Future requests on this issue would be more likely to be approved if the licensee clearly demonstrates compliance with the provisions of this NUREG position. The following should be considered when developing relief requests for these cases:

(1) Indicate in the request that a safety analysis review was performed to determine the safety function(s) of the subject valves.
(2) Indicate in the request that only one of the valves is necessary to perform the safety function.
(3) Indicate in the request that neither valve performs a function that requires leakage to be limited to a specific amount.
(4) Indicate in the request that both valves are included in the IST program.
(5) Indicate in the request that both valves are subject to equivalent quality assurance criteria.
(6) Provide the justifications for not testing quarterly and during CSDs, as applicable.
(7) Demonstrate that the acceptance criteria is appropriate for the safety function performed.
(8) Indicate that both valves will be declared inoperable until they are repaired or replaced if the acceptance criteria is exceeded.

Requests that meet the items listed above should be approved. Where all of the above items are not met, a request for relief may still be found to be acceptable. However, in these cases the licensee

must clearly demonstrate that the proposed alternative provides an adequate assessment of valve operational readiness.

(2) Testing Multiple Check Valves as a Group

Many plants have piping configurations which include check valves in configurations with no provision for verifying that each valve can open or close. The Code requires valves performing safety functions to be stroked to the position(s) required for the valves to perform those functions. Systems containing these valves may have provisions for verifying the closure or open capability of the group as a unit. The provisions would enable the licensee to measure or observe an operational parameter such as leakage, pressure, or flow for the group of valves. We considered 12 requests that involved testing multiple check valves as a group.

The guidance in NUREG 1482, Section 4.1.1, addresses testing series check valve pairs as a unit. Although these valves are not in a simple series configuration, some of the same concerns that apply to the series pairs also apply to these valves. Group testing should not be used if it permits a required redundant capability to be compromised. Therefore, as indicated in NUREG 1482, the licensee should review the plant safety analysis to determine if group testing would permit a capability for which credit is taken to go untested. If only one of the redundant series valves or parallel flow paths is credited in the safety analysis (that is, the other could be removed without creating an unreviewed safety question or creating a conflict with regulatory or license requirements), then verification that the group of valves is capable performing the required function should be acceptable for IST. If relief is requested on this basis, all group check valves must be included in the IST program and be subject to equivalent quality assurance criteria. Testing is required during each quarter or at an extended interval in accordance with the Code. If the licensee finds indication that the open or closure capability of the group of valves is questionable, all valves in the group must be declared inoperable and corrective actions taken for all valves, as necessary, before being returned to service."

The following examples are provided of requests to test a group of check valves as a pair.

Example for High Pressure Coolant Injection System from Peach Bottom Units 2 and 3

Relief is requested from exercising the HPCI turbine exhaust line vacuum breaker check valves in accordance with the requirements of Section XI, Paragraph IWV-3521. The licensee proposed to verify an operable flow path quarterly.

<u>Licensee's Basis for Requesting Relief:</u>

These check valves function as vacuum relief valves, are installed in series-parallel, and were not provided with air operators to facilitate testing (exercising). The piping configuration in the high pressure coolant injection system does not allow for individual testing of these valves. Since a series-parallel arrangement was used, there are multiple combinations of flowpaths any one of which would provide vacuum relief. No single valve failure would prevent the system from providing vacuum relief. Because single valve failure will not prevent the system from functioning as designed, and system configuration does not allow for individual valve testing, testing as a unit will verify the system can provide vacuum relief as designed.

<u>Alternate Testing:</u>

These vacuum relief valves will be tested quarterly, in the forward direction, as a unit.

Evaluation

Relief was granted pursuant to 10 CFR 50.55a (f)(6)(i) with the following provisions. The licensee must verify group reverse flow closure during quarterly pump testing. Also, if either the forward flow or reverse flow closure capability of this group becomes questionable, all valves in the group must be declared inoperable and be repaired, replaced, or individually verified operable. The proposed testing does not provide indication of the condition of each valve, however, it does provide positive indication that at least one valve in each of the two parallel flow paths is capable of opening.

Due to the cross-connected series-parallel valve arrangement, no single valve failure can prevent flow in the forward direction or allow flow in the reverse direction. Because of this design feature, the licensee's proposal to verify valve operational readiness as a unit, i.e., an operable forward flow path through the four valve group, should provide reasonable assurance of the groups ability to perform its safety function in the open position. These valves also perform a function in the closed position to prevent steam from being introduced directly into the torus airspace. Due to the series-parallel arrangement and the lack of test connections, these valves cannot be individually verified in the closed position. However, the reverse flow closure of the group can be verified by monitoring a high temperature alarm installed upstream of the valve assembly that would indicate steam leakage past these valves during turbine operation. This closure verification can be performed during the quarterly pump test.

Example for Containment Cooling and Purge System from WNP Unit 2

Relief was requested from exercising the suppression chamber to drywell vacuum breaker valves in accordance with the requirements of Section XI, Paragraphs IWV-3426 and 3427, and it was proposed to full-stroke exercise these valves at least once every 18 months by opening each valve using a torque wrench and verifying closure of all of these valves by conducting a drywell-to-suppression chamber bypass leak test.

Licensee's Basis for Requesting Relief:

These check valves cannot be tested individually, therefore, assigning a limiting leakage rate for each valve is not practical. The purpose of this leak rate test is to assure that the leakage from the suppression pool chamber to the drywell does not exceed TS limits. The WNP-2 TS specifies conservative corrective actions commensurate with the importance of the safety function being performed by these valves.

Alternate Testing:

These valves will be leak tested according to WNP-2 TS, at least once per 18 months by conducting a drywell-to-suppression chamber bypass leak test. These valves are verified closed by redundant position indicators, tested in the open direction using a torque wrench, and each valve seat is visually inspected. Corrective actions will be as specified in the TS. The leakage criteria and corrective actions specified in the WNP-2 TS is the most practical approach to assessing the adequacy of these valves in performing their specified safety function. Following the WNP-2 TS provides adequate assurance of material quality and public safety.

Evaluation

Relief was granted pursuant to 10 CFR 50.55a (f)(6)(i). The licensee proposed to measure a combined leakage rate through these valves during the drywell-to-suppression chamber bypass leak test, to perform a visual inspection of each valve seat, to test the valve in the open direction measuring torque, and to verify valve closure by redundant position indication every 18 months. This testing should provide adequate assurance that these valves can perform their safety function in the

closed position and provides a reasonable alternative to the Code requirements. If the reverse flow closure capability of this group becomes questionable, all valves in the group must be declared inoperable and be repaired, replaced, or individually verified operable.

<u>Summary and Additional Comments</u>

Few of the reviewed relief requests were unconditionally approved. Most were denied, granted for an interim time, or granted with provisions. Many requests did not clearly demonstrate that the alternate testing would verify the group of valve's capability to perform its safety function(s). The following should be considered when developing relief requests for these cases:

(1) Indicate in the request that a safety analysis review was performed to determine the safety function(s) of the subject valves.
(2) Indicate in the request which valves and flow paths are necessary to perform the safety function(s).
(3) Indicate in the request that all group valves are included in the IST program.
(4) Indicate in the request that all group valves are subject to equivalent quality assurance criteria.
(5) Provide the justifications for not testing quarterly or during CSDs, as applicable.
(6) Demonstrate that the acceptance criteria is appropriate for the safety function(s) performed.
(7) Indicate that all group valves will be declared inoperable until they are repaired, replaced, or individually verified operable if the acceptance criteria is exceeded.

Requests that meet the items listed above should be approved. Where all of the above items are not met, a request for relief may still be found to be acceptable. However, in these cases the licensee must clearly demonstrate that the proposed alternative provides an adequate assessment of valve operational readiness.

(3) Using System Functional Testing to Exercise Check Valves

We considered 12 requests that involved verifying check valve exercising while conducting system functional tests. These requests varied widely but most involved cases where the valves could not practically be exercised to one or more safety position because of the lack of necessary test taps, isolation valves, or other test provisions.

The following examples are provided that deal with using system functional testing to exercise check valves.

Example for Diesel Fuel Oil Transfer System from Nine Mile Point Unit 1

Relief was requested from the exercising requirements of Section XI, Paragraph IWV-3520, for the diesel fuel oil storage tank foot valves, and it was proposed to exercise these valves during the TS monthly test of the EDGs.

<u>Licensee's Basis for Requesting Relief:</u>

The Diesel Fuel Oil Storage Tank foot valves are submerged inside the Diesel Fuel Oil Storage Tanks and thus are inaccessible. TS EDG monthly start and operability tests are performed for a minimum time of one hour. Since the Diesel Fuel Oil Day Tanks are filled during the EDG operability test, these valves are verified operable when the tanks are filled.

<u>Alternate Testing:</u>

Exercise these valves during the TS monthly test of the EDGs.

Evaluation

In the preceding example, the proposed alternative was authorized pursuant to 10 CFR 50.55a(a)(3)(i). The alternate testing provides an acceptable level of quality and safety. During the monthly DG start and operability tests, the flow rate through the positive displacement DG fuel oil transfer pumps is measured. If the fuel oil transfer pump flow rate is satisfactory, these foot valves are verified to full-stroke exercise open.

Example for the Instrument Air System from Robinson Unit 2

Relief was requested from the exercising requirements of Section XI, Paragraph IWV-3520, for nitrogen and air supply check valves. The licensee proposed to functionally test these valves during their associated component or system tests.

Licensee's Basis for Requesting Relief:

Defining and verifying full flow through small check valves in air and gas systems is typically impractical. Check valves installed in air and gas systems are to regulate pressure not flow. These valves will only open when a differential pressure exists across the valve, in which case the valve is only required to open enough to reestablish the pressure. The valves are functionally tested during their associated component and/or system test. Defining and trying to verify maximum accident flow through the check valve would not provide additional assurance of the associated components operability. Disassembly of these valves to verify full stroke is not practical due to their size and design.

Alternate Testing:

All safety related check valves in gas and air systems will be functionally tested during their associated component and/or systems test. Opening and/or closing of these valves will be verified, as applicable, during these tests.

Evaluation

In this case, interim relief was granted for one year or until the next RFO, whichever is longer, pursuant with 10 CFR 50.55a (f)(6)(i). The licensee did not provide sufficient information about the test methods or frequency of the associated component testing to allow an evaluation of the adequacy of the proposed functional testing of these check valves. Therefore, long term relief should not be granted as requested. These valves allow nitrogen/air to pass from the supply headers into the valve operator accumulators. Flow is initiated only when the pressure in the accumulators falls below the supply header pressure. The design accident flow for the check valve would be experienced when the accumulator is recharged in sufficient time for the power operated valve to meet its intended safety function.

Additional information is necessary to demonstrate the long term adequacy of the functional testing. The licensee should consider alternate testing that verifies a full-stroke exercise of these valves at the Code required frequency should be developed and implemented. An interim period should be provided for the licensee to investigate the options and develop the necessary documentation.

The licensee responded that two of the six check valves are not safety-related valves but were included in the relief request in accord with Position 11 of Generic Letter 89-04. For the remaining four check valves in the nitrogen system, the licensee determined that a partial-stroke exercise was adequate to verify the capability of these valves pursuant to OM-10, Paragraph 4.3.2.2. Further testing was added to re-pressurize the isolation valve seal water tank after the nitrogen cover gas pressure has been lowered. This test will allow for trending and will provide additional assurance that the valves are capable of performing the design function of maintaining the isolation valve seal water tank pressure.

Example for the Instrument Air System from Perry

Relief was requested from the requirements of Section XI, IWV-3424, -3426, and -3427, for the containment and drywell airlock door seal accumulator supply check valves. The licensee proposed to perform a pressure decay test on these valves according to plant TS.

<u>Licensee's Basis for Requesting Relief:</u>

These valves serve as the pressure boundary to ensure adequate seal pressure is maintained upon loss of the instrument air (P52) supply. The inflatable seal system pressure boundary is verified operable by conducting a seal pneumatic system leak test and verifying that system pressure does not decay more than 1.5 psig from 90 psig within 24 hours or 0.45 psig from 90 psig within 8 hours. Satisfactory completion of the decay pressure test verifies the valve leak rate test requirements.

The normal closed position verification will be satisfied by obtaining a satisfactory pressure decay test. Verifying the normal position by other means than a pressure decay test is not practical. This test makes the airlocks inoperable for an extended period of time, thus restricting access to the containment. Therefore, performance of the normal position verification on other than the TS frequency would result in a hardship without a compensating increase in the level of safety due to prolonged restriction of access, causing a possible safety concern and unnecessary wear of sealing parts.

<u>Alternate Testing:</u>

Exercise by conducting a seal pneumatic system leak test per TS, which also will perform the normal closed position verification.

<u>Evaluation</u>

The proposed alternative was authorized pursuant to 10 CFR 50.55a(a)(3)(i). The licensee proposes to verify closure of these valves by performing a pressure decay test, with strict acceptance criteria. The acceptance criteria for these valves are based on their safety function. By satisfying the criteria the licensee verifies each valve's ability to accomplish its safety function. Therefore, the licensee's proposal provides an acceptable level of quality and safety, which is essentially equivalent to that provided by the Code.

Example for the Service Water System from Hatch, Units 1 and 2

Relief was requested from exercising the SW pump discharge check valves in accordance with the requirements of Section XI, Paragraph IWV-3522(b), and it was proposed to verify reverse flow closure during normal equipment rotation.

<u>Licensee's Basis for Requesting Relief:</u>

There are no direct means to verify closure of these valves

<u>Alternate Testing:</u>

Closure must be verified to ensure that flow from an operating pump on the train is not diverted back through a non-operating pump and thereby degrading the performance of the operating pump. Closure of the valve is confirmed whenever the pump is shut off since performance of the other pump does not degrade. Note: Opening is verified by required flow.

Evaluation

The licensee did not demonstrate the impracticality of exercising these valves closed at the Code specified frequency nor did they show that performing the Code testing would be a hardship without a compensating increase in the level of quality and safety, therefore, relief should not be granted to defer exercising these valves as requested. These simple check valves cannot be exercised to the closed position unless the associated SW pump is stopped. Stopping or shifting SW pumps when SW cooling requirements are high could result in equipment damage or a forced plant shutdown. It may be impractical to exercise each of these valves closed quarterly during power operation because plant cooling requirements and SW intake temperature may require running all of the pumps. However, the licensee has not provided an adequate basis for not switching operating SW pumps during CSDs when the cooling loads are lower. Therefore, the licensee should verify the closure of each of these valve during CSDs unless a valve has been exercised closed during normal equipment rotation during the previous three months.

Summary and Additional Comments

These requests proposed unusual methods of verifying that the check valves are exercised. In some cases, insufficient information was provided to demonstrate the impracticality or unusual hardship of performing the Code testing. In other cases, insufficient information was provided about the proposed testing for it to be evaluated and approved. The requests need to be more detailed and complete than these examples. The following should be considered when developing relief requests for these cases:

(1) Demonstrate the impracticality of full-stroke exercising the valves with flow or other positive means during power operations and CSDs, if applicable.

(2) Demonstrate that the longer test interval should provide adequate assurance of continued valve operational readiness.

(3) Demonstrate the adequacy of the alternate test method to verify the valve's ability to perform its safety function.

Requests that meet the items listed above should be approved. Where all of the above items are not met, a request for relief may still be found to be acceptable. However, in these cases the licensee must clearly demonstrate that the proposed alternative provides an adequate assessment of valve operational readiness.

3 PUMP RELIEF REQUESTS

3.1 Pump Testing Frequency

The currently approved pump testing Codes (through the 1989 Edition of the ASME Code) require that IST of safety-related pumps be performed every 3 months. Earlier editions of the Codes (e.g., 1974 Edition) required monthly testing; however, it was determined that for most pump installations, this frequency was a hardship on the Owner and did not provide a compensating increase in the level of quality and safety. Some safety-related pumps operate frequently or continuously during plant power operations and would be subjected to degradation caused by normal wear. Quarterly testing of these pumps is necessary to monitor their continued operational readiness. However, some pumps are in standby and are only required to operate to mitigate the consequences of an accident or shut the plant down to a safe shutdown condition. These standby pumps are generally not subjected to degradation mechanisms except when they are operated for testing. The Code committees recognized the need for different testing schedules for these two different pump usage categories and created the separate testing schemes of the Comprehensive Pump Test in Subsection ISTB of the 1995 OM Code.

There are situations where it is impractical or a hardship without a compensating increase in the level of quality and safety to perform all or part of the Code required testing every 3 months. Unlike the valve testing Codes (IWV and OM-10), the pump testing Codes do not provide for alternative test frequencies. Therefore, when it is impractical or a hardship to meet a Code required test frequency, the licensee must process a relief request.

Requirements

Section XI, IWP-3400(a), and OM-6, Paragraph 5.1, require that IST of safety-related pumps be performed nominally every 3 months. The once every 3 month or quarterly frequency is defined in some facility TS as being at least once every 92 days. In the guidance in NUREG 1482, 3.1.3, the NRC recommends (NRC 1995) that this definition be used even if this frequency is not included in the plant's TS. The Code does not provide for variations from the specified frequencies. However, some station TS and the Standard TS allow a 25% variance for surveillance frequencies. The guidance in NUREG 1482, 3.1.3, indicates this 25% allowance may be used without relief from the Code.

Another frequency issue is the testing frequency for pumps lacking required fluid inventory, such as those located in dry sumps. Section XI does not specifically address these pumps, therefore, they are included with all other safety-related pumps in IST programs. OM-6, Paragraph 5.5, exempts these pumps from quarterly testing and requires that the necessary inventory be provided and the pumps be tested at least once every two years.

ISTB-1995 (ASME 1995) introduces a new approach to pump testing wherein pumps are divided into two basic groups, with an enhanced baseline and three periodic tests. This modified pump testing program is commonly referred to as the Comprehensive Pump Test (Hartley, R. S. 1994). The grouping criteria of ISTB-1995 are based on the way the pumps are operated at the plant. There are two groups, routinely operated pumps (group A) and standby pumps (group B). ISTB-1995 requires a quarterly test of group A pumps that is essentially the same as the ISTB-1990 testing with an added requirement to test at flow rates near design flow, if practicable. The test consists of measuring speed (for pumps with variable speed drivers), flow rate, d/p (for centrifugal pumps), discharge pressure (for positive displacement pumps), and vibration. Group B pumps are also tested quarterly, however, the group B test does not require a minimum run time and only requires measurement and evaluation

d) inability to operate the pumps for testing during power operations because the pumps only suction source is a normally dry sump (see Item 4).

(1) Pumps With Non-instrumented Test Flow Paths

For some pump installations, the only flow path that is practical for testing quarterly during power operations is a non-instrumented minimum flow recirculation line. There are no provisions for measuring pump flow rate in these paths and the maximum flow rate achievable is a fraction of the nominal pump flow rate. Pumps operating at the relatively low flow rates that are typically achievable in minimum-flow recirculation lines can experience high rates of turbulence and cavitation. This increased turbulence and cavitation can cause degradation that can reduce the expected pump lifetime. NRC Bulletin 88-04, (NRC 1988), advised licensees of the potential for pump damage while running pumps in the minimum-flow condition. Testing at relatively low flow rates also makes it more difficult to detect mechanical degradation using vibration measurements. The increased vibration due to the turbulence and cavitation associated with the low flow rate could mask vibration due to pump bearing degradation. Additionally, at low flow rates, the pump is generally operating on a relatively flat portion of the pump transfer characteristic curve, which makes it more difficult to detect pump degradation by comparing flow rate and d/p to reference values.

In many of these situations, the licensee can test these pumps either at CSDs or RFOs in an instrumented flow path where a more substantial flow rate can be established. Five of the pump test frequency requests examined for this report are of this type. This issue is addressed in GL 89-04, Position 9 (NRC 1989). Position 9 approves using a non-instrumented test loop for quarterly testing provided the pumps can be tested at substantial flow in an instrumented path at CSDs or RFOs. The Generic Letter requires that at least d/p and vibration be measured during the quarterly test and that all of the specified test parameters be measured during the CSD or RFO testing.

Example From North Anna Units 1 and 2

North Anna Units 1 and 2 requested relief from the Section XI test frequency and test duration requirements for their boric acid transfer pumps. They propose to test these pumps quarterly on the recirculation loop without measuring flow rate. The pumps will be tested at RFOs by operating them on the recirculation loop for three minutes and then directing full flow to the RCS for two minutes. All required parameters will be measured while pumping to the RCS.

Licensee's Basis for Requesting Relief:

> Permanent flow instrumentation is not installed on the recirculation piping, which is the only test loop available for quarterly testing. To measure flow, flow must be established to the emergency and alternate boration paths and then to the charging pump suctions. This flow would increase the RCS boron inventory and cause a reactivity transient during normal operation.
>
> During CSD, the emergency and alternate boration path valves are tested with flow. However, this test is short in duration to minimize the amount of boric acid injected into the RCS. The pump test requires an extended period of boric acid injection, which would upset the RCS boron balance and possibly impact the ability of the plant to restart. Therefore, this test should only be performed during CSDs on the way to reactor refueling while the RCS is being borated or during reactor refuelings.

During RCS boration or during reactor refuelings, extended periods of pump operation on high speed can either interfere with the boration process or adversely affect the boron balance in the RCS. Therefore, to limit the amount of boric acid injected into the RCS during the pump tests, the pumps will be run for two minutes with flow to the RCS before the test quantities are measured.

Alternate Testing:

These pumps will be tested every quarter on the recirculation loop. Inlet pressure, d/p and vibration will be measured. Every reactor refueling, inlet pressure, d/p, flow and vibration will be measured after the pumps have been run for two minutes with flow to the RCS.

Evaluation

GL 89-04, Position 9, addresses the issue of testing pumps that can only practically be tested in a non-instrumented test loop during power operations. This position states: "In cases where flow can only be established through a non-instrumented minimum-flow path during quarterly pump testing and a path exists at CSDs or RFOs to perform a test of the pump under full or substantial flow conditions, the staff has determined that the increased interval is an acceptable alternative to the Code requirements provided that pump d/p, flow rate, and bearing vibration measurements are taken during this testing and that quarterly testing also measuring at least pump d/p and vibration is continued. Data from both of these testing frequencies should be recorded as required by IWP-6000. Since the above position is a deviation from the Code required testing, it should be documented in the IST program." GL 89-04 approved relief pursuant to 10 CFR 50.55a(f)(6)(i) for cases where flow can only practically be established through a non-instrumented minimum-flow path during power operation provided the alternate testing is performed in accordance with all of the provisions of Position 9.

Because the proposal to measure at least d/p and vibration while testing on the minimum-flow recirculation line quarterly and to measure all Code required parameters while the pump is operating at a full or substantial flow rate during CSDs or RFOs is approved by GL 89-04, relief need not be requested for this alternative.

Summary and Additional Comments

Relief is not needed for cases where pumps can be tested only in a non-instrumented minimum-flow recirculation path quarterly and are tested at substantial flow at CSDs or RFOs. The following should be considered when developing the testing program in these cases:

(1) The proposed alternative is in accordance with all provisions of GL 89-04, Position 9.
(2) The alternative is documented in the program plan.
(3) The interval between pump tests should not be lengthened if there is a high likelihood of pump failure during the interval. Consider items such as the pump's failure and repair history.

In cases where the alternative is not in complete compliance with the Generic Letter position or if there is another part of the proposed testing that is not in compliance with Code requirements, a request must be submitted for approval. In this example, in addition to testing in a non-instrumented path quarterly, the licensee requested relief from the minimum run time requirement of the Code. They proposed to run these pumps for 3 minutes on the recirculation line and then for 2 minutes at

full flow into the RCS to prevent over boration of the RCS and maintain proper chemistry control. OM-6 requires that a pump be run at least two minutes after pump conditions are as stable as the system permits. The licensee's proposal conforms with the test duration specified in OM-6, which was approved by rulemaking to 10 CFR 50.55a effective September 8, 1992. The NRC staff imposed no limitations to OM-6 associated with test duration. Accordingly, the licensee's proposed alternate pump run time is in compliance with the rulemaking effective September 8, 1992, and relief is not required.

(2) Pumps Whose Flow Rate Cannot Practically be Measured During Quarterly Testing

In some cases, the system configuration, administrative requirements, or interlocks make it impractical to establish conditions that permit measurement of flow rate for individual pumps. This issue is the subject of 11 of the relief requests in this group. Most are for cooling systems where the flow instrumentation is in a combined header and not in individual pump lines. The system cannot be configured to allow testing of one pump during power operations.

Example From Pilgrim Station

Pilgrim Station requests relief from the flow rate measurement requirements of Section XI, IWP-3100, for the reactor building closed cooling water (RBCCW) pumps. The licensee proposed to measure pump shutoff head quarterly and measure flow rate on an alternating basis during CSDs.

Licensee's Basis for Requesting Relief:

> RBCCW system instrumentation is not configured to measure individual pump flowrate during plant operation. Redesign of the system would be necessary to install flow instrumentation or to utilize portable flow instrumentation. Piping configuration does not permit installation of flow orifices on the pump discharge piping that would be consistent with good instrument practices. Adequate distance downstream of elbows is not available on the individual pump discharge prior to where discharge piping joins a common header.
>
> The RBCCW System is part of the ultimate heat sink for containment cooling functions and reactor vessel shutdown cooling. Test loops do not exist for individual pump flow tests; therefore, disturbance of the system normal configuration during operation and some CSD conditions will have a negative impact on the plant's ability to safely operate or maintain the plant in the CSD condition.
>
> Since the RBCCW cooling demands are reduced in a CSD condition, the RBCCW cooling loads can be split to minimize a loop's loads on the approach to CSD so each of the three pumps in a loop may be tested on an alternating basis during each CSD. A CSD test frequency implies that pump testing using the Code Test Method should begin as soon as practicable (within 48 hours after obtaining CSD conditions) and continue until all pumps are tested or plant is ready to startup, if not previously tested quarterly using the Code Test Method. When all pumps are to be tested in a loop (i.e. during extended CSDs) the 48 hour limit does not apply.

Alternate Testing:

Measure pump shutoff head quarterly. Measure each loop's individual pump flowrate on an alternating basis during CSD not to exceed a refueling interval.

Evaluation

Because it was determined that it is impractical to test these pumps quarterly during power operation in accordance with the Code requirements and that requiring the licensee to comply with the Code requirements for these pumps would be burdensome, this request was granted pursuant to 10 CFR 50.55a(f)(6)(i) with a provision. The provision is that the licensee perform a study of the maintenance history of these pumps to determine if they are subject to frequent failures where the degradation has not been detected by the quarterly shutoff head testing. If it is determined that these pumps are subject to such failures, the licensee was required to develop a test method capable of detecting degradation that can be performed more frequently than the proposed pump flow test.

The licensee's proposal appears to be the best practical testing for these pumps given the current system design, and is similar to the guidance provided in GL 89-04, Position 9. The provision was imposed in the evaluation of this request because the proposed testing of measuring pump shutoff head and vibration quarterly has many limitations and may not provide meaningful indication of pump performance. Pump hydraulic degradation may not be detected because there is no flow and many possible degradation mechanisms will not be detectible by a pump shutoff head measurement. Pump operation at shutoff head can be unstable, which can result in excessive cavitation induced vibrations that could mask increases in vibration due to bearing degradation. Additionally, prolonged operation at shutoff head can result in pump damage (refer to NRC 1988). Because of these limitations, if these pumps are subject to frequent failures and the degradation is not detected by the shutoff head testing, the licensee should develop a test method capable of detecting degradation that can be performed more frequently than the proposed pump flow test, even if this involves system modifications.

Summary and Additional Comments

The relief requests in this group where the pump flow rate could not practically be measured during power operations were all approved. In cases where the adequacy of the proposed testing was not clearly apparent, the requests were approved for an interim period or approved with provisions. The main considerations in this determination are:

(1) It is impractical to establish conditions during plant power operations that permit testing the pump(s) in accordance with the Code requirements or doing so would constitute a hardship without a compensating increase in the level of quality and safety.
(2) If practical, d/p and vibration measurements are taken quarterly during power operations.
(3) If a more comprehensive test is not performed every CSD (but not more frequently than once every 3 months), it is impractical or a hardship to establish the conditions that permit this testing.
(4) The testing performed at CSDs and/or at RFOs adequately monitors pump operational readiness.
(5) The interval between the more involved pump tests should not be lengthened if there is a high likelihood of pump failure during the interval. Consider items such as the pump's failure and repair history.

Licensees submitting requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

(3) Where Pump Flow Cannot be Established for Testing Quarterly

In some cases the system configuration, administrative requirements, or interlocks make it impractical to establish flow in any pump flow path for testing during power operations. This issue is the subject of 3 of the relief requests in this group. This condition doesn't occur frequently because systems generally have at least a minimum-flow recirculation path that can be used for testing during power operations. However, there are some systems, where the pump can only discharge into one flow path and it is impractical to utilize that path for testing during power operations, e.g., the pump is incapable of producing sufficient head to overcome the normal operating pressures seen in the discharge path. In these cases licensees generally propose to test the pumps during CSDs or RFOs. The following example illustrates a request where pump flow cannot be established for testing during power operation.

Example From North Anna Units 1 and 2

North Anna Units 1 and 2 requests relief from the quarterly test frequency requirements for the RHR pumps, as required by Section XI, IWP-3400(a). The licensee proposed to test these pumps during RFOs.

Licensee's Basis for Requesting Relief:

> The low pressure pumps take suction from and discharge to the RCS which operates at 2235 psig. This pressure is well above the operating pressure of the pumps, therefore, testing during normal operation is not possible.
>
> During CSDs of short duration or if the reactor coolant pumps (RCPs) are left running during the CSD, both trains of RHR may be required for DHR and to maintain RCS temperature. Taking one train of RHR out of service for testing purposes even for a short period could allow the RCS temperature to increase to the point that the pressurizer power-operated relief valve would be challenged. Therefore, these pumps should only be tested during reactor refuelings.
>
> Alternate Testing
>
> These pumps will be tested every reactor refueling.

Evaluation

Relief is generally granted from the test frequency requirements of the Code in these requests because there is no practical method to establish flow through these pumps quarterly during power operation. In some cases, such as this example, the proposed alternate testing may not be acceptable for the long term. In this case it was found acceptable pursuant with 10 CFR 50.55a(f)(6)(i) for an interim period. During the interim period the licensee was to evaluate whether it would be practical to at least perform a partial test of these pumps during CSDs.

In this particular case, the RHR pump's sole suction source and discharge path is the RCS. The RHR system is a low pressure system that would rupture if exposed to the normal operating RCS pressure. Also, the RHR motor-operated suction valves are interlocked with RCS pressure and cannot be opened when the RCS is at normal operating pressure. Therefore, compliance with the Code test frequency requirements (quarterly) is impractical. Major plant modifications are needed to allow quarterly testing of the RHR pumps according to the Code requirements.

Both trains of RHR may be needed for DHR and to maintain RCS temperature during short duration CSDs or if the RCPs are left running during the CSD. Taking one of the two trains of RHR out of service could allow the RCS temperature and pressure to increase and challenge the pressurizer power-operated relief valve (PORV). Therefore, it may be impractical to test the RHR pumps according to the Code test method requirements in cases such as these. The RHR flow path used for DHR operations is an instrumented path (equipped to measure pump inlet and discharge pressure, and system flow rate). This instrumentation may make it practical to obtain some meaningful test data during DHR operations. The RHR pumps are running continuously during most CSDs and are subjected to increased wear and other operational degradations. Thus, it may not be prudent to arbitrarily extend the test interval to RFOs if meaningful testing (though not in strict compliance with the Code method requirements) is practicable during CSDs.

<u>Summary and Additional Comments</u>

The relief requests in this group where pump flow cannot practically be established during power operations were all approved. In cases where the adequacy of the proposed testing was not clearly apparent, the requests were approved for an interim period or approved with provisions. The main considerations in this determination are:

(1) It is impractical to establish conditions during plant power operations that permit testing the pump(s) in accordance with the Code requirements or doing so would constitute a hardship without a compensating increase in the level of quality and safety.
(2) If the Code testing is not performed every CSD (but not more frequently than once every 3 months), it is impractical or a hardship to establish the conditions that permit this testing.
(3) If the Code testing is not performed every CSD (but not more frequently than once every 3 months) and if other meaningful testing is practical at CSDs and does not constitute a hardship without a compensating increase in the level of quality and safety, this testing should be performed during CSDs.
(4) The testing performed at CSDs and/or at RFOs adequately monitors pump operational readiness.
(5) The failure history of the pump(s) indicates that the pump(s) generally does not fail more frequently than the interval between the more involved test.

Licensees submitting requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assurance of pump operational readiness.

(4) Pumps Whose Only Suction Source is a Normally Dry Sump

Some plants have pump installations where the only suction source for the pump is a sump that is normally dry or contains insufficient fluid inventory to perform IST. This situation is frequently

encountered at Westinghouse NSSS plants with subatmospheric containments. In these cases, there are generally one or more reasons that quarterly testing is impractical (e.g., testing requires containment entry, flooding the sump could damage equipment, filling the sump for testing generates a large amount of radioactive water to be disposed of, testing requires the installation of spool pieces that render the safety-system inoperable). This issue is the subject of 2 of the relief requests in this group.

Example From Indian Point Unit 3

Indian Point Unit 3 requests relief from the test frequency and from measuring flow rate and d/p according to IWP-3100, for the recirculation sump pumps. The licensee proposed to measure and evaluate the pump discharge pressure and vibration during pump testing. No test frequency is specified.

Licensee's Basis for Requesting Relief:

The normal test loop for these pumps is from the containment sump and return via the individual minimum flow piping and the common minimum flow line. There is no flow instrumentation installed in the flow loop that could provide the capability of obtaining the required flow rate measurement. It should be noted that these lines are constructed of 3/4-inch piping that are capable of passing only a small fraction of the rate of flow of these pumps. Thus, any flow rate measurements would be of little value in identifying any pump degradation. During the testing, pump discharge pressure and vibration are measured and evaluated. These parameters will provide adequate indication of pump degradation. Further, since these pumps stand idle and dry except for periods of testing, significant inservice degradation is unlikely.

Alternate Testing

Whenever these pumps are tested, pump discharge pressure and vibration will be measured and evaluated.

Evaluation

Relief is generally granted from the test frequency requirements of the Code in these requests. In some cases, such as this example, the proposed alternate testing is not considered to be acceptable for the long term. In this case it was found acceptable pursuant with 10 CFR 50.55a(f)(6)(i) for an interim period to allow the licensee time to develop an acceptable alternative.

Regarding the test frequency for pumps lacking the required fluid inventory, OM-6, Paragraph 5.5 states: "Pumps lacking required fluid inventory, (e.g., pumps in dry sumps) need not be tested in accordance with this Subsection every 3 months. These pumps shall be tested at least once every 2 years except as provided in Paragraph 5.4. The required fluid inventory shall be provided during this test."

Regarding the adequacy of the proposed alternate testing, the proposal to measure only discharge pressure and vibration with the pump running on a small diameter minimum-flow recirculation line may not provide sufficient information to permit detection of changes in pump condition. Pump hydraulic condition may not be adequately monitored solely by a discharge pressure measurement in lieu of the two interrelated parameters required by the Code (i.e., flow rate and d/p). Measuring

discharge pressure instead of d/p has the additional effect of reducing the ability to detect pump degradation because of the inaccuracies introduced by variations in suction pressure, which in this case is due to the liquid level in the recirculation sump. In addition, flow instabilities and cavitation are frequently present when a pump is operated with flow solely through a small diameter minimum-flow recirculation line. These conditions could cause flow induced vibrations that could reduce the ability of the vibration measurements to detect pump mechanical degradation.

GL 89-04, Position 9, provides guidance on testing pumps that can only practically be tested on a non-instrumented minimum-flow recirculation line, even at extended frequencies. The stated position is that flow rate instruments, which meet the requirements of IWP-4110 and 4120, must be installed in the minimum-flow return line. Pump flow rate is needed so the data can be evaluated with d/p to monitor pump hydraulic degradation.

NOTE: The licensee later withdrew this relief request and indicated that the requirements of the code would be met.

Summary and Additional Comments

As discussed in the previous paragraphs, relief is not necessary from the quarterly test frequency requirements of the Code for pumps that lack the required fluid inventory provided they are tested in accordance with the requirements of OM-6, Paragraph 5.5 (however, if a plant has not updated to OM-6, NRC approval pursuant to 10 CFR 50.55a(f)(4)(iv) is necessary). Relief is still needed from the Code testing requirements if the licensee proposed to not measure all of the Code required parameters. The licensee should demonstrate that their proposed alternative provides adequate information to determine the operational readiness of the affected pumps. In cases such as the example, where the pumps can practically be tested only in a non-instrumented minimum-flow recirculation line, the licensee should follow the guidance in GL 89-04, Position 9.

Operating pumps at significantly reduced flow rates in minimum-flow recirculation lines can result in accelerated degradation and premature failure. NRC Bulletin 88-04 (NRC 1988), advised licensees of the potential for pump damage while running pumps in the minimum-flow condition. In situations such as this, licensees should also consider whether the vibration measurements taken on the pumps while operating in the minimum-flow recirculation line are capable of detecting mechanical degradation of the pump prior to catastrophic failure. If not, they might consider modifications that permit testing at a higher flow rate.

3.2 PUMP FLOW RATE MEASUREMENTS

The Code requires quarterly measurement and evaluation of flow rate as part of the assessment of pump operational readiness. For centrifugal pumps reference points of flow rate and d/p can serve as a tool to detect changes in pump performance characteristics. For positive displacement pumps, the Code also requires evaluation of flow rate and pressure. The Code requires comparison of the measured flow rate and pressure with reference values of those parameters to detect changes in performance. The majority of relief requests that were reviewed involving the measurement of flow rate involved methods for indirect calculation based on a level change of a suction source such as a tank. However, licensees have submitted requests for a variety of other issues related to flow rate.

Requirements

Section XI, Subsection IWP, IWP-3100, requires quarterly measurement of flow rate during pump testing. Table IWP-3100-1, Inservice Test Quantities, requires measurement of flow rate (Q). Measured values must be compared to acceptance criteria based on reference values. The acceptance criteria of Table IWP-3100-2, for Q is: Acceptable Range 0.94-1.02Q_r, Alert Range Low Values are 0.90-0.94Q_r and High Values are 1.02-1.03 Q_r Required Action Range Low Values <0.90Q_r and High Values >1.03 Q_r. Corrective action for deviations are described in IWP-3230. IWP-4600 Flow Measurement states "Flow rate shall be measured using a rate or quantity meter installed in the pump test circuit. The meter may be in any class that provides an overall readout repeatability within the accuracy limits of Table IWP-4110-1. Where the meter does not indicate the flow rate directly, the record shall include the method used to reduce the data."

OM-6 states that ". . . parameters shown in Table 2 shall be determined and recorded . . ." Table 2, Inservice Test Parameters . . . requires the measurement of flow rate (Q). The measured parameters must be compared to acceptance criteria based on the reference value. The acceptance criteria of Table 3b, for Q differs depending on the pump type.

> For positive displacement and vertical line shaft pumps the Acceptable Range is 0.95-1.10Q_r and the Alert Range Low Values are 0.93-<0.95Q_r (there are no High Values). The Required Action Range Low Value is <0.93Q_r and High Value is >1.10 Q_r.
>
> For centrifugal pumps the Acceptable Range is 0.90-<1.10Q_r, There are no Alert Range Low or High Values. The Required Action Range Low Value is <0.90Q_r and High Value is >1.10 Q_r.

Corrective action for deviations are described in paragraph 6.1. Paragraph 4.6.5 Flow Rate Measurement states "When measuring flow rate, use a rate or quantity meter installed in the pump test circuit. If a meter does not indicate the flow rate directly, the record shall include the method used to reduce the data."

Table 3-2. Summary Table of Key Requirements and Guidance for Flow Rate

Document	Section	Requirement/Guidance
Section XI/ OM-6	IWP-3100/ Paragraph 5.2	Measure flow rate.
Section XI/ OM-6	IWP-3500/ Paragraph 5.6	Duration of tests.
Section XI/ OM-6	IWP-4600/ Paragraph 4.6.5	Measurement of flow rate.
GL 89-04	Position 9/ Questions 47-50	Pump Testing Using Minimum-Flow Return Line With or Without Flow Measuring Devices.
NUREG 1482	5.3	Allowable Variance from Reference Points and Fixed-Resistance Systems.

Relief Request Analysis:

There were several issues related to the requirements to measure flow rate in the requests we reviewed. They included the calculating flow rate, frequency of testing, flow testing using the mini-flow line, testing in flow paths where there is an unmetered diversion upstream of the main flow rate sensing element, establishing a tolerance about the flow rate reference value, and several proposals to substitute other parameters for flow rate. These issues are discussed on the following sections of this report.

Major Issues:

a) inability to directly measure flow rate led to the need to calculate flow rate (see Item1);
b) inability to test the pump at the Code specified frequency (see Item 2);
c) lack of provisions to test pumps at flow rates greater than minimum flow (see Item 3);
d) issues involving unmetered flow paths diverting flow prior to the test flow rate measuring device (see Item 4);
e) system operational constraints made it difficult or undesirable to achieve an exact value of flow rate for testing (see Item 5).

These five major issues are addressed in the following sections of this report.

(1) Requests Proposing to Calculate Flow Rate

The following example is typical of requests proposing to calculate the flow rate through a pump based on the rate of change in the level of a suction tank. We reviewed several requests on this topic. The bulk of the requests were submitted for relief from the requirements of Section XI, IWP-4600, though several indicated Table IWP-3100-1 or Paragraph IWP-3100. IWP-4600 is explicit that a rate or quantity meter in the main flow path be used. OM-6 was changed to allow determination of flow rate. Virtually all requests of this nature are approved. The basis and alternative that follows best illustrated the information that supports approval of those requests.

Example from Millstone Nuclear Station, Unit 1

Millstone requested relief from the requirements of OM-6, Paragraph 4.6.5, to measure flow using a rate or quantity meter installed in the pump test circuit, for the DG fuel forwarding pumps and the SLC pumps.

<u>Licensees Basis for Requesting Relief</u>

DG fuel forwarding and the SLC systems have no installed flow instrumentation. A test tank (M8-57) is installed in the SLC system which allows for the injection of demineralized water into the storage tank. During the operability test, the selected pump takes a suction from the test tank and discharges into the storage tank. The fuel forwarding pumps pump diesel fuel from the storage tank (M8-19) directly to the day tank (M8-30). Tank level is monitored over time to determine flowrate. The test results are compared to a previously established reference value in accordance with OM-6, Section 6.1.

Alternate Testing

Perform calculation using tank level change to determine flowrate during system quarterly operability surveillance test.

Evaluation

The evaluation of this request pointed out the change to OM-6, Paragraph 4.6.5, Flow Rate Measurement. It stated that relief is not required if the measurement of tank level over the period of test performance meets the requirements of Paragraph 4.6.5 for "a rate or quantity meter installed in the pump test circuit," and the test procedure includes the method used to reduce the data for calculation of flowrate. For cases where these requirements cannot be met, the staff has determined that the use of a tank level to calculate flowrate is an acceptable alternative to the Code, provided the calculated results meet the accuracy requirements of OM-6. In the preceding case, the proposed alternative to the Code requirements was authorized pursuant to 10 CFR 50.55a(a)(3)(i) based on the alternative providing an acceptable level of quality and safety.

Summary and Additional Comments

1) Where the alternative meets the requirements of OM-6, Paragraph 4.6.5, a relief request is not needed, provided the method of reducing the data is included in the test procedure.
2) Where these requirements cannot be met, the use of a tank level to calculate flowrate is an acceptable alternative to the Code, provided the calculated results meet the accuracy requirements of OM-6.
3) The guidance in NUREG 1482 addresses this issue in Section 5.5.3, "Use of Tank or Bay Level to Calculate Differential Pressure." The NRC recommendation stresses the preceding points.

(2) Test Frequency

Four requests addressed test frequency for measuring flow rate. The requests involved SW, reactor building closed loop cooling, and feedwater coolant injection condensate system pumps. The bases all cited system design limitations. The pump discharge lines leading to a common header were not amenable to proper installation of flow rate instruments. System constraints, such as cooling demands, made it impractical to stop pumps for any length of time solely to test an individual pump through the combined flow path. Two of the requests proposed to measure shutoff head quarterly and individual flow rate on an alternating basis during CSDs. The third proposed to monitor the pump quarterly without flow measurement and to measure flow rate during RFOs.

Example From Millstone Nuclear Power Station, Unit 1

The request sought relief from the requirements of OM-6, Paragraph 5.1, for the SW and feedwater coolant injection condensate pumps. The request proposed to monitor the pumps quarterly without individual flow measurement and test them during RFOs with flow measurements recorded.

Licensee's Basis for Requesting Relief

Individual pump flow instrumentation is not installed. The required length of straight pipe without obstructions (approximately 10 diameters upstream and 5 diameters downstream) to obtain an accurate flow measurement and comply with OM-6, Paragraph 4.6.1.1, is not available on individual lines on the suction or discharge side of each pump.

There is a flow element on the condensate line which is a common line for all 3 pumps downstream of the steam packing exhauster. All 3 condensate pumps and at least 2 of 3 condensate booster pumps are required for operation at 100% power. The condensate pumps are also operated as necessary during CSD to maintain reactor vessel water level. The condensate booster pumps' fuses are pulled to prevent a feedwater pump start for reactor vessel over pressurization protection in case of a feedwater coolant injection initiation signal during CSD. Therefore, individual flow measurement is not possible during power operation or cold shutdown.

During normal operation at least 2 SW pumps are required to operate to maintain heat load. This means that measurement of single pump flowrate is not possible during plant operation using the strainer bypass line. Flow instrumentation is installed on the strainer bypass line (common to all 4 SW pumps). This path was determined to be the only path practical for flow measurement; however, it can only be used at refuel when heat load can be minimized to allow single pump operation.

<u>Alternate Testing:</u>

Pump d/p and vibration will be recorded on a quarterly basis. These quarterly measurements will be analyzed and compared to reference values per OM-6. Due to the varying SW system conditions, an expanded allowable range will be used for evaluating d/p during quarterly testing. Past experience has proven these owner specified ranges still allow for early detection of pump degradation.

Each pump will be individually tested during every reactor RFO. Individual pump flow, d/p, and vibration will be recorded. Either pump flow or pump discharge pressure will be throttled to a reference value as close as practical to the value that each pump is expected to achieve during operation. For the condensate pumps (M2-6 A/B), the flow element on the 16-inch minimum flow line downstream of the Steam Jet Air Ejectors will be used to throttle to a known reference value to measure flow. For the condensate booster pumps (M2-7 A/B), the flow will be throttled to a known reference value and the suction flow will be measured using the flow element downstream of the steam packing exhauster. This testing will be performed when the pumps are known to be operating acceptably. The allowable percentage changes in measured values identified in OM-6, Table 3B, will be used to evaluate the condition of each pump tested.

<u>Evaluation</u>

The basis for relief in the preceding request addresses the quarterly versus RFO testing. The alternative testing also addresses using an expanded allowable range for d/p during quarterly testing. The evaluation of this request stressed that the intent of IST per OM-6 is to assess the operational readiness of pumps and to monitor for degrading conditions. The evaluation cited the importance of monitoring both d/p and flow rate to determine pump hydraulic performance in GL 89-04, Position 9, "Pump Testing Using Minimum-Flow Return Line With or Without Flow Measuring Devices." Based on the early construction of Millstone-1, design features for measuring individual pump flow to enable quarterly IST were not provided for the SW pumps and the feedwater coolant injection (condensate) pumps.

<u>SW Pumps:</u> The only available instrumented flow path for testing the SW pumps is the strainer bypass line. Testing with flowrate measurement must be conducted during RFOs when the plant heat loads are low enough to allow single pump operation. Therefore, based on design limitations, it is

impractical to measure flow during quarterly testing. Individual pump testing is impractical during cold shutdown due to plant heat load considerations. Quarterly testing evaluates the condition of the pumps based on d/p and vibration. Vibration data provides information on the mechanical condition of the pumps, which may be indicative of degrading conditions prior to indications in the hydraulic parameters. The licensee indicates that the expanded range for d/p will "still allow for early detection of pump degradation." Expansion of the range during quarterly testing is necessary because the SW system conditions vary depending on plant heat load conditions. Additionally, the four SW pumps discharge into a common supply header, possibly having an impact on the discharge pressure of a single pump, depending on the number of pumps running when the measurement is taken. Degradation in the hydraulic conditions could be masked in this manner; however, by performing testing that conforms to the requirements of OM-6, other than the frequency, during RFOs, the hydraulic conditions of the pumps can be monitored. Imposition of the requirements to measure flowrate quarterly in accordance with OM-6 would be a burden on the licensee in that installation of flow instrumentation in the individual SW lines from the pumps to the common supply header could not be effected without major modifications to the piping system.

Feedwater Coolant Injection (Condensate) Pumps: The condensate pumps and condensate booster pumps operate in a normal mode during power operation to provide condensate to the suction of the reactor feedwater pumps. The 'A' and 'B' condensate pumps and condensate booster pumps also perform a safety-related function to inject coolant into the reactor vessel in the event of a design basis LOCA. Individual pump flowrate measurement is not available during power operations because the flow element in the condensate line measures total condensate flow. During cold shutdown conditions, the condensate pumps operate to maintain reactor vessel level and the condensate booster pumps are electrically prohibited from operating for over pressurization protection of the reactor vessel. Therefore, the IST for these pumps will consist of quarterly testing which monitors d/p and vibration, and testing conducted during RFOs which conforms to OM-6 requirements, other than frequency and flowrate instrument accuracy (see R-2 below). Vibration data will provide information on the mechanical condition of the pumps, which may be indicative of degradation conditions prior to indications in the hydraulic parameters. By performing testing that conforms to the requirements of OM-6, other than the frequency, during RFOs, the hydraulic conditions of the pumps can be monitored. Imposition of the requirements to measure flowrate quarterly in accordance with OM-6 would be a burden on the licensee in that installation of flow instrumentation in the individual condensate lines from the pumps to the common line could not be effected without major modifications to the piping system.

The evaluation of these requests considered the benefits and limitations of the proposed quarterly and RFO testing. Relief was granted in this case pursuant to 10 CFR 50.55a(f)(6)(i) based on the impracticality of performing testing in accordance with Code requirements, and in consideration of the burden on the licensee if the Code requirements were imposed on the facility.

Summary and Additional Comments

The following list identifies some of the key points made in the submittal and evaluation regarding the interval extension:

1) System design limitations made it impractical to measure individual pump flow rates during quarterly testing without making extensive design changes.
2) The quarterly test gathered information on pump condition by measuring d/p and vibration.
3) Refueling outage testing conforms with OM-6 requirements, except as stated in other relief requests.

(3) *Flow Testing Using Minimum Flow Line*

Two requests were evaluated involving testing solely through instrumented miniflow lines. Both cases involved CS pumps in Westinghouse-design plants, the plants involved were Prairie Island and Indian Point 3. Many CS systems do not have provisions for testing the pumps at a substantial flow rate. In one case, the miniflow line was instrumented, but received only about 20% of the total system flow during the quarterly test. During RFO testing, the flow rate through the main flow path would be determined by calculation based on the rate of change of RWST level. In the other case, the miniflow line received all the flow, but the licensee needed time to install an instrument in the line. The subject Code does not require testing at high flow rates, therefore, both requests were approved.

<u>Summary and Additional Comments</u>

For similar cases involving flow testing using the minimum flow line, licensees should consider the guidance of GL 89-04, Position 9.

The performance characteristics of centrifugal pumps make it difficult to detect degradation when testing at low flow rates. Additionally, ISTB-1995 recognizes the importance of periodically testing centrifugal pumps, such as CS pumps, at high flow rates. It also recognizes classes of pumps based on their system operational characteristics. Containment spray pumps at most plants would be classified as group B or standby pumps. If they were tested according to ISTB-1995, the quarterly testing would be minimal. During RFOs, the licensee would be required to test at the higher flow rates with high accuracy instruments. The changes in ISTB-1995 represent an improvement to the testing requirements for these pumps by minimizing run time under low-flow conditions. However, the change requires periodic testing at high flow rates, which does not accommodate the design limitations of CS systems without high flow rate test loops.

(4) *Flow Testing With Diversion of Flow*

The following example regards the measurement of flow in a main line when a portioin of the flow rate developed by the pump is diverted through an uninstrumented line.

Example from Prairie Island

This request seeks relief from measuring all the flow thru the motor driven cooling water pump. Paragraph 4.6.5 of OM-6 specifies that, when measuring flow rate, a rate or quantity meter installed in the pump test circuit is to be used.

<u>Licensee's Basis for Requesting Relief:</u>

Installing flowmeters or flow orifices on bypass lines to meet code accuracies is not warranted due to the expense involved with no commensurate benefit. Estimated costs required to install 2% accuracy flowmeters is $25,000 per pump. The unmetered screen house flows are small and are continually in service.

The piping design and therefore system resistance of each bypass line will remain constant for each test. It can be shown that the pressure, flow and flow paths of the system during the pump testing, as controlled by the procedure, will assure negligible changes in the unmetered flow path. The pump metered flow and pressure readings taken during regular testing can be trended per code requirements and will give

adequate indication should pump degradation occur. The installation of code accuracy metering instrumentation on these bypass lines would place an undue burden on the plant without a compensating increase in either quality or safety.

Alternate Testing:

121 cooling water pump has a portion of its discharge flow which is unmetered. Specifically, small unmetered loads exist in the screen house, e.g., supply to chemical treatment and filtered water and affect the diesel cooling water pumps. Flow to the chemical treatment is estimated at 1% and flow to filtered water at ½ % of reference flow [total 1.5%]. These flows are normally inservice and are held constant during the tests.

Evaluation

The evaluation of this request stated that these pumps are similar to other pumps (in the Prairie Island IST program) in that the recirculation cooling cannot be isolated; however, the cooling flow is a relatively small percentage of the reference flow and has less potential to mask degrading flow rates. The design limits performance of the test with the recirculation flow isolated. Imposition of the Code requirements to measure [total] flow would be a burden in that instrumentation would have to be installed or some other alternative would be necessary to preclude a plant shutdown because testing could not be performed in accordance with the Code. Therefore, long-term relief can be granted with the provision that the licensee determine if the acceptance criteria or measured values of flow rate require any adjustment to ensure that the test conservatively identifies degrading conditions.

In this case, relief was granted to continue to use installed flow instrumentation and not measure the recirculation cooling flow. This was pursuant to 10 CFR 50.55a(f)(6)(i) based on the impracticality of the design of the pumps and the pump cooling systems, consideration of the burden if Code requirements were imposed, and the alternative providing assurance of the operational readiness of the pumps. The granting of the relief was provisional on the licensee ensuring that the manner of testing is conservative. The licensee was asked to include a description of the actions taken to address the provision and revise the relief request, if necessary, within one year.

Summary and Additional Comments

The following list identifies key points made in the submittal and evaluation regarding unmetered flow:

1) Imposition of the Code requirements would have constituted a burden on the licensee in that instrumentation would have to be installed or some other alternative would be necessary to preclude a plant shutdown because testing could not be performed in accordance with the Code
2) Long-term relief can be granted. However, Licensees should determine if the acceptance criteria or measured values of flow rate require any adjustment to ensure that the test conservatively identifies degrading conditions.

(5) Requests to Establish a Tolerance About the Reference Value of Flow Rate

Four requests were reviewed regarding proposals to establish a tolerance about the reference value of flow rate. The following request is typical of those requests.

Example from Zion Station, Units 1 and 2

The licensee requested relief from OM Part 6, Paragraph 5.2(b), for their chemical and volume control charging pumps. The requirement states "The resistance of the system shall be varied until the flow rate equals the reference value. The pressure shall then be determined and compared to its reference value. Alternatively, the flow rate can be varied until the pressure equals the reference value and the flow rate shall be determined and compared to the reference flow rate value."

Licensee's Basis for Requesting Relief

The following facts apply:

1) The "normal" charging pump IST test is performed with the unit at power on a quarterly frequency.
2) The flow is varied by taking manual control of the normal makeup in order to maintain a constant value. This flow control valve is normally in automatic to maintain constant pressurizer level.
3) The IST test takes 15 to 30 minutes to perform for each pump.
4) The reference value of 90 gpm was chosen due to the fact that normal flow to maintain pressurizer level constant is approximately 90 gpm. Thus, this value is the most readily duplicated value for the normal at power test.
5) It is important while operating at power to maintain a relatively constant pressurizer level since pressurizer level changes are primary initial indicators of some accidents and malfunctions.

Zion has assigned a tolerance on attainment of the reference flow (the set-value) due to the combination of the above listed facts. This tolerance is assigned as ±5 gpm from a reference value of 90 gpm. This tolerance represents a deviation from the Code requirement referenced above and exceeds ±2% of the reference value as discussed in the NRC Safety Evaluation dated June 14, 1993. The assigned tolerance of ±5 gpm represents ±5.56% of the flow reference value.

The instrument used to measure flow for this test is 1(2)FI-121 with smallest increments on the control room indicator being 5 gpm. A flow tolerance tighter than ± 5 gpm may not allow for the manually adjusted flow to be set such as to maintain steady pressurizer level conditions during the test. Data taken with this flow tolerance is trendable and the trends appear to be informative. From a review of the trend graphs for all four pumps, it is not apparent that a tighter flow tolerance would enhance the trend graphs or provide any additional information, especially in light of the fact that the pump curve is essentially horizontal between 85 and 95 gpm.

Alternate Testing

Zion will use a flow tolerance of ±5 gpm from the reference (set-value) when testing the centrifugal charging pumps. The d/p will be compared to Table 3b limits to ensure the measured value is within ±10% of the pressure reference value.

Evaluation

The reviewer stated that OM Part 6 Paragraph5.2(b), specifies that pumps are to be tested quarterly by varying the resistance of the system until either the flow rate or the pressure equals a reference value, and the corresponding pressure or flow rate determined and compared to reference values. The Code does not allow for variance from a fixed reference value. The basis for the NRC's acceptance of the ±2% of the reference value is from Section XI, IWP-4150 which provides the requirements for instrument fluctuation. IWP-4150 allows symmetrical damping devices or averaging techniques to reduce instrument fluctuations to within 2% of the observed reading. The use of the ±2% of the reference value in this position is to allow the licensee to specify values in the implementing procedures.

As discussed in the Licensee's basis, the reference flow of 90 gpm (approximate flow required to maintain pressurizer level constant) is set by manually controlling the flow control valve, which is normally in the automatic mode to maintain constant pressurizer level. A flow tolerance greater than ±5 gpm may not be achievable due to the readability of the flow instrument and may not permit the flow to be manually set to maintain steady pressurizer level during the test. The licensee stated that data with this tolerance is trendable, and that a tighter tolerance would not provide additional information, especially for this flow, since the pump curve is "essentially horizontal between 85 and 95 gpm."

The reviewer noted that from the information provided in the Basis, a primary factor in setting the expanded range was the increments on the flow instrument and that the licensee did not state whether the instrument was analog or digital. As discussed in the Basis of Section 5.3 of NUREG-1482, the precision of an analog gauge is determined by the increments on the scale. Readings would be acceptable to a degree of precision no greater than one-half the smallest increment. In this instance, that would correspond to ±2.5 gpm (±2.7%). Nevertheless, since the pump curve is essentially horizontal in this flow region, the effect on the d/p would be minimal, and should not impact the ability of the test to detect pump degradation.

The licensee established a ±5 gpm tolerance on the flow, which exceeds the ±2% Code requirement by ±3.56%. This expanded tolerance range represents a flow difference of ±2.7 gpm which should not significantly impact the ability of the test to detect pump degradation and operability, since the shape of the pump curve in this region is essentially horizontal. Compliance with the Code requirement would result in an unusual difficulty based upon the need to maintain a steady pressurizer level, without a compensating increase in the level of quality and safety.

The reviewer recommended that the alternate be authorized pursuant to 10 CFR 50.55a(a)(3)(ii). The licensee was asked to modify their Basis to discuss instrument accuracy as requested by the NRC in Section 3.2.2 of the June 14, 1993 SER, and incorporate the instrument accuracy guidance provided in NUREG-1482. The licensee was also asked to ensure that the minimum flow line is isolated using manual valves VC 8479A and B (per VC-05, MOV-VC-8110 and 8111 cannot be isolated) during the performance of the flow test to ensure that the flow measured by 1FE-121 is the total pump output. If isolating the individual minimum flow lines is not practical, the licensee should revise this relief request accordingly.

3.3 Pressure Measurements

Pressure measurements for pump testing may involve inlet, differential (d/p), and/or discharge pressures. Section XI requires the measurement of inlet and d/p for all pumps as part of the process of assessing pump operational readiness. OM-6 requires measurement of d/p for centrifugal pumps

and discharge pressure for positive displacement pumps. The majority of relief requests involving pressure measurements are for cases where inlet pressure gauges or sensing lines are not installed at the inlet of the affected pumps. The lack of inlet pressure gauges or sensing lines impacts the ability to measure both the inlet pressure and the d/p. Therefore, even for those cases where inlet pressure measurements are not required, the inability to measure inlet pressure can affect the licensee's ability to measure or determine pump d/p.

The following sections address issues related to pressure measurements. Section 3.3.1 addresses inlet pressure, 3.3.2 addresses d/p, and 3.3.3 discusses positive displacement pump pressure issues.

3.3.1 Inlet Pressure Measurements

Inlet or suction pressure is essentially the fluid pressure available at the inlet plenum or suction bell of a pump. Adequate inlet pressure is vital to proper pump operation. Inlet pressure is a primary constituent of pump net positive suction head (NPSH). Insufficient NPSH will result in cavitation and hydraulic instability during pump operation, which reduces pump performance and accelerates degradation. Therefore, adequate inlet pressure is important for good pump performance and continued operational readiness.

Requirements

Section XI, IWP-3100, requires that the test quantities shown in Table IWP-3100-1, which includes inlet pressure, be measured or observed. Each measured test quantity is required to be compared with the reference value of the same quantity. Note 1 for Table IWP-3100-1 requires that pump inlet pressure be measured both before pump startup and during the test. The Code requires that any deviations between the measurement and the reference value be compared with the limits given in Table IWP-3100-2 and that the specified corrective action be taken. Note 2 of Table IWP-3100-2, indicates that the acceptance criteria for inlet pressure shall be within the limits specified by the Owner in the record of tests.

OM-6 does not require measurement of pump inlet pressure. This parameter was not included in OM-6 because IWP did not include acceptance criteria (Zudans, J.J 1990). Inlet pressure measurements were included in IWP to help the Owner prepare for the test and recognize that adequate suction pressure needs to be specified in the test procedure. OM-6 recognized that the Owner is responsible to address testing limitations in the procedures.

Table 3-3. Summary Table of Key Requirements and Guidance for Inlet Pressure Measurement

Document	Section	Requirement/Guidance
Section XI	IWP-3100	Measure inlet pressure prior to pump start and during operation.
OM-6	5.2	Measure d/p (inlet pressure is not a specified parameter).
GL 89-04	N.A.	N.A.
NUREG 1482	5.1.2	The Owner may eliminate measurement of inlet pressure, however, testing limitations must be addressed in their procedures.
NUREG 1482	5.5.3	If a licensee uses a bay or tank level to calculate inlet pressure, the calculation must be included in the implementing procedure and the reading scale for measuring the level and the calculational method must yield an accuracy within ± 2 percent.

Relief Request Issues

There are several issues in the reviewed relief requests regarding pump inlet pressure measurements.

Major Issues:

a) inability to measure inlet pressure because of the lack of installed instruments or sensing lines on vertical line shaft pumps (see Item 1);
b) static inlet pressure measurements for pumps that are in operation (see Item 2).

These inlet pressure issues are discussed in the following sections of this report. Requests have been submitted regarding other inlet pressure issues, however, a discussion of these issues was not judged to be beneficial because of their peculiarity and the Owner's ability to exclude measurement of this parameter.

(1) Inlet Pressure Measurements for Vertical Line Shaft Pumps

For many pump installations, inlet pressure cannot be measured directly due to the lack of installed instrumentation. This is generally the case for vertical line shaft pumps, which are submerged in the working fluid (refer to the definition in NUREG 1482, Section 5.9). Fourteen of the twenty-four requests in this group deal with submerged vertical line shaft pumps. Licensees frequently propose to measure the level of fluid above the pump inlet and to use this value to calculate pump inlet pressure. OM-6 does not require the measurement of inlet pressure, but it does require the measurement or determination of pump d/p. The guidance in NUREG 1482, Section 5.1.2, indicates that licensees not yet using OM-6 for IST of pumps may eliminate the inlet pressure parameter from IST requirements. However, as pointed out in the NUREG, the Owner is responsible for addressing testing limitations in the procedures. Except as needed to determine or calculate pump d/p, inlet pressure need not be obtained. Therefore, we have not included examples of relief requests that relate solely to inlet pressure measurements.

(2) Inlet Pressure Measurements Prior to Pump Start for Operating Pumps

Section XI requires measurement of inlet pressure prior to pump start. Four of the twenty-four requests in this group propose not to measure static inlet pressure when performing a test on a pump that is already in operation because this would necessitate stopping and restarting the pump. The measurement of static inlet pressure for a pump can indicate whether there is sufficient NPSH to support pump operation. However, observing the operation of a running pump can also indicate that there is adequate NPSH. A pump without adequate NPSH will experience cavitation and exhibit degraded hydraulic performance. Starting and stopping pumps to measure static inlet pressure subjects them to additional mechanical stresses, which can lead to unnecessary degradation. In addition, OM-6 does not require the measurement of inlet pressure and GL 89-04, Supplement 1, via NUREG 1482 permits exclusion of this parameter. Therefore, we have not included an example of a relief request on this subject.

3.3.2 Differential Pressure Measurement

Pump d/p is the difference between the pressure at the discharge of a pump and the pressure at its suction or inlet. For centrifugal pumps, d/p and flow rate are dependent parameters that can be used

to determine the hydraulic condition of the pumps. The operating characteristics of positive displacement pumps differ from those of centrifugal pumps, such that flow rate and d/p are not dependent parameters.

Requirements

Section XI, IWP-3100, requires that the test quantities shown in Table IWP-3100-1, which includes d/p, be measured or observed. Each measured quantity is required to be compared with the respective reference value. The Code requires that any deviations between the measurement and the reference value be compared with the limits given in Table IWP-3100-2 and the specified corrective action be taken. Section XI, Paragraph IWP-3100 requires: "The d/p across a pump shall be determined by use either of a d/p gauge or a d/p transmitter that provides direct measurement of pressure difference, or by taking the difference between the pressure at a point in the inlet pipe and the pressure at a point in the discharge pipe." The requirements for d/p measurements in OM-6, are essentially identical to the requirements in Section XI.

Table 3-4. Summary Table of Key Requirements and Guidance for Differential Pressure Measurement

Document	Section	Requirement/Guidance
Section XI	IWP-3100	Measure d/p for all pumps.
Section XI/ OM-6	IWP-4240/ Para 4.6.2.2	Use either a d/p gage or transmitter, or take the difference between the pressure at a point in the inlet pipe and the pressure at a point in the discharge pipe.
OM-6	5.2	Measure or determine d/p for centrifugal pumps. Measure discharge pressure for positive displacement pumps.
GL 89-04	N.A.	N.A.
NUREG 1482	5.1.2	Owner may eliminate d/p measurements for positive displacement pumps, however, the discharge pressure must be monitored with the specified limits of OM-6.
NUREG 1482	5.5.3	If a bay or tank level is used to calculate d/p, the calculation must be included in the implementing procedure and the reading scale for measuring the level and the calculational method must yield an accuracy within $\pm$ 2 percent.

Relief Request Issues

Eighteen of the relief requests examined involve the Code requirement to measure pump d/p. These requests are generally for cases where the inlet pressure cannot be directly measured because of the lack of inlet pressure instruments or sensing lines. In most of the requests in the sample, the licensee proposed to either calculate pump inlet and d/ps or use the discharge pressure to evaluate pump operational readiness.

Major Issues:

a) inability to measure d/p for vertical line shaft pumps because of the lack of installed instruments or sensing lines (see Item 1);
b) where inlet pressure is insignificant to d/p (see Item 2).

(1) Differential Pressure Measurements for Vertical Line Shaft Pumps

As discussed in the preceding, for many pump installations, inlet pressure cannot be measured directly due to the lack of installed instrumentation or sensing lines. This is generally the case for vertical line shaft pumps which are usually submerged in the working fluid. Six of the eighteen requests in this group deal with vertical line shaft pumps. Because these pumps are submerged directly in the working fluid, they do not have suction piping, therefore, it is impractical to install inlet pressure instrumentation. The pumps would have to be replaced or modified extensively to permit direct measurement of inlet and d/ps. Licensees frequently propose to measure the level of fluid above the pump inlet and use this value to calculate pump inlet and d/ps. OM-6 does not require the measurement of pump inlet pressure, but it does require the measurement or determination of pump d/p. NUREG 1482, Section 5.1.2, indicates that licensees not yet using OM-6 for IST of pumps may eliminate the inlet pressure parameter from IST requirements. The following examples illustrate issues associated with d/p measurements for vertical line shaft pumps.

Example From Fitzpatrick Station

Fitzpatrick submitted a relief request from the Section XI, Paragraph IWP-3100, requirement to measure inlet and d/p for the SW and emergency SW pumps, which do not have installed inlet pressure instruments. They proposed to determine pump inlet and d/p by calculating the pressure due to the head of water above the pump inlet.

> <u>Licensee's Basis for Requesting Relief:</u>
>
> These pumps are of a vertical submerged open line shaft design. There is no installed instrument for direct measurement of the inlet pressure. Instead, the minimum pumping level is monitored to insure adequate NPSH is available for pump operation. Since the forebay water level is not expected to change significantly during the testing of these pumps, only one measurement is required.
>
> <u>Alternate Testing:</u>
>
> During each test, the difference in elevation between the forebay water level and the pump discharge pressure gauge will be determined by measurement to the nearest foot, which corresponds to approximately 0.5 psi. This value will be verified to be less than or equal to the value corresponding to the minimum water level required for pump operation and will also be used to calculate pump d/p.

<u>Evaluation</u>

This and similar relief requests where the licensee is unable to directly measure inlet pressure and determine d/p, were generally approved pursuant with either 10CFR50.55a(a)(3)(i), (a)(3)(ii), or (f)(6)(i). In some cases, such as the previous example, these requests were approved or granted with provisions. The provisions generally deal with the accuracy of the level measurements and the associated calculations of inlet and d/p. The measurements and calculations are generally required to provide results that are at least as accurate as pressure measurements taken by instruments that meet the Code requirements. The main considerations for making these determinations are:

(1) The Code required acceptance criteria are not relaxed.
(2) The level measurement and pressure calculations yield results that are at least as accurate as measurements taken with instruments that meet Code requirements.

(3) If significant blockage occurs at the pump suction, this condition would affect the discharge pressure and/or flow rate measurement and would be detected.

Requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

Summary and Additional Comments

Licensees seeking relief from d/p measurements pursuant with 10CFR50.55a(a)(3)(ii) or (f)(6)(i), should demonstrate in their basis for relief the hardship or excessive burden of installing inlet pressure instrumentation or otherwise modifying the pumps to allow direct measurement of inlet and d/ps.

Example From Prairie Island

Prairie Island submitted a relief request from the OM-6, Subsection 4.2, requirement to measure inlet and d/p for the diesel and motor driven cooling water pumps, which do not have installed inlet pressure instruments, and proposed to determine pump inlet and d/p by calculating the pressure due to the head of water above the pump inlet.

Licensee's Basis for Requesting Relief:

The pumps have a submerged suction in the cooling water intake bay and inlet pressure indication is not available. The method is in accordance with a determination of d/p allowed by the Code. By including the calculation in implementing procedures, the test can determine the d/p in a manner that is consistent and repeatable from test to test. This method will yield the information needed for monitoring the hydraulic condition of the applicable pumps without the need to install suction (inlet) pressure gauges which is not practical.

Alternative Testing:

Pump bay level will [be] used to calculate the suction (inlet) pressure and allow the determination of pump d/p. The calculation of bay level will be included in the surveillance procedure and supported by error analysis which shows the measurement of level and the calculational method yield an accuracy within $\pm 2\%$.

Evaluation

Because the Code allows the alternative of using the difference between the pressure at a point in the inlet and the pressure at a point in the discharge pipe, the proposed calculational method may be implemented without obtaining relief. When inlet pressure gauges are not installed in the inlet of a vertical line shaft pump, it is impractical to directly measure inlet pressure for use in determining d/p for the pump. If a bay level is used to calculate the inlet pressure for use in determining d/p as permitted by Paragraph 4.6.2.2 of OM-6, the calculation must be included in the implementing procedure and the reading scale for measuring the level and the calculational method must yield an accuracy within $\pm 2\%$. By including the calculation in implementing procedures, the d/p can be determined in a manner that is consistent and repeatable from test to test. This method will yield the information needed for monitoring the hydraulic condition of the applicable pumps without the need to install inlet pressure gauges. If direct measurements are impractical for other types of pumps with

suction from a tank, the licensee should apply similar controls. The method of determining the inlet pressure using calculation should meet quality assurance requirements and be included in a procedure.

Summary and Additional Comments

Relief is not needed to use a calculated inlet pressure in the determination of d/p. When using this method, licensees should follow the guidance in NUREG 1482, Section 5.5.3. In addition to including the calculation method in the implementing procedures, the licensee may wish to indicate that this method is being used by inserting a note or comment in their program plan.

(2) Cases Where Inlet Pressure is Insignificant to the Differential Pressure Measurement

In some cases, variations in pump inlet pressure are so small in relation to the discharge pressure, that discharge pressure could be used in lieu of d/p to evaluate pump hydraulic performance without causing a significant decrease in the ability to monitor pump operational readiness. In such cases, requiring the licensee to measure of calculate inlet pressure may be a hardship without a compensating increase in the level of quality or safety. The following example illustrates this point.

Example From North Anna Units 1 & 2

North Anna submitted a relief request from the Section XI, Paragraph IWP-3100, requirement to measure pump inlet pressure and d/p for an SW pump. The licensee proposed to measure pump discharge pressure and use it in lieu of d/p. Inlet pressure will not be measured for these pumps.

Licensee's Basis for Requesting Relief:

This pump takes suction from Lake Anna. No inlet pressure instrumentation is installed. The North Anna lake level indicator is located outside and several feet away from the observation point. Also, the measuring stick tends to collect residue from the surface of the lake, thus obscuring the markers. Therefore, measuring the lake level can be difficult during periods of inclement weather or low light conditions.

However, the lake level fluctuates very little from test to test and can be considered to be constant. The lake has a minimum level of 244 feet elevation as required by TS, and maximum and minimum recorded levels during past testing of 250.24 feet and 248.16 feet, respectively. Therefore, the expected maximum variation in lake level is about 2 feet, which is less than 1 psi. The discharge pressure gauge has a full scale reading of 100 psig and the discharge pressures range from 50 to 65 psig. Even the maximum variation, which in all probability will not occur between successive tests, is a small percentage of the total head developed by the pump. Therefore, the repeatability of the tests and the ability to detect degradation will not be significantly affected if only discharge pressure is measured.

Applying the Code acceptance criteria to discharge pressure instead of d/p is a conservative application of the acceptance criteria for the deep draft pump. For this pump, the total developed head is calculated by adding the measured discharge pressure to the height from the discharge pressure gauge to the pump impeller, and subtracting the height from the lake surface to the pump impeller.

Therefore, the measured discharge pressure will always be a smaller number than the actual total head developed by the pump. Applying the Section XI acceptance criteria to just the

discharge pressure instead of the total developed head for a deep draft pump is a conservative application of the acceptance criteria because the operability band is smaller.

Alternate Testing:

Discharge pressure will be measured in place of d/p.

Evaluation

It was determined that because of the inability to directly measure inlet pressure to allow calculation of d/p and the hardship of making modifications that would permit this measurement, requiring the licensee to directly measure these parameters would be a hardship without a compensating increase in the level of quality and safety. Therefore, the alternative was approved pursuant with 10CFR50.55a(a)(3)(ii). The main considerations in this determination are:

(1) The inlet pressure is small in comparison with the discharge pressure (maximum deviation of 2%).
(2) The maximum expected variation in inlet pressure from test to test is relatively small as determined by control procedures and TS limits and as verified by historical data.
(3) The Code required acceptance criteria are not relaxed.
(4) Even though some uncertainty is introduced by this method, applying the Code acceptance criteria for d/p to discharge pressure for this application should add conservatism.
(5) If significant blockage occurs at the pump suction, this condition would affect the discharge pressure and/or flow measurement and would not go undetected.

Licensees submitting requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

Summary and Additional Comments

The SW pump addressed in the preceding request is the subject of other relief requests in the licensee's submittal. One request addresses the use of reference curves of d/p and flow rate. Another requests a relaxation of the instrument accuracy requirements for the discharge pressure instrument. Taken separately, these requests appear to be reasonable approaches to Code testing alternatives. However, taken together, they may not be acceptable. For instance, the reduced accuracy of the discharge pressure instrument will affect the uncertainty associated with the acceptance criteria for curve testing. In this case, the proposed alternate was authorized with the provision that the licensee performs a complete assessment of the impact of the combination of requests on the ability to assess the operational readiness of these pumps.

When more than one Code requirement is impractical or will not be performed for a specific pump or group of pumps, submitting separate relief requests for each requirement is recommended because it allows the issues to be addressed separately, thereby reducing confusion. However, if several requests are submitted for a specific pump or group of pumps, the licensee should consider and address the cumulative effects of all of the requests upon their ability to monitor the operational readiness of those pumps.

3.3.3 Pressure Measurements for Positive Displacement Pumps

Pump d/p is the difference between the pressure at the discharge of a pump and the pressure at its suction or inlet. For centrifugal pumps, d/p and flow rate are dependent parameters that can be used to indicate the hydraulic condition of the pumps. Because the operating characteristics of positive displacement pumps differ from centrifugal pumps, d/p and flow rate are not dependent parameters.

Requirements

Section XI, IWP-3100, requires that the test quantities shown in Table IWP-3100-1, which includes inlet and d/ps, be measured or observed for all safety-related pumps. Section XI does not distinguish between pump types such as centrifugal, positive displacement, or vertical line shaft designs. OM-6, Subsection 5.2 and Table 2, requires measurement of d/p for centrifugal pumps (including vertical line shaft pumps) and measurement of discharge pressure for positive displacement pumps.

Table 3-5. Summary Table of Key Requirements and Guidance for Pressure Measurements for Positive Displacement Pumps

Document	Section	Requirement/Guidance
Section XI	IWP-3100	Measure inlet and d/p for all pumps.
OM-6	5.2	Measure discharge pressure for positive displacement pumps.
GL 89-04	N.A.	N.A.
NUREG 1482	5.1.2	Owner may eliminate d/p measurements for positive displacement pumps, however, the discharge pressure must be monitored with the specified limits of OM-6.

Relief Request Issues

Ten of the requests related to pump d/p are for positive displacement pumps. Six of the ten are for SLC pumps at BWRs, two are for diesel fuel oil transfer pumps, and one each for RCS standby makeup and chemical injection pumps at Westinghouse PWRs.

Positive displacement pumps generally do not have inlet pressure instruments. Instrumentation is not installed because inlet and d/p are not meaningful parameters for evaluating the operational readiness of positive displacement pumps. A positive displacement pump will produce the minimum discharge pressure necessary to establish flow into the available flow path. The flow rate will remain fairly constant at least up to the rated discharge pressure of the pump. OM-6, does not require measurement of inlet or d/p for these pumps, but rather requires measurement of pump discharge pressure. The guidance in NUREG 1482, Section 5.1.2, through GL 89-04, Supplement 1, permits the licensee to eliminate measurement of pump d/p for positive displacement pumps provided that discharge pressure is monitored with the specified limits of OM-6. Measuring and evaluating discharge pressure and flow rate adequately monitors the hydraulic condition of these pumps.

Summary and Additional Comments

Licensees may eliminate measurement of inlet and d/p for positive displacement pumps as stated in the preceding and need not submit relief requests.

The recent revision of the Code, ISTB-1995, refines the requirements for testing positive displacement pumps. The change recognizes that some types of degradations may not be detected by testing performed at low discharge pressures. ISTB 4.1(b) states "...reference values shall be taken at or near pump design pressure...." This change is consistent with the way most plants implement IST of positive displacement pumps either because of TS requirements or good engineering practices.

3.4 PUMP CURVE TESTING

The pump testing Codes require establishment of reference value or values of test parameters. When performing IST of pumps, the reference flow rate or reference d/p is established and the other parameter is measured and compared to the reference value. For some system designs it is not practical to return to an established reference point for testing. For these systems, it is necessary to establish an alternate method for evaluating the operational readiness of the pumps.

Cooling water systems, such as the SW, component cooling water, and reactor building closed cooling water systems, often cannot practically be returned to an established reference point for quarterly pump testing. These systems have multiple flow loops where the flow rate is either preset to insure a required flow rate or automatically controlled to maintain a set temperature. The flow rates through these flow loops can fluctuate because of variations in system heat loads, cooling water temperature, and other system conditions. In some cases, these flow rates cannot be manually controlled to achieve reference conditions. In many cases, changing the flow rate to achieve reference conditions, if possible, could cause either over or under cooling of safety equipment and result in equipment damage and/or plant operability problems. In these cases, it may be necessary to test the pumps in the as-found condition. A common method of performing this testing is to plot pump curves for comparison with as-found IST measurements.

The Code permits establishment of multiple reference points for pump testing. Pump curve testing is similar to establishing multiple reference points. However, curve testing has some drawbacks which make its use undesirable when testing at one or more fixed reference points is practical. Improperly performed curve testing could result in increased test uncertainty due to factors such as poor curve fit and curve interpretation errors. This uncertainty, in combination with other test uncertainty like instrument inaccuracy, may be sufficient to mask changes in pump capability that is indicative of degradation. Excessive uncertainty can also result in deviations in test data that is not due to pump degradation, which could result in false positive test results (i.e., an undegraded pump entering the Alert or Required Action range).

Excessive test uncertainty in conjunction with expanded allowable range limits may make detection of degradation prior to catastrophic failure unlikely. The inability of testing to detect degradation along with possible false positive results are both problematic and may be costly to the licensee. In the case of false positive test results, the licensee could be required to perform corrective action on a non-degraded pump. This could result in the licensee removing the pump from service, entering an LCO Action Statement, and performing costly maintenance activities. In cases where degradation is masked by test method uncertainty, a degraded pump could remain in service, even though its ability to perform its safety function in the event of an accident may be compromised.

Requirements

IWP-3100 states that when performing IST of a safety-related pump, the resistance of the system should be varied until either the measured flow rate or the measured d/p equals the corresponding reference value. OM-6 requires establishment of reference flow rate or d/p for centrifugal and

vertical line shaft pumps as is required by IWP. For positive displacement pumps, OM-6 requires that the resistance be varied to achieve the reference discharge pressure and then the flow rate is measured and compared to its reference value. For the Group A and Comprehensive Pump Tests, the ISTB-1995 requirements are the same as OM-6. The ISTB-1995 Group B test for centrifugal and vertical line shaft pumps do not require varying system resistance to establish a reference pressure or flow rate, but requires that one of these parameters be measured and evaluated. The Group B test for positive displacement pumps requires only a flow rate measurement.

Table 3-6. Summary Table of Key Requirements and Guidance for Pump Curve Testing

Document	Section	Requirement/Guidance
Section XI/ OM-6	IWP-3100/ 5.2(b)	The resistance of the system shall be varied until either the measured flow rate or the measured d/p equals the corresponding reference value. The other parameters shall then be measured and compared to their reference values.
OM-6	5.2(c)	Where system resistance cannot be varied, flow rate and pressure shall be determined and compared to their reference values.
ISTB-1995	ISTB 5.2.1 ISTB 5.2.2 ISTB 5.2.3	**Group A Test**: Centrifugal and vertical line shaft pumps shall be tested the same as in OM-6. To test positive displacement pumps, the system resistance shall be varied until discharge pressure equals the reference point and then the flow rate shall be measured and compared to its reference value. **Group B Test**: Centrifugal and vertical line shaft pumps shall have their d/p or flow rate measured and compared to its reference value. For positive displacement pumps, the flow rate shall be measured and compared to its reference value. **Comprehensive Test**: Same as for Group A.
NUREG 1482	5.2	The use of pump curves for reference values of flow rate and d/p may be found acceptable if the impracticality of establishing a fixed set of reference values is demonstrated in a relief request. To obtain approval for a proposed method of evaluating these pump parameters to detect hydraulic degradation and determine pump operability, the licensee must demonstrate that the acceptance criteria is equivalent to the Code requirements in Table IWP-3100-2 (or Table 3b of OM-6) for allowable ranges using reference values. To use this test method, the licensee must follow the seven elements listed in this NUREG Section.
NUREG 1482	5.3	If the design does not allow for establishing and maintaining the reference value at an exact value, achieving a steady flow rate or d/p at approximately the set value does not require relief for establishing pump curves. The allowed tolerance for setting the fixed parameter must be established for each case individually including the accuracy of the instrument and the precision of its display. For a tolerance greater than ± 2 percent, an adjustment to acceptance criteria may be made to compensate for the uncertainty, or an evaluation performed and documented justifying a greater tolerance. The use of Paragraph 5.2(c) of OM-6 for systems in which resistance cannot be varied (fixed-resistance systems) is acceptable pursuant to 10 CFR 50.55a(f)(4)(iv). The only related requirement is to compare the flow and pressure to limits of Table IWP-3100-2, or OM-6 Table 3b if using OM-6 limits.

Reference Flow Rate or Differential Pressure Cannot be Exactly Duplicated Each Test

For IST of pumps the Code requires system resistance to be varied until either the measured d/p or the measured flow rate equals the corresponding reference value. Certain designs do not allow pump flow rate to be set at an exact value because of limitations in instruments, controllers, and control elements. Operating characteristics and requirements for other designs do not allow flow rate to be adjusted to exact values. The Code does not allow for variance from a fixed reference value. Licensees have requested relief to establish a range of values similar to using a pump curve, but with a very narrow band.

In NUREG 1482, Section 5.3, the NRC explains that if a design does not allow for establishing and maintaining flow at an exact value, achieving a steady flow rate or d/p at approximately the set value does not require relief for establishing pump curves. The allowed tolerance for setting the fixed parameter should be established for each case and should take into account the instrument accuracy and the precision of its display. The staff indicated in Section 5.3 that a total tolerance of ± 2 percent of the reference value or less is allowed without approval from the NRC. If the tolerance is greater than ± 2 percent, a corresponding adjustment should be made to the acceptance criteria to compensate for the uncertainty, or an evaluation that justifies a greater tolerance should be performed and documented. The variance and the method for establishing the variance should be documented in the IST program or implementing procedures.

Example From Surry Units 1 and 2

The Surry Units 1 and 2 IST programs request relief from the requirements of OM-6, Paragraph 4.3 to measure flow and d/p at repeatable points of operation, for the component cooling pumps. The licensee proposed to use a straight line approximation method to determine d/p reference points as a function of flow between the two test points. The measured d/p will be compared to the upper required action limit, which is set at 110% of P_{rdiff}, and the lower required action limit at 90% of P_{rdiff}. No alert range will be assigned.

Licensee's Basis for Requesting Relief:

During testing of the component cooling water pumps, flow is adjusted to the reference flow rate using an 18 inch butterfly valve. The butterfly valve is a crude throttling device and does not provide the fine tuning that is required to duplicate the reference flow rate from test to test. Consequently, throttling to the same reference flow rate during each test is not practical.

Alternate Testing:

Two reference points of flow versus d/p will be established from the reference test for each pump. A straight line approximation will be used to determine d/p reference points as a function of flow between the two test points. By keeping the difference between two test points small, the straight line is a good approximation of the pump curve within the two test points. During the subsequent tests, test flow will be throttled as close as practical to the reference flow value. The test flow must fall between the two reference points used to establish the straight line approximation. The test flow and the corresponding d/p will be compared to either graphical and/or tabular acceptance criteria based on the straight line approximation of the reference pump curve. For example, given the straight line equation determined from the two reference points for flow and d/p:

$P_{rdiff} = a + b*Q$ where

P_{rdiff} = the reference d/p based on the test value for Q recorded during subsequent tests and, a and b are constants,

The acceptance criteria for the flow (Q) would be as follows:

Upper Required Action = $1.1*P_{rdiff}$
Lower Required Action = $0.90*P_{rdiff}$

The multipliers on P_{rdiff} are taken from Table 3b in OM Part 6. The actual recorded d/p (P_{adiff}) will then be compared to the acceptance criteria determined from P_{rdiff}. Also, the test results can be trended from test to test by normalizing P_{adiff} to P_{rdiff}. For acceptable operation, the ratio of P_{adiff}/P_{rdiff} must fall between 0.9 and 1.1. A decrease in the ratio from test to test would indicate a steady degradation in pump performance.

<u>Evaluation</u>

This request was granted pursuant to 10 CFR 50.55a(f)(6)(i) with the provision that the licensee comply with the seven curve testing criteria identified in the guidance of NUREG 1482, Section 5.2. The review of this request pointed out that component cooling water system supplies many independent loads and the flow rate can only be adjusted during tests by throttling a butterfly valve. These design limitations make it difficult to attain a specific reference point, which makes compliance with the Code requirements impractical. The system would have to be redesigned and modified to allow accurate adjustment of flow rate to a specific reference value.

The proposed alternative employs a straight line approximation method to approximate the pump curve between two closely-spaced points. Corrective actions will be performed if the d/p varies from the reference d/p by $\pm 10\%$. The distance between endpoints and the shape of the pump curve over the range of the straight line approximation will affect the appropriateness of the acceptance criteria. Pump curves are generally relatively flat at low flow rates and convex downward at higher flow rates. However, some pump curves are different than standard curves and some pumps have areas of instability that cause unusual fluctuations in their curves. Pump curves and their associated acceptance criteria will be most accurate at the reference points used to establish the curve. The curves and acceptance criteria will be less accurate in areas where the curve is interpolated. Where a straight line method of interpolation is used for a convex downward area of the curve, the acceptance criteria will be less conservative for a degraded pump than actual reference points.

Although this request was approved with the provision that the curve testing consider the curve testing criteria of the guidance in NUREG 1482, Section 5.2, it may be practical to repeatedly return to within ± 2 percent of the reference value and meet the criteria identified in NUREG 1482, Section 5.3. If these pumps can be practically tested in accordance with Section 5.3, the licensee may desire to withdraw this request and utilize this test method.

Example From Duane Arnold

Relief was requested from the pump test procedure requirements of Section XI, Paragraph IWP-3100, for the River Water, Core Spray, RCIC, and RHR pumps. They proposed to measure the flow rate and d/p at points above and below the established reference flow rate and to determine the corresponding d/p using linear interpolation between the two measured values.

Licensee's Basis for Requesting Relief:

Operating experience has shown that flow rate (independent variables during inservice performance testing) for these pumps cannot be readily duplicated with the present flow control systems. Flow control for these systems can only be accomplished through the operation of relatively large gate and globe valves as throttling valves. Because these valves are not generally equipped with position indicators which reflect percent open, the operator must repeatedly "jog" the motor or air operator to try to make adjustments in flow rate. These efforts, to exactly duplicate the reference values, would require excessive valve manipulation which could ultimately result in damage to valves or operators.

Alternate Testing:

The alternative approach calls for the establishment of reference values for flow rate and d/p during a reference value test. The reference flow rate (Q_r) and d/p (dP_r) define a point on the pump performance curve. If the pump characteristics were to degrade during time, the pump would operate on a different curve. Given that Q_r cannot be duplicated exactly in subsequent tests, inservice tests will be performed by taking two sets of measurements and establishing a dP which corresponds to Q_r for the inservice test as described.

After the pump has run for at least five minutes, a flow rate will be obtained which is lower than the reference flow rate (Q_r) but greater than a specified lower limit as established in the test procedure. When the lower flow rate (Q_l) is established, the suction pressure during testing (P_{il}) and the discharge pressure (P_{dl}) will be measured. The d/p (dP_l) corresponding to the lower flow rate is computed by:

$$dP_l = P_{dl} - P_{il}$$

After the test quantities corresponding to Q_l have been recorded, the flow rate is adjusted to a value higher than Q_r but less than a specified upper limit as established in the test procedure. When the higher flow rate (Q_h) is established, the suction pressure and discharge pressure will be measured and the d/p (dP_h) corresponding to Q_h will be computed. Two points have been established that define a small portion of the pump curve. By linear interpolation between the two points, a d/p corresponding to Q_r can be computed. The general equation at the line between points (Q_l, dP_l) and (Q_h, dP_h) is:

$$dP = a - bQ$$

Writing the above equation in terms of Q_l, dP_l, Q_h, and dP_h and solving for Q_r yields:

$$dP = dP_l + [(dP_l - dP_h)/(Q_h - Q_l)](Q_l - Q_r)$$

Assuming that the pump curve is nearly linear between Q_l and Q_h, this equation gives an accurate value for dP which corresponds to Q_r. The precise value of dP obtained analytically can then be compared to the Alert and Required Action limits which are computed using dP_r.

The major assumption in the approach described above is that the pump curve is nearly linear between Q_l and Q_h. Therefore, values for Q_l and Q_h should fall within a narrow range of Q_r so that the curve in that range approaches linearity. The appropriate flow rate range between the lower and upper procedural limits have been determined on a pump by pump basis.

Evaluation

Relief was granted from the Code requirement to exactly duplicate a reference point during pump testing. It was determined that it is impractical to meet this requirement with the existing system design and that the proposed method of calculating d/p and procedure for evaluating for pump hydraulic degradation should provide an acceptable level of quality and safety. Accurately duplicating the reference variable during IST for these pumps requires excessive valve manipulation due to the lack of a precise means of throttling the flow rate. Jogging these valves in an attempt to set the flow rate or d/p at the reference value results in excessive valve wear and can cause premature valve failure.

Although this request was approved as submitted, it may be practical to repeatedly return to within ±2 percent of the reference value and meet the criteria suggested in the guidance in NUREG 1482, Section 5.3. If these pumps can be practically tested in accordance with Section 5.3, the licensee may desire to withdraw this request and utilize this test method.

Example From Beaver Valley Station Units 1 and 2

Relief was requested from the requirements of IWP-3100 and Table IWP-3100-1 to vary system resistance to adjust the d/p or flow rate to the appropriate reference value when testing the SW pumps. The licensee proposed to measure the pump flow rate and dp at as-found conditions and to utilize a pump curve to evaluate pump hydraulic condition.

Licensee's Basis for Requesting Relief:

Operating experience has shown that plant conditions due to heat loads requiring cooling by the SW system may preclude returning the SW pumps to the exact flowrate or d/p during pump surveillance testing. The SW system is dependent on seasonal Ohio River water temperatures and flow may vary from approximately 6,000 gpm in the cool winter months to approximately 12,000 gpm in the warm summer months.

In order to increase flow to a reference value during cold winter months, idle heat exchangers would need to be placed into service or additional flow would be needed through heat exchangers already in service. Increased cooling flow through primary and secondary component cooling and chiller unit heat exchangers already in service could result in a thermal transient and a potential plant trip. Clean heat exchangers may require placement into service prematurely if additional flow is required to return to a reference value. Idle heat exchangers are normally held in reserve following cleaning to improve plant reliability and safety until one of the inservice heat exchangers becomes fouled.

In order to throttle flow to a reference value during warm summer months, any inservice primary and secondary component cooling and chiller unit heat exchangers would need flow reduced or isolated which could interrupt flow of cooling water to Train A or Train B cooling loads resulting in a thermal transient and potential plant trip. In addition, the added thermal cycling due to placement and/or removal of heat exchangers from service for pump testing could prematurely degrade the heat exchangers.

The thermal transients created by increasing or throttling SW system flow to the turbine plant cooling loads raises operational concerns of stability problems. Changes in oil temperature from the turbine generator lube oil system may create vibration problems. Changes in the hydrogen gas cooler temperatures could imply problems or mask real problems with the

generator. Chiller unit heat exchanger flow disturbances often result in a trip of the chiller unit causing reactor containment temperature risks of exceeding the TS limit.

IWP-3112 provides for multiple sets of reference values. A pump curve is merely a graphical representation of the fixed response of the pump to an infinite number of reference values verified by measurement. Relief is, therefore, requested to use a pump curve, which should provide an equivalent level of quality and safety in trending pump performance degradation. Flow will be permitted to vary as system conditions require. Delta-P [d/p] will be calculated and converted to a developed head for which ASME ranges will be applied.

Alternate Testing:

A pump curve will be used to compare flowrate with developed pump head at the flow conditions dictated by SW system loads per 2OST-30.2, 2OST-30.3, and 2OST-30.6 each quarter. Since normal flow varies based on SW system requirements due to seasonal Ohio River water temperatures, the most limiting vibration acceptance criteria will be used over this range of flows based on baseline vibration data obtained at various flow points on the pump curve.

Evaluation

This request was granted pursuant with 10 CFR 50.55a(f)(6)(i) with the provision that the licensee incorporate curve testing guidance identified in the evaluation, which is consistent with the guidance of NUREG 1482, Section 5.2. Some designs, such as the SW system described above, do not facilitate testing at a single reference point of a set of multiple reference points. In these cases it may be necessary to develop pump curves to use as the basis for variable reference points. It is impractical to perform testing in accordance with the Code requirements for the SW pumps based on the thermal transients created by throttling the flow to a specified reference value. To impose the Code-required test method would be an undue burden on the licensee in that damage to the plant equipment or a plant transient/trip could occur. The alternative testing can provide an adequate level of assurance of operational readiness of the subject pumps without creating these adverse conditions.

The NRC approves the use of variable reference values of flow rate and d/p in those cases where the licensee clearly demonstrates in the relief request the impracticality of establishing a fixed set of reference values. The licensee must ensure that the method of evaluating these pump parameters to detect hydraulic degradation and determine pump operability is essentially equivalent to the Code requirements for allowable ranges in Table IWP-3100-2.

The licensee must establish a valid pump characteristic curve to employ this test methodology. This curve must be developed from empirical data or supplied by the pump manufacturer and verified by measurements taken when the pump was known to be in good operating condition. The following is an example of a test plan that would be acceptable:

> Pump flow rate is measured with the pump operating as found. This flow rate is used to set a point on the pump characteristic curve. The pump d/p is then measured with the pump operating as found. This d/p is compared to the d/p obtained from the pump curve for the measured flow rate. The pump is in the acceptable range if the measured d/p is 0.93 to 1.02 times the value from the pump curve, and is in the alert range if the measured d/p is 0.90 to 0.93 or 1.02 to 1.03 times the value from the pump curve. The pump is in the required action range if the measured d/p is < 0.90 or > 1.03 times the value from the pump curve.

Since pump vibration readings may vary widely with changes in pump flow rate and d/p, the licensee must propose a method of evaluating pump vibration measurements taken with the pump operating in possible as-found conditions to ensure that a degraded pump would be declared inoperable and repaired.

The following elements are to be incorporated into the IST of pumps utilizing pump curves:

1) Curves are developed, or manufacturer's pump curves are validated, when the pumps are known to be operating acceptably.
2) The reference points used to develop or validate the curve are measured using instruments at least as accurate as required by the Code.
3) Curves are based on an adequate number of points, with a minimum of five.
4) Points are beyond the "flat" portion (low flow rates) of the curves in a range which includes or is as close as practicable to design basis flow rates.
5) Acceptance criteria based on the curves does not conflict with TS or Facility Safety Analysis Report operability criteria, for flow rate and d/p, for the affected pumps.
6) If vibration levels vary significantly over the range of pump conditions, a method for assigning appropriate vibration acceptance criteria should be developed for regions of the pump curve.
7) When the reference curve may have been affected by repair, replacement, or routine service, a new reference curve shall be determined or the previous curve revalidated by an inservice test.

A method for evaluating pump operability is necessary for variable flow systems where it is not practical to return to the same flow configuration for each subsequent inservice pump test. This may be the case for systems where temperature or flow is controlled at a variety of locations, such as SW systems. It may not be practical for the licensee to take manual control of each of these local stations and duplicate the overall system reference conditions, as required by the Code, during quarterly pump testing.

Utilizing the manufacturer pump-specific curves for flow and d/p may enable the licensee to evaluate the pump in as-found system conditions. In this case, these values must be confirmed by in-situ testing. Another method would be the development of pump curves by varying system conditions and plotting a graph of the results over the range of conditions expected during the system's normal operation. It is also important to develop a method of evaluating pump vibration measurements taken with the pump operating over the range of possible as-found conditions, since this is a variable pump parameter. This is to ensure that a severely degraded pump, either hydraulically or mechanically, is declared inoperable and repaired. The licensee's proposed alternative does not specify details of the referenced test procedures (2OST-30.2/3/6); therefore, a review by the licensee must be performed to ensure that all of the guidance discussed above is incorporated into the testing utilizing pump curves.

Relief is granted pursuant to 10 CFR 50.55a (f)(6)(i) based on the impracticality of testing the subject pumps in accordance with the Code requirements and the burden if these requirements were imposed, provided the licensee incorporate the guidance discussed in the evaluation into the implementation of the IST.

<u>Summary and Additional Comments</u>

In the proceeding relief requests, the adjusted parameter for the affected pumps may only be practicably regulated within a specified tolerance of the reference values. In these cases, this

parameter should be set as closely as practicable to the reference value, if it can be set within ±2 percent of the reference point during each test, this should be done rather than using a pump curve to evaluate pump condition. If, upon establishing trends in data, the licensee determines that the parameter cannot practicably be set within ±2 percent of the reference point, they may need to establish pump curves and request relief for the applicable pumps.

Relief may be granted for cases where the flow instruments used for IST do not meet the Code requirements. The following should be considered when developing relief requests for these cases:

(1) Establishing an exact reference point or points during periodic testing is impractical and it would require extensive system modifications to permit this testing.
(2) The reference parameter is consistently adjusted to within ±2 percent of the reference point or an evaluation justifying a greater tolerance is performed.
(3) The Code allowable ranges are utilized to evaluate the pump parameter measurements or these ranges are tightened to account for increased test uncertainties, as appropriate.
(4) The test variance and the method for establishing the variance must be documented in the IST program or implementing procedures.
(5) Procedures and controls are established that permit measurements sufficiently repeatable to allow monitoring pump operational readiness and detection of pump degradation.

Licensees that meet the guidance listed in NUREG 1482, Section 5.3, as summarized in the five items listed above, need not submit relief requests to use pump reference curves. Where all of the conditions identified in NUREG 1482, Section 5.3, are not met, a request for relief for curve testing may still be found to be acceptable provided that it complies with the guidance of NUREG 1482, Section 5.2, and the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

3.5 PUMP VIBRATION MEASUREMENTS

Section XI requires quarterly measurement and evaluation of the pump vibration amplitude measurements to monitor for mechanical degradation of the pump bearings. These measurements are compared to the limits specified in Table IWP-3100-2, *Allowable Ranges of Test Quantities*. It is impractical to measure the vibration in accordance with the Code for specific pump types, such as vertical line shaft pumps, which are submerged in the working fluid. Many licensees desire to use vibration velocity measurements in lieu of displacement measurements because the velocity measurements are much more sensitive to high frequency vibrations that result from bearing degradation on pumps that operate at speeds above 600 rpm. For pump with low rotational speeds it is often difficult to obtain vibration instruments that meet the Code frequency response range requirements.

Requirements

Section XI, Subsection IWP-3100, requires measurement or observation of the pump parameters listed in Table IWP-3100-1. Table IWP-3100-1 lists vibration amplitude as one of the parameters to be measured. IWP-4510 includes specific requirements for the number of measurements, the location and direction of measurements, and measurements on special pump types. IWP-4520 provides requirements for the instruments used for pump vibration measurements. Acceptance criteria and corrective actions for deviations are specified in IWP-3210 and -3230. OM-6 provides similar requirements with the exceptions that it permits vibration velocity measurements, requires measurement in one additional direction (3 measurements rather than 2), and has a more restrictive

frequency response range for the vibration transducers (one-third minimum pump shaft rotational speed versus one-half minimum speed for IWP-4520(b).

Table 3-7. Summary Table of Key Requirements and Guidance on Vibration Measurement

Document	Section	Requirement/Guidance
Section XI	IWP-3100 and -3400	These sections require quarterly pump testing and measuring the parameters of Table IWP-3100-1 including vibration amplitude.
OM-6	Paragraphs 5.1 and 5.2	These sections require quarterly pump testing and measuring the parameters of Table 2 including vibration displacement/velocity.
Section XI/ OM-6	IWP-4110/ Paragraph 4.6.1.1	This section requires instrument accuracy to be ±5%. For Section XI this is percent of full scale and for OM-6 it is percent of full scale for analog instruments, percent of total loop accuracy for a combination of instruments, and over the calibrated range for digital instruments.
Section XI/ OM-6	IWP-4120/ Paragraph 4.6.1.2	Requires instrument full-scale range to be three times reference value or less. OM-6 specifies the above for analog instruments and provides range requirements for digital instruments, but excludes vibration instruments from the range requirements.
Section XI	IWP-4510	Requires a peak-to-peak displacement measurement perpendicular to the rotating shaft and one in the horizontal or vertical direction that has the largest deflection.
OM-6	Paragraph 4.6.4	Velocity or displacement measurements shall be taken in a plane perpendicular to the shaft in two orthogonal directions on each pump bearing housing and in the axial direction on each pump thrust bearing housing. On vertical line shaft pumps the measurements shall be taken on the upper motor bearing housing in three orthogonal directions, one of which is axial.
Section XI	IWP-4520	The frequency response of vibration measuring equipment shall be from one-half of minimum speed to at least maximum pump shaft rotational speed.
OM-6	Paragraph 4.6.1.6	The frequency response of vibration measuring equipment shall be from one-third of minimum pump shaft speed to ≥1000 Hz.
OM-1995	ISTB 5.2	Vibration measurements are not required for quarterly Group B pump testing.
NUREG 1482	5.4	This section of the NUREG states that relief is not required from Section XI to use OM-6 for monitoring vibration for IST if they meet all related requirements in OM-6 paragraphs 4.6.1, 4.6.4, 5.2, and 6.1.

Relief Request Issues

There were 58 relief requests in the review group related to pump vibration measurements. Twenty of these requests were to use vibration velocity measurements instead of the displacement measurements required by Section XI. Thirteen requests were for relief from the acceptance criteria

of the Code. Eleven were for vertical line shaft pumps which mainly involved the location for test measurement and acceptance criteria. Eight were for the frequency response of vibration equipment used for measurements on slow speed pumps. The remainder were for various issues such as setting minimum acceptance criteria for smoothly running pumps.

Major Issues:

a) Proposals to use vibration velocity measurements in lieu of displacement (see Item 1)
b) Proposals to use less restrictive vibration acceptance criteria (see Item 2)
c) Proposals for measuring vibration on vertical line shaft pumps (see Item 3)
d) Vibration instruments that don't meet the Code frequency response limits (see Item 4)

Each of these issues is discussed separately in the following sections of this report.

(1) Proposals to Use Vibration Velocity Measurements in Lieu of Displacement

We considered 20 requests that involved the use of vibration velocity measurements in lieu of vibration displacement. These requests are common because pump vibration velocity can provide a great deal of information about pump mechanical condition that could not be obtained by using vibration displacement readings. Pump bearing degradation results in increased vibration at frequencies several times the rotational speed of the pump. These high frequency bearing noises would not produce a significant increase in pump vibration displacement measurements for pumps with rotational speeds of 600 rpm or greater and could go undetected. However, the high frequency noises would result in relatively large changes in pump vibration velocity measurements which could permit detection of bearing degradation and corrective action prior to catastrophic failure. Because of the high frequencies of the vibrations associated with the bearings of pumps with rotational speeds of 600 rpm or greater, vibration velocity measurements are generally much better than vibration displacement measurements in monitoring the mechanical condition of these pumps and detecting bearing degradation.

The advantages of measuring vibration velocity instead of displacement for monitoring the mechanical condition of pumps, with the exception of low speed pumps, are widely acknowledged in the nuclear industry. The guidance in NUREG 1482, Section 5.4, permits licensees to use the vibration velocity measurement requirements of OM-6 if all related requirements are met. The NUREG states in part: "The staff has determined that if the licensee uses OM-6 for monitoring vibration in the IST program, the program must include all of the requirements for such monitoring. Licensees may update their programs in accordance with this position without further relief if they meet all related requirements for monitoring vibration in paragraphs 4.6.1, 4.6.4, 5.2, and 6.1 of OM-6, pursuant to 10 CFR 50.55a(f)(4)(iv)."

Therefore, although relief is no longer required to use vibration velocity units for IST, the conditions of NUREG 1482, Section 5.4, should be referenced and met in the IST program for those plants not updated to OM-6. Even though relief is no longer needed for these cases, the following examples are provided to give additional information on this topic.

Example for Vibration Velocity Measurements from Arkansas Nuclear One Unit 1

Relief was requested from the pump vibration amplitude measurement and allowable range requirements of Section XI, Paragraphs IWP-3100 and -4500, for all pumps in the IST program. The licensee proposed to measure and analyze vibration velocity per OM-6.

Licensee's Basis for Requesting Relief:

Due to improvements in vibration measurement and analysis techniques that have occurred since the publication of the Code of record for ANO-1 (ASME Section XI, 1980 Edition, Winter 1981 Addenda), the use of velocity is now considered to be the preferred indicator for use in determining equipment condition. In fact, more recent code revisions recognize these improved techniques and incorporated them into their requirements. ANO-1 proposes to utilize measurement of vibration velocity as opposed to displacement for pumps with rotational speeds greater than 600 RPM in order to better define pump mechanical condition.

Alternate Testing:

It is proposed to conduct all phases of this activity in accordance with the requirements of the ASME approved OM-6 (ASME 1988) IST standard for pumps. NOTE: All pumps currently included in the IST Program operate at rotational speeds greater than or equal to 600 RPM. If any pump were to be added to the program with rotational speeds less than 600 RPM at a later date, then vibration displacement would be utilized to monitor the condition of that pump in accordance with OM-6.

Evaluation

Section XI does not provide allowable ranges for vibration velocities. Since the relationship between displacement and velocity is frequency dependent, a mathematical conversion of the Code displacement ranges is not appropriate. OM-6 provides a set of allowable ranges for pump vibration velocity measurements that has been found to be acceptable by the NRC. The licensee indicated that they are using the ranges and limits specified in OM-6. The licensee further proposed to conduct all phases of the vibration measurement activity in accordance with the requirements of OM-6 for all pumps in their IST program. Measuring pump vibration in velocity units is at least equivalent to the Code requirements and is an acceptable alternative.

Section XI, Paragraph IWP-4510, requires vibration measurements to be taken on a bearing housing or its structural support, provided it is not separated from the pump by a resilient mounting. ASME OM-6 permits vibration measurements on the upper motor bearing housing for vertical line shaft pumps. This alternate location is permitted due to the inaccessibility of the pump, since it is submerged in the working fluid, and the high failure rate of permanently installed vibration sensors. A study performed by EPRI entitled *On-Line Vibration Monitoring for Submerged Vertical Shaft Pumps*, EPRI NP-5704M, found that vibration measurements taken on pump motor housings may not detect pump bearing and shaft problems. Therefore, it may not be possible to monitor pump mechanical condition or detect pump degradation by measuring vibration on the upper motor bearing housing. The licensee should determine if this is the case. If so, they should investigate other testing alternatives that would permit monitoring pump mechanical condition, such as installing specially designed permanent detectors on the submerged pumps.

Based on the determination that the licensee's proposed testing is equivalent or better than the Code required testing for non-vertical line shaft pumps, relief was granted from the Code requirements, with the provision that the licensee verifies that the proposed testing would detect any significant mechanical degradation of vertical line shaft pumps. If it is determined that significant mechanical degradation cannot be detected, the licensee should investigate alternate testing methods. If an acceptable alternate method is found, it should be incorporated within two years. If the investigation shows that no acceptable alternatives exist, this should be documented in the program and the proposed testing continued until an alternative is found and implemented.

Example for Vibration Velocity Measurements from Palisades

Relief was requested from the requirements of IWP-4500 and Table IWP-3100-2 for measurement and recording of pump bearing vibration amplitude in "peak-to-peak" mils displacement. The licensee proposed to implement the vibration measurement requirements of OM-6 for the listed pumps.

<u>Licensee's Basis for Requesting Relief:</u>

Relief is requested from the requirements of ASME Section XI, Subsection IWP, Article IWP-4500 and Table IWP-3100.2. Palisades has reviewed the requirements of Subsection IWP against those in Part 6 of the OMa-1988 Addenda to OM-1987 (Part 6) for pump vibration testing and prefers to implement the more current requirements found in Part 6. CPCo believes that alternate rules in Part 6 provide an acceptable level of quality and safety as is required by 10 CFR 50.55a(a)(3)(i). This is best demonstrated by the NRC's approval of the 1989 Edition of ASME Section XI (ref: 10 CFR 50.55a(b)(2) and 10 CFR 50.55a(b)(2)(viii). The 1989 Edition of ASME Section XI replaced the rules of IWP with those of ANSI/ASME OM (Part 6).

The vibration requirements of Part 6 will be applied with one exception. An analysis of previous pump test results found that the vibration limits in Table 3a of Part 6 are acceptable for most pumps at Palisades. However, the pumps discussed below were found to regularly exceed the "> 0.325 in/sec" Alert Range Limit when they were known to be operating acceptably. Analysis of this data against a "> 0.325 in/sec" Part 6 Alert Range Limit yields the following results:

P-54A - Five of the last six tests would have been in the alert range.
P-54B - The last six tests would have been in the alert range.
P-54C - The last six tests would have been in the alert range.
P-67A - Four of the last six tests would have been in the alert range.
P-67B - Three of the last six tests would have approached the alert range.

As shown above, application of this alert limit would inappropriately require these pumps be regularly placed on Alert and their test frequency doubled. This additional testing burden would not be warranted based on the pumps history of acceptable performance at these vibration levels and could lead to pump degradation. Furthermore, no benefit can be expected from this additional testing. Therefore, in accordance with 10 CFR 50.55a (a)(3)(ii), implementation of the "0.325 in/sec" Alert Range Limit for these specific pumps represents an undue hardship without a compensating increased in quality or safety. These pumps cannot meet this requirement because they are tested at low flow rates through a minimum recirculation line.

This conclusion is supported by the fact that when the CS pumps are tested at higher flow rates during cold shutdowns per TSs procedure QO-10, the vibration levels are less than half of the vibration levels recorded when the pumps are tested during minimum recirculation. Also, vibration levels recorded during special test T-261, LPSI [low pressure safety injection] Pump Performance Test, indicated that vibration levels recorded at design flow rates were less than half the vibration recorded when the pumps are tested during minimum recirculation.

Alternate Testing:

CPCo will implement the Part 6 of the OMa-1988 Addenda to the OM-1987 Edition for pump vibration testing with the following exception. The "0.325 in/sec" Alert Limit will be replaced with the limits listed below. Note that the "> 2.5V to 6V" Alert Range will be maintained. In addition, the "> 0.70 in/sec" Required Action Limit will be replaced with the limits listed below.

	Alert Limit	Required Action Limit
CS Pump (P-54A)	> 0.74 in/sec	> 1.20 in/sec
CS Pump (P-54B)	> 1.00 in/sec	> 1.50 in/sec
CS Pump (P-54C)	> 0.85 in/sec	> 1.30 in/sec
Low Pressure Injection Pump (P-67A)	> 0.70 in/sec	> 1.00 in/sec
Low Pressure Injection Pump (P-67B)	> 0.70 in/sec	> 1.00 in/sec

Evaluation

The reviewer stated that for the AFW pumps, boric acid pumps, charging pumps, component cooling water pumps, high pressure safety injection (HPSI) pumps, and SW pumps, the licensee's proposed alternative is in accordance with OM-6. Based on the incorporation of the 1989 Edition of Section XI in 10 CFR 50.55a(b), the licensee may implement the requirements of OM-6 pursuant to 10 CFR 50.55a (f)(4)(iv) provided all related and requirements are met. The NRC has determined that licensee's may implement the vibration monitoring requirements of OM-6 per Paragraph (f)(4)(iv) and relief is not required. For pumps that operate above 600 rpm, measurement of pump vibration in units of velocity rather than in units of displacement provides a better indication of anti-friction bearing wear and other type of pump degradation; hence, this method can result in more timely repairs. Related requirements for vibration measurement in OM-6 include Paragraphs 4.6.1, 4.6.4, and 6.1. Whether all related requirements are met is subject to NRC inspection.

For the CS pumps and the low pressure injection pumps, the basis for relief does not indicate the basis for consideration that these pumps could continue to perform acceptably, for extended periods at higher flow rates, with the proposed limits for "alert" and "required action." The licensee notes that the testing of these pumps is performed using minimum recirculation test loops. The lower flow rates may be the reason that vibration levels are high during testing; however, the licensee proposes no additional monitoring of vibration for IST during the higher flow tests. At the lower flow rates, vibration velocity peaks above 0.3 in./sec. indicate the pump would be operating in a "rough" range. Above 0.7 in./sec., the pump would be operating in a "danger" or "very rough" range considered to be indicative of a problem. The licensee notes that previous test data indicates that each of these pumps would be operating in the "alert" range of OM-6 (> 2.5 V_r to 6 V_r or > 0.325 in./sec.); however, the licensee has provided no discussion of the cause for the high vibration levels being experienced for these pumps other than the lower flow conditions. Increasing the limit for "alert" action might be justified for an interim period (based on the test data included in the submittal) in order to determine the cause of the higher than normal vibration. However, there is no basis for increasing the limit for "required action" to values above those considered acceptable for pump operation without additional information, such as certification from the pump vendor, an analysis indicating that the pump is not degrading by testing at the lower flow rates, etc. Therefore, the proposed alternative for these pumps is unacceptable without additional justification that the pumps

are operating in acceptable condition. The vibration monitoring for the CS pumps and the low pressure injection pumps must be in accordance with the requirements of IWP or OM-6.

The reviewer concluded that based on the incorporation of the 1989 Edition of Section XI in 10 CFR 50.55a(b), the licensee may implement the requirements of OM-6 pursuant to 10 CFR 50.55a (f)(4)(iv) provided all related requirements are met and subject to Commission approval. The NRC has determined that licensee's may implement the vibration monitoring requirements of OM-6 and relief is not required. Related requirements for vibration measurement in OM-6 include Paragraphs 4.6.1, 4.6.4, and 6.1. Whether all related requirements are met is subject to NRC inspection.

The proposed limits for the CS pumps and the low pressure injection pumps have not been justified and are therefore not authorized for implementation pursuant to 10 CFR 50.55a (a)(3)(ii) as requested. The licensee must continue to meet the Code requirements for vibration monitoring of these pumps. If the licensee believes that additional information may support interim approval of increasing the "alert" limit, or may provide a basis for considering these pumps acceptable for continued operation at higher levels, a revised relief request should be submitted including the additional information. The licensee may consider assigning IST limits for the higher flow test as part of a proposed alternative which could verify that the pumps would operate at design basis conditions with lower vibration levels.

Example for Vibration Velocity Measurements from Zion Units 1 and 2

Relief was requested from OM Part 6, ¶ 5.2(d) and Table 2, "Inservice Test Parameters," which states that for vibration measurements, if velocity measurements are used, they shall be peak for the Component Cooling (0CC003 through 7), Containment Spray (1(2)CS001 through 3), Auxiliary Feedwater (1(2)FW004 through 6), Residual Heat Removal (1(2)RH001 and 2), Safety Injection (1(2)SI003 and 4), Service Water (1(2)SW001 through 3), and Charging (1(2)VC006 and 7) pumps.

<u>Alternate Testing:</u>

Vibration measurements will be taken in Root Mean Square (RMS) in lieu of peak. Ranges for all centrifugal and vertical line shaft pumps, except for 1(2)CS003 which are explained in Relief Request PR-04, with pump speed greater than or equal to 600 rpm will be as follows:

Acceptable Range: <2.5 Vr
Alert Range: 2.5 Vr to 6 Vr or .23 in/sec RMS
Required Action Range: > 6 Vr or .49 in/sec RMS

Vr is the vibration reference value in in/sec RMS.

<u>Licensee's Basis for Requesting Relief:</u>

Zion Station proposes to take vibration velocity measurements in Root Mean Square (RMS), as an alternative to measurements being taken in peak. The European standard of reporting vibration measurements is in RMS. The North American standard of measuring vibration is in peak. Experts have written that RMS is a quantity most representative of component condition. Zion has had a long history of monitoring pump vibrations and these past measurements have been in RMS. Zion has found RMS to be an appropriate means for monitoring pump vibration. With RMS, Zion has been able to identify vibration-induced problems with pumps and has taken appropriate corrective actions prior to failure.

There are several attributes to taking vibration measurements in RMS. RMS is a measure of the effective energy used to produce the vibration of the machine. RMS has a direct relationship to the power content of the vibrations. RMS provides a better indication of overall vibration severity since RMS measurements take all vibration peaks into account over a given time period.

Peak measurements are useful for pure harmonic vibration. For other types of vibration, peak measurements may not be as effective because they are based only on the highest instantaneous peak vibration amplitude. Zion's pumps do not experience pure harmonic vibration the majority of the time.

The IST pumps are a small subset of Zion's overall rotating equipment currently monitored as part of Zion's Vibration Program. The Vibration Program currently uses RMS values as the standard measurement parameter for all machines measured.

Conducting future vibration measurements in peak instead of RMS would result in establishing and maintaining 2 different vibration standards. Zion would be required to perform the arduous tasks of administration and implementation of procedure changes (>50); to retrain vibration test personnel to recognize which equipment required RMS and peak; and to monitor through analysis and evaluation 2 sets of data in either RMS or peak for the entire pump/motor combination.

Zion has developed alert and action limits in in/sec RMS calculated with the .707 multiplier. This would provide for the absolute limiting values of the Alert Range >0.23 in/sec RMS in lieu of the >.325 in/sec of Part 6 and the Required Action Range 0.49 in/sec RMS in lieu of the 0.70 in/sec peak. The reference value multipliers of 2.5 and 6 for Alert and Required Action would remain unchanged. Zion Station meets the other requirements for vibration measurements contained in the Code (except for pumps 1(2)CS003 which have the exceptions explained in Relief Request PR-04).

<u>Evaluation</u>

As the licensee stated, the United States standards generally use vibration measurements in peak or peak-to-peak, while European standards use RMS. OM Part 6, ¶5.2(d) requires vibration velocity measurements to be broad band (unfiltered) and peak. The licensee has stated that "Experts have written that RMS is a quantity most representative of component condition," without reference to the "experts." The root-mean-square measurement is the total area beneath the vibratory curve, i.e.,

$$RMS = \sqrt{\frac{1}{T}\int_{o}^{T} v\ (t)^2 dt}$$

It is calculated by a circuit which square the instantaneous amplitude, sums it over time, averages the result, and then computes the square root of that value. The peak measurement is the absolute highest amplitude reading over a given period of time. The issue between using peak or RMS vibration measurements is whether the measurement "should be responsive to non-sinusoidal, high frequency impact excitation (true peak) or to low frequency energy (RMS)." Based on our literature review, there does not appear to be an industry consensus that RMS readings provide a better indicator of pump condition.

RMS is the unit in which electronic instruments measure amplitude of sine waves. The RMS is a measure of the energy content of the sine wave and is equal to 0.707 (sine of 45°) multiplied by the peak (for pure sine waves). Besides sine waves, which are pure tones, there are two other types of vibrations: (1) random, such as tones caused by friction, and (2) shock pulses, such as tones caused by impacts. True peak values may be far greater than 1.414 (1/sine 45°) times RMS. The recently published ASME Guide titled "Vibration Monitoring of Rotating Equipment in Nuclear Power Plants," Part 14 (ASME OMb-S/G-1992, Part 14, "Vibration Monitoring of Rotating Equipment in Nuclear Power Plants"), states that RMS amplitudes "are useful for varying amplitudes but tend to mask impact signals." Vibration consultant James Berry, of Technical Associates of Charlotte, Inc. ("Required Vibration Analysis Techniques and Instrumentation on Low Speed Pumps," J. E. Berry, Technical Associates of Charlotte, 347 North Caswell Road, Charlotte, NC 28204, Second Edition, 1992) states, "The real disparity between true peak and true RMS readings occurs when problems such as rolling element bearing wear, a worn or broken gear tooth, cavitation, rub, or other problems which may involve impact are present. In these cases, the time waveform can show pronounced spikes which tend to smooth out and then reoccur when the impact event takes place. In essence, RMS measurements tend to average the "energy under the curve" whereas true peak or true peak-to-peak measurements will measure the total height travelled." Bentley Nevada, a supplier of peak-to-peak vibration instruments, in a paper titled "Understanding Vibration Measurement" ("Understanding Vibration Measurement," R. Chitwood, *Orbit*, Bentley Nevada, March 1994), "strongly recommends use of the zero-peak measurement...zero-to-peak is synonymous with true peak....Diagnostic instruments need a broadband high speed response to capture as much information from the signal as possible, to provide a machinery diagnostic engineer with the data necessary to diagnose machinery and instrumentation faults."

One source ("A Comparison of Peak and rms for Measuring Vibration," J. S. Mitchell, *Vibrations*, Vol. 3, No. 3/4, December 1987) recommended using both RMS and peak measurements to assess pump condition. "The rule of thumb then is to use either RMS measurements or RMS measurements multiplied by a conversion factor at low frequencies at which damage is largely a function of the energy being put into the system. Use true peak measurements at high frequencies to detect defects that indicate impacts and potential problems". A number of sources ("Required Vibration Analysis Techniques and Instrumentation on Low Speed Pumps," J. E. Berry, Technical Associates of Charlotte, 347 North Caswell Road, Charlotte, NC 28204, Second Edition, 1992; "Understanding Vibration Measurement," R. Chitwood, *Orbit*, Bentley Nevada, March 1994; Goldman, S., *Vibration Spectrum Analysis, A Practical Approach*, Industrial Press Inc., 1991) state that when most analyzers measure vibration, the readings are in RMS and are simply multiplied by 1.414 for converting to peak measurements.

The ASME Operation and Maintenance Code Committees have recently considered the use of RMS in lieu of peak. Section XI, prior to the 1988 Addenda, required that vibration be 'read' in peak-to-peak. This could be interpreted to mean that it is acceptable to measure RMS, convert it to peak-to-peak, and read it as peak-to-peak. OM Part 6 removed this ambiguity and requires vibration to be measured in peak or peak-to-peak. Newer digital equipment now measures directly in peak. The ten-year update required by 10CFR 50.55a of the ISI and IST programs reflects the need for licensees to incorporate new technologies incorporated into the Codes. However, there is continuing debate within the Code committees on whether the use of RMS measurements is acceptable for determining the operational readiness of pumps. A Code inquiry has been submitted (ASME file #OMI94-2). The Code committees have recently clarified the intent of the Code, which is to allow the use of a calculated peak (based on a mathematical conversion of RMS).

Based on the ASME Code interpretation, the use of RMS was considered equivalent to the use of the Code required peak measurements. The alternative was authorized in accordance with 10CFR50.55a(a)(3)(i).

(2) Proposals to Use less Restrictive Vibration Acceptance Criteria

We considered 13 requests that dealt with the use of less restrictive vibration acceptance criteria. Some pump installations have higher vibration levels than other installations because of various factors such as system or driver induced vibrations. At times, these pumps have vibrations that are above the Code alert or required action acceptance criteria. This situation is covered under Section XI, IWP-3210, which states in-part: "If these ranges cannot be met, the Owner shall specify in the record of test (IWP-6000) the reduced range limits to allow the pump to fulfill its function, and those ranges shall be used in lieu of the ranges given in Table IWP-3100-2." However, OM-6 does not permit the owner to expand the Code allowable ranges. The following examples are provided that deal with use of less restrictive vibration acceptance criteria.

Example for Vibration Acceptance Criteria from Quad Cities Units 1 and 2

In this example relief was requested from the pump vibration acceptance criteria requirements of Section XI, Table IWP-3100-2, for the HPCI pumps.

Licensee's Basis for Requesting Relief:

The specific limits assigned to the HPCI pumps are based on extensive experience with these pumps and the inherent high vibration levels associated with pumps of this design. The HPCI pump impellers have been modified to reduce vibration levels (~50%) yet absolute levels remain high. The turbine and pump rotating components have been re-balanced and extensive realignment work has been performed with little overall improvement in vibration levels. The station is confident that the existing vibration levels are not indicative of a degraded condition. Should the station be successful in reducing the vibration levels consistently below 0.300 ips, this relief request will be withdrawn.

Alternate Testing:

Measure pump vibration velocity and apply acceptance criteria with an Alert Range absolute limit of 0.425 in/sec.

Evaluation

The reviewer noted that the vibration acceptance criteria are established so that appropriate corrective actions are taken on pumps with significant degradation. The request seeks relief to measure vibration velocity in lieu of displacement. This is authorized pursuant to 10 CFR 50.55a(f)(4)(iv), provided the licensee implements all related requirements of OM-6. The OM-6 vibration velocity acceptance criteria are given in Table 3a. The absolute limits of OM-6, Table 3a, are set at levels that indicate significant degradation for most pump installations, regardless of the reference vibration value. The licensee proposes to extend the Alert Range absolute limit from 0.325 in/sec to 0.425 in/sec.

The licensee performed extensive analysis and maintenance of this pump installation to reduce the high vibration levels. The HPCI pump impellers have been replaced, the turbine and pump have been re-balanced, and components have been re-aligned. The HPCI pump vibration levels have been

reduced, however, they are still high and the vibration measurements still frequently exceed the Alert Range absolute limit of OM-6, Table 3a. The licensee's analysis indicate that the high vibration levels are due to system configuration and design and that they do not indicate pump mechanical degradation or represent phenomena that could prevent the pump from performing its intended function. The licensee's proposed vibration acceptance criteria should result in corrective action being taken on a pump with significant degradation. Therefore, the proposal should provide an acceptable level of quality and safety.

The licensee proposes to comply with the OM-6 Required Action Range absolute vibration limit. Compliance with the OM-6 Alert Range absolute limit could result in corrective actions being required for a pump that is in good operating condition. Increasing the test interval when the OM-6 Alert Range absolute vibration limit is exceeded would result in additional testing of the pump, which could cause accelerated wear and tear. Increasing the test frequency for a pump that is operating acceptably would be an unusual hardship for the licensee and would not significantly increase the level of quality and safety.

The reviewer concluded that the alternative be authorized pursuant to 10 CFR 50.55a(a)(3)(ii) based on the determination that compliance with the Code would be a hardship without a commensurate increase in the level of quality and safety and considering the proposed testing.

Example for Vibration Acceptance Criteria from Washington Nuclear Unit 2

In this case, relief was requested from the vibration acceptance criteria of OM-6 for the fuel pooling cooling and diesel fuel oil transfer pumps. Less restrictive limits were proposed for these pumps.

<u>Licensee's Basis for Requesting Relief:</u>

Measurement of vibration velocity provides more concise and consistent information with respect to pump and bearing condition. The usage of vibration velocity measurements can provide information as to a change in the balance of rotating parts, misalignment of bearings, worn bearings, changes in internal hydraulic forces, and general pump integrity prior to the condition degrading to the point where the component is jeopardized.

The fuel pool cooling and diesel fuel oil transfer pumps have a history of operating at high vibration levels. These pumps are currently being evaluated by the supply system to try to reduce vibration levels to the OM-6 upper limits. The limits established in Alternate Testing Proposed, Item 4 (of this relief request) will ensure that required action is taken if vibration levels increase, and ensure the pump isn't prematurely declared inoperable. The Supply System will use these higher limits until the vibration is decreased and new limits, or those of OM-6 can be used. These limits are based on a reasonable deviation from the reference valve.

<u>Alternate Testing:</u>

All pumps will be tested at approximately the design flow rate of the pump. Hydraulic parameters will be taken in accordance with ASME Section XI, and the hydraulic acceptance criteria of Section XI will be used. Vibration velocity measurements will be taken at the locations specified in OM-6. Vibration alert levels and required action levels in accordance with OM-6 will be individually established for each pump and will be specified in the surveillance procedures. An exception is for DO-P-1A, -1B, and 2 and FPC-1A, and -1B. The upper limit for vibration velocity for these pumps shall not exceed:

PUMPS	ALERT	REQUIRED ACTION
FPC-1A and -1B	0.55 in/sec	0.7 in/sec
DO-P-1A, -1B, and 2	1.4 in/sec	1.6 in/sec

<u>Evaluation</u>

The reviewer noted that utilizing vibration velocity measurements has been shown to provide better indication of pump degradation. ANSI/ASME OM-6 provides guidelines for measuring vibration velocity and determining the allowable ranges and action levels and has been determined by the NRC to be an acceptable alternative.

The licensee's proposed alternate vibration velocity acceptance ranges for these pumps exceeds those listed in OM-6. These pumps have historically shown high vibration levels at the motor, however, these high levels complicate the process of evaluating the pump's performance and determining operational readiness. Therefore, the licensee's proposed limits do not provide an acceptable long-term alternative. Requiring the licensee to use the OM-6 acceptance criteria might result in prematurely declaring these pumps inoperable, which would be a hardship on the licensee that would not be offset by a compensating increase in quality or safety.

The licensee is currently evaluating these pumps to determine if the vibration levels can be reduced to allow compliance with the acceptance criteria of OM-6. The licensee has also proposed to operate the pumps near pump design flow during testing and to use vibration velocity for evaluating these pumps. This should allow adequate evaluation of operational readiness and provides a reasonable alternative to the Code requirements for an interim period of one year or until the next RFO, whichever is longer. During this period the licensee should evaluate methods for reducing the measured vibration levels to allow use of OM-6 criteria or otherwise adequately evaluating the mechanical condition of these pumps to determine their operational readiness.

Based on the determination that the licensee's proposal provides a reasonable alternative to the Code requirements and that the hardship associated with compliance with the Code requirements would not be offset by a compensating increase in the level of safety, interim relief should be granted for one year or until the next RFO, whichever is longer.

Example for Vibration Acceptance Criteria from Vermont Yankee

In this example relief was requested from the vibration acceptance criteria of OM-6, Table 3, for the HPCI main or high pressure pump. The licensee proposed to perform vibration spectrum monitoring quarterly and to extend the Alert Range absolute limit from 0.325 in/sec to 0.675 in/sec.

<u>Licensee's Basis for Requesting Relief:</u>

Relief is requested on the basis that the proposed alternatives would provide an acceptable level of quality and safety. Past testing and analysis performed on the HPCI system by Vermont Yankee, the pump manufacturer, and by independent vibration consultants has revealed characteristic pump vibration levels which exceed the acceptance criteria stated in Table 3 of OM-6. This testing and analysis meets the intent of Paragraph 4.3 and footnote 1 of OM-6.

The root causes of the higher vibration levels have been determined to be an acoustical resonance in the piping connecting the low pressure and high pressure pumps, and the presence of a

structural resonance in the horizontal direction on the high pressure pump. These resonance conditions are design related and have existed since initial pump installation. They have been documented over a number of years of operating experience. An additional past contributor to the higher vibration levels was the excitation resulting from the blade pass frequency from the previously installed four vane impeller in the low pressure pump. In an effort to reduce/eliminate this effect, the four vane impeller was replaced with a five vane impeller during the 1989 RFO. This replacement significantly reduced vibration levels in both the low pressure and high pressure pumps. However, due to the resonance effects referenced above, the high pressure pump vibration levels remain higher than the acceptance criteria stated in Table 3 of OM-6.

Although existing vibration levels in the high pressure pump are higher than standard acceptance criteria, they are acceptable and reflect the unique operating characteristics of the HPCI pump. It has been concluded that there are no major vibrational concerns that would prevent the HPCI pump from performing its intended function.

Alternate Testing:

To allow for practicable vibration monitoring of the HPCI high pressure pump, alternate vibration acceptance criteria are required. Full spectrum vibrational monitoring will be performed during each quarterly test and the following criteria will be used for the high pressure pump:

Test Parameter	Acceptable Range	Alert Range	Required Action Range
V_v	$\leq 2.5V_r$ but not > 0.675 in/sec	$> 2.5V_r$ to and including $6V_r$ but not > 0.70 in/sec	$> 6V_r$ or > 0.70 in/sec

In addition, the resonance peaks will be evaluated during each test and will have an Acceptable Range upper limit of 1.05 V_r and an Alert Range upper limit of 1.3 V_r.

Evaluation

The reviewer pointed out that vibration acceptance criteria of OM-6, Table 3, are established so appropriate corrective actions are taken on pumps with significant mechanical degradation. The absolute limits are set at levels that signify significant degradation for most pump installations, regardless of the reference vibration value. The licensee proposes to perform vibration spectrum monitoring quarterly and to extend the Alert Range absolute limit from 0.325 in/sec to 0.675 in/sec.

This proposal was previously covered under Section XI, Paragraph IWP-3210, which states in-part: "If these ranges cannot be met, the Owner shall specify in the record of test (IWP-6000) the reduced range limits to allow the pump to fulfill its function, and those ranges shall be used in lieu of the ranges given in Table IWP-3100-2." However, OM-6 does not permit the owner to expand the Code allowable ranges without submitting and receiving approval in a relief request. The licensee has performed extensive analysis of this pump installation and determined that the high vibration levels are due to effects of acoustical and structural resonance. These high levels do not indicate pump mechanical degradation and do not represent phenomena that could prevent the pump from performing its intended function. The licensee's proposed vibration acceptance criteria together with their proposal to perform pump vibration spectrum analysis quarterly, with an Alert Range of 1.05 V_r and a Required Action Range of 1.3 V_r for the resonance peaks, should result in corrective action being taken on a pump with significant degradation. A spectrum analysis measures a narrow vibration band width over a wide frequency range and indicates the frequency and magnitude of

vibration peaks, which permits identification of problems with bearings and other pump mechanical components. The spectrum analysis allows a more comprehensive evaluation of pump condition than the Code required wide range vibration measurements. Therefore, the proposal should provide an acceptable level of quality and safety.

The reviewer recommended that the alternative should be authorized pursuant to 10 CFR 50.55a(a)(3)(i) based on the determination that the licensee's proposal should provide an acceptable level of quality and safety,.

Example for Vibration Acceptance Criteria from Zion Units 1 and 2

In this example, relief was requested from OM-6, Table 3a, which provides vibration amplitude allowed ranges, and Paragraph 6.1, which states corrective action based on Table 3a.

<u>Licensee's Basis for Requesting Relief:</u>

The diesel driven CS Pumps have an inherent higher normal vibration level as compared with other pumps by virtue of their having a reciprocating engine as a pump driver. The reciprocating action of the engine creates vibration transients which are then induced into the pump. These transients cause vibration levels which frequently place the component in the alert range.

The proposed revision of vibration allowable limits allows trending and observation of the subject component, without unnecessarily declaring a component in the alert or action range. This stance is reasonable in light of the fact that Table 3a assigns different values for positive displacement pumps than for centrifugal pumps. Reciprocating (positive displacement) pumps are not required to have an absolute limit for vibration assigned. The parallel reasoning may be easily drawn between pumps and drivers; specifically a reciprocating engine driver (with its reciprocating linear motion and the attendant power strokes) that would generate significantly more vibration than a motor or turbine driven pump.

A detailed study of the vibration and maintenance history of this driver/pump combination has been performed, and no detrimental vibration characteristics have been observed in the pump. Bearings, impeller, shaft and body have displayed no undesirable conditions which can be attributed to vibration. In an effort to mitigate the effects of the diesel engine on the pumps, flexible couplings have been installed but observed vibration levels remain in excess of the alert range absolute value. While observed vibration levels were reduced slightly, no significant improvement was noted.

During evaluation of frequency spectrum plots, the diesel engine displays certain component type-specific frequency characteristics. These characteristics, also appearing in the pump spectrum plot, are unlike those generated by a motor-driven pump of this design. The frequency plot can discriminate between discrete frequencies, so that engine-generated vibration will not mask the vibration characteristics generated by a degraded pump.

The high observed pump vibration levels display frequency characteristics identical to those observed on the diesel engine. The engine supplier has indicated that the current engine vibration amplitudes are acceptable. In addition, the engine shares a common rigid mounting base with the pump. These engine frequency characteristics are attributable to installation-specific driver-induced vibration, and are not considered to be detrimental to proper component or system operation for the following reasons.

While high vibration is certainly a condition to be avoided in any installation, the recorded maintenance and vibration history of this component shows no indication of any induced adverse effects. The observed vibration predominant peak is at a frequency normally associated with misalignment. But this vibration is not attributable to misalignment, since this component has been aligned satisfactorily as evidenced by maintenance records. The possibility of temperature effects on alignment have been addressed. The pump has proven to consistently operate at its normal vibration level independent of component temperature. The other possible causative condition for this type of frequency characteristic is the pump's structural coupling with the diesel engine driver. The frequency characteristics demonstrate that the engine is clearly inducing vibration into the pump.

Vibration levels of a constant amplitude are less detrimental to rotating equipment at lower frequencies than those at higher frequencies. Any vibration thus generated by the diesel engine would be considerably less detrimental to the pump than the high frequency of vibrations normally associated with pump rotating element degradation because of the naturally lower frequency of incidence of the engine vibration. Any incidence of unbalance, misalignment or other detrimental conditions could be detected by spectral analysis and corrected.

A physical solution to high vibration was explored, that of physically splitting the pump/driver base to structurally isolate the pump from the driver. Aside from the physical challenge presented by this modification, significant mechanical and structural re-analyses would be necessitated. These analyses would be prohibitively expensive without a corresponding increase in quality, safety or reliability.

Alternate Testing:

A rigorous preventive maintenance program is proposed whereby the flexible coupling rubber blocks would be removed, examined, compared to previous removals to detect significant changes, and replaced each RFO. This particular item is proposed because the flexible coupling is the power transmission link between the diesel engine and the pump, and would generally be the first physical indication (exclusive of observed vibration levels) of any detrimental engine-induced vibration effects.

Zion Station recommends, for the reasons given in the basis above, that the alert and action range absolute values be deleted and the multipliers of Vr (Vr = vibration reference value) which determine the allowable ranges be reduced to define reasonable allowable ranges (i.e., Alert: >1.2 Vr to 1.5 Vr; Action: >1.5 Vr) for the diesel driven CS Pumps.

Additionally, pump vibration spectrum plots would be recorded each time the required quarterly test is performed. The resultant spectra would be compared to spectra previously obtained and a thorough analysis would be performed on deviations identified. Thus, a realistic trending effort would be undertaken whereby minute changes to pump performance could be evaluated far in advance of any actual degradation. This vibration trending methodology would provide confidence in equipment reliability and exceeds the requirements addressed by Subarticle 5.2.d.

Evaluation

The reviewer noted that OM Part 6, Paragraph 5.1, requires pump vibration to be measured quarterly and compared with corresponding reference values. Deviations from these reference values shall be

compared with the limits given in Table 3a, and corrective actions taken per Paragraph 6.1. OM Part 6 allows for the use of either pump displacement or velocity vibration measurements, and provides acceptance criteria for each. Specific acceptance criteria is provided for both centrifugal and reciprocating (positive displacement) pumps. Centrifugal pumps have an absolute limit for vibration assigned, while reciprocating pumps do not.

The licensee stated that though the CS pump is a centrifugal type pump, because the driver is a reciprocating engine, it may be more appropriate to use the limits for reciprocating pumps, which does not include an absolute limit. International Standard ISO-2372, "Mechanical Vibration of Machines with Operating Speeds From 10 to 200 rev/s-Basis for Specifying Evaluation Standard," 1974 Edition, provides guidance for several classes of machines. For Class VI machine and mechanical drive systems with unbalanced inertial effects (due to reciprocating parts), root-mean-square "velocities of 20 to 30 mm/s (.8 to 1.2 in./sec.) and higher may occur without causing trouble. In addition, if couples are acting, large displacements may be caused at points which are at some distance from the center of gravity. Resiliently mounted (Class VI machines) permit a greater tolerance in this respect." Therefore, the pump/engine unit may operate at a higher level of vibration without detrimental effects.

The licensee indicated that a detailed study of the vibration and maintenance history associated with this pump/driver combination was performed, and no detrimental vibration characteristics were observed in the pump. Bearings, impeller, shaft, and body displayed no undesirable condition which could be attributed to vibration. In an effort to mitigate the effects of the diesel engine on the pumps, flexible couplings were installed, but observed vibration levels remained in excess of the alert range absolute value. While observed vibration levels were reduced slightly, no significant improvement was noted.

If the Code requirements were imposed, the licensee would be required to physically split the pump/driver base to structurally isolate the pump from the base. In addition to the physical changes required to accomplish this, significant mechanical and structural reanalysis would be required. This would present a hardship without a corresponding increase in quality, safety, or reliability. Continuing to test the diesel-driven pump as per the Code, with vibration levels frequently in the alert range, will result in doubling the frequency of the test, which may cause unnecessary wear to the diesel, resulting in a potentially less-reliable diesel-driven pump.

In lieu of the Code requirements, the licensee's proposed rigorous preventive maintenance program (consisting of flexible coupling removal, inspection, and replacement each refueling), coupled with quarterly spectrum analysis, with an alert range defined as >1.2Vr to 1.5Vr, and a required action range defined as >1.5Vr, provides a reasonable alternative. The quarterly spectrum analysis of the quarterly vibration data (including trending of the data to previous data) will provide a comprehensive and sensitive technique of assessing pump condition capable of providing indications of pump degradation. Together, the alternative will provide adequate pump monitoring.

The reviewer recommended that the licensee's alternative be authorized in accordance with 10 CFR 50.55a(a)(3)(ii) based upon the undue burden upon the licensee if the Code requirements were imposed without a corresponding increase in quality and safety, and that the proposed alternative provides a reasonable alternative to assuring the operability of the pump.

(3) Proposals for Measuring Vibration on Vertical Line Shaft Pumps

We considered 11 requests that dealt with measuring vibration on vertical line shaft pumps. The majority of the requests dealt with the location for taking the pump vibration measurements. Section XI does not address this issue. The OM Task Group on Pumps has recently proposed to define "vertical line shaft pumps" as "a vertically suspended pump, where the pump driver and pumping element are connected by a line shaft within an enclosing column which contains the pump bearings, making pump bearing vibration measurements impracticable." OM-6, Paragraph 4.6.4(b), specifies that the vibration measurements for these pumps be taken on the upper motor bearing housing. Because this issue is clearly addressed in OM-6 and rulemaking approved the use of all or portions of OM-6, this should no longer be an issue for IST of these pumps. Therefore, no examples of these requests are included.

(4) Vibration Instruments That Do Not Meet the Code Frequency Response Limits

We considered 8 requests that dealt with vibration instruments that do not meet the Code frequency response limits. Some pumps operate at very slow speeds, therefore it is difficult to procure vibration instruments that meet the Code frequency response requirements. The OM committee changed the frequency response range requirements from one-half to one-third of the minimum pump shaft rotational speed in order to encompass all noise contributors that could indicate degradation. Instruments with a frequency response range which meets these requirements for slow-speed pumps may be commercially available but not widely used. The unavailability of instruments, alone, is not adequate justification for obtaining relief or approval of an alternative, but may be a major element of the justification. Additionally, frequencies less than running speed may not be indicative of problems for certain types of bearings; however, subharmonic frequencies may be indicative of rotor rub, seal rub, loose seals, and coupling damage. The type of bearings and the other subharmonic concerns should be discussed in the justification for relief.

3.6 Instrumentation Accuracy and Full-Scale Range

The currently approved pump testing Codes require that instruments used for IST of safety-related pumps meet specified limits for accuracy and full-scale range. Many plants have instruments that for one reason or the other do not meet the specified requirements for accuracy, full-scale range, or both. Instrument accuracy and full-scale range limits are important to ensure that pump IST obtains measurements that permit the detection of pump degradation. It is important to detect pump degradation during IST so a pump with significant degradation can be repaired prior to the pump degrading to the point where there is the likelihood that it will not be capable of performing its safety function if called on to do so to mitigate the consequences of an accident.

Instrument inaccuracy results in uncertainty in the test measurements. This data scatter may be sufficient to mask changes in pump capability that is indicative of degradation. Excessive uncertainty can also result in deviations in test data that is not due to pump degradation, which could result in false positive test results. The problem can be exacerbated when the data scatter due to instrument inaccuracy is sufficient that the Owner relaxes the acceptance criteria as allowed by IWP-3210. Data scatter in conjunction with expanded allowable range limits may make detection of pump degradation prior to catastrophic failure unlikely. Both of these situations are problematic and may be costly to the licensee. In the case of false positive test results, the licensee could be required to perform corrective action on a non-degraded pump. This may require the licensee to remove the pump from service, which might result in the plant entering an LCO Action Statement, and perform costly

maintenance activities. In cases where degradation is masked by instrument inaccuracy, a degraded pump could remain in service, even though its ability to perform its safety function in the event of an accident may be compromised.

There are many possible reasons why plant instruments do not meet the Code requirements. Some examples are: the system design does not have the necessary straight run of piping, an instrument is exposed to operating conditions that could over-range an instrument that meets the Code range requirements, the loop accuracy of all elements exceeds the limit, and the sensor cannot be calibrated to the required accuracy at the necessary frequency range.

Requirements

IWP-4110 states that instrument accuracy must be within the limits of Table IWP-4110-1. Table IWP-4110-1 specifies an accuracy of ±2 percent of full-scale for the pressure, flow, and speed instruments and ±5 percent of full-scale for the temperature and vibration instruments. OM-6 and ISTB require an accuracy of ±2 percent for instruments used for pressure, flow, and speed measurements and ±5 percent for the vibration instruments. These accuracies are percent of full-scale for analog instruments, percent of the reading over the calibrated range for digital instruments, and percent of total loop accuracy for a combination of instruments. ISTB-1995 requires the same accuracy for Group A and Group B tests, but requires an accuracy of ±.5 percent for instruments used for pressure measurements for the comprehensive and preservice tests. Section XI requires each instrument to have a full-scale range of 3 times the reference value or less. The OM Code states that the full-scale range of each analog instrument shall not be greater than 3 times the reference value. The OM Code further requires that each digital instrument be such that the reference values do not exceed 70 percent of the calibrated range of the instrument. However, the OM Code exempts vibration instruments from these full-scale range requirements.

Table 3-8. Summary Table of Key Requirements and Guidance on Instrument Accuracy and Range

Document	Section	Requirement/Guidance
Section XI	IWP-4110	Accuracy of ±2 percent of full-scale for pressure, flow, and speed instruments and ±5 percent of full-scale for temperature and vibration instruments.
OM-6	4.6.1.1	Accuracy of ±2 percent for pressure, flow, and speed instruments and ±5 percent for vibration instruments. Accuracies are percent of full-scale for analog instruments, percent of the reading over the calibrated range for digital instruments, and percent of total loop accuracy for a combination of instruments.
ISTB-1995	ISTB 4.7.1	Group A and Group B tests - same as for OM-6 above. Comprehensive and Preservice tests - same as for OM-6 above except an accuracy of ±0.5 percent for instruments used for pressure measurements.
Section XI	IWP-4120	The full-scale range of each instrument shall be three times the reference value or less.

Document	Section	Requirement/Guidance
OM-6	4.6.1.1	The full-scale range of each analog instrument shall not be greater than three times the reference value. Digital instruments shall be selected so that the reference value does not exceed 70 percent of the calibrated range. Vibration instruments are exempt from the above range requirements.
NUREG 1482	5.5.1	The range of an installed instrument may be greater than 3 times the reference value if the instrument is more accurate than required and the combination of range and accuracy yields a reading at least equivalent to the reading achieved from instruments that meet the Code requirements.
NUREG 1482	5.5.2	When using digital flow and pressure instruments, follow the accuracy and range requirements of OM-6 even if the Code of record is Section XI. Relief need not be requested from IWP if the requirements of OM-6 are met.
NUREG 1482	5.5.3	When the inlet pressure is determined by some means other than direct pressure measurement, the reading scale and the calculational method must yield an accuracy within ±2 percent.
NUREG 1482	5.5.4	The accuracy of analog instruments applies only to the calibration of the instrument. However, when test results indicate a change, the staff recommends that the Owner consider phenomena that could affect the indication other than pump degradation.

Relief Request Issues

Instrument issues were involved in fifty-two of the pump relief requests examined for this report. Eighteen requests in this group deal mainly with instrument accuracy issues, twenty-five deal mainly with instrument range issues, and the issue is both instrument accuracy and range in the remaining ten requests. Instrument range and accuracy are closely related and both are stipulated by the Code to ensure that the Code measurements provide data that can be used to detect pump degradation. Instrument full-scale range for analog instruments is a concern because the instrument accuracy is specified as a percentage of full-scale range. For analog instruments of the same percentage accuracy, the instruments with higher full-scale range will have greater inaccuracy or uncertainty of the indication. For example, an instrument with an accuracy of ±2 percent of the full-scale range with a range of 0 to 100 psig will yield readings with an uncertainty of ±2 psig, while a ±2 percent accurate instrument with a range of 0 to 200 psig will have a reading uncertainty of ±4 psig.

Major Issues:

a) flow rate instruments that do not meet the Code accuracy requirements (see Item 1);
b) digital instruments that do not meet the Code accuracy requirements (see Item 2);
c) how is the accuracy of flow calculations based on measurements of associated parameters related to the Code accuracy requirements (see Item 3);
d) instruments that do not meet the Code full-scale range requirements (see Item 4);
e) inlet pressure instruments used for d/p determination under OM-6 that do not meet the Code full-scale range requirements (see Item 5);

f) vibration instruments that do not meet the Code full-scale range requirements (see Item 6);
g) digital instruments that do not meet the Code full-scale range requirements (see Item 7).

These major issues are discussed in the following sections of the report.

(1) Flow Rate Instruments that do not Meet the Code Accuracy Requirements

For some pump installations, the only instruments available for measuring pump flow rate do not meet the accuracy requirements of the applicable Code. Since flow rate and dp (discharge pressure for positive displacement pumps) are used to evaluate pump hydraulic performance, accurate flow rate measurements are essential for IST. Excessive flow instrument inaccuracy can result in measurements with a high level of uncertainty that can give either false indication of pump degradation or mask actual degradation In cases where there is an excessive amount of measurement uncertainty, licensees frequently relax the acceptance criteria to reduce the number of false positive test results. Relaxing test acceptance criteria can further reduce the ability of the testing to detect pump degradation, therefore, the appropriate corrective actions may not be taken prior to pump failure.

Example From H. B. Robinson Unit 2

The licensee requested relief from the Section XI instrument accuracy requirements for the flow rate instrumentation for all safety related pumps listed in the H. B. Robinson IST program. The licensee proposed to utilize ultrasonic flow instruments that are accurate to ±3% of the indicated flow rate.

<u>Licensee's Basis for Requesting Relief</u>:

The majority of H. B. Robinson Unit 2 systems do not have instrumentation installed that will measure flow rates. The licensee will use ultrasonic equipment to measure flow rates in accordance with the Code. Manufacturer specifications for the ultrasonic equipment quote an intrinsic accuracy of 1-3%. IWP-4110 requires flow rates to be measured with an accuracy of ±2% of full scale. From discussions with the manufacturer and from previous experience in use of ultrasonics for flow measurement, the licensee anticipates highly accurate results. The licensee will require an accuracy of ±3% when employing ultrasonics. The benefits of a possible ±1% increase in accuracy for an internally installed instrument over the ultrasonics would not warrant the expense of many plant modifications. Furthermore, use of externally mounted ultrasonic transducers will preclude incidence of problems inherently associated with an internally installed measurement device e.g., increased system resistance, flow obstruction, inoperability of system for maintenance or repair. The licensee requests generic relief to employ ultrasonics with a required accuracy of ±3% for all Section XI pumps as desired.

<u>Alternate Testing</u>

The ultrasonic equipment, which is accurate to ±3% at any point on the calibrated range, will be utilized to measure flow rates for all Section XI pumps as desired.

<u>Evaluation</u>

The reviewer stated that the Code required instrument accuracy for flow instruments is ±2 percent of the full-scale range. The ±3 percent accuracy of the proposed instruments does not meet the Code requirement, however, it is at least as accurate as a reading obtained from analog instruments that meet the Code requirements (i.e., up to ±6 percent of the reference value, see Section 5.5.1 of

NUREG 1482). Although the licensee doesn't specifically indicate that the proposed ultrasonic flow instruments have digital indication, they did state that the accuracy was based on the indicated reading which is normally the case for digital instruments. In addition, most ultrasonic instruments are digital. Section 5.5.2 of NUREG 1482 states that since Section XI does not specify requirements for digital instruments, the requirements of OM-6 should be applied to these instruments. OM-6 requires digital instruments to be accurate to ±2 percent of the reading over the calibrated range and for reference values not to exceed 70 percent of the calibrated range. The proposed alternative does not meet the guidance of the NUREG 1482 discussion.

The proposal to utilize ultrasonic instruments accurate to ±3 percent of the indicated reading may provide measurements that are sufficiently repeatable to monitor pump condition and detect hydraulic degradation. However, it was determined that insufficient information is provided in this relief request for a determination of the long term acceptability of the licensee's proposal, therefore, interim relief was granted for one year or until the next RFO, whichever is longer. Long term relief could be granted in this type of situation if additional information is provided in the request. The in-situ accuracy and repeatability of these instruments in each system application should be specified. Procedures and controls should be established that permit measurements sufficiently repeatable to allow detection of pump degradation. The request should also indicate if the flow measurements are sufficiently repeatable to use the Code allowable ranges or if expanded ranges are specified by the licensee.

The Code does not define or provide criteria for the repeatability of instrumentation. However, in situations where portable instrumentation is used, repeatability can be an important factor. If there is significant data scatter of the test measurements so the allowable ranges of Code cannot be applied, it is questionable that the measurements are sufficiently repeatable to detect pump degradation. The NRC issued Information Notice 95-008, "Inaccurate Data Obtained With Clamp-On Ultrasonic Flow Measurement Instruments," on January 30, 1995, to inform licensees of certain problems with these measurement devices.

Example From Salem Units 1 and 2

In this example the licensee requested relief from the Section XI instrument accuracy requirements for the flow rate instrumentation for the chilled water pumps. The licensee proposed to utilize the existing flow instruments that are accurate to ±3 percent of the instrument full-scale range.

<u>Licensee's Basis for Requesting Relief</u>:

At present, flow measurement for the chilled water pumps 11, 12, 21, and 22 is taken using an instrument which is calibrated to an accuracy of 3%. The existing instrumentation is a Fischer Porter rotameter, which can only be calibrated to 3% accuracy. The test flow rate specified in the pump test procedure is the pump design flow. This flow is 18% greater than the system design flow requirements. The additional 1% inaccuracy from the flow meter would reduce the excess flow margin to approximately 17%. The reduction in flow margin will not impact the ability of the pumps to perform the required safety function. Past pump data has been reviewed assuming the larger tolerance. No operability concerns were noted.

<u>Alternate Testing</u>:

Use the existing flow instrumentation.

Evaluation

It was determined that the licensee did not show that the proposal provides a reasonable long-term alternative to the Code. Therefore, interim relief was granted for one year or until the next RFO. More information is needed to fully assess the proposal and grant long-term relief. The licensee should describe the in-situ instrument accuracy and/or repeatability and evaluate the suitability of the acceptance criteria. The licensee indicated that past test data was reviewed considering the reduced accuracy of the installed instruments and that no operability problems were noted. However, the operability requirements identified in plant TS, are typically based on system requirements, such as the minimum rate of cooling flow needed to a cooler. The TS operability requirements are not intended to evaluate degradation of a specific component and might not be appropriate in that capacity. Therefore, the absence of system operability problems might not indicate the satisfactory condition of a pump whose capacity exceeds system requirements.

Example From Millstone Unit 1

The licensee requested relief from the OM-6 instrument accuracy requirements for the flow rate instrumentation for the feedwater coolant injection pumps. The licensee proposed to utilize the existing 3 to 5 percent accurate flow instruments until cycle 15 RFO after which they will use upgraded flow instruments that are accurate to approximately ±2.9 percent of the reading.

Licensee's Basis for Requesting Relief:

The flow measurement equipment configuration currently installed has analog indicators and does not allow for a loop accuracy of 2%. The current loop accuracy is between 3 - 5%. However, during the cycle 14 RFO (RFO), MP1 (Millstone Plant, Unit 1) is performing control room design reconstruction which will replace the feedwater instrumentation with digital flow indicators with 0.25% accuracy which will increase the loop accuracy to less than 3%. This accuracy is not significantly outside the code limit of 2% and will provide repeatable test results to facilitate detection of pump degradation.

Alternate Testing:

Use existing instrumentation with an accuracy of 3 - 5% until the digital equipment installation is completed during the cycle 15 RFO. Use upgraded flow measurement equipment with an accuracy of ≈ 2.9% once installed.

Evaluation

The reviewer determined that the licensee did not show that the proposal provides a reasonable long-term alternative to the Code. Therefore, interim relief was granted for six months. More information is needed to fully assess the proposal and grant long-term relief, if needed. In cases where an instrumentation loop consisting of a combination of analog instruments is used, the accuracy should be interpreted to be the loop accuracy, which represents the accuracy of the final measured value obtained from the loop. As clarified in OM Code Interpretation (IN) 91-3, issued May 14, 1991, the accuracy requirements apply only to the calibration of the instruments, and attributes such as orifice plate tolerances, tap locations, and process temperatures are not to be included in the determination of loop accuracy. In consideration of this guidance, a review of the loop accuracy and the calibrated range for the digital instruments being installed may indicate that relief is not necessary for flow rate instrument accuracy in this case.

If relief is still necessary, the actual instrument accuracy and/or repeatability should be described in the request. In addition, the licensee would have to determine if meaningful test results can be obtained, and if necessary, adjust the acceptance criteria to account for instrument inaccuracies.

Example From Braidwood Units 1 and 2

In this example the licensee requested relief from the Section XI instrument accuracy requirements for the flow rate instrumentation for the component cooling and essential SW pumps. The licensee proposed to utilize ultrasonic flow instruments that are accurate to ±4 percent over the calibrated range.

<u>Licensee's Basis for Requesting Relief</u>:

Ultrasonic flowmeters provide an accurate means of measuring flow rate. They utilize a digital display whose accuracy is independent of the full-scale range. The ultrasonic flowmeter is well within the requirements of IWP-4110 and IWP-4120, which refer to an instrument accuracy of ±2% of full-scale for an instrument with a range of three times the reference value or less. The following examples will illustrate this point. The CC pumps have a reference value of approximately 4500 gpm. Using the Code requirements, an instrument with a full-scale range of 13,500 gpm (3 x 4500 gpm), the acceptable instrument accuracy is ±270 gpm (.02 x 13500 gpm). Using the ultrasonic flowmeter, with an accuracy of ±4% of the indicated reading, provides an instrument accuracy of ±180 gpm (.04 x 4500 gpm). Use of an ultrasonic flowmeter, with totalizer and integrator feature, instead of other instruments allowed by IWP-4110 and IWP-4120, will provide more precise and accurate flow measurements.

<u>Alternate Testing</u>:

Ultrasonic flowmeters, with digital readouts and totalizer features will be utilized to obtain Section XI flow data.

<u>Evaluation</u>

In this example the licensee's basis for relief is based on the ultrasonic instruments being more accurate than readings from analog instruments that meet the Code requirements (i.e., ±6 percent of the reference value). This discussion is similar to the NRC guidance in NUREG 1482, Section 5.5.1. However, the proposal is not in accordance with the NRC guidance regarding digital instruments in NUREG 1482, Section 5.5.2. This section states that digital instruments should meet the requirements of OM-6, which specifies that digital instruments must be accurate to ±2% over their calibrated range. The proposal to utilize ultrasonic instruments accurate to ±4% of the indicated reading may provide measurements that are sufficiently repeatable to monitor pump condition, detect degradation, and take corrective actions at the appropriate level. However, the repeatability of these portable instruments is not known and there could be significant data scatter of the test measurements. Therefore, the licensee should either demonstrate that these instruments provide adequate repeatability or they should develop a method to compensate for the additional 2% inaccuracy when evaluating these pumps. One possible method of accounting for the additional uncertainty would be to add 2% onto measurements above the reference value and subtract 2% from measurements below the reference value when comparing to the allowable ranges of flow rate.

Summary and Additional Comments

Relief may be granted for cases where the flow instruments used for IST do not meet the Code requirements. The following should be considered when developing relief requests for these cases:

(1) The installed or available instruments cannot be calibrated to the Code accuracy requirements.
(2) The in-situ accuracy and/or repeatability of the installed or available instruments in each system application is specified.
(3) Procedures and controls are established that permit measurements sufficiently repeatable to allow monitoring pump operational readiness and detection of pump degradation.
(4) Application of instruments that meet the Code requirements would necessitate one or more of the following activities: a) purchase of new instruments, b) system modifications to install the instruments, c) system modifications to achieve a piping configuration that allows accurate instrument indication, and/or d) modifying test procedures to accommodate new instruments. These changes are shown to be a hardship without a compensating increase in the level of quality and safety.
(5) The Code allowable ranges are utilized to evaluate the pump hydraulic parameter measurements or these ranges are tightened to account for increased instrument inaccuracies, as appropriate.
(6) The relief request should provide information for each instrument that does not meet the Code requirements.

Licensees submitting requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

(2) Digital Instruments that do not Meet the Code Accuracy Requirements

In some pump installations, the instruments available for measuring pump parameters are digital instruments that do not meet the accuracy and/or range requirements of the Section XI Code. Digital instruments are different in several ways from analog instruments. The analog instruments are read using a scale with divisions at intervals based on the full-scale range and the size of the gauge face. These instruments are susceptible to reading variations due to subjective interpretation and parallax induced errors. Digital instrument indications are precise with small intervals and are not subject to reading variations. While most analog instruments have a fixed scale and have their accuracy specified as a percentage of the full-scale range, most digital instruments can indicate over a wide range, using linear response or multiple overlapping scales, and have their accuracy specified as a percentage of any reading within the calibrated range. Because of these differences, the requirements for analog instruments should not be applied to digital instruments. Section XI does not specify requirements for digital instruments, however, requirements are provided for these instruments in OM-6. The guidance of Section 5.5.2 of NUREG 1482 states that the requirements of OM-6 should be applied to digital instruments. OM-6 requires digital instruments to be accurate to ± 2 percent of the reading over the calibrated range and for reference values not to exceed 70 percent of the calibrated range.

Excessive instrument inaccuracy can result in measurements with a high level of uncertainty that can give either false indication of pump degradation or mask actual degradation In cases where there is an excessive amount of measurement uncertainty, licensees frequently relax the acceptance criteria to reduce the number of false positive test results. Relaxing test acceptance criteria can further reduce

the ability of the testing to detect pump degradation, therefore, the appropriate corrective actions may not be taken prior to pump failure.

Example From H. B. Robinson Unit 2

The licensee requested relief from the instrument accuracy and full-scale range requirements of the Code, Paragraphs IWP-4110 and -4120, for digital instruments used for testing safety related pumps in the IST program. The licensee proposed to use digital instrumentation with an accuracy of ±3% or better at any point of the calibrated range.

Licensee's Basis for Requesting Relief:

Digital instrumentation generally does not have a defined upper-end to their scale like analog instrumentation, they usually go to infinity. The digital instrumentation used at H. B. Robinson has been demonstrated by calibration to have an accuracy of ±3% or better at any point on their scale in lieu of the Code required ±2% of full scale. The ±3% accuracy at any point on the scale converts to an absolute accuracy equal to or better than the code required ±2%. For example, using a pressure reference of 100 psi and an actual full scale range of 300 psi.

(a) Code
3 x reference value of 100 psi = 300 psi
instrument accuracy, 2% x 300 psi = ±6 psi

(b) H. B. Robinson
reference value = 100 psi
instrument accuracy at point where reading is taken = 3% x 100 psi = 3 psi.

As demonstrated above, the utilization of digital instrumentation which is calibrated to ±3% or better at any point on the scale would exceed the accuracy requirements of Section XI. Using the digital instruments would also eliminate the need to maintain the wide range of analog instruments presently required for various pump tests.

Alternate Testing: Digital instrumentation, when utilized for Section XI pump testing, will be required to be calibrated to an accuracy of ±3% or better at any point of the calibrated range.

Evaluation

The reviewer noted that digital instruments do not have indication scales or graduations and are equally accurate for all readings over wide ranges. Therefore, the full-scale range requirements of IWP-4120 are not appropriate for these instruments when they are used for measurements within their calibrated range. Since the indication readability for digital instruments over their specified range is equivalent or better than analog instruments, the O&M Code does not specify a range limit for these instruments. The only range restriction for digital instruments is that the reference value cannot be greater than 70 percent of their calibrated range. These instruments, as well as all others, should be used in accordance with the operating instructions provided by the instrument manufacturer.

IWP-4110 specifies that the instruments (both analog and digital) used for IST measurements be accurate to ±2 percent of the full-scale range for pressure, flow, and speed and accurate to ±5 percent of the full-scale range for vibration. Since applying these accuracy limits over the full-scale

range is not appropriate for digital instruments, OM-6 specifies that digital instruments meet these accuracies over their calibrated ranges. Digital instruments that meet the OM-6 requirements would be more accurate than analog instruments that meet the Code requirements. It is advantageous and desirable to utilize the most accurate instruments possible for IST to minimize uncertainty and permit more reliable determination of degradation. Factoring the maximum allowable instrument full-scale range of IWP-4120 with the minimum allowable instrument accuracy of IWP-4110 produces a worst case criteria for instrument quality. It is not desirable that this worst case combination be utilized to justify the use of less accurate instruments for IST.

The reviewer concluded that the licensee did not indicate the specific applications where these digital instruments might be used. Further, they have not indicated if the currently utilized test instruments in these applications provide more accurate measurements of the test parameters. It may not be appropriate to permit the use of instruments that do not meet the Code accuracy requirement when more accurate instruments are available for pump testing. Therefore, general relief was not granted for this request. For specific applications where the digital instruments provide more accurate and repeatable measurements than the currently used test instruments, the use of these digital instruments should be acceptable. However, if there is significant scatter of the test measurements so the allowable ranges of Table IWP-3100-2 cannot be applied, it is questionable that the measurements are sufficiently repeatable to detect pump degradation and use of the instruments may not be acceptable. To obtain relief for this case, a request would have to be resubmitted that documents the specific applications where digital instruments that are less accurate than the Code requirements are to be used.

<u>Summary and Additional Comments</u>

Relief may be granted for cases where the digital instruments used for IST do not meet the Code requirements. The following should be considered when developing relief requests for these cases:

(1) The installed or available instruments cannot be calibrated to the Code accuracy requirements.

(2) The in-situ accuracy and/or repeatability of the digital instruments in each system application is specified.

(3) Procedures and controls are established that permit measurements sufficiently repeatable to allow monitoring pump operational readiness and detection of degradation.

(4) Application of instruments that meet the Code requirements would necessitate one or more of the following activities: a) purchase of new instruments, b) system modifications to install the instruments, c) system modifications to achieve a piping configuration that allows accurate instrument indication, and/or d) modifying test procedures to accommodate new instruments. These changes are shown to be a hardship without a compensating increase in the level of quality and safety.

(5) The Code acceptance criteria are utilized to evaluate the test parameter measurements or these ranges are tightened to account for increased instrument inaccuracies, as appropriate.

Licensees submitting requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

(3) Accuracy of Flow Calculations Based on Measurements of Associated Parameters

Some system configurations do not permit direct measurement of pump flow rate. In many of these cases, the flow rate is calculated from other parameters, such as the change in tank level over time. Since this method uses equipment other than a single flow instrument to determine pump flow rate (e.g., a level instrument and a stop watch), it is unclear how to apply the instrument accuracy and full-scale range requirements of the Code.

Sometimes the readings used to calculate flow rate are obtained from local observations instead of measurements taken from a calibrated instrument (e.g., observing the water level on a scale mounted on the side of the intake structure). It is difficult to determine the accuracy of these types of measurements, the scale may be accurate, but there may be fluctuations due to wave action that make accurate measurements difficult. Likewise, a stop watch could be extremely accurate, however, the operators response time in turning a pump on and off in conjunction with the stop watch may result in test variation and uncertainty. Because of these concerns, these methods should be used only when direct readings are impractical. These indirect methods should also be carefully controlled to ensure good repeatability, such that the test results are sufficiently sensitive to pump condition to allow detection of degradation.

Example From Hatch Units 1 and 2

The licensee requested relief from the required instrument accuracy and minimum five minute run time for the SLC pumps in accordance with the requirements of Section XI, Table IWP-4110-1 and Paragraph IWP-3500, and proposed to calculate flow rate and run the pumps for two minutes during quarterly testing.

Licensee's Basis for Requesting Relief: Instrumentation was not provided during construction to measure the required flowrate. Also, due to the size of the test tank, the required 5 minute test cannot be met.

Alternate Testing: The system is aligned so that it forms a closed loop through the test tank. Flow is recirculated through the pump and tank until conditions stabilize, and then the system is realigned to perform the testing described below. Flowrate is measured by the change in the standby liquid control (SBLC) test tank level during a two minute test period. The SBLC is aligned so that each pump takes suction from a demineralized water source and discharges through a throttle valve adjusted to obtain a reference discharge pressure. The level of the test tank is then measured and the pump is run for two minutes. After the two minute run, the tank level is again measured. Flowrate is then determined by the following equation.

$$\text{Flow (gpm)} = \frac{\text{differential tank level (in.)} \times 4.91\ \text{gal/in.}}{2\ \text{min.}}$$

For a situation in which the flowrate is measured by instrument, a 0-100 gpm instrument would normally be used for the SBLC pump flowrate of approximately 43 gpm. The required accuracy of this instrument would be ± 2 percent or ± 2 gpm. This corresponds to a ± 0.4 inch/min water level in the test tank. Therefore, the accuracy of the measured flowrate should be well within Code allowance.

Evaluation

This request was approved pursuant to (a)(3)(i), because it was determined that the proposed alternative of calculating pump flow accurate to at least ±2 percent should provide an acceptable level of quality and safety. Due to system design, there are no instruments installed to measure pump flow directly, however, the flow rate can be readily obtained by measuring the level change of the test tank over a period of time. This method of indirect measurement should provide sufficiently accurate and repeatable data to use in monitoring pump degradation.

The guidance in NUREG 1482, Section 5.5.3, "Use of Tank or Bay Level to Calculate Differential Pressure," recommends that when inlet pressure cannot be directly measured that it may be determined by measuring the bay or tank level above the pump suction provided that the reading scale for measuring level and the calculational method yield an accuracy within ±2 percent. This NUREG does not directly address flow rate calculations, however, the technique is similar for flow rate calculations and OM-6 permits pump flow rate to be determined. Therefore, applying the guidance in NUREG 1482, Section 5.5.3, recommendations to the flow rate calculations should be acceptable. The NUREG considers that the calculational methods meet the Code and guidance may be used without relief requests provided that the method is included in the implementing procedure and meets quality assurance requirements.

Summary and Additional Comments

Relief may not be necessary for cases where the flow rate is determined based on changes in tank level over the pump operating time if the criteria identified in NUREG 1482 are met. Relief would be necessary if these NUREG conditions are not met or if there are other issues involved as in the preceding example. The following should be considered when developing a test procedure and/or relief requests for these cases:

(1) There are no instruments installed or available for test measurements that can be calibrated to the Code accuracy requirements.
(2) The in-situ accuracy and/or repeatability of the reading scale and calculational method in each system application is specified and yields an accuracy of ±2 percent.
(3) Procedures and controls are established that permit measurements and calculations sufficiently repeatable to allow monitoring pump operational readiness and detection of degradation.
(4) The calculational method and test procedure meet quality assurance requirements.
(5) If Items 2, 3, and 4 are not met, the testing cannot be considered to be equivalent to the Code and it must be demonstrated that installing instruments that meet the Code requirements is a hardship without a compensating increase in the level of quality and safety.
(6) The Code acceptance criteria are utilized to evaluate the test parameter measurements or these ranges are tightened to account for increased instrument inaccuracies, as appropriate.

Licensees submitting requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

(4) Instruments that do not Meet the Code Full-Scale Range Requirements

For some pump installations, the only instruments available for measuring pump test parameters do not meet the full-scale range requirements of the applicable Code. Many times the instrument range

is established to prevent damage during expected system operating modes. Instrument full-scale range for analog instruments is a concern because the instrument accuracy is specified as a percentage of full-scale range. For analog instruments of the same percentage accuracy, the instruments with higher full-scale range will have greater reading inaccuracy. Excessive instrument inaccuracy can result in measurements with a high level of uncertainty that can give either false indication of pump degradation or mask actual degradation.

Example From Arkansas Nuclear One, Unit 2

This example requested relief from the full-scale range requirements of Section XI, Paragraph IWP-4120, for the flow rate instruments used to test the charging pumps. The licensee proposed to measure pump flow rate using the installed flow rate instrument with a full-scale range of 150 gpm.

<u>Licensee's Basis for Requesting Relief:</u>

The normal charging pump flow for a single pump is 44 gpm. The flow instrumentation for the charging pumps is in an injection header that all three pumps tie into. The range for this instrumentation is 0-150 gpm. The full-range for this instrumentation is slightly more than the three times reference value. In an emergency boration condition, all three pumps would be operating concurrently, injecting 132 gpm through this common header. Thus, the flow instrumentation is sized correctly for the intended safety function of the charging pumps. The installed instrumentation provides accurate repeatable data and has detected pump degradation. To install flow instrumentation in each charging pump header would constitute a backfit.

<u>Alternate Testing:</u>

None.

<u>Evaluation</u>

This request was approved pursuant to 10 CFR 50.55a(a)(3)(ii) for an interim period only. It was determined that the request did not provide sufficient information to justify granting long term relief from the Code full-scale range requirements. The proposed alternate was judged to provide an adequate assessment of pump operational readiness during an interim period of one year or until the next RFO. Requiring the licensee to install instruments that meet the Code full-scale range requirements immediately was thought to be a hardship without a compensating increase in the level of quality and safety.

The licensee did not provide information on the installed instrumentation with the detail necessary to completely evaluate this request for relief. Long term relief should not be granted for instrumentation that may not be sufficiently accurate or repeatable to assess pump condition. To obtain long term relief, it is necessary to specifically address the instrument data (accuracies, reference values, and ranges) and demonstrate that it is adequate to detect pump degradation. Additionally, this relief request should identify the burden of using test or portable instruments that meet the Code requirements. The NRC does not consider that the installation of flow instrumentation is a backfit unless it requires considerable piping modifications (see response to Question 105 in Minutes of Public Meetings on Generic Letter 89-04).

In a revised relief request, more information on the installed instrument accuracy and range and on the reference values was provided. To date, the NRC has not completed a review of the revised request.

Example From Cooper Unit 1

The licensee requested relief from the full scale range requirement of IWP-4120 when measuring the speed of the reactor core isolation cooling (RCIC) pump/turbine. Hand-held tachometers that are more accurate than required by the Code will be used.

<u>Licensee's Basis for Requesting Relief:</u>

Based on previous work history, permanent plant tachometer, RCIC-SI-3067, for the measurement of RCIC pump/turbine speed, may not provide the required consistency needed for IST unless calibration is performed immediately prior to each test. Performing such calibration places an additional burden on limited personnel resources. Hand-held tachometers have proven to be more reliable instruments. The tachometers available to be used for IST have ranges of 10-99,999 rpm or 6-30,000 rpm. The reference rpm of the pump in question is 4500 rpm. Therefore, the range limitation imposed by IWP-4120 of 3 times the reference value (13,500 rpm) is not met by these hand-held tachometers.

However, the accuracy of the 10-99,999 rpm tachometer is ±9 rpm. An instrument accuracy of ±9 rpm on a full range of 0-13,500 rpm would be ± 0.07% of full range which is better than the accuracy of ± 2% required by IWP-4110. For the 6-30,000 rpm tachometer, the accuracy is ± 99 rpm (i.e., ± 0.73% accuracy on a range of 0-13,500 rpm), which is also better than the accuracy required by the Code. Therefore, the proposed ranges and accuracies result in measurement with accuracies better than Code requirements and will provide reasonable assurance of component operational readiness.

<u>Alternate Testing:</u>

As an alternative to meeting the requirements in IWP-4120, RCIC pump/turbine speed will be measured with available tachometers with accuracies as specified above.

<u>Evaluation</u>

This request was approved pursuant to 10 CFR 50.55a(a)(3)(i). It was determined that the proposed alternative provides an acceptable level of quality and safety. The licensee's proposal, involving the use of hand-held tachometers for the measurement of RCIC pump/turbine speed, does not meet the full scale range requirement of IWP-4120. However, the accuracies of these tachometers are better than the accuracy required by the Code. The higher accuracies of the instruments will in effect provide an acceptable indication of pump speed.

The licensee did not indicate whether the hand-held tachometers are analog or digital instruments. If they are digital instruments, different requirements should apply since NUREG 1482, Section 5.5.2, states that the requirements of OM-6 should be applied to digital instruments. OM-6 requires digital instruments to meet the accuracy requirements of Table 1 over their entire calibrated range. The only range requirement for digital instruments is that the reference value must not exceed 70 percent of the instrument's calibrated range. Since the 3 times reference value range limit is not applicable for digital instruments under OM-6, relief is not necessary for this type of situation. However, compliance with the OM-6 accuracy limits is required and these instruments would not meet the OM-6 requirements at lower speeds. The 10-99,999 rpm tachometer would be well within the Code requirements at the 4500 rpm reference point, however the 6-30,000 rpm instrument would exceed the ±2 percent limit at the reference point (±2.2 percent). Therefore, if the 6-30,000 rpm tachometer is digital, it should not be used for IST of the HPCI pumps.

Summary and Additional Comments

Relief may be granted for cases where the instruments used for IST do not meet the Code full-scale range requirements. The following should be considered when developing relief requests for these cases:

(1) The reasons that the installed or available instruments do not meet the Code full-scale range requirements is provided.
(2) The parameter reference value, instrument full-scale range, and instrument in-situ accuracy in each system application is specified.
(3) The test measurements are shown to be sufficiently accurate and repeatable to permit the monitoring of pump operational readiness and detection of degradation.
(4) Application of instruments that meet the Code requirements would necessitate one or more of the following activities: a) purchase of new instruments, b) system modifications to install the instruments, c) system modifications to achieve a piping configuration that allows accurate instrument indication, and/or d) modifying test procedures to accommodate new instruments. These changes are shown to be a hardship without a compensating increase in the level of quality and safety.
(5) The Code acceptance criteria are utilized to evaluate the test parameter measurements or these ranges are tightened to account for increased instrument inaccuracies, as appropriate.

Licensees submitting requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

(5) Inlet Pressure Instruments Used for Differential Pressure Determination Under OM-6

OM-6 does not require measurement and evaluation of pump inlet pressure. However, since there are some pump installations that have no direct reading d/p instruments, inlet pressure must be measured to determine the d/p developed across the pumps. Therefore, the quality and range of these inlet pressure instruments must be considered to assure that the d/p measurements are sufficiently accurate and repeatable to permit detection of pump degradation. For some pump installations, the only instruments available for measuring pump inlet pressure do not meet the accuracy and/or full-scale range requirements of the applicable Code. Excessive instrument inaccuracy can result in measurements with a high level of uncertainty that can give either false indication of pump degradation or mask actual degradation.

Example From Vermont Yankee

Vermont Yankee requested relief from the instrument full-scale range requirements of OM-6, Paragraph 4.6.1.2, for the HPCI main and booster pumps. The licensee proposed to measure d/p using the existing station inlet pressure instruments that have a full-scale range of 85 psig.

Licensee's Basis for Requesting Relief:

Relief is requested on the basis that the proposed alternatives would provide an acceptable level of quality and safety. D/p across the HPCI pumps is determined by the difference between pressure measurements taken at a point in the inlet pipe and at a point in the discharge pipe as allowed by OM-6, Paragraph 4.6.2.2. The installed HPCI pump inlet

pressure indicators are designed to provide adequate inlet pressure indication during all expected operating and post accident conditions. The full scale range, 85 psig, is sufficient for a post accident condition when the suppression chamber is at the maximum pressure. This, however, exceeds the full-scale range limit of three times the suction pressure reference value as required by OM-6, Paragraph 4.6.1.2(a) (Value = approximately 26 psig, Limit = 78 psig).

The suction pressure measurement is used to verify prescribed NPSH requirements and to determine pump d/p. The installed gauges are calibrated to within ±1.58% accuracy (FS), thus the maximum variation in measured suction pressure due to inaccuracy would be ±1.34 psi. This is considered to be suitable for determining that adequate NPSH is available for HPCI pump operation. Pump discharge pressure during testing is approximately 1170 psig, which results in a calculated d/p of approximately 1144 psig. The resulting inlet pressure inaccuracy of ±1.34 psi represents an error in d/p measurement of ±0.12% (1.34 psi/1144 psid = 0.0012). This is consistent with OM-6, Table 1, which requires that instrument accuracy for d/p be better than 2% of full-scale.

Alternate Testing:

D/p will be measured using the existing station system installed inlet pressure indicators.

Evaluation

This request was approved pursuant to (a)(3)(ii). Even though the installed inlet pressure instruments slightly exceed the Code full-scale range requirements, they are more accurate than required, therefore, requiring the installation and use of instruments that meet the Code requirements would be a hardship without a compensating increase in the level of quality and safety.

OM-6 does not require measurement of inlet pressure, but d/p is a required test parameter. There are no direct reading d/p instruments installed for these pumps, however, this parameter can be readily obtained by measuring the difference between the pressure at a point in the pump inlet pipe and the pressure at a point in the discharge pipe as allowed by the Code. In cases such as this, it is not clear if the Code instrument quality and range requirements apply to the individual instruments used for the determination of d/p, or if it applies only to the overall determination. Since d/p is the Code required parameter used to evaluate pump condition, as long as the accuracy of the determination of this parameter meets the Code and is sufficiently sensitive to permit detection of pump degradation, it may not be necessary for the instrument used to measure inlet pressure to meet the Code requirements.

The installed inlet pressure instrument full-scale range is greater than three times the test reference value (85 psig in lieu of ≤78 psig). The higher range is necessary to prevent instrument damage due to over-ranging during expected plant operating and post-accident conditions, therefore, installing an instrument that meets the range requirements may not be prudent. The accuracy of the installed instrument (±1.58%) is better than is required for pressure instruments in OM-6, Table 1 (±2%). The proposed inlet pressure instrument reading inaccuracy might be as great as ±1.34 psi (±5.17% of the reference value). However, the rated discharge pressure of these pumps is 1170 psig and the inlet pressure is so small in comparison that a slight inaccuracy in inlet pressure is meaningless (the ±1.34 psi inaccuracy is only ±0.12% of the 1144 psid reference d/p). Use of the installed inlet pressure instrument would have no appreciable impact on the ability to evaluate the condition of these pumps. Test instruments that meet the Code could have up to a ±1.56 psi inaccuracy at the reference value, therefore, installing test instruments that comply with the Code for testing would be a hardship without a compensating increase in the level of quality and safety.

Summary and Additional Comments

Relief may be granted for cases where the instruments used for IST do not meet the Code full-scale range requirements. The following should be considered when developing relief requests for these cases:

(1) The reasons that the installed or available instruments do not meet the Code full-scale range requirements is provided.
(2) The parameter reference value, instrument full-scale range, and instrument in-situ accuracy in each system application is specified.
(3) The test measurements are shown to be sufficiently accurate and repeatable to permit the monitoring of pump operational readiness and detection of degradation.
(4) Application of instruments that meet the Code requirements would necessitate one or more of the following activities: a) purchase of new instruments, b) system modifications to install the instruments, c) system modifications to achieve a piping configuration that allows accurate instrument indication, and/or d) modifying test procedures to accommodate new instruments. These changes are shown to be a hardship without a compensating increase in the level of quality and safety.
(5) The Code acceptance criteria are utilized to evaluate the test parameter measurements or these ranges are tightened to account for increased instrument inaccuracies, as appropriate.

Licensees submitting requests for similar situations that meet the above criteria should be found to be acceptable. Where all of the above conditions are not met, requests may still be found to be acceptable provided that the licensee demonstrates that the proposed alternative provides an adequate assessment of pump operational readiness.

(6) Vibration Instruments that do not Meet the Code Full-Scale Range Requirements

Most vibration instruments are portable and designed to measure vibration on various types of rotating equipment. To permit use on an assortment of equipment, these instruments must be capable of measuring vibrations over a wide range of amplitudes. To perform this task with acceptable accuracy and readability, these instruments generally use multiple overlapping scales. Some instruments will auto-range or automatically select the appropriate range based on the amplitude of the vibration being measured. The range of other instruments is controlled by the operator. The multiple overlapping range design feature makes compliance with the Code full-scale range requirements impractical. The accuracy of many of these instruments is based on the reading no matter which scale is selected. The accuracy of other instruments is based on the range of whichever scale is selected. Since the main concern of the instrument full-scale range requirement is to assure adequate accuracy at the reference point, the range of multiple scale vibration instruments should not be a concern.

Example From Farley, Units 1 and 2

Here the licensee requested relief from the full-scale range requirements of Section XI, Paragraph IWP-4120, for vibration instrumentation and proposed to utilize digital vibration instrumentation.

Licensee's Basis for Requesting Relief:

Farly uses an IRD Model 818 for monitoring pump vibrations. The IRD Model 818 is a microprocessor controlled digital vibration monitor. When used in the English measurement

mode, the instrument autoscales in decade ranges. The requirement of IWP-4120 is not appropriate for vibrational measurement using this type of instrument. The accuracy of the instrument is ±5% over all ranges. The IRD provides a digital display of vibration measurement to three decimal places. This instrument provides significantly higher accuracy than an analog amplitude meter which is read visually and subject to human error and parallax. The use of a digital vibration meter has been reviewed by the ASME Code Committee and approved per Code Case N-472.

Alternate Testing:

The autoscaling digital vibration monitor will be used for Code required pump vibration measurements.

Evaluation

This request was approved because it was determined that the proposed alternative would provide an acceptable level of quality and safety. Utilizing digital vibration instrumentation that automatically selects the appropriate scale is a reasonable alternative to the Code full-scale range requirement because the accuracy of the instrument meets the accuracy requirements of the Code on all scales.

The Section XI instrumentation requirements are general for all types of instruments, however, OM-6 differentiates between analog and digital instruments. In addition, OM-6, Paragraph 4.6.1.2(c), exempts vibration instruments from the range requirements that apply to other types of instruments. OM-6 has been approved by rulemaking. The guidance in NUREG 1482, Section 5.4, "Monitoring Pump Vibration in Accord with OM-6," establishes the guidelines for plants whose programs are based on Section XI to monitor pump vibration in accordance with OM-6. Section 5.4 indicates that licensees may update their IST programs in accordance with that position without relief if all related requirements for monitoring vibration are met (OM-6 Paragraphs 4.6.1, 4.6.4, 5.2, and 6.1).

Example From Perry

In the following example, the licensee requested relief from the instrument range requirements of Section XI, IWP-4120. The licensee proposed to use their existing vibration instruments.

Licensee's Basis for Requesting Relief

The analog instrumentation (IRD) used to measure vibration amplitude has a range selector with multiples of 3 and 1 (i.e., full-scale ranges of .03, .1, .3, 1, 3, and others for full-scale readings). The IWP-4120 range requirements translates into requiring all measurements to be in the upper 66% of the meter scale. When measuring reference values that fall between; 0.030 to 0.033, 0.30 to 0.33, and 3.0 to 3.3, this requirement can not be met. For these specific cases, the upper 70% of full-scale must be used. The Code deviation described above occurs infrequently and is so minute the effects are insignificant when compared to the many variables encountered during vibration data collection. Measuring reference values using the upper 70% of the meter full-scale does not impact vibration measuring consistency for monitoring pump degradation. Therefore, conformance with this Code requirement is impractical for the facility and the alternate testing provides an acceptable level of quality and safety.

Alternate Testing:

Pump vibration reference values will be measured within the upper 70% of the vibration meter's full-scale.

Evaluation

The proposed alternative was recommended to be authorized pursuant to (a)(3)(i), based on the consideration that using the proposed vibration instruments to measure pump vibration should provide an acceptable level of quality and safety.

The evaluation considered the following issue. The analog instruments used by the licensee to measure pump vibration have multiple ranges. With the range multiples of these instruments, it is possible to have readings that are off scale for one range but low enough on the next range to exceed the full-scale range requirements of IWP-4120. This situation should not occur frequently and does not significantly affect reading accuracy. Therefore, the use of this instrument should not impact the licensee's capability of monitoring for pump degradation. Further, OM-6 has been approved by rulemaking, and Paragraph 4.6.1.2(c) excludes vibration instruments from the full-scale range requirements.

Summary and Additional Comments

Relief from the full-scale range requirements of Section XI is not necessary for vibration instruments because OM-6 exempts vibration instruments from the range requirements that apply to other analog and digital instruments.

(7) Digital Instruments that do not Meet the Code Full-Scale Range Requirements

Most digital instruments can indicate over a wide range and have their accuracy specified as a percentage of any reading within the calibrated range. Their accuracy is not based on the instrument full-scale range as is generally the case with analog instruments.

Example From Zion Station, Units 1 and 2

In this example the licensee requested relief from the full-scale range requirements of Section XI, Paragraph IWP-4120, for all digital instruments. The licensee proposed that all electronic digital instruments used for testing meet the calibration and accuracy requirements throughout their range but be exempted from the range requirements of Section XI.

Licensee's Basis for Requesting Relief:

Zion Station requests relief for electronic digital instrumentation from the requirement that the full scale range of the instrument shall be three times the reference value or less. Electronic digital instruments meet the required accuracies at both the high and low sides of their range. Therefore accuracy is independent of the instrument's range. The range of a dial instrument is more important when an operator is judging what the actual value is, using the scale provided on the instrument. If this scale is too large the accuracy of the operator's reading will greatly decrease. Since a digital instrument only displays one value, there will be no additional operator judgement error that will decrease the accuracy of the instrument.

Alternate Testing:

Zion Station proposed that all electronic digital instruments used for testing equipment will meet the calibration and accuracy requirements throughout its range but will be exempt from the range requirements of Section XI. This alternative will provide adequate assurance of the required level of safety and that operational readiness is maintained.

Evaluation

This request was approved because it was determined that the licensee's proposed alternative would provide an acceptable level of quality and safety. The Section XI instrumentation requirements are general for all instruments and do not distinguish between analog and digital instrument types. However, OM-6 does specify separate requirements for analog and digital instruments. OM-6 requires digital instruments to meet the accuracy requirements of Table 1 over their entire calibrated range. The only range requirement for digital instruments is that the reference value must not exceed 70 percent of the instrument's calibrated range. Section 5.5.2 of NUREG 1482 states that the requirements of OM-6 should be applied to digital instruments. Since the 3 times reference value range limit is not applicable for digital instruments under OM-6, relief is not necessary for this type of situation. However, compliance with the OM-6 accuracy limits is required.

The licensee has proposed using digital instruments that have a measurement accuracy over their calibrated range that meets the Code requirements and is independent of the instrument full-scale range. These digital instruments would, therefore, provide measurements sufficiently accurate to be sensitive to changes in pump condition and permit detection of degradation.

Summary and Additional Comments

OM-6 does not include the full-scale range requirement of Section XI for digital instruments, but does specifically address digital instruments whereas Section XI does not. The guidance in NUREG 1482 indicates that the requirements of OM-6 should be applied to digital instruments. Relief from the instrument full-scale range requirements will not be necessary for most situations where digital instruments are employed for IST. The only range requirements for digital instruments is that the reference value should not be greater than 70 percent of the instruments range. Since digital instruments generally have very wide ranges, this requirement will seldom be a concern.

3.7 BEARING TEMPERATURE MEASUREMENTS

Section XI requires quarterly measurement and evaluation of the temperatures of all centrifugal pump bearings outside the main flow path and of the main shaft bearings of reciprocating pumps. These measurements are compared to the limits specified by the owner in the record of tests. It is impractical to measure these temperatures for most pumps because they are not instrumented for bearing temperature and taking these measurements necessitates gaining access to the pump bearing and taking the temperature using a portable instrument.

Requirements

Section XI, Subsection IWP-3100, requires quarterly measurement of pump bearing temperature. Acceptance criteria and corrective actions for deviations are specified in IWP-3210 and -3230.

Table 3.9. Summary Table of Key Requirements and Guidance on Bearing Temperature Measurement

Document	Section	Requirement/Guidance
Section XI	IWP-3100 and -3400	These sections require quarterly pump testing and measuring the parameters of Table IWP-3100-1 including bearing temperature.
Section XI	IWP-4300	This section requires measurement of the temperatures of all centrifugal pump bearings outside the main flow path and of the main shaft bearings of reciprocating pumps.
OM-6	N.A.	OM-6 and later Code Editions do not include bearing temperature as a pump testing parameter.
NUREG 1482	5.1.2	This section of the NUREG states that relief is not required from Section XI to delete the measurements that are excluded from pump testing in OM-6.

Relief Request Issues

There were 24 relief requests in the review group related to pump bearing temperature measurement. Most requested relief to not measure this parameters for all pumps in the affected programs. The primary reason for these requests is that data associated with bearing temperatures taken at one-year intervals provides little statistical basis for determining the incremental degradation of a bearing or any meaningful trending information or correlation. Vibration measurements are a significantly more reliable indication of an imminent or existing bearing failure.

While bearing temperature, if monitored continuously, is an excellent indicator of bearing degradation, the annual measurements required by Section XI were not proven beneficial. The ASME Code committees recognized this and measurement of bearing temperatures is, therefore, not required by ASME/ANSI OMa-1988, Part 6.

The guidance in NUREG 1482, Section 5.1.2 states in part: "The staff has determined that licensees not yet using OM-6 for IST of pumps may (1) eliminate the parameters deleted from the IST requirements by OM-6 with consideration of the discussion above of the reasons why these parameters were deleted, and (2) include them in a maintenance program, as applicable, pursuant to Section 50.55a (f)(4)(iv) of Title 10 of the *Code of Federal Regulations* (10 CFR 50.55a (f)(4)(iv)). Relief requests need not be submitted to delete the measurement of these parameters which are no longer required to be monitored. There are no specific related requirements for using this recommendation; however, discharge pressure for positive displacement pumps must be monitored with the specified limits of OM-6. If this recommendation is used, the documents for the IST program must discuss the implementation."

Pursuant to 10 CFR 50.55a (f)(4)(iv) and as provided in GL 89-04, Supplement 1, relief is not required for deletion of bearing temperature measurements. Therefore, no example relief requests are provided.

REFERENCES

ASME 1986a. "Inservice Testing of Pumps in Nuclear Power Plants," *ASME Boiler and Pressure Vessel Code*, Section XI, Subsection IWP, New York.

ASME 1986b. "Inservice Testing of Valves in Nuclear Power Plants," *ASME Boiler and Pressure Vessel Code*, Section XI, Subsection IWV, New York.

ASME 1988a. American Society of Mechanical Engineers, "Inservice Testing of Pumps in Light-Water Reactor Power Plants," *Operation and Maintenance of Nuclear Power Plants*, Part 6, ASME/ANSI OM-1987, 1988 Addenda, New York.

ASME 1988b. American Society of Mechanical Engineers, "Inservice Testing of Valves in Light-Water Reactor Power Plants," *Operation and Maintenance of Nuclear Power Plants*, Part 10, ASME/ANSI OM-1987, 1988 Addenda, New York.

ASME 1990a. American Society of Mechanical Engineers, "Inservice Testing of Pumps in Light-Water Reactor Power Plants," *Code for Operation and Maintenance of Nuclear Power Plants*, Section IST, Subsection ISTB, New York.

ASME .990b. American Society of Mechanical Engineers, "Inservice Testing of Valves in Light-Water Reactor Power Plants," *Code for Operation and Maintenance of Nuclear Power Plants*, Section IST, Subsection ISTC, New York.

ASME 1995a. American Society of Mechanical Engineers, "Inservice Testing of Pumps in Light-Water Reactor Power Plants," *Code for Operation and Maintenance of Nuclear Power Plants*, Section IST, Subsection ISTB, New York.

ASME 1995b. American Society of Mechanical Engineers, "Inservice Testing of Valves in Light-Water Reactor Power Plants," *Code for Operation and Maintenance of Nuclear Power Plants*, Section IST, Subsection ISTC, New York.

Hartley, R. S. 1994. *Description of Comprehensive Pump Test Change to ASME OM Code, Subsection ISTB*, NUREG/CP-0137, Proceedings of the Third NRC/ASME Symposium on Valve and Pump Testing, pp. 493-509, July.

NRC 1980. *Clarification of TMI Action Plan Requirements*, NUREG-0737, November.

NRC 1988. *Potential Residual Heat Removal Pump Loss*, NRC Bulletin 88-04, May.

NRC 1989. *Guidance on Developing Acceptable Inservice Testing Programs*, Generic Letter 89-04, April.

NRC 1991. *Operating Experience Feedback Report - Solenoid Operated Valve Problems*, Vol.6, February

NRC 1995. *Guidelines for Inservice Testing at Nuclear Power Plants*, Campbell, P., NUREG-1482, April.

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10. SUPPLEMENTARY NOTES
P.L. Campbell, NRC Project Manager

11. ABSTRACT *(200 words or less)*

In this report, the Idaho National Engineering Laboratory reviewers discuss issues related to requests for relief from the American Society of Mechanical Engineers code requirements for inservice testing (IST) of safety-related pumps and valves at commercial nuclear power plants. This report compiles information and examples that may be useful to licensees in developing relief requests submitted to U.S. Nuclear Regulaltory Commission (NRC) for their consideration and provides insights and recommendations on related IST issues. The report also gives specific guidance on relief requests acceptable and not acceptable to the NRC and advises licensees in the use of this information for application at their facilities.

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