Session 3(A)

General Issues on Air-Operated Valves

Session Chair
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MOV and AOV Diagnostic Equipment Comparison

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Abstract

This paper will review the history of Motor Operated Valve (MOV) diagnostic equipment, explaining why the MOV Nuclear Industry required independent accuracy testing of the equipment. The paper will then review the application of Air Operated Valve (AOV) diagnostic equipment and how the lessons learned from the MOV effort should be applied to safety significant AOVs. The paper will also present some basic information regarding accuracies that may be useful to the AOV Nuclear Industry.

Background

MOV diagnostic testing was essentially non-existent prior to 1983. Even in major industry test programs to evaluate valve performance, little or no force or load information was collected from the valve. In a few laboratory test programs, valve stems were instrumented with strain gages to evaluate opening and closing forces under dynamic conditions.

In the early 1980s, industry and regulatory groups began identifying a substantial number of MOV maintenance problems as a concern. Early approaches to addressing these issues utilized springpack displacement and switch position to evaluate valve and actuator maintenance condition. The time based traces of these parameters provided a wealth of information that could be used to improve reliability and performance.

By 1985, a series of more significant events pointed to the need for proving performance capability for at least some of the safety related valves. Bulletin 85–03 was issued in June of 1985 to address this need. The test results provided in response to this bulletin became the primary basis for Generic Letter 89–10 which expanded the scope of design basis review and testing to all safety related valves.

The need to demonstrate by test that the force delivered to the valve stem was high enough to overcome design basis flow conditions, coupled with valve/actuator combinations that were at times marginal, made accurate stem thrust measurement essential.

Accuracy Issues

Efforts were made to change the springpack displacement approach to valve testing into a stem thrust measuring method. Displacement of the spring pack was correlated to top mounted load cell measurements, and the correlation was used to obtain stem thrust from displacement measurements made in subsequent valve strokes.

With time, a number of problems with this methodology began to emerge. The primary concerns pertained to the application of the information, not the accuracy of the transducers used to make the measurements. Test to test variations, directional differences, load rate effects, and degradation with time, all affected the correlation used to determine thrust. The magnitude of error caused by any of these factors was very much valve/actuator dependent making it difficult to assess.

In addition to emerging problems with springpack approach to thrust determination, industry testing was exposing problems with sizing equations and other design criteria. In severe flow conditions, some valves had the potential to damage internals as they closed. In most cases, the friction coefficients used to size the gate valves were lower than those found in flow testing. Valve factor variations were seen from test to test and in some cases degraded with time. Revised calculations to account for these problems pushed the required thrust up, and at the same time upper limits on many valves were tightening as a result of reduced voltage and other considerations. The resulting narrow windows heightened the concern for accurate stem force measurements.

MUG Validation Program

Concern over accuracy issues prompted a number of utility and regulatory individuals to explore the possibility of a validation program to assess MOV diagnostic systems. Initial discussions began in January 1990 and after several meetings the testing was planned for December of that year. The Nuclear Regulatory Commission agreed to provide the Motor Operated Valve Load Simulator (MOVLS) and personnel to operate it at the Idaho National Engineering and Environmental Laboratory (INEEL) for the validation. Utility personnel were to manage the test program and provide personnel for oversight, and diagnostic equipment vendors were to provide the test equipment.

Vendor and utility concerns about the test stand delayed the validation testing until April/May of 1991. The testing consisted of one week for each of five vendors and one vendor performed a retest in the fall of 1991. An interim report was issued in July of 1991, and the final report was issued in February of 1992.

Test Stand Description

The test stand consisted of a rising stem valve actuator mounted on a standard valve yoke in a test stand. A hydraulic cylinder loaded the stem. The load and load rate applied to the stem were controlled by varying the pressure and level in an accumulator connected to the valve stem side of the cylinder. Only compression loads were applied because the cylinder was not attached to the stem.

Thrust was measured by an in-line load cell, and torque by instrumenting an anti-rotation arm. Spring pack displacement, current, voltage and switch position were also monitored.

Primary Results of MUG Validation

The primary finding of the validation is that the springpack method is affected by three factors, the most significant of which is the stem factor changes. The second is the compression-only loading that removes more stem lubrication each time the valve is stroked. And the third is the rate at which the stem is loaded.

Timing problems were found with most of the data collection systems. These problems resulted from software errors, filtering, and other unknown sources. In most cases, these problems would not have caused incorrect valve setup, but they made analysis of the validation test results very difficult and in a few cases inconclusive.

Other Issues Identified

Hardware failures affected some test results. Inadvertent grounding, unexpected noise, and other types of hardware failures were experienced by some of the vendors. These types of problems are not uncommon and seem to be more prevalent under high-pressure situations.

Uncertainty regarding stem material properties affected some strain measurements. Young's Modulus numbers used by vendors varied from 29 to over 31 million with corresponding variations in thrust predictions. While this is not an equipment validation issue it creates a lot of uncertainty when trying to evaluate the results. It also highlights the need for accurate material property numbers when plant valves are tested using strain-based instruments that cannot be directly calibrated to force.

The vendors that measured stem torque all questioned the standard used in the MOVLS. After some research, it was determined that the thrust bearing at the bottom of the stem assembly was binding as the load increased and acting as a parallel load path to the torque arm. This binding reduced the measured torque, incorrectly indicating that the vendor instruments were reading high.

AOV Parallels to MOV Diagnostics

In some respects the evolution of AOV diagnostics is similar. The standard test approach is focused on control valve setup and maintenance. The methodology uses nominal, not conservative, numbers to optimize valve performance. The data collected provides a wealth of information about valve condition and performance.

With MOV issues mostly addressed, the question now being asked is, "How do the lessons learned from MOVs apply to AOVs?" In particular, will the valve open or shut under design basis conditions? The NRC has evaluated some of the plants and may issue some type of generic communication to ensure appropriate action is taken.

The primary method used to determine force in the valve stem is indirect. The force is calculated based on measured pressure(s) and assumed effective diaphragm or piston area. The sensors used for pressure measurement and position are accurate but application questions remain.

Comparison of Equipment/Sensor Calibration

From a process point of view, standard approaches to calibration were in place prior to MOV diagnostics. Utilities had well established programs and ensured through auditing that diagnostic vendor programs were functioning properly. There should be no real issues in this area for MOVs or AOVs.

Comparison of Software Validation

On the other hand, software validation processes and standards for verification and validation were just emerging in the mid to late 80s. Design documentation during this period was sketchy, and testing was generally informal and poorly documented.

Since that time, vendors and utilities have become have become much more aware of the need for tight control in this area. Most software quality programs are well established. Formal specifications and design descriptions are required and the testing is extensive and well documented. Utility auditors have become very knowledgeable and they provide significant input to the software quality process.

Comparison of Hardware Validation

In the mid to late 80s, hardware validation was conducted in a similar manner to software testing. Control was loose and the results were often undocumented or documented in memos. (Single test setups were often used as a basis for conclusions resulting in conclusions that were not always valid.) Traceability of standards used in validation was poorly (or not) recorded.

Today most quality programs require formal plans and reports. Multiple test configurations are typically used to ensure that expected and unexpected variations are included in the testing. Standards and calibrated equipment are recorded and as found calibration results are obtained to ensure that results are not affected by defective equipment.

Valve Bodies

There is little difference between the types of valve bodies used for MOVs and AOVs. The majority of the safety significant valves that are used in the nuclear industry either travel linearly or are quarter turn. Within those classifications the valves that travel linearly are mostly Globe or Gate type valves. The quarter turn valves are normally Butterfly or Ball type valves. The mix might be different with more gates used in MOV applications and more globes used in AOV applications. The significant advantage for the AOVs is that, with a few exceptions, the same basic calculations that were developed to determine the forces required to operate the MOVs can be used for the AOVs. The one difference that was talked about at the January 2000 *3rd Joint Meeting of the Air Operated Valve and Motor Operated Valve Users' Groups*, held in Clearwater Beach, Florida, was that some of the conservatism that was applied to MOVs would have to be evaluated in some cases for the AOVs because of the relatively smaller actuators. In general the valve body designs are the same, and the calculations to evaluate them will be similar.

Valve Actuators

For MOVs there is essentially one manufacturer of the actuator with a second manufacturer supplying a relatively small number of actuators to the industry. The design concepts for the different actuators being supplied by these manufacturers are similar and can be documented, e.g., motor type and size, gear ratio, etc.

For AOVs there are many different vendors, sizes and designs. There are essentially two different methods of supplying power, either pistons or diaphragms. To get this power to the valve we have single or double acting, with or without spring return, linear or quarter turn using all kinds of transmission devices to transmit the power to the valve body, e.g. Sigma F™, Bettis actuators, Scotch Yoke, Camflex® and many others.

While there could be a definable metric of MOV actuator outputs, trying to establish a metric for AOV actuators would be virtually impossible. This of course leaves it to the plant owner to establish the actuator output for each of the plant's AOVs.

AOV Diagnostics

The industry has come to accept the term Diagnostics to mean the equipment used to automatically record and evaluate valve performance. In reality any tool used to measure and evaluate could be considered a diagnostic tool; for example a six-inch scale and a pressure gauge are diagnostic tools. The tools we are talking about to do AOV diagnostics are sophisticated, electronic, multi-channel, data recording tools that can record information, and store and help analyze the performance, calibration and set points of AOVs.

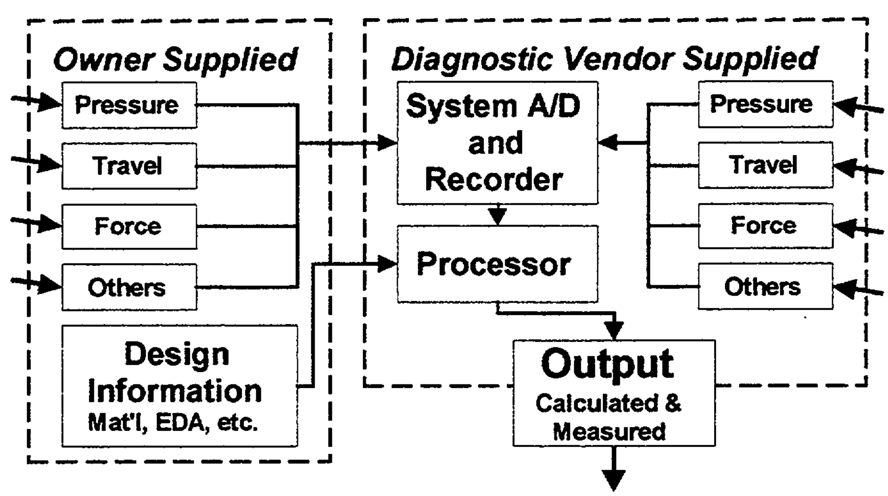
The use of AOV Diagnostic equipment has already been documented[1] to have saved the AOV industry many megawatts of lost energy, reduced maintenance costs, been useful in troubleshooting valve problems and improved operating plants.

AOV Diagnostic equipment can also be used to prove and document Design Basis Requirements such as seat load, actuator capability, opening and/or closing time, and maintaining position. If done under strict controls, with trained personnel, these same requirements can be proved and documented using tools such as a pressure gauge, stopwatch, six inch scale and/or strain gauge.

[1]Presentations to both the NRC/ASME Symposium of Valve and Pump Testing and the Air Operated Valve User's Group

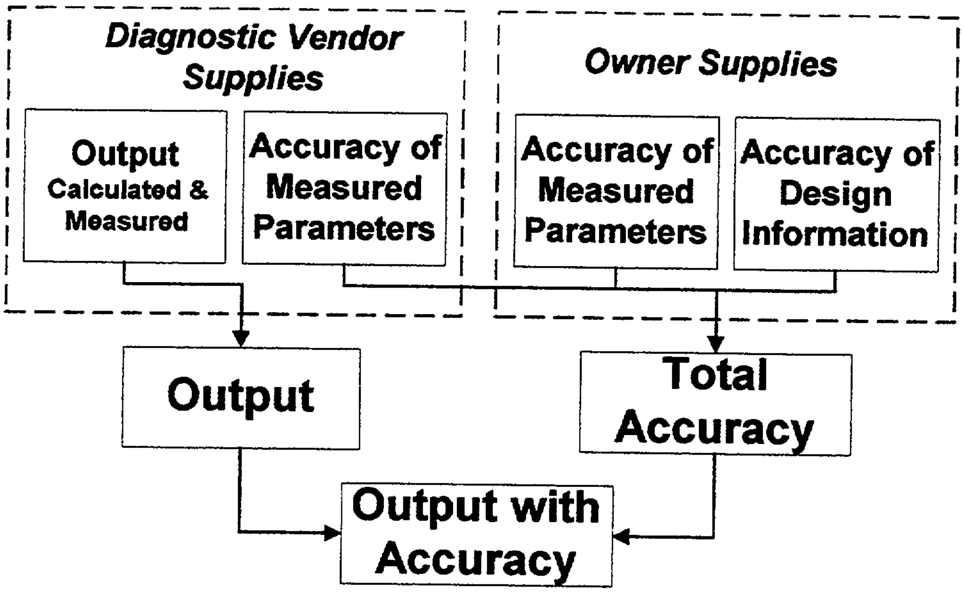
AOV Diagnostic Equipment

This diagram represents how the AOV Diagnostic Equipment (Vendor) handles inputs from the Plant Owner (Owner) and inputs directly into and through the equipment. In most cases the Vendors supply a number of instruments that measure such things as travel, pressures, electronic values and possibly strain. The left side of the diagram shows that the Owner can also supply instruments that can be plugged into the equipment and design information that is used by the Vendor's software to provide the output calculations.



Final AOV Diagnostic Final Results

This diagram shows that all the different accuracies have to be combined to provide a final output with a total accuracy. The Vendors should be providing the overall accuracies for each instrument/parameter supplied and the overall accuracy of their electronic equipment. If the Owner is plugging in other parameters to the vendor's equipment the Owner will have to combine the accuracy of that parameter with the accuracy of the Vendor's electronic equipment for an overall accuracy for that parameter. The Vendors should also provide verifiable documentation, with their equipment/software, that verifies their output calculations and the methods they used for their accuracy calculations.



The Owner is be responsible for providing the accuracy of the design information that is used as an input to the Vendor's software. Also the Owner must know the accuracy of the instruments that they used to plug into the Vendor's equipment. And finally the Owner must correctly add the Vendor's accuracies, the design information accuracy and any instrumentation accuracies the Owner might have supplied for the total accuracy.

As can be seen the Owner should have most of the responsibility for the total accuracy of the information provided by the Vendor's software.

Summary MOV and AOV Comparison

In general valve bodies and designs are similar whether driven by an MOV or AOV and the calculations that were used to determine forces required to operate MOVs can be used for AOVs. There are people working on trying to determine whether some of the calculations might be too conservative for the AOV actuators.

The MOV and AOV actuators cannot be handled in the same way. In most cases the thrust or torque output of the motor was determined by the MOV Diagnostic Vendors. In the case of the AOVs there are too many manufacturers, designs, and variations within the designs, for the AOV Diagnostic Vendors to know all the possible combinations.

The nuclear plant Owner has the final responsibility for everything provided and documented at the plant. In the case of the diagnostic equipment, whether AOV or

MOV, the Vendor is only responsible to provide the owner with the software documentation and accuracy for equipment provided by the vendor. The Owner is still responsible for verifying the documentation, assimilating all the information and providing the final information.

Conclusions

The problems with indirect methods of determining force and torque are much better understood than in early MOV testing.

While some minor problems might be found, validation testing of AOV Diagnostic Equipment might not be cost effective at this time.

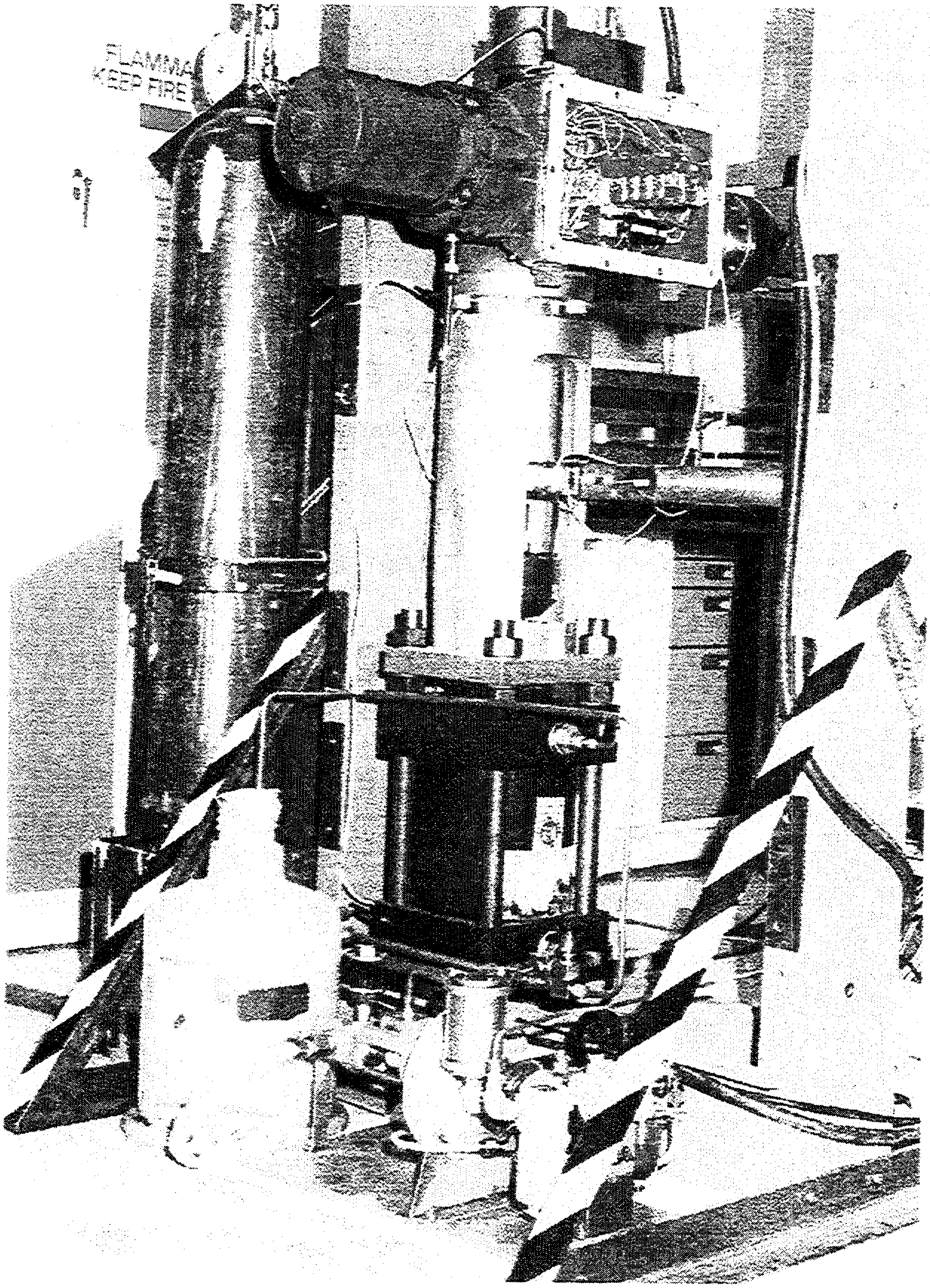
Recommendations

It is recommended that plant owners, when purchasing or using any diagnostic equipment, make sure that the verified documentation is provided for the software and accuracy statements.

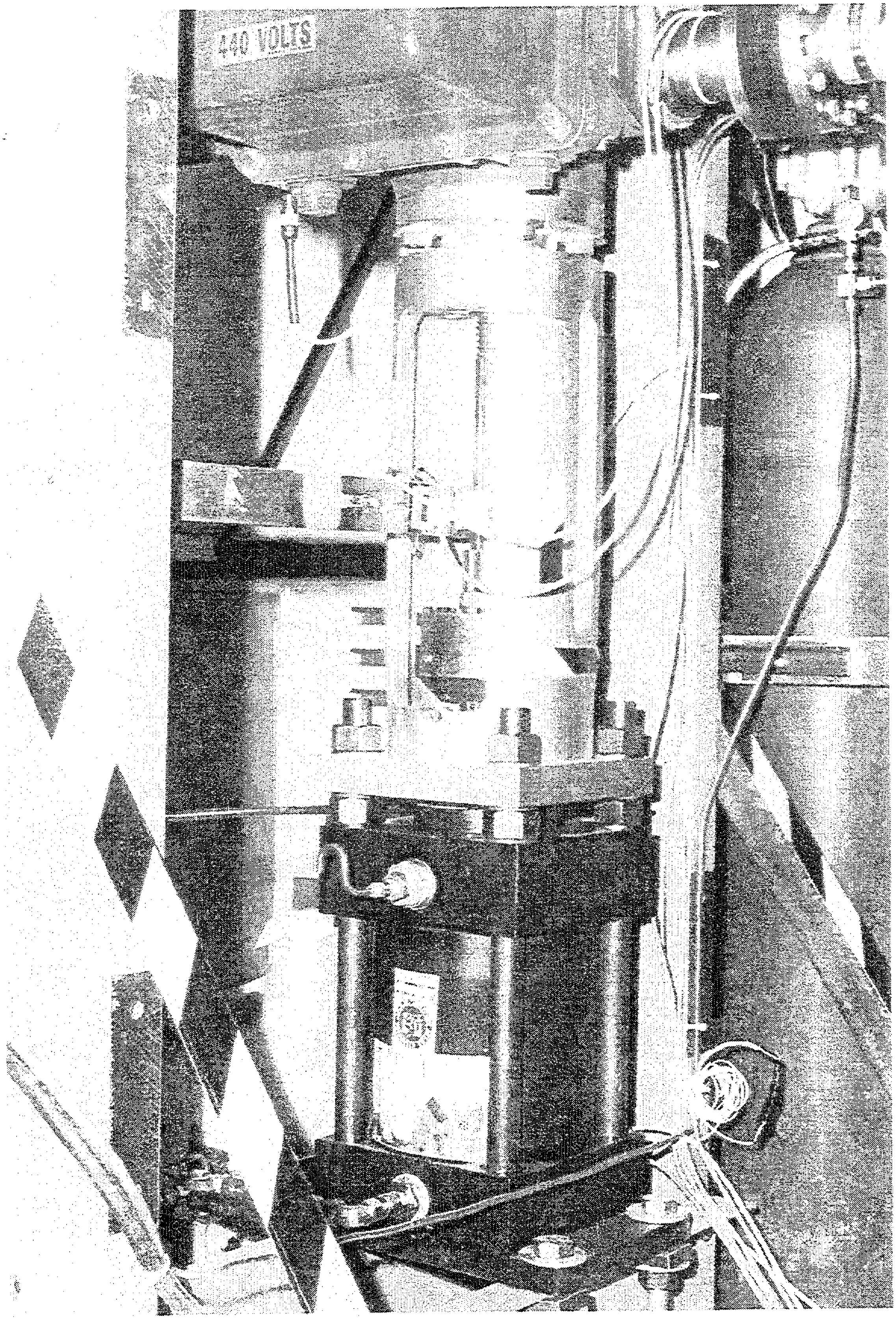
The Effective Diaphragm Areas (EDA) and the different methods used to transmit actuator forces to the valve should be evaluated and documented so that everyone is using the same values.

The industry or a combined MOV/AOV committee should handle common MOV and AOV issues. An example of this might be the implication that there is a side loading problem with all globe valves.

The AOV Diagnostic Vendor Focus Group might handle issues common to the diagnostic equipment such as software timing issues.



INEEL MOV Test Stand



INEEL MOV Test Stand

Improved Method for Predicting Thrust Requirements for Balanced Disk Globe Valves

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Abstract

The balanced disk globe valve model in the EPRI MOV Performance Prediction Methodology (PPM) provides bounding predictions of required stem thrust for balanced disk globe valves. Because of the wide range of balanced disk globe valve designs, simplifying assumptions were made in the PPM. For example, the imbalance load was assumed to be 10% of the differential pressure (DP) multiplied by the guide area, and the side load on the valve disk was based on testing of a Y-pattern globe valve with no disk cage. Since the majority of motor-operated globe valves are unbalanced and MOVs that have balanced disks typically have high margin, these assumptions were appropriate for MOVs.

Based on EPRI's Pilot AOV Programs at four nuclear plants, the population of balanced disk globe valves is higher in AOVs than in MOVs. In addition, the majority of air-operated balanced disk globe valves are used to control flow and have disk cages designed to minimize the side load on the disk. Since margins for AOVs are typically smaller than for MOVs, EPRI has developed an improved balanced disk globe valve model to more accurately predict thrust. The key features of the improved model are 1) the imbalance load is calculated explicitly, based on information from the valve manufacturer, and 2) disk side loading accounts for specific valve design features, such as cages, that are designed to minimize disk side loading.

The improved balanced disk globe valve model has been validated against data from in-plant testing at several nuclear power plants. This paper describes development of the model and summarizes the results of the validation. Implementation of the method is also discussed.

Introduction

In the early 1990's, the Electric Power Research Institute (EPRI) carried out the MOV Performance Prediction Program (PPP) to better understand the performance of motor-operated valves (MOVs) in nuclear power plants. The key products of this program were improved methods for predicting the thrust or torque required to operate typical safety-related MOVs in nuclear power plants. For most solid and flexible wedge gate valves, globe valves and butterfly valves, the methods are implemented using the Performance Prediction Methodology (PPM) computer program.

The PPM Globe Valve Model, which is documented in Reference (2), uses conservative approaches for balanced disk globe valves to calculate the required thrusts due to imbalance load and disk-to-body friction. Specifically, the imbalance load is assumed to be 10% of the maximum valve DP times the disk guide area, in a direction that opposes disk motion, and the disk-to-body friction load is determined using a side load correlation that is based on test data for an uncaged, balanced disk, Y-pattern globe valve. These conservative modeling approaches were adequate for MOVs because balanced disk motor-operated globe valves typically have high margin; however, since the PPM is being used to evaluate balanced disk air-operated globe valves, which typically have less margin, a required thrust model for balanced disk globe valves that better addresses disk imbalance load and disk-to-body friction load is needed.

To address this need, EPRI has sponsored work to develop and justify a refined model for predicting the stem thrust required to operate typical balanced disk globe valves under dynamic conditions, i.e., conditions with flow and differential pressure. The key refinements in the model include a revised approach for predicting disk side loading and explicit modeling of the imbalance area. This paper presents the basic equations used for the refined model and the associated assumptions and limitations. In addition, refined model predictions are compared to predictions from the original PPM Model (Reference 2) and to valve test data as a basis for validating the model. The refined model described in this report, which is implemented by a hand-calculation, is an alternative to the original PPM Method for globe valves, which is documented in Reference (2) and implemented per Reference (1) using the PPM computer program.

Model Description

Scope and Approach

Balanced disk globe valves are designed to reduce the effect of differential pressure on the thrust required to stroke the valve. This reduction is achieved with a port or hole through the disk that equalizes the pressures above and below the disk. In addition, balanced disk globe valves include seals between the disk and cage or body (to seal the gap between the disk and the cage/body and prevent leak-by). Figure 1 shows a typical balanced disk globe valve.

The refined balanced disk globe valve model calculates stem thrust required to operate balanced disk globe valves under flow and differential pressure conditions specified by the user. The refined balanced disk globe valve model is based on the EPRI MOV Performance Prediction Methodology (PPM) for globe valves, as documented in the Globe Valve Model Report (Reference 2). The equations developed in Reference (2) predict the required stem thrust to open or close unbalanced and balanced disk, rising and rising/rotating stem globe valves. In this refined model, the original PPM method for balanced disk globe valves is modified as follows:

- The prediction of stem thrust due to friction between the valve disk and the body or cage due to side loads on the disk considers specific valve design features that affect the magnitude of the disk side loading (e.g., disk cages).
- The prediction of stem thrust due to disk imbalance loads is modeled explicitly, using valve dimensions or

information obtained from the valve vendor.

- An equation for valve sealing load is included.
- Equations and methods are provided to calculate the required thrust at the fully open, as well as the fully closed, position.

Thrust Components

The typical forces required to stroke a balanced disk globe valve are shown in Figure 2.

The PPM balanced disk globe valve model includes seven thrust components— (1) disk and stem weight, (2) packing load, (3) upper seal friction load (included in packing load), (4) stem rejection load, (5) disk guide/body friction load, (6) DP load (includes pressure imbalance) and (7) torque reaction load. These seven thrust components are considered in the refined balanced disk globe valve model, along with main disk and upper disk sealing load thrust components, when applicable. The total required opening and closing thrusts are calculated using the equations below.

Opening Stroke

$$F_o = (F_{DS} + F_P + F_{US} + F_{SR} + F_{DP} + F_{DF})/TRF$$

Closing Stroke

$$F_c = (F_{DS} + F_P + F_{US} + F_{SR} + F_{DP} + F_{DF} + F_{SL} + F_{UDSL})/TRF$$

where:

F_O = Required opening thrust, lb

F_C = Required closing thrust, lb

F_{DS} = Stem thrust due to disk and stem weight, lb

F_P = Stem thrust due to packing friction, lb

F_{US} = Stem thrust due to friction at upper seal (e.g., seal ring away from disk to seat interface), lb

F_{SR} = Stem thrust due to stem rejection load, lb

F_{DP} = Stem thrust due to differential pressure (imbalance load), lb

F_{DF} = Stem thrust due to disk-to-body/cage friction, lb

F_{SL} = Stem thrust due to main disk sealing load, lb

F_{UDSL} = Stem thrust due to upper disk sealing load, lb (upper disk seats only)

TRF = Torque reaction factor, dimensionless

For balanced disk globe valves, the maximum required thrust typically occurs at or near the fully closed position. However, the maximum required thrust can occur at the fully open position (e.g., if the direct pressure loads assist disk motion and exceed the friction loads due to DP). The maximum required thrust predicted by the refined model will always occur at either the fully open or fully closed position. In addition, for AOVs, the actuator capability may vary with disk position, and the minimum actuator capability may occur at the fully open position. Accordingly, the model equations determine the required thrust at the fully open and fully closed positions. The convention used in this model is that positive thrusts oppose disk motion (i.e., thrust must be provided by the actuator) and negative thrusts assist disk motion.

The required thrusts due to disk and stem weight (F_{DS}), stem rejection (F_{SR}) and torque reaction friction loads are calculated using the methods described for the EPRI PPM in Reference (2) except that for air-operated valves, the TRF is set to 1.0 since air actuators do not transmit torque to the valve stem. Because the packing friction and upper seal friction loads depend on how the valve is designed and assembled, this method does not try to predict these terms. Packing load (F_P) and upper seal friction load (F_{US}) should be determined from static test data.

Refined methods for determining the disk-to-body/cage friction load (F_{DF}) and DP load (F_{DP}) are described below.

Disk-to-Body/Cage Friction Load

Disk-to-body/cage friction covers friction loads between the disk and the body or cage, as applicable. In theory, a disk-to-body/cage friction load exists if there is a pressure variation around the disk circumference that creates a side load on the disk, forcing it against the body/cage. Flow through the valve tends to cause a pressure variation around the disk due to flow losses from one side of the disk to the other. Because the resistance for the flow path around the disk is greater than the resistance for the flow path directly to the outlet port, the flow around the disk is less than the flow directly to the outlet port, assuming underseat flow. As a result, the pressure on the side of the disk away from the outlet port is greater than the pressure on the outlet port side of the disk. The disk-to-body/cage friction load is the side load (side DP times area) multiplied by the coefficient of friction between the disk and the cage or body bore. For this refined model, the disk is assumed not to tip, i.e., flat-on-flat contact between the disk and cage/body is assumed.

Significant variations exist in balanced disk globe valve designs that influence the potential pressure variation around and across the disk. These features include body pattern and flow direction, guide and trim type, and flow distribution. For a given flow resistance around the disk, the side bearing load decreases as the flow resistance from under the disk to the outlet port (for underseat flow) is increased. Therefore, the side load for cage guided valves is expected to be less than for body guided valves. For example, some balanced disk globe valves use a fine mesh or "anti-cavitation/hush" cage that is designed to absorb a significant portion of the total DP across the valve. For these valves, the flow resistance through the cage is much higher than the flow resistance around the disk, and the pressure difference from one side of the disk to the other is small.

The disk-to-body/cage friction load is set to zero at the fully open position, consistent with the fact that in the fully open position the valve disk is typically not blocking the cage holes/orifices and any fluid in the annulus/channel between the disk and the guide is relatively static.

For valves without a disk cage, the stem thrust due to disk-to-body/cage friction load at fully closed is calculated in the refined method using the original EPRI PPM per Reference (2).

For Angle and T-pattern cage guided designs, a more accurate model of the thrust requirement at fully closed is developed. For this model, the side DP is a function of the DP across the valve. As a result, the calculated side load is maximum when the valve DP is maximum, i.e., when the valve is fully closed. It is recognized, however, that the side load actually reaches a maximum prior to full valve closure, and the side load is zero at disk seating since the flow through the valve is stopped. This modeling approach is used to provide some conservatism in the model to cover the range of disk cage designs.

The disk-to-body/cage friction load is:

$$F_{DF} = \mu(DP_{side})(Area)$$

where:

μ = Disk-to-body/cage friction coefficient, dimensionless

DP_{side} = Lateral (or side) differential pressure on valve disk, psi

Area = Disk side load area, in^2

The side DP is a function of the flow resistance around the cage and the flow resistance through the cage. Scoping calculations indicate that the flow resistance through the cage varies with the ratio of the cage hole area to the total cage area (A%) raised to some power. For this model, the side DP is conservatively assumed to vary linearly with A%. In addition, the side load area is calculated as the outside diameter of the disk multiplied by the valve stroke length.

This equation then becomes:

$$F_{DF} = \mu(DP)(constant)(A\%)(d_{SEAT-OD})(L)$$

where:

μ = Disk-to-body/cage friction coefficient, dimensionless

DP = Design basis DP, psi

A% = Ratio of total cage hole area to total cage wall area, dimensionless

$d_{SEAT-OD}$ = Outside diameter of disk seat, inches

L = Full stroke length, inches

constant = Developed from testing a T-pattern, caged, balanced disk globe valve in the EPRI MOV Program, dimensionless

A disk-to-body/cage coefficient of friction of 0.6 is used in the refined model. This value is consistent with the original PPM and is a bounding value for carbon steel, stainless steel and Stellite for temperatures from ambient to 150°F.

The value of A% should be obtained from the vendor but can also be estimated from a cross-sectional drawing of the valve. For "hush" trim type cages (e.g., stacked disk type), A% approaches zero, which is consistent with the expectation that F_{DF} goes to zero as most of the pressure drop occurs across the cage rather than the disk.

A "screen" is provided to identify valve applications where the calculated disk-to-body/cage side load is negligible and can be ignored. Briefly, if the valve application meets the following criteria, the disk-to-body/cage friction load is negligible and is set to zero.

$$A\% < \frac{(constant)(d_s)}{(DP)(L)(d_{SEAT-OD})}$$

where:

d_s = disk stem area

The constant is defined such that if a valve meets the screening criteria (i.e., A% is less than the value calculated), the calculated disk-to-body/cage friction load is less than 5% of 1000 pounds times the stem diameter. One thousand pounds times the stem diameter is an estimate of the valve packing load; therefore, for valves that meet the criteria, the disk-to-body/cage friction load is less than 5% of the estimated packing load.

DP (Imbalance) Load

For balanced disk valves, the pressure above the disk is the same as the pressure below the disk. Therefore, imbalance loads result from differences in the sealing areas at the top and bottom of the disk.

The DP or imbalance load is set to zero at the fully open position. The required thrust due to DP or imbalance load at the fully closed position is calculated as follows.

$$F_{DP} = \pm\ (DP)(A_I)$$

where:

A_I = Imbalance area, in^2
D_P = Design basis DP, psi

F_{DP} is positive if it opposes disk motion and negative if it assists disk motion. The direction of the imbalance load F_{DP} depends upon the upper and lower sealing areas and the flow direction. Note that in this model, the lower sealing area is at the disk-to-body seat (normally Stellite), and the upper seal is the sliding seal on the disk or in the body/cage.

The imbalance area, A_I, can be calculated by taking the difference between the sealing areas at the top and bottom of the disk (i.e., the difference between the area based on the upper seal diameter and the area based on the mean seat diameter) or it can be obtained from the valve manufacturer or vendor catalogues. If the imbalance area is obtained from the vendor, it is recommended that the imbalance load be set to zero if it assists disk motion to account for any uncertainties in the imbalance area. However, if the imbalance area is calculated using valve dimensions (the upper seal diameter and the mean seat diameter), then the imbalance load can be included when it assists disk motion.

Sealing Load

Sealing load is only applicable to closing strokes and at the fully closed position. The main disk sealing load (to ensure leaktightness) is calculated as a function of the required seat stress and seat area using the method in Reference (3).

For some balanced disk globe valve designs, a sealing load must be applied to compress an upper disk seal. Because the upper disk sealing load is strongly dependent on how the valve is assembled and the relative clearances between the plug and the upper seat, this model does not attempt to predict the upper disk sealing load. Upper disk sealing load (F_{UDSL}) should be determined from static test data. Evaluation of test data for a valve with a deformable upper seal showed that the upper disk sealing load appears to increase from the static test to the dynamic test. This increase may be caused by deformation of the upper seal due to valve internal pressure or by the trapping of fluid between the upper seal and the valve body. Based on this evaluation, it is recommended that a factor be applied to the measured thrust to compress the upper seal during a static test. If test data is not available, values for this load may be obtained from the valve manufacturer.

Similar to the main disk sealing load, the upper disk sealing load is only applicable for closing strokes and at the fully closed position. Also, the upper disk sealing load opposes the closing disk motion and is therefore positive. Some valve designs include spring type upper disk seals that tend to assist opening; however, it is conservative to neglect this force in the opening direction.

Note that the approach described above to determine these loads is not within the scope of the refined model validation.

Model Validation

Approach

The refined globe valve model has been validated by comparing model predictions to measured stem thrusts obtained during DP testing of five globe valves. Model predictions were also compared to predictions using the original EPRI PPM globe valve model. All five valves were T-pattern valves with cage-guided disks. Four of the valves were balanced disk globe valves, and the other valve was a pilot-operated globe valve. For the pilot-operated valve, model predictions were compared to the portion of the valve stroke during which the "main" disk (rather than the pilot disk) was stroking. During this portion of the stroke, the valve behaves like a balanced disk globe valve. Since the refined model for Y-pattern and uncaged globe valves is the same as the original PPM globe valve method, except that the actual imbalance area is used to calculate the DP (or imbalance) load, no Y-pattern or uncaged valves were included in the validation matrix.

Model validation utilized data obtained during globe valve testing conducted by utilities as part of the JOG MOV Periodic Verification (PV) program. These data are the property of the individual plants that performed the tests and submitted them to the JOG Program. EPRI obtained permission from each plant supplying data to utilize the data in this effort.

The five globe valves were manufactured by various vendors and were tested under various flow conditions. Table 1 lists the valves tested and provides information about the valve designs and test conditions. The maximum differential pressure listed occurred when the valve was fully closed and the maximum flow velocity occurred when the valve was fully open. For each flow condition, data were obtained for closing and opening strokes. Key measured test parameters used for model validation include stem thrust, upstream pressure, and valve differential pressure.

The approach used for validation was designed to verify that:

- Model predictions of total required stem thrust bound the stem thrust measured during testing, and
- Model predictions of disk-to-body/cage friction load bound the measured disk-to-body/cage friction load.

Validation of Total Required Stem Thrust Predictions

The refined globe valve model predicts required thrusts at the fully open and fully closed predictions. For three of the five valves, measured thrusts at the fully open position and fully closed positions were compared to predictions using the refined and original globe valve models. For the other two valves, comparisons were only made at the fully closed position, either because the valve was not fully opened during the test, or because pressure data at the fully open position was not available. For three of the valves, the test data was obtained in digital format from the plants, and measured thrusts are compared to predictions using the refined and original globe valve models for the entire stroke. The equations described above were used to predict total required stem thrust using the refined model. Equation 2–2 of Reference (2) was used to predict total required thrust using the original globe valve model. Key inputs to the models include:

- For each validation stroke, static test thrust data were reviewed for each valve to determine the sum of the disk and stem weight, the packing load and the upper seal friction load.

- For stem rejection loads (F_{SR}), the measured valve upstream pressure was used as the bonnet pressure at each stroke position for underseat flow (where flow passes through the valve seat before passing the valve disk), and the downstream pressure was used for overseat flow (where flow passes the valve disk before passing through the valve seat).

- The refined globe valve model does not attempt to predict the thrusts at intermediate disk positions. However, to allow predictions to be made for comparison to data at intermediate disk positions (three of the five valves), the refined model equations were used except that disk-to-guide friction and imbalance loads were calculated as a function of stroke position. The measured DP was used at each disk position to calculated F_{DF} and F_{DP} loads.

- For the refined model, a value of zero was used for imbalance load if it assisted disk motion. The original PPM imbalance load was included as a required thrust regardless of whether it opposed or assisted disk motion.

- Sealing load was not considered in validation and is set to zero in the model predictions.

Validation of Disk-to-Body/Cage Friction Load

For valves BG5.1, BG6.1 and BG7.1, digital test data obtained from the plants was used to validate the prediction of the disk-to-body/cage friction load. Measured values of disk-to-body/cage friction load were determined from the data by comparing the measured opening and closing stroke stem thrusts. After synchronizing the data for stroke position and normalizing it for pressure effects, the difference between the measured opening and closing thrust data at each disk position is the sum of the packing and disk-to-body/cage friction loads at that disk position. The disk-to-body/cage friction load was then obtained by removing the packing load.

Predictions of disk-to-body/cage friction load were made using the refined and original globe valve models. Plots were then made comparing the measured disk-to-body/cage friction load to values predicted by the refined and original models.

Results

Results of the comparisons between measured stem thrusts and stem thrusts predicted using the refined and original globe valve models are shown in Figures 3 through 10 for each of the five globe valves. Key points regarding the data comparisons are discussed below.

Valve No. BG2.1

This valve is a pilot-operated balanced disk globe valve. The refined balanced disk globe valve model is not nominally applicable to pilot-operated globe valves; however, test data for this valve was used for validation of the refined model, as described below.

In this design, the valve stroke has two distinct regions. For a portion of the valve stroke, the main disk strokes open or closed with the pilot disk in the open position. For this portion of the stroke, the valve behaves like a balanced disk globe valve, and the refined and original globe valve models can be used to predict the required stem thrust. For the remainder of the stroke, the main disk is stationary (seated), and the pilot disk strokes open or closed. For this portion of the stroke, the valve behaves like an unbalanced disk globe valve, and the refined globe valve model cannot be used to predict the required thrust. For this validation, only the portions of the opening and closing strokes during which the main disk strokes were considered.

Figure 3 is a plot of measured stem thrust versus stroke position for valve BG2.1. This figure also shows the required thrusts predicted by the refined and original globe valve models at the fully open and fully closed positions. Note that a negative thrust represents a self-actuating thrust (actuator is restraining the valve). In this case, a prediction with a lower absolute value is conservative (i.e., less self-actuating). As shown, the refined model predictions bound the test data at the fully open and fully closed positions.

Valve No. BG5.1

This valve is a 4-inch, cage-guided globe valve. The cage design includes 8 holes about 1¾ inch in equivalent diameter, such that about 30% of the flow area is blocked.

Figure 4 is a plot of measured stem thrust versus stroke position for valve BG5.1. This figure also shows the required thrusts predicted by the refined and original globe valve models over the full stroke of the valve. As shown, the refined model predictions bound the test data at all stroke positions.

For this valve, the disk-to-body/cage friction load is determined to be non-negligible using the screening criteria, and this conclusion is supported by the test data. Figure 5 is a plot of the measured disk-to-body/cage friction load for valve BG5.1. This figure also shows the disk-to-body/cage friction load predicted using the refined and original globe valve models. As shown, the measured disk-to-body/cage friction load is about 100 pounds near the fully closed position, and refined model predictions bound the test data at all stroke positions while providing a more accurate prediction that the original globe valve model. Note that the packing load for the DP test of this valve appears to be less than the packing load for the static test, near the fully open position. As a result, the method for calculating the disk-to-body cage friction load from the test data yields negative values for a portion of the stroke.

Valve No. BG6.1

This valve is a 10-inch, cage-guided globe valve with "hush" trim. Figure 6 is a plot of measured stem thrust versus stroke position for valve BG6.1. This figure also shows the required thrusts predicted by the refined and original globe valve models over the full stroke of the valve.

As shown, the refined model predictions bound the test data at all stroke positions except the beginning of the opening stroke (at unseating). This result is attributed to the valve seat angle of 20°, which results in wedging of the disk in the seat during valve closure. As a result, additional thrust is required to unwedge the disk during opening. Valve unwedging effects are not covered by the model (i.e., the model assumes the disk does not wedge in the seat).

For this valve, the disk-to-body/cage friction load is determined to be negligible if A% is less than 0.10. This valve has a cage consisting of concentric cylinders, each with a series of holes. The cylinders can be rotated such that the holes line up with each other, and in this orientation, A% is calculated to be 0.28, based on the size and number of holes. However, the cylinders are rotated slightly at installation. Since a value of A% could not be determined for the cylinders in this offset position, 0.28 was conservatively used in the model predictions.

Figure 7 is a plot of the measured disk-to-body/cage friction load for valve BG6.1. This figure also shows the disk-to-body/cage friction load predicted using the refined and original globe valve models. As shown, the refined model predictions bound the test data at all stroke positions except near the fully open position. This result is considered acceptable since the disk-to-body/cage friction load is expected to be zero at the fully open position. The non-zero disk-to-body/cage friction load near fully open may be due to slight changes in the packing load from the static to the DP test (e.g., due to increased pressure in the bonnet). Since the disk-to-body/cage friction load is essentially constant (and close to zero) over the stroke, it is likely that A% for this valve is less than 0.28, which was used for model validation.

Valve No. BG7.1

This valve is a 10-inch, cage-guided globe valve with a labyrinth cage. This valve was "short-stroked," i.e., the valve was not fully opened during the test. Accordingly, thrust comparisons cannot be made for the entire stroke of the valve.

Figure 8 is a plot of measured stem thrust versus stroke position for valve BG7.1. This figure also shows the required thrusts predicted by the refined and original globe valve models at disk seating and unseating.

As shown, the refined model predictions bound the test data. For this valve, the packing load for the DP test appears to be much lower (by about 2000 pounds) than the packing load for the static test. As a result, the refined and original model predictions are conservative for this valve, since the packing load used in the model predictions is based on the static test results.

For this valve, the disk-to-body/cage friction load is determined to be negligible using the refined model screening criteria, and this conclusion is supported by the test data. Figure 9 is a plot of the measured disk-to-body/cage friction load for valve BG7.1. This figure also shows the disk-to-body/cage friction load predicted using the refined and original globe valve models. The packing load for the DP test of this valve appears to be much less than the packing load for the static test. As a result, the method for calculating the disk-to-body cage friction load from the test data yields negative values. However, it is concluded from Figure 9 that the disk-to-body/cage friction load for this valve is negligible since the measured data does not increase as the valve closes.

Valve No. BG8.1

This valve is a 2-inch, cage-guided globe valve with a "disk stack" cage. Figure 10 is a plot of measured stem thrust versus stroke position for valve BG8.1. This figure also shows the required thrusts predicted by the refined and original globe valve models at the fully closed position. Predictions were not made at the fully open position because pressure data at fully open was not available. Note that a negative thrust represents a self-actuating thrust (actuator is restraining the valve). In this case, a prediction with a lower absolute value is conservative (i.e., less self-actuating). As shown, the refined model predictions bound the test data at the fully closed position.

For this valve, the disk-to-body/cage friction load is determined to be negligible if A% is less than 0.12. A value of A% could not be determined for this valve, and a value of 0.2 is used in the model predictions; however, because of the design of the cage in this valve, A% is judged to be less than 0.12. The test data supports the conclusion that disk-to-body/cage friction load is negligible for this valve.

Model Predictions Using Imbalance Loads That Assist Disk Motion

The refined globe valve model allows the user to include the imbalance load when it assists disk motion if the imbalance area is calculated based on valve dimensions. In validation of the method (described above), vendor-supplied imbalance areas are used for some valves, and imbalance areas calculated from valve dimensions are used for other valves. For consistency, imbalance load was set to zero for all valves if it assisted disk motion. To validate model predictions that include the imbalance load when it assists disk motion, additional model predictions are made at the fully closed position for validation strokes for which the imbalance load assists disk motion (one stroke per valve). These new model predictions include the imbalance load, which results in a lower stem thrust prediction than obtained during validation. A comparison of these model predictions to the maximum measured stem thrusts showed that the results are bounding for two of the five valves, BG2.1 and BG5.1. The results for BG6.1 and BG8.1 showed slight under-predictions (<3%) that are well within the uncertainty ranges of the measured data. Consequently, the under-predictions for these valves are not considered significant.

For BG7.1, the DP test data showed significant "noise" and a significant increase in thrust just prior to disk seating. In particular, the thrust changes from approximately 4,700 lbs to 7,207 lbs within the last 0.5% of the closing stroke. This sudden increase in thrust is considered attributed to disk seating effects and is not considered a DP effect since the DP conditions do not change significantly over the ranged of stroke positions. The predicted thrust (with the DP load assisting closure) bounds the measured thrust data for all other points prior to the disk seating.

Conclusions

The refined balanced disk globe valve model is based on a combination of first-principles modeling and empirical results from testing of a balanced disk globe valve by EPRI. The model has been validated, and shown to provide bounding overall stem thrust predictions, for five balanced disk globe valves tested by nuclear plants. In addition, the method for predicting disk-to-body/cage friction load, which is a key refinement in the model, has been shown to provide bounding results for the three valves for which digital test data was available to isolate the disk-to-body/cage friction load from the total measured stem thrust. Accordingly, the model is considered an adequate predictor of required thrust for balanced disk globe valves. The model has also been shown to provide more accurate (i.e., lower) thrust predictions than the original PPM method for balanced disk globe valves.

It is recognized that the data used for validation of the refined model is limited. However, the five valves used for validation cover a range of cage designs, from highly restrictive cages, such as hush trim, disk stacks and labyrinth cages, to cages that only block about 30% of the flow area through the valve. For the highly restrictive cages, the measured disk-to-body/cage friction load was found to be negligible. For the valves with cages that block 30% of the valve flow area, the disk-to-body cage friction load predicted by the refined model bounded the measured load. Accordingly, the model is considered applicable for valves with disk cages that block at least 30% of the valve flow area. For valves with blockage ratios less than 30%, the original EPRI PPM balanced globe valve model is recommended.

Model Applicability

The refined balanced disk globe valve model is applicable to balanced disk globe valves that meet the applicability requirements listed in Table 2.

Implementation of Refined Model

The refined model is implemented by hand calculation and can be used as an alternative to the original PPM method. The EPRI Model description report (Reference 4) includes worksheets to calculate the thrust components at the fully open and fully closed positions for both the opening and closing stroke directions. The significant design features, dimensions and materials needed from the valve manufacturer to support the implementation include guide type (body or cage guided), disk and guide material, valve stroke length, imbalance area, total cage hole flow area, disk top and guide diameters, and cage or body guide inside diameter. The EPRI report also includes a specification that can be used to obtain this information from the valve manufacturer.

References

1. EPRI TR–103244, "EPRI MOV Performance Prediction Program—Performance Prediction Methodology Implementation Guide," Revision 2.

2. EPRI TR–103227, "EPRI MOV Performance Prediction Program—Globe Valve Model Report," Revision 0.

3. EPRI TR–107322, "Air-Operated Valve Evaluation Guide," April, 1999.

4. EPRI TR–113558, "A Refined Model for Prediction of Balanced Disk Globe Valve Thrust Requirements," December, 1999.

Table 1
Balanced Disk Globe Valve Tests Used for Model Validation

Valve No.	Manufacturer	Size (inches)	ANSI Class	Design Features	Test Conditions
BG2.1	Fisher	4	900	T-pattern Rising stem Carbon steel cage Stainless steel disk Cage-guided Pilot Plug	Flow overseat 71°F water 16.4 ft/sec 1925 psid
BG5.1	Fisher	4	300	T-pattern Rising stem Cage-guided Stainless steel cage Stainless steel disk	Flow underseat 87°F water 44 ft/sec 220 psid
BG6.1	Copes–Vulcan	10	150	T-pattern Rising stem Stainless steel cage Stainless steel disk Cage-guided Hush trim	Flow underseat 49°F water 11 ft/sec 100 psid
BG7.1	Valtek	10	900	T-pattern Rising stem Carbon steel body Aluminum-bronze cage Stainless steel disk Labyrinth cage	Flow underseat 87°F water 20 ft/sec 1400 psid
BG8.1	CCI	2	900	T-pattern Rising stem Inconel cage Stainless steel disk Disk stack Soft seat (TFE)	Flow overseat 78°F water 49 ft/sec 657 psid

Table 2 Applicability of Refined Balanced Disk Globe Valve Model	
Category	**Applicability Requirements(s)**
Valve design	Balanced disk globe valves (excludes pilot operated valves) with single inlet and outlet ports (excludes double seat and three-way valves)
Body type	T-pattern, Y-pattern or angle
Cage design	Cage blocks at least 30% of the valve flow area (i.e., A% is 0.7 or less)
Flow type	Incompressible flow up to 150°F
Flow direction	Flow overseat or underseat
Actuator type	Any type (e.g., motor, air or hydraulic actuated)

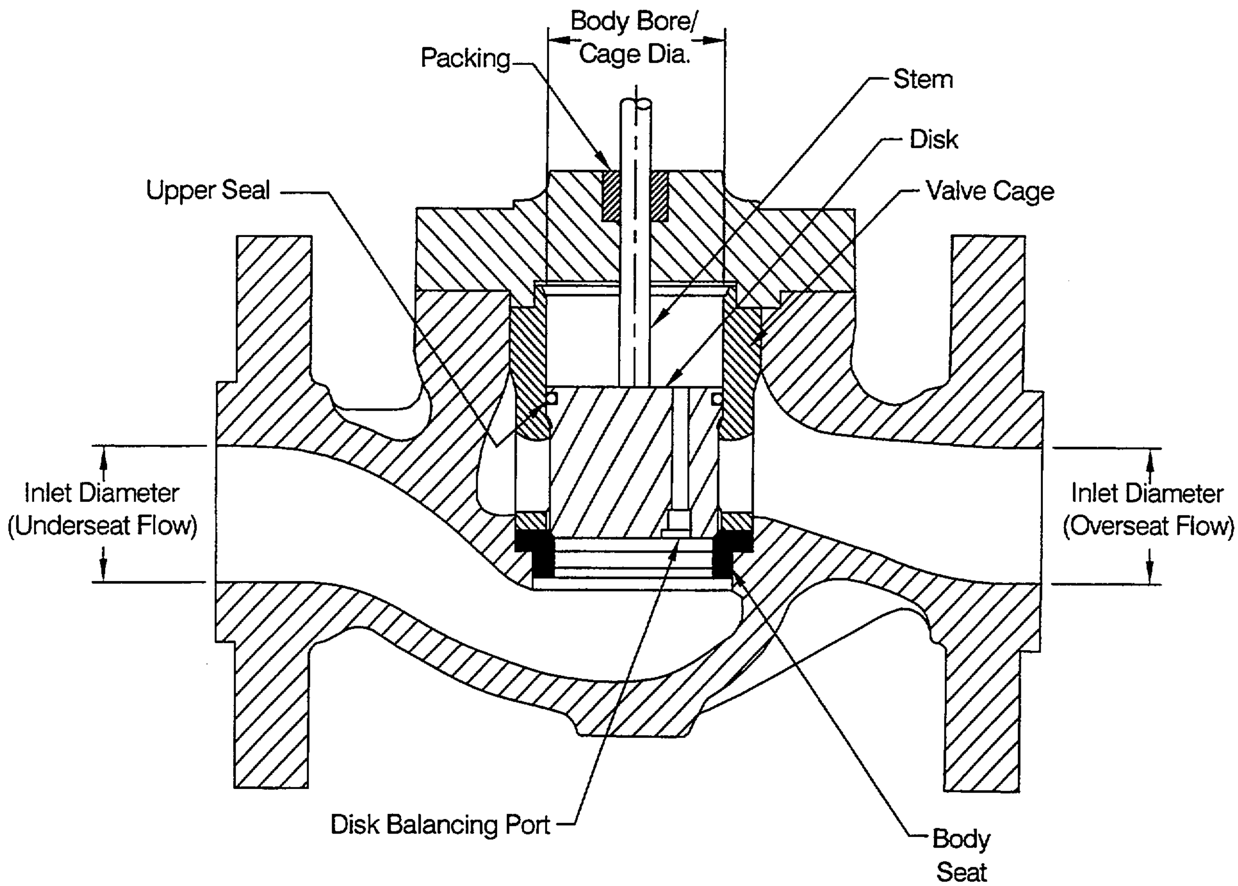

Figure 1. Typical Balanced Disk Globe Valve

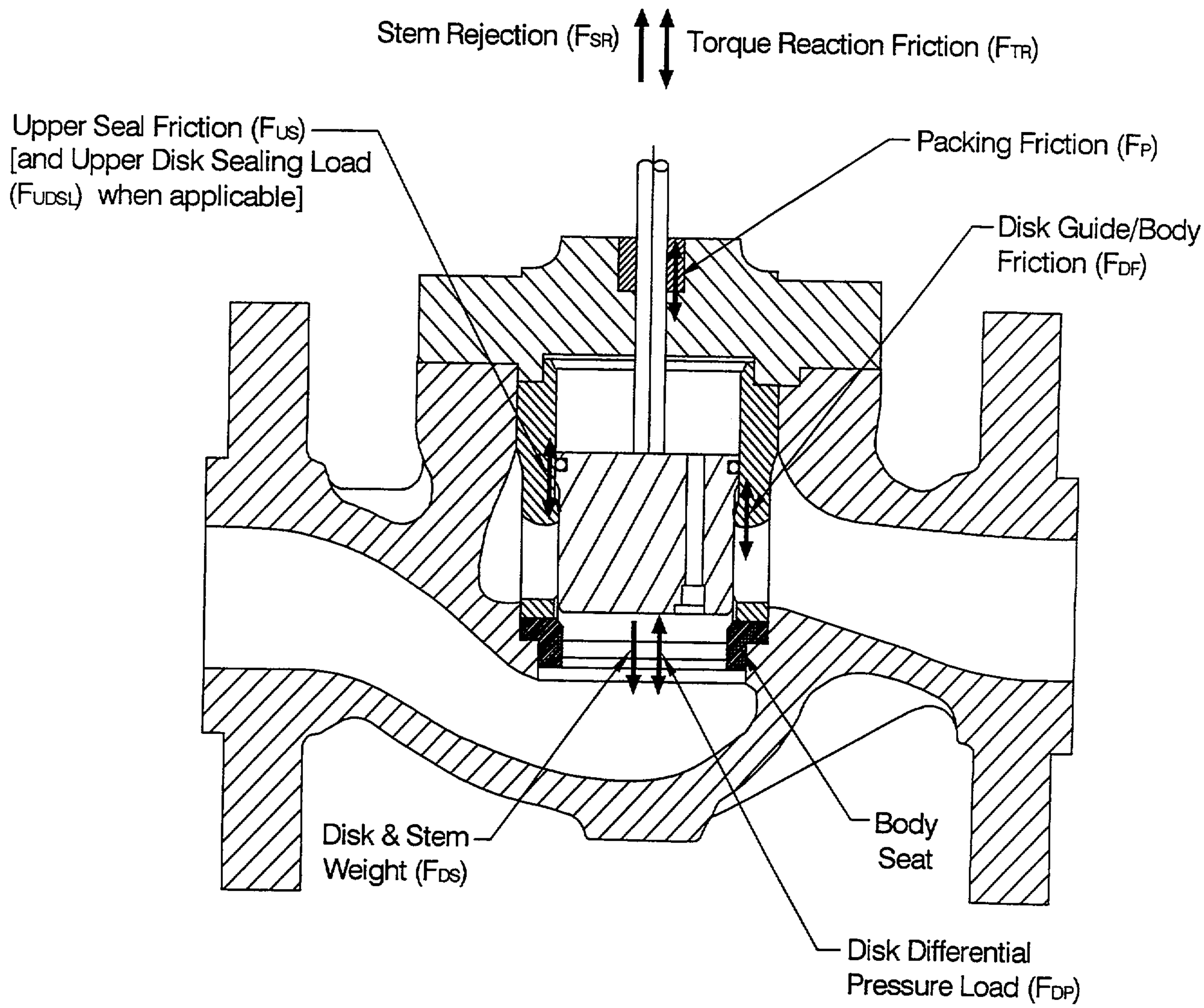

Figure 2. Typical Balanced Disk Globe Valve Stem Force Components

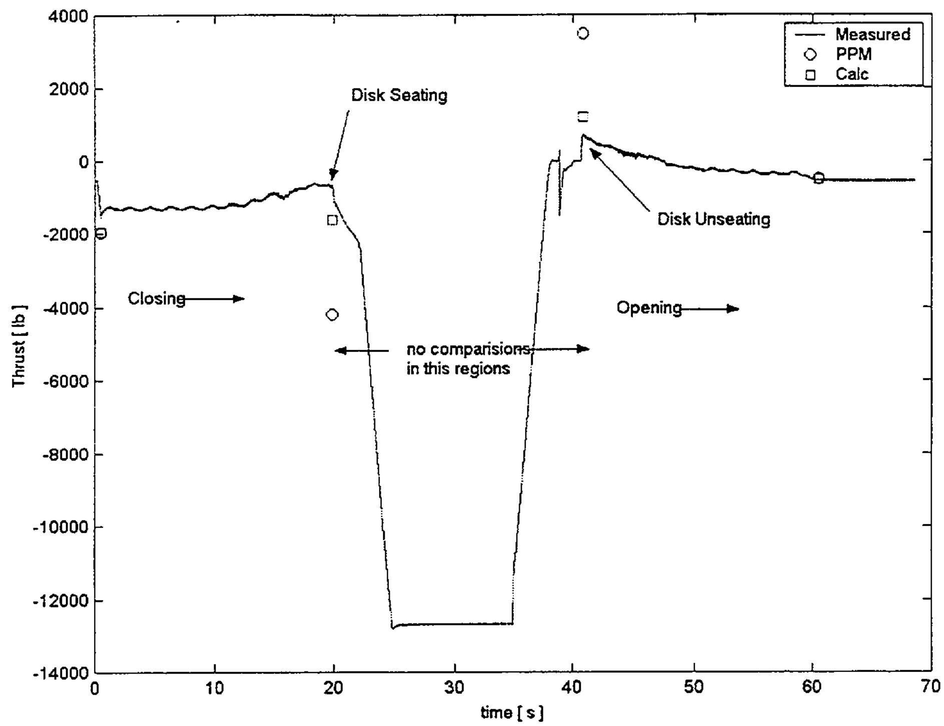

Figure 3. Measured and Calculated Stem Thrust for Valve No. BG2.1

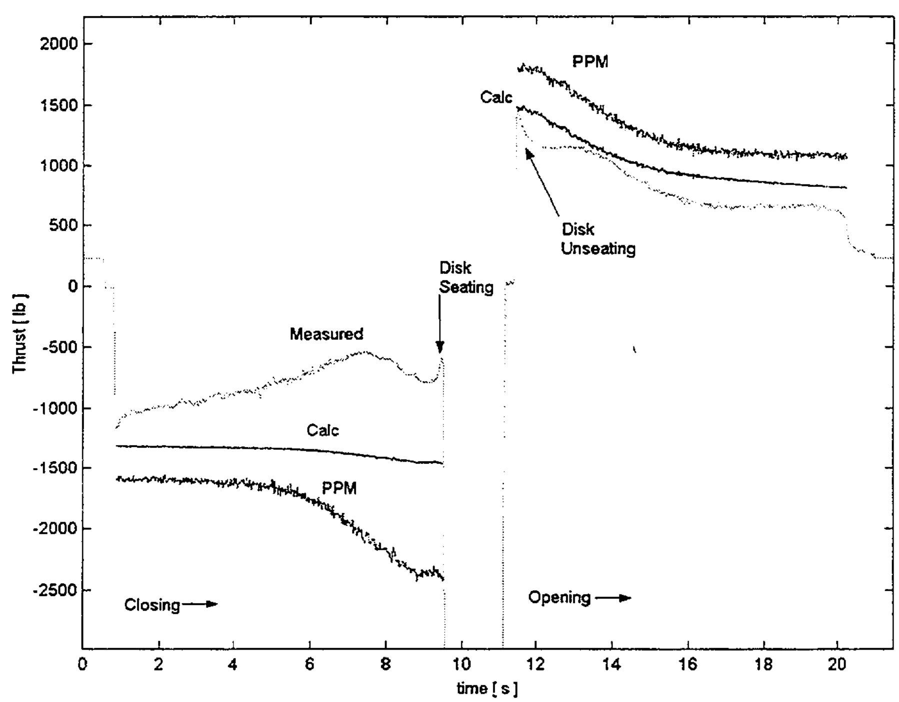

Figure 4. Measured and Calculated Stem Thrust for Valve No. BG5.1

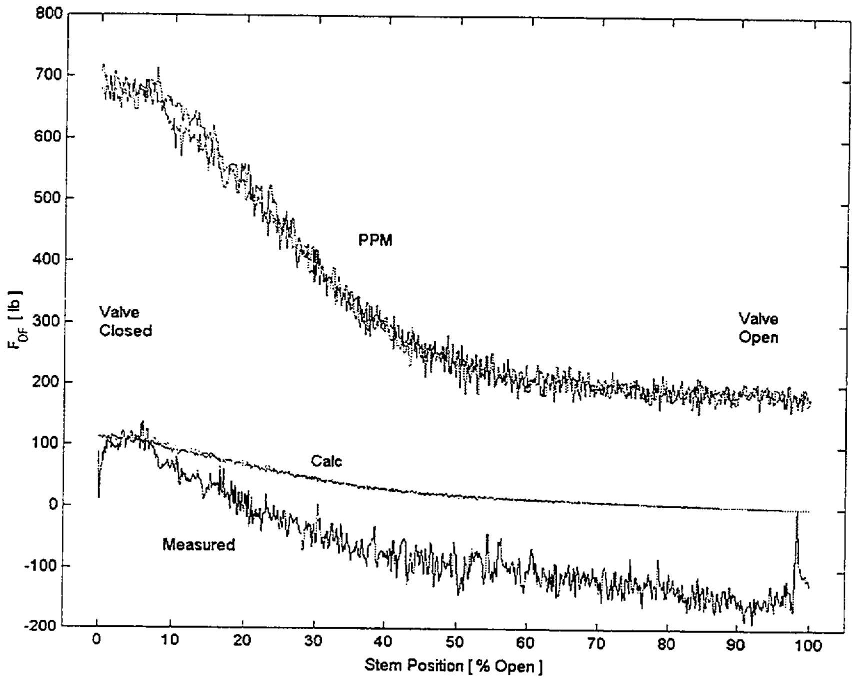

Figure 5. Measured and Calculated F_{DF} Results for Valve No. BG5.1

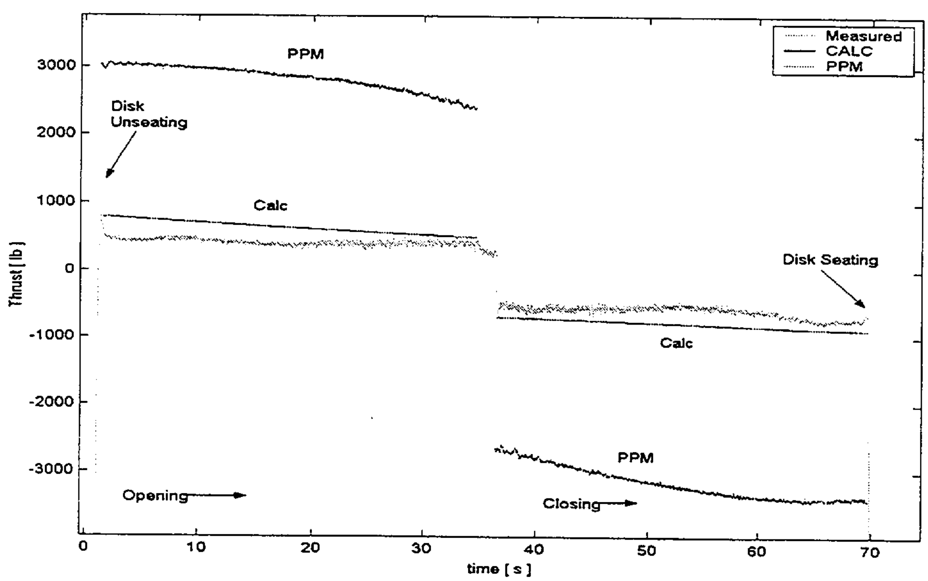

Figure 6. Measured and Calculated Stem Thrust for Valve No. BG6.1

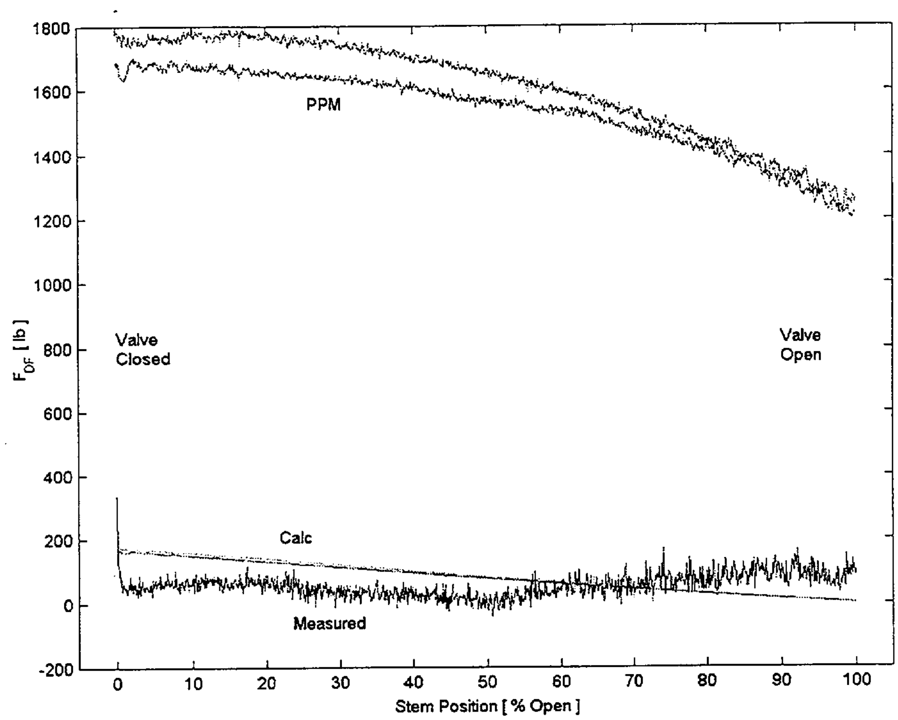

Figure 7. Measured and Calculated F_{DF} Results for Valve No. BG6.1

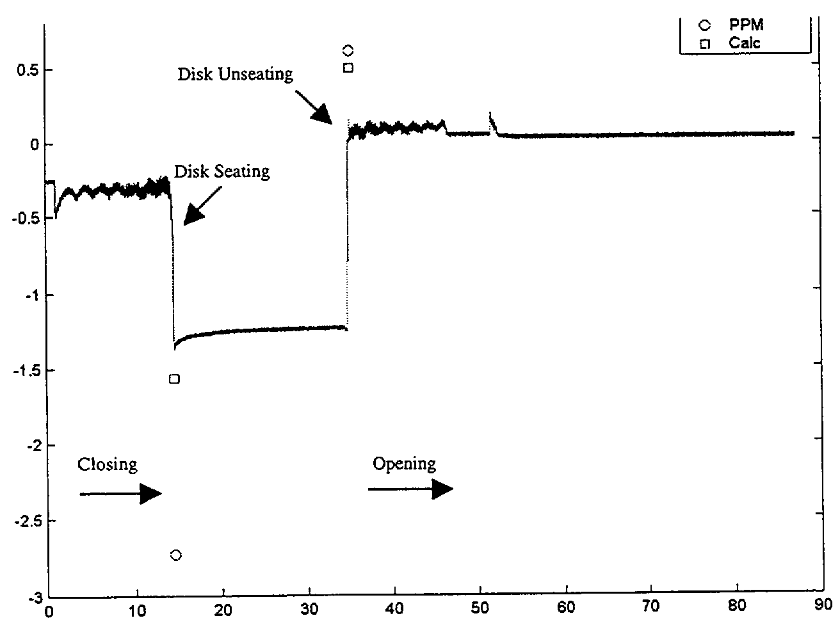

Figure 8. Measured and Calculated Stem Thrust for Valve No. BG7.1

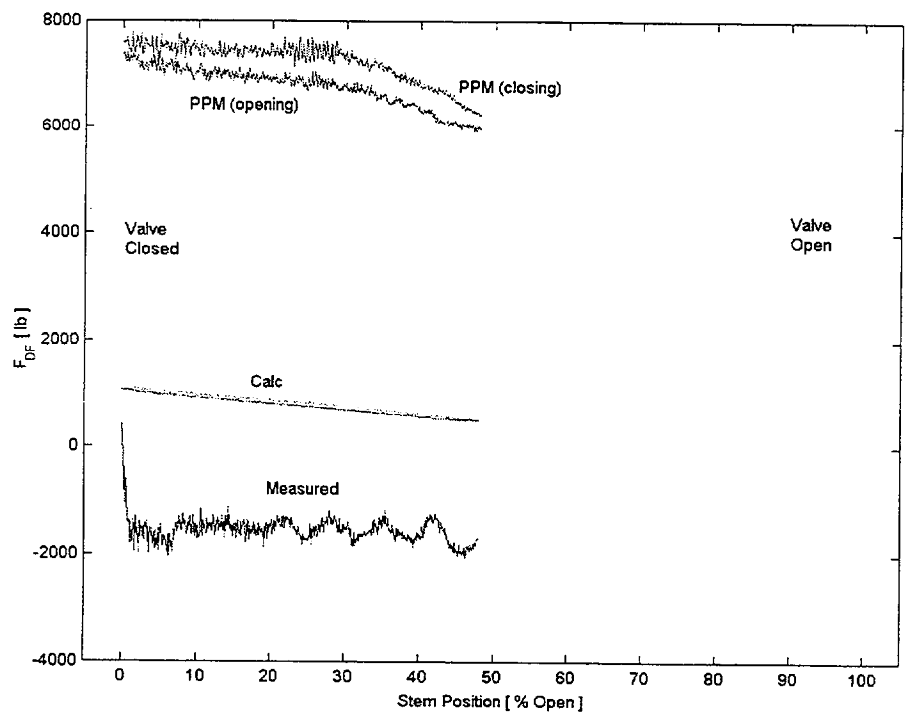

Figure 9. Measured and Calculated F_{DF} Results for Valve No. BG7.1

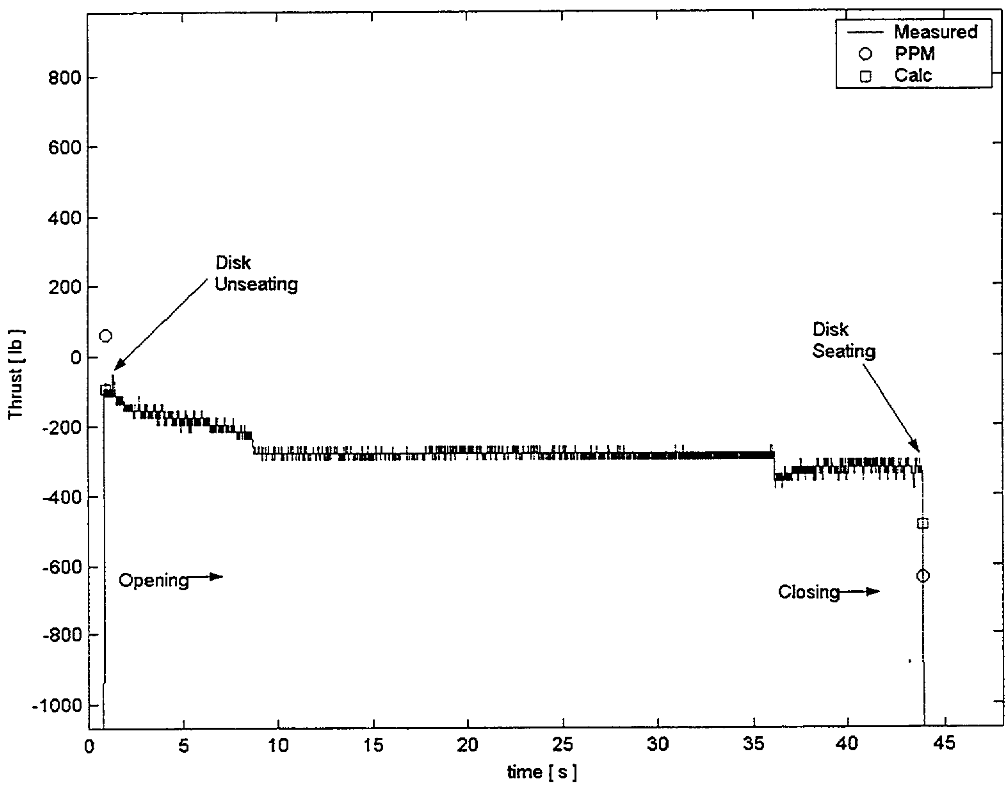

Figure 10. Measured and Calculated Stem Thrust for Valve No. BG8.1

Solutions to Performance Problems with Air Operated Valves

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Abstract

Performance problems with Air Operated Valves (AOVs) are all too common and create windows of opportunity for monetary loss, unscheduled maintenance and safety issues. Discussion provides solutions for common problems with AOVs and associated instrumentation. Topics include sizing issues, monetary loss, actuator maintenance, valve, actuator, AOV setup, calibration, and safety.

Introduction

Although performance problems with AOVs are many times due to improper sizing, AOVs are only as good as the personnel working them. Therefore, diligent training programs and procedure adherence are paramount. Concerning monetary loss, AOVs are the final element of the control loop. If they are poorly maintained, the complete loop will over work itself, and cost will rise. Unscheduled or emergent maintenance is very costly, especially if done in other-than-outage mode. Not enough can be said about safety, as it is paramount in our industry. Poorly maintained AOVs and associated instrumentation have the potential to cause personal injury and/or catastrophic events.

Improper valve sizing, concerns and solutions

Improper sizing is common considering AOVs are often sized according to calculated numbers, which may or may not be correct under dynamic conditions. Considering this, AOVs must be properly maintained to allow systems to operate at optimum levels.

- Improper application of a control valve can have many affects on the system it serves. Of the most common symptoms, we find *cavitation* and *flashing*. When *cavitation* occurs within a valve, it will leave distinguishing damage, which has the appearance of a sponge. Basically, *cavitation* and *flashing* are the result of "flow starvation" or "choking" the flow. This phenomenon occurs when the ΔPmax is exceeded. For example, if calculated pressures upstream and downstream are greater than the maximum allowable ΔP, the result may be cavitation or flashing.
- Although there are exceptions, these two phenomena are typically controlled through proper sizing. The result is increased valve-life, a more efficient AOV, and considerable cost reduction.

Valve Maintenance, concerns and solutions

Considering the many styles and types of valves, only skilled technicians should maintain them. An improperly assembled valve brings with it several potential concerns.

- Wrong stack height
- Improperly cut seats

- Improper seat contact
- Misalignment
- Wrong materials

Alignment, what it affects

During assembly, alignment is critical. Alignment will affect many things:

- Shutoff
- Seat load
- Friction
- Wear on trim parts, valve stem, bushings, packing
- Unseating
- Calibration
- Undue stress on complete AOV

Ensure all parts are correct and seats are true to avoid alignment problems. Tolerances are often very close and with that in mind, the following assembly technique is suggested.

1. Assemble the valve loosely (body to bonnet bolts/nuts finger tight).

2. Install enough packing to keep the stem aligned (two or three rings) consolidated.

3. If possible, use the actuator to seat the valve. If not, lightly tap the plug into the seat with a soft mallet. This will bring everything into alignment.

4. Open the valve and ensure bolt/nuts are still finger tight. Pay attention to any unusual dragging within the body.

5. Repeat step three.

6. Make initial torque pass 25% or less.

7. Open and close the valve assuring there are no restrictions.

8. Continue torque an additional 25% or less.

9. Repeat step seven.

10. Repeat steps eight and nine until desired torque is reached.

Utilizing this technique will assure the best possible shutoff, reduce internal friction and "zero" re-works.

Improper actuator sizing, concerns and solutions

As sized, many times actuators (particularly diaphragm) do not supply enough force to produce expected results under dynamic conditions. Consequently, they are taken to maximum limits, which can have a direct affect on life span. Understanding that, here are two recommended solutions:

Change the diaphragm actuator to a cylinder actuator.

- It can be used as a single or double acting unit.
- Typically it will handle much higher supply pressures.
- Response times are typically better.
- Most times this change is non-intrusive.
- The cylinder offers more options.

Resize the trim and or valve.

- Flow calculations may prove that reduced trim may be used allowing the original actuator to produce expected results.

Improper instrument sizing, concerns and solutions

As with the valve and actuator, conditions change and original instrumentation is not sufficient. Response times may no longer handle the application.

- Consider upgrading to high volume.

- Many manufacturers offer retrofit kits to improve performance.

Monetary Losses

Monetary losses are felt in many areas:

- AOVs are the final control element of the control loop and many times are over worked because of improper set-up. The purpose of the control loop, as the name suggests, is to control a process within predetermined parameters. If any element of the control loop is not maintained, the whole loop suffers.

- Proper maintenance of AOVs and associated instrumentation will most assuredly add to the life span, reduce unscheduled repair and increase revenue.

- Undue stress on air compressors leads to major repairs or replacement.

- Air leaks and faulty mechanical parts can cause constant cycling of an AOV, which affects actuator, instrument, valve and internal parts. Therefore, the life span is diminished. Cycling also has detrimental affects on system performance that can be costly.

The following Air Leak chart (Table 1) will show expected monetary loss from air leaks.

Table 1: AIR/HP LOSS (Exhausting from 100 psig to atmosphere)

ORIFICE SIZE	SCFM	EQUIV. HP
1/32”	1.62	0.35
1/16”	6.49	1.44
1/8”	26.0	5.8
1/4”	104.0	23.1
3/8”	234.0	52.0
1/2”	415.0	92.2
3/4”	934.0	247.5
1”	1661.0	369.1
Increased system pressure is required to compensate for the air leaks.		

Leak Size	Loss (CFD)	Loss ($/Day)	Loss ($/Year)
1/64”	576	0.13	48.00
1/32”	2,304	0.51	186.00
1/16”	9,288	2.04	744.00
1/8”	37,152	8.17	2,981.00
3/16”	83,952	18.47	6,738.00
Based on 100 psig, $0.22/mcf, 8760 hrs./yr.			
Leak Size	Loss (CFD)	Loss ($/Day)	Loss ($/Year)
1/64”	576	0.18	66.00
1/32”	2,304	0.71	259.07
1/16”	9,288	2.00	1,051.00
1/8”	37,152	11.52	4,202.00
3/16”	83,952	26.03	9,496.00
Based on 100 psig, $0.31/mcf, 8760 hrs./yr.			

Table 1: Air Leak Chart

Diaphragm actuator, concerns and solutions

Diaphragm actuators come in many styles and sizes and have unique issues. Correct maintenance and safety is of the utmost importance. Only qualified personnel should maintain them. The following items will affect the performance of a diaphragm actuator.

Over tightening of the housing/casing will produce several effects.

- Depending on the actuator material, over tightening of the actuator housing is a common cause for leakage. When torque procedures are not adhered to, the upper and lower diaphragm cases become stressed and subject to warping.

- This not only causes a leak path; it also places undue stress on the diaphragm.

- If tightened enough, the case can cut through the diaphragm, allowing it to tear or come loose from the fasteners.

A simple but relevant solution is to follow torque procedure.

Note: Keep in mind, one leak can mask another. For example, if both the diaphragm casing and stem bushing are leaking, you may not detect this until the casing leak is repaired.

Improper installation of the diaphragm to diaphragm plate and actuator shaft can cause damage to diaphragm and create opportunity for air leaks.

- Follow torque guidelines.
- Make sure replacement diaphragm is like for like.
- Check new diaphragm for proper date and any signs of aging.

Note: If the actuator has been painted, do not assemble until the paint is completely dry. Diaphragm materials will adhere to wet paint and after drying, can tear when the actuator is stroked.

Dynamic seals are of concern with diaphragm actuators. Typically, these seals are in the form of elastomer (o-rings/seals) or packing. Proper installation and maintenance is necessary.

- O-rings and seals must have proper lubricant and extreme care must be taken to prevent damage during installation of the actuator shaft or bushings.

- When packing is used, lubricant may be required.

- Proper torque technique must be followed so the actuator can function properly.

- The actuator stem must have the correct finish to allow minimum friction during stroke.

During assembly, the actuator spring arrangement has a few items of concern that should be checked.

- Always inspect for cracks.

- Spring should be rust-free and coated with a rust preventative.

- Adjusting screws must be clean and lubricated.

- Spring buttons/guides must be properly aligned.

- Bearings must be clean and lubricated.

After proper assembly, the actuator benchset should be performed according to procedure.

- Typically, benchset is done with the actuator uncoupled from the valve.

- A benefit of diagnostic testing is that the user can perform benchset without uncoupling.

Benchset affects the performance of the AOV.

- In a flow up/under, fail close situation, if the benchset is not properly adjusted the valve may lift off the seat under dynamic conditions.
- In a flow down/over, fail open situation, if the bench set is not properly adjusted the valve may not lift off the seat under dynamic conditions.
- Due to flow condition or sizing issues, often times the benchset is adjusted under dynamic conditions to achieve required seat load.
- A rule of thumb is that supply pressure is set at least 5 psi above the benchset.

Benchset can be affected by friction and or mechanical binding.

- New packing may have high enough friction to keep the valve from failing close.
- Alternative packing material may need to be installed.
- The number of packing rings can create enough friction to affect the benchset.
- Proper valve stem finish is necessary.
- Mechanical binding of any sort must be eliminated.

Note: Benchset and packing adjustments made after the AOV is setup will affect the calibration. Never exceed the manufacturer's recommended pressure for any actuator.

Diaphragm actuator, safety concerns

Diaphragm actuators usually are spring loaded and must never be maintained by untrained personnel.

- Never assume the energy of the spring is gone when disassembling the actuator.
- Never exceed the recommended supply pressure.
- Follow manufacturer's maintenance guidelines.

Cylinder actuator, concerns and solutions

It is not uncommon for a cylinder actuator to maintain performance for as many as twenty years. A few things should be considered when applying them. Cylinder actuators many times are spring loaded and must **never** be maintained by untrained personnel. Improper disassembly or assembly could cause serious bodily harm.

- Cylinder actuators are meant to be mounted in a vertical fashion.
- Mounting a cylinder actuator in a horizontal fashion creates a significant side-load effect and the life span of the cylinder, soft goods and bushings will greatly diminish.
- While maintaining cylinder actuators, pay particular attention to foreign material exclusion requirements. Any foreign material could cause leakage and or wear.
- Pay particular attention to o-rings when assembling to prevent cutting. If horizontal mounting is unavoidable, then consider the use of teflon or other compatible material for use as backup rings to help avoid premature wear on the cylinder.

The cylinder actuator tested in Figure 1 is mounted in a vertical fashion. Note the significant leakage (Top and Bottom Cylinder Pressures) past the piston o-ring.

Cylinder actuator, safety concerns

- Never assume the energy of the spring is gone when disassembling the actuator.
- Never exceed the recommended supply pressure.
- Never disassemble while under pressure of any sort.
- Follow manufacturer's maintenance guidelines.

AOV instrumentation, concerns and solutions

AOV instrument problems tend to repeat in many plants. The most common are air leaks, air starvation, calibration/setup, mounting, and premature wear.

Air Leaks

Air leaks stem from a variety of reasons and affect the entire control loop:

- Poor maintenance, only qualified personnel should perform instrument maintenance
- Over tightening of tube fittings
- Poor tube bending practices
- Improper or no thread sealant
- Improper lubrication
- Extruding soft goods due to over tightening of components

Of these, over tightening of the tube fitting is probably the most common. Tube fitting procedures are in place and should be adhered to. Tube fittings are very expensive and though it may sound simple, there are proper techniques associated with tightening. Over tightening of a tube fitting can and will cut through copper tubing.

Consider the fact that air is the lifeblood of an AOV. Leaks of any size are never considered acceptable. Refer to Table 1, Air Leak Chart. Air leaks will have a significant impact on the AOV and all associated components. AOVs are the final element of a control loop and if they do not perform properly, it affects the whole loop.

- Hysteresis
- Dead band
- Calibration errors
- Cycling or hunting
- Premature wear of the AOV and all of its components causing early replacement of parts

Many times associated current to pressure transducers (I/P) are mounted too far from the AOV and the result is a huge dead band error which will result in cycling/hunting, stem and component wear (See Figure 2). This can prove to be very costly.

Note: Considering all of these issues, the monetary loss associated with air leaks is phenomenal. Many expensive AOV components, accessories, and air compressors have been replaced prematurely, simply because air leaks have not been taken seriously. Figure 3 (Supply Pressure) shows how a compressor continued to cycle because of air leaks. Consequently, the AOV continued to be over worked along with all of its components.

Air leak safety concerns

Air leaks never get better, only worse. Considering this, what is impacted if an AOV fails due to air leaks?

- An air leak on a fail-safe/lockup system will prove to have a tremendous impact if the AOV fails in the wrong position.
- Losses could involve everything from process control to public safety.

Note: This sort of erratic supply will diminish the life span of the AOV and all associated parts.

Air starvation, concerns and solutions

Air starvation happens when the instrument and actuator call for more air than is being supplied. Two major reasons for air starvation are improper tubing size and leaks. Personnel should be aware of the ramifications of using improper tubing sizes and air leaks. Many times, there are several different sizes of tubing installed on an AOV. There may be three different sizes from the main air supply to the output of the instrument. These practices will cause the valve to perform at minimal levels.

- Repair air leaks as they are unacceptable and greatly increase air starvation.
- It is recommended that main air supply tubing to the instrument be no less than .375 inch.

Figure 4 diagnostic test data reveals air starvation. Note how the supply pressure never totally recovers. Diaphragm pressure shows how air starvation makes it difficult to saturate.

Note: Air starvation becomes more critical on air-to-close valves because they may not completely close or control against process pressure.

Calibration/setup, concerns and solutions

Personnel should be aware of the ramifications of improper setup. Before calibrating an instrument, several things must take place in the following order:

- Perform benchset if applicable.
- Adjust travel in accordance with manufacturer's guidelines.
- Install instruments in accordance with manufacturer's guidelines.
- Perform mid-travel alignments as required (typically with a manual loader or handwheel).
- Perform instrument alignments (beam, relay, etc.) if required.
- Calibrate according to manufacturer's specifications.

Note: If an I/P is involved, calibrate it first then use it to calibrate the positioner. When possible, use diagnostic equipment to perform setup and calibration. Always check for air leaks, binding, high friction, linkage problems, etc. before beginning calibration.

Positioner mounting, concerns and solutions

- Mounting a positioner improperly on an AOV has a significant impact on performance. If not mounted according to manufacturer's recommendations, the possibility of failure or unacceptable performance exists. Some positioners have many mounting positions. Technicians should be aware of the ramifications of improper mounting.

- Can cause premature linkage wear and or failure
- Non-linear stroke
- Difficulty in calibration
- Damage to instrument

Note: Depending on circumstances, there are exceptions to the rule when mounting a positioner on an AOV. Under normal mounting conditions, follow manufacturer guidelines.

Linkage failure, concerns and solutions

Vibration is probably the most common cause of linkage failure. Improper installation follows close behind. Other causes include oscillation (hunting) due to over tightening of packing, improper calibration, boosters out of adjustment, bad relays, air leaks and normal wear and tear. It is important to make sure there is no interference. The linkage will typically run parallel or perpendicular to the valve stem. Mounting linkage in a manner that is at an angle to the stem is not suggested in that it can affect many things.

- Calibration
- Hysteresis
- Deadband
- Repeatability
- Linearity
- Binding in the linkage and/or feedback mechanism
- Breakage of linkage and associated parts

When possible, eliminate vibration in the instrument. A possible solution is to replace the instrument with one that is not affected by vibration. Some positioners can be remotely mounted. Proper installation and calibration are very important. Proper packing torque is also important. Check the instrument and any accessories for proper operation and leaks.

Figure 5 shows the effect of binding in the linkage of a position transmitter.

Safety

Given the many types and styles of AOVs, the process of maintaining them becomes very complex. AOVs produce tremendous forces that create many dangers. Only qualified personnel should maintain them. Many untrained personnel have been injured while attempting to perform maintenance on them. Proper training and qualifications are paramount.

The ramifications of AOV failure could be catastrophic.

Concluding Remarks

Many concerns and solutions have been addressed in the paper, which should open eyes to the importance of maintaining AOVs. AOVs have operated for years in this industry, some with problems, some without, but not necessarily at optimum levels. Changing the mind set and showing benefits of new technology will prove to be a tremendous benefit. With properly trained technicians and the use of diagnostics, there is no reason why the AOVs can not produce at optimum levels. Bottom line, AOVs can only produce at optimum levels if properly designed and maintained.

References

Air Loss Chart provided by:
Enercheck Systems, Inc.
www.enercheckystems.com/index.html

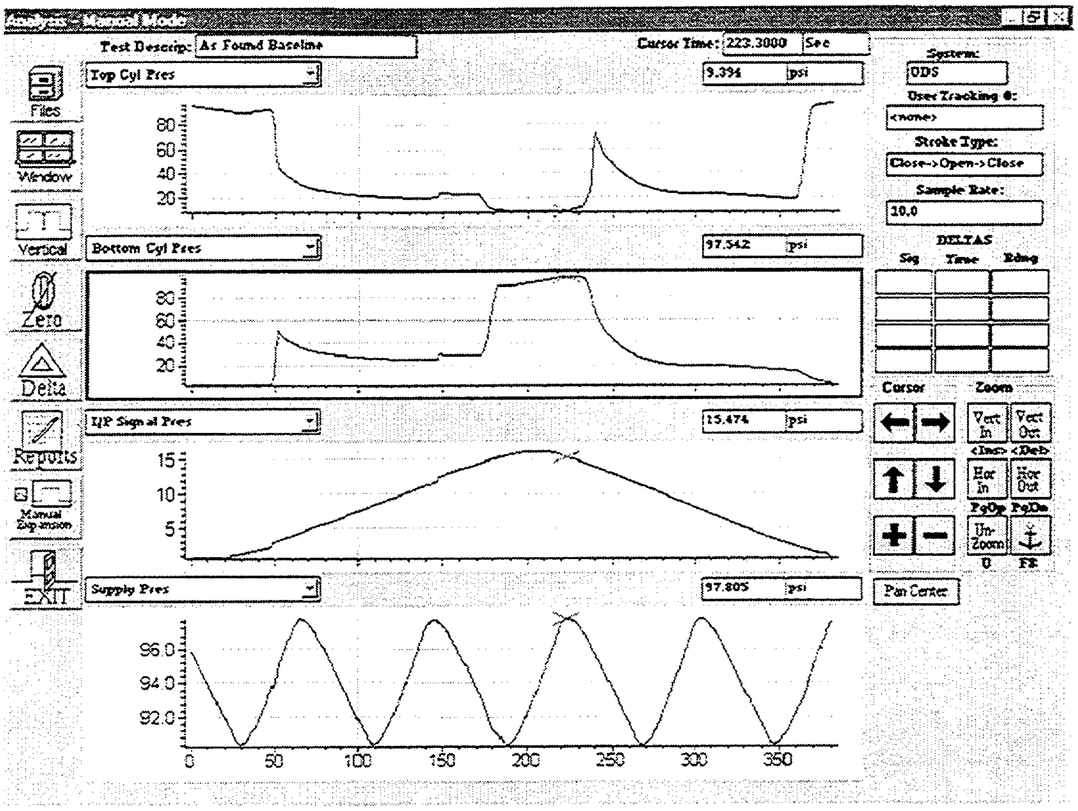

Figure 1: Piston O-Ring Leak

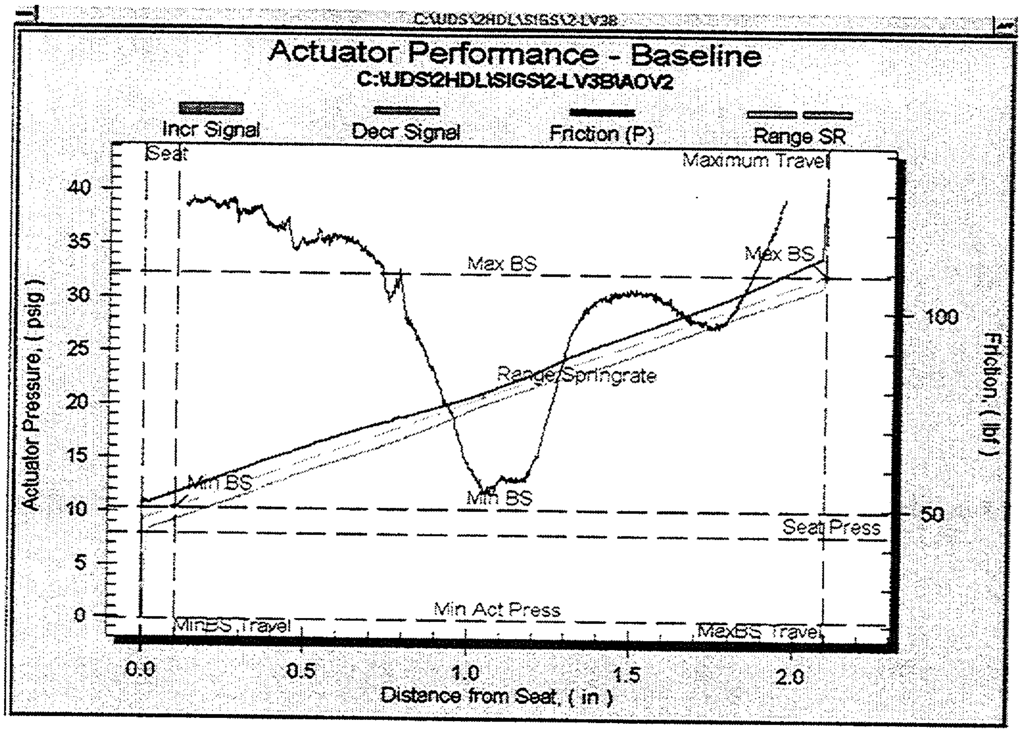

Figure 2: Stem Wear

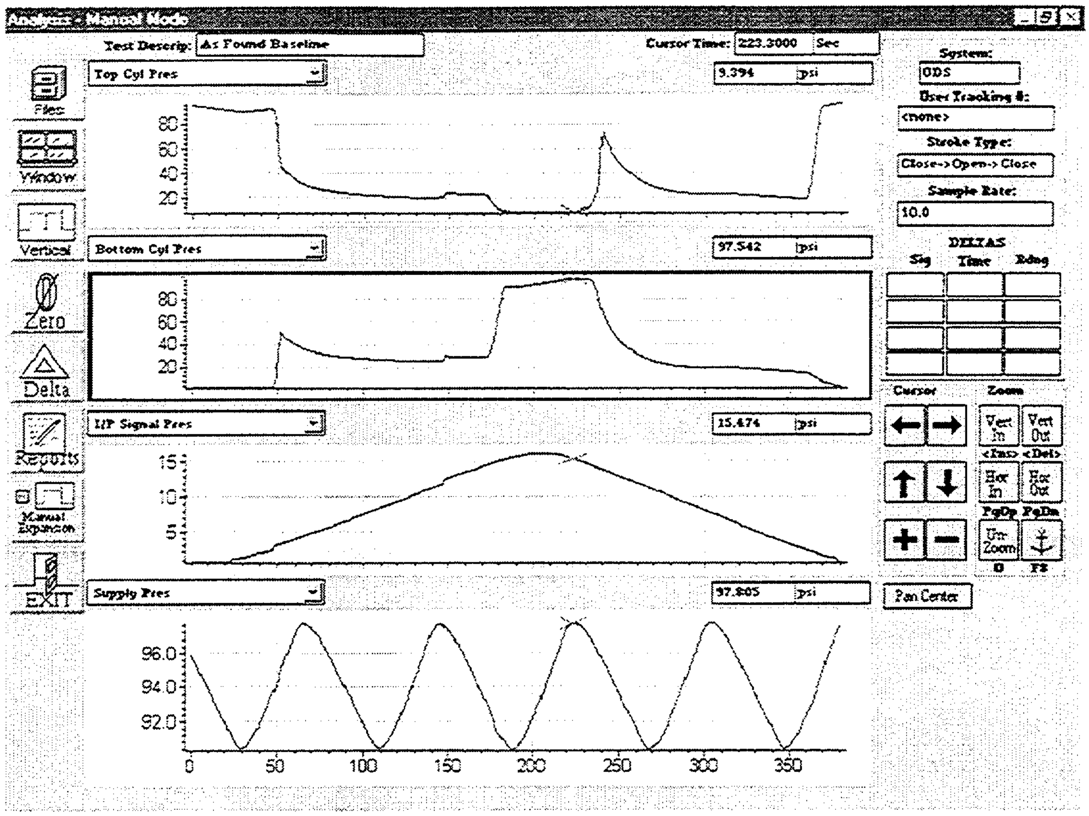

Figure 3: Compressor Cycling Because of Air Leak

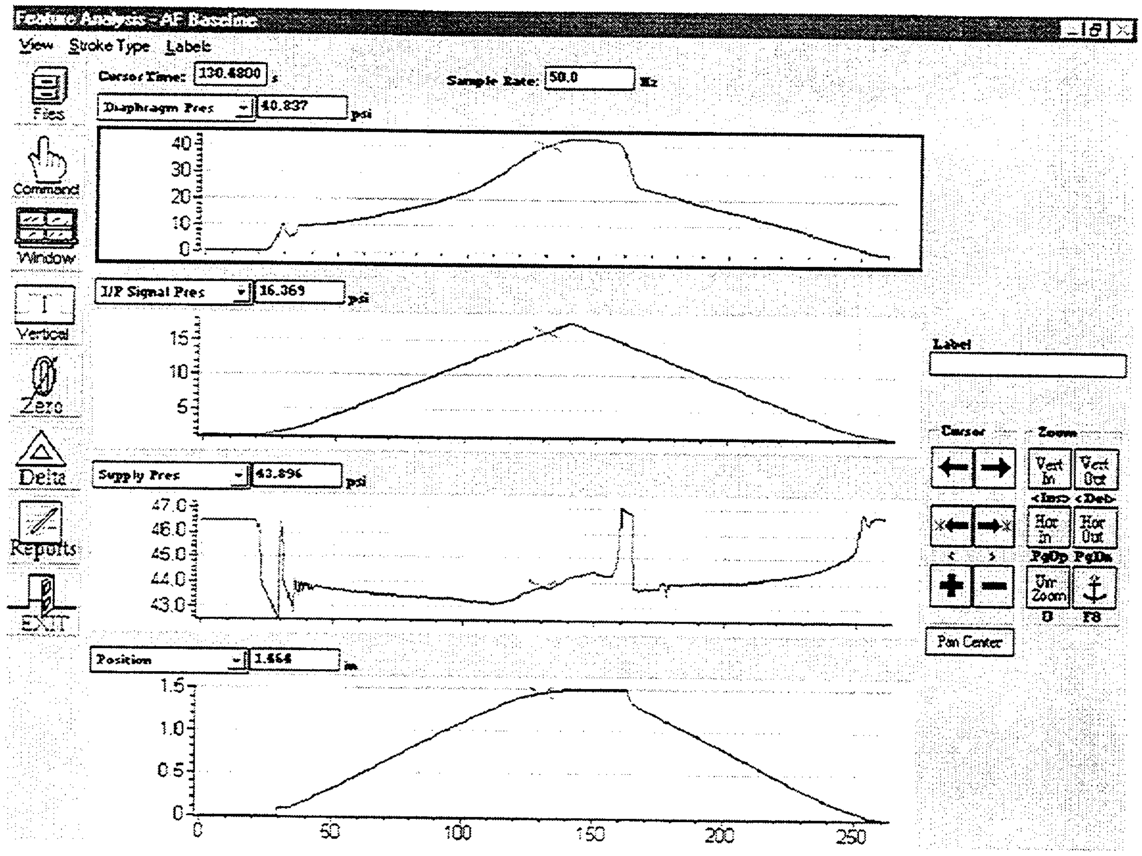

Figure 4: Air Starvation

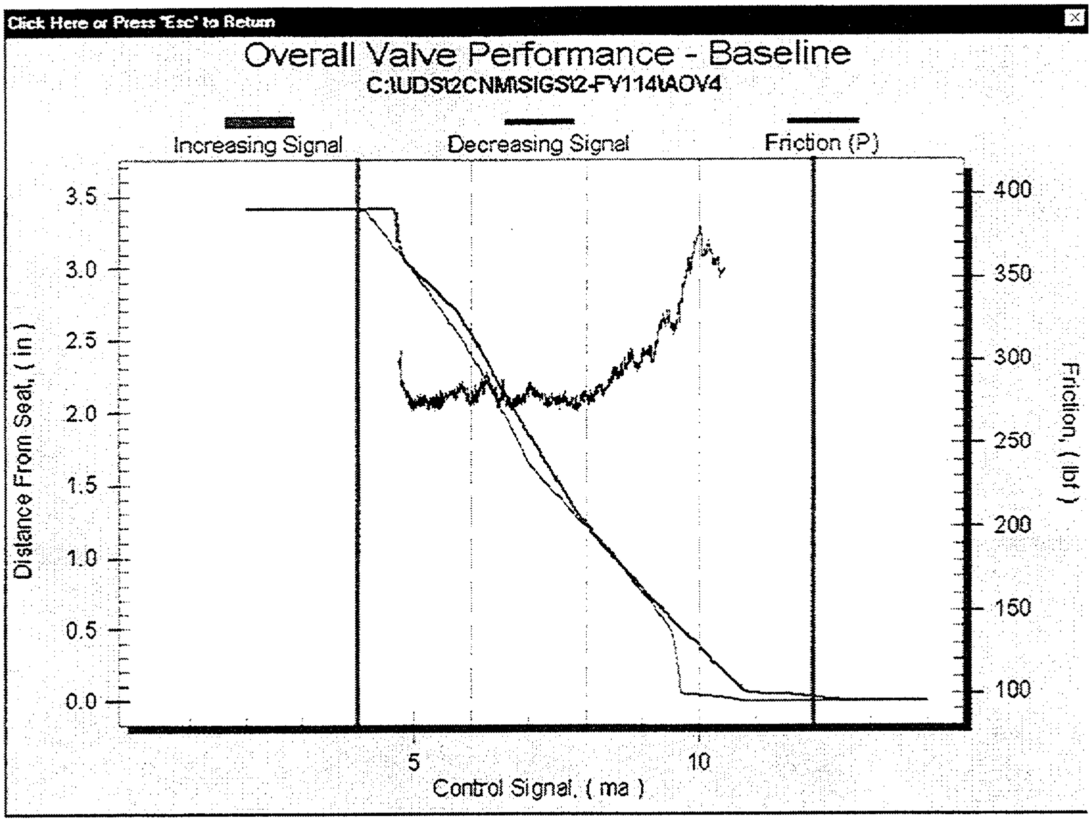

Figure 5: Binding in Linkage

Dynamic Torque Models for Quarter-Turn Air-Operated Valves

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Abstract

The U.S. nuclear power plants are currently developing and implementing air-operated valve (AOV) programs to ensure that safety-related as well as high-safety-significant valves will function reliably under their design basis conditions. The AOV population in the U.S. nuclear power plants has several types of quarter-turn valves for which *validated* models are not available. Under Electric Power Research Institute's Motor-Operated Valve Performance Prediction Program (EPRI MOV PPP), validated models were developed for symmetric and single-offset butterfly valves; however, these models address only 2 out of more than 6 different types of quarter-turn valves used in AOV applications. Furthermore, these butterfly valve models that were developed for MOVs have been found to be overly conservative for AOVs, leading to unnecessary equipment modifications to address invalid operability concerns in many cases.

To address these issues generically and fill an important industry need, Kalsi Engineering, Inc. initiated a comprehensive program to develop validated models for quarter-turn valves in November 1999. The program includes development of first principle models, extensive computational fluid dynamics (CFD) analyses, and flow loop tests on all common types of AOV quarter-turn valves. The test program includes systematic evaluation of elbow orientations and proximities to quantify elbow effects on required torque. The program is conducted under a quality assurance program that meets 10CFR50 Appendix B requirements. The product of this program is a model report and supporting documentation that describes the methodologies and provides torque coefficient, flow coefficient, and elbow influence data.

The quarter-turn valve program results will benefit the utilities by providing reliable models for accurately predicting required torque for different types of AOVs; thus ensuring reliable operation while eliminating unnecessary and costly technical effort and equipment modification.

Introduction and Background

Problems with AOV operation can lead to safety concerns, reactor scrams, reduced plant efficiency, and increased maintenance cost [1, 2, 3]*. To address these issues and ensure that safety-related as well as highly safety-significant AOVs will function reliably under design basis conditions, the U.S. nuclear power plants are in the process of developing and implementing AOV programs. The Joint Owners Group for Air Operated Valves developed a document to provide programmatic guidance and

*Numbers in brackets denote references listed at the end of this paper.

recommendations to the utilities for their AOV programs. EPRI, in collaboration with four utilities, performed AOV design basis calculations under the EPRI pilot program. The methodology used in the pilot program for evaluating various types of valves is documented in Reference 7.

Implementation of the AOV evaluation methodology [7] and butterfly valve models developed under EPRI MOV PPP [5, 6] revealed two key issues for quarter-turn valves:

1. There are *no validated models* for several types of quarter-turn valves that constitute a large AOV population, and

2. EPRI MOV PPP methodology for symmetric and single-offset butterfly MOVs is based on a bounding approach that is *overly conservative*, and which in many cases leads to unjustified negative margin concerns in AOVs.

The first issue is due to the fact that the scope of the EPRI MOV PPP addressed only symmetric disc and single-offset butterfly valves because these cover a vast majority of the quarter-turn valve population in MOVs. However, far more variations exist in quarter-turn valves used in AOV applications (e.g., double-offset disc butterfly, spherical ball, partial ball, plug). Since there are no validated models for these common variations, industry is resorting to using "best available information" to determine torque requirements. Best available information includes data from technical publications for valve geometries that have significant differences in hydrodynamic characteristics (e.g., Refs. 10, 11), and manufacturers' sizing procedures (e.g., Refs 12, 13). Lessons learned during the MOV program to address USNRC's Generic Letter 89–10 concerns have shown this to be an unreliable approach.

The second issue is due to the fact that the EPRI MOV PPP used a bounding approach for the symmetric and single-offset butterfly valve models. These models were found to be satisfactory for MOV evaluations and benefited the utilities by eliminating the need for dynamic and periodic verification testing in many applications. However, the MOV actuators have generally higher output capabilities than their AOV counterparts, and their output is constant throughout the stroke. Consequently, excessive conservatism in the EPRI MOV PPM butterfly model over certain portions of the stroke imposes no significant penalty for MOVs. In contrast, the output from AOV actuators is typically lower and it varies significantly with stroke (e.g., Fig. 1). Therefore, excessive conservatism in the models can seriously penalize AOV evaluations resulting in invalid negative or low margin concerns in many cases.

Quarter-Turn Valve Model Development Program

Objectives

To fill the industry need, a comprehensive quarter-turn AOV model development program was initiated in November 1999. The objectives of the program are to

1. Develop improved models for symmetric and single-offset butterfly valves that accurately predict torque requirements and overcome limitations of the earlier models [5];

2. Develop torque prediction models for double-offset butterfly valves and other types of quarter-turn ball and plug valves that are commonly used in AOV applications at nuclear power plant.

3. Perform tests to support model development and validation. All tests must meet quality assurance requirements of 10CFR50 Appendix B.

Since upstream flow disturbances, e.g., elbows, can significantly influence the hydrodynamic torque [5], the models must include the effect of elbow orientation and proximity on the required torque.

Technical Approach

The key activities of the technical approach followed in the quarter-turn valve model development program are described below:

Population Survey

To determine which types of quarter-turn valves should be included in the program, a nuclear power utility survey was conducted. Survey data from 10 utilities that had categorized their valves based on the approach recommended by the AOV Joint Owners Group were evaluated. Results of the survey show that the six types of quarter-turn butterfly, ball, and plug valves shown in Table 1 cover more than 80% of the AOV population.

Cylindrical and tapered plug valves were given a low priority because they contribute less than 5% of the population.

Analytical Models

Torque prediction models for the design variations shown in Table 1 were developed by rigorous application of first principles. Hydrodynamic torque exerted by the fluid flowing around the valve internals is a significant part of the total dynamic torque, and it is sensitive to disc geometry. Extensive computational fluid dynamics (CFD) analyses, as well as scale model flow tests satisfying the similitude requirements, were performed to accurately quantify the hydrodynamic torque on the discs of different shapes.

For butterfly valves, disc geometries included are symmetric, single-offset, and double-offset. The maximum thickness at the center of the butterfly valve discs can vary significantly depending upon the valve size and pressure class. An earlier survey [6] had shown that variations in the ratio of disc thickness to disc outside diameter (also called disc aspect ratio) from 0.15 to 0.35 cover the vast majority of nuclear power plant applications.

The model development approach includes full spherical ball, segmented ball (also called partial ball or V-Ball), and an eccentric plug (also called Camflex) valve designs. For ball valves, the ratio of spherical ball diameter to mean seat diameter is relatively constant for pressure classes ranging from ANSI 150 through ANSI 1500. This is because the minimum spherical diameter necessary for sealing is geometrically related to the mean seat diameter; the resulting strength of the full spherical ball structure is adequate to handle differential pressures up to ANSI 1500 for commonly used materials.

Our review of the recently published ball valve model [8] for AOV/MOV predictions shows that data from an earlier scaled model test performed on a *ribbed* ball valve [10] were used to predict hydrodynamic torque on *full spherical* ball designs (Figs. 2A, 2B). It should be noted that, to save weight, the ball closure element in large ball valves is typically a ribbed structure (which has sufficient strength to handle the ΔP and operating loads) instead of a full spherical ball structure. The ribbed spherical ball designs are commonly used in large pipelines and hydroelectric power plants, but not in fossil or nuclear power plants. When a ribbed ball is partially open, the flowing fluid exerts forces on both the outside rib structure and the inside flow path in the ball (Figs. 2, 3). Accordingly, the hydrodynamic performance of a ribbed ball design is not applicable to a full spherical ball design because of these gross differences in geometries and flow patterns. Our model development included flow loop testing of a full spherical ball design to overcome this deficiency.

CFD Analyses

Extensive 2–D and 3–D coupled fluid structure analyses were performed to support the development of ball, plug, and butterfly valve models (e.g., Figs. 3, 4). Figure 4 shows the details of a 3–D CFD model of a symmetric disc butterfly valve used to improve accuracy over the earlier validated models [5], which were based on approximate solution using 2–D streamline functions [9]. To obtain reliable solutions by CFD, the current state-of-the-art requires the user to have an in-depth fundamental understanding of the approaches used in the analysis codes, including their applicability and limitations [14]. Both the fluid domain and the butterfly disc structure were discretized to obtain flow velocities and pressure distributions as well as the resultant force and torque on the disc. The stability and convergence of the solutions were confirmed by performing a sufficiently large number of iterations and evaluating the resultant key parameters of interest, i.e., torque, ΔP, valve resistance coefficient, K_v, and the torque coefficient, C_t, as shown in Figure 5. The analytical predictions were validated against test results as discussed later in this paper.

Flow Loop Testing

The model development effort included extensive flow loop testing (Fig. 6). The test specimen matrix covered the six types of valve geometries shown in Table 1. The key objective of these tests was to accurately determine hydrodynamic torque coefficients and flow coefficients (or valve resistance coefficients) for each valve geometry under baseline conditions as well as in the presence of upstream elbows.

Test valves and the flow loop were instrumented with a digital data acquisition system to measure and record the following parameters:

- Flow rate
- ΔP across the test valve section
- Upstream pressure
- Downstream pressure
- Stem torque
- Disc position

Detailed procedures were developed for test specimen inspection, assembly, testing, data reduction, and data plotting. The procedures follow the same approach as the one pursued earlier for butterfly valves [4], which had the benefit of independent design review and input from the EPRI MOV PPP Technical Advisory Group utility members.

For each valve, the test matrix includes:

- Baseline tests consisting of 18 static and dynamic strokes (Table 2)
- Dynamic strokes under 3 ΔPs and 2 flow rates to verify nondimensionality of torque and flow coefficients.
- Tests in both flow directions for nonsymmetric valves (i.e., segmented ball, Camflex plug, single-offset

butterfly and double offset butterfly), and

- Effect of upstream elbows with 3 orientations and several elbow proximities ranging from 0 to 20 pipe diameters.

Test data from various tests are reduced and compared to ensure data accuracy, repeatability, and reliability, and to develop torque and flow coefficients (C_t, C_v) in both flow directions, and torque multiplying factors (C_{up}) for the elbow influence.

All tests were performed on 6" nominal size valves. Applicability of the nondimensional torque and flow coefficients and models to larger size valves was previously validated by performing full-scale tests on a 42" butterfly valve [4].

Test procedures and the flow loop set-up were streamlined to allow an efficient evaluation of other valve geometries that are not covered by the current test matrix.

Test Results

Figure 7 shows typical measured raw torque data and averaged torque data (per degree) for an opening and closing stroke of a full ball valve. These data are used to calculate hydrodynamic torque and friction torque components using procedures described in Refs. 5, 6. The nondimensional torque coefficient, C_t, as a function of disc opening angle for a full spherical ball from different maximum ΔP tests, is shown in Figure 8A. The results from different tests overlap well, confirming the nondimensionality of C_t.

Figure 8B shows Ct results for a partial ball (nonsymmetric design) in both flow directions. The differences in torque coefficients in the two directions are very significant. This shows that torque requirements in both directions under various plant conditions as well as design basis conditions need to be appropriately considered to ensure that the valve will perform its function under all applicable scenarios. It is noted that the manufacturers' sizing equations (e.g., Ref. 13) do not address both flow directions.

The results of elbow tests show that the magnitude of the elbow effect on the torque requirements for quarter-turn ball valves of different shapes is quite different from that found for the butterfly valves [4, 5, 6]. Accordingly, the elbow effect models for full ball, partial ball, and eccentric plug valves are different from those for the butterfly valves.

Model reports for each valve fully document analytical methodologies, torque coefficients, C_t, flow coefficients, C_v, and the peak torque ratio factors, C_{up}, for different upstream elbow orientations and proximities.

Validation of CFD Predictions

Figure 9 shows a comparison of the CFD predictions against test data of a symmetric disc butterfly valve torque coefficients, C_t, and valve resistance coefficients, K_v. The good agreement provided the basis for more accurate torque prediction models for butterfly valves.

Example of Model Application

Figure 10 shows a comparison of torque requirements for a 16" symmetric disc butterfly valve in a service water application based upon the earlier model [5, 6] and the more accurate model developed under the new program. The predictions are for the same bearing friction coefficient and other operating parameters. As seen, the new model revealed an adequate margin for this AOV in contrast to the negative margin predicted by the MOV PPM. This major benefit is due to the improved quantification of the hydrodynamic torque component. It should be emphasized that, unlike friction coefficients, the hydrodynamic torque component is constant for a given geometry and operating conditions and is not subject to degradation. Therefore, more accurate hydrodynamic models provide major benefits in AOV evaluations, and this benefit is particularly dramatic for large valve sizes.

Quality Assurance

All testing and model development activities were conducted in accordance with a quality assurance program that satisfies 10CFR50 Appendix B requirements .

Conclusions

1. Accurate models for symmetric and single-offset butterfly valves have been developed that can be used to reliably predict torque requirements without the excessive conservatism of earlier models.

2. Additional models for double-offset butterfly valve, full ball valve, partial ball valve, and eccentric plug (Camflex) valve resulting from this program fill the industry need for reliable design basis calculations for quarter-turn AOVs without excessive conservatism.

3. These models eliminate the potential for unwarranted operability concerns and unnecessary equipment modifications, thus increasing plant availability and ensuring reliable operation of AOVs.

To facilitate efficient use of the models for AOV evaluations and design basis calculations, the methodologies and flow, torque, and elbow influence coefficients have been incorporated into a user-friendly software.

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Table 1: Types of Quarter-Turn Valves Covered by the Program		
Item	*Type*	*Description*
1	Butterfly	Symmetric disc
2	Butterfly	Single-offset disc
3	Butterfly	Double offset disc
4	Ball	Full spherical ball valve (both floating and trunnion mounted designs)
5	Ball	Segmented (also called partial or V-notch) ball valve
6	Plug	Eccentric plug (also called Camflex) valve
Note: The test matrix includes cylindrical and tapered plug valves at lower priority.		

Table 2: Description of Typical Test Sequence for Baseline and Elbow Tests					
Stroke	*Description*	*Direction*	*Flow (% Nominal)*	*Pressure (% Max.)*	*ΔP (% Max.)*
Pre-Test Packing Friction					
1	Static Test	O→C	0	0	0
2	Static Test	C→O	0	0	0
3	Static Test	O→C	0	100	0
4	Static Test	C→O	0	100	0
Bearing Checkout Test					
5	Bearing Torque (thrust) Test	C→10° O	Any	100	100
6	Bearing Torque (thrust) Test	10° O→C	Any	100	100
Flow and ΔP Parametric Tests					
7	Flow and ΔP	O→C	100	100	100
8	Flow and ΔP	C→O	100	100	100
9	Flow and ΔP	O→C	100	67	67
10	Flow and ΔP	C→O	100	67	67
11	Flow and ΔP	O→C	100	33	33
12	Flow and ΔP	C→O	100	33	33
13	Flow and ΔP	O→C	200	100	100
14	Flow and ΔP	C→O	200	100	100
Post-Test Packing Friction					
15	Static Test	O→C	0	0	0
16	Static Test	C→O	0	0	0
17	Static Test	O→C	0	100	0
18	Static Test	C→O	0	100	0
Notes: 1. Nominal flow velocity is 15 fps. 2. Maximum ΔP is 90 psi (nominal).					

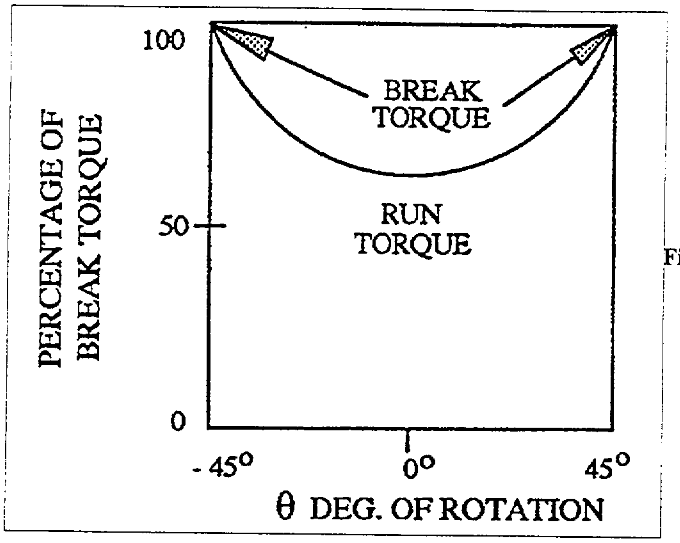


Figure 1 Torque Output Varies Significantly with Stroke for Quarter-Turn AOV Actuators

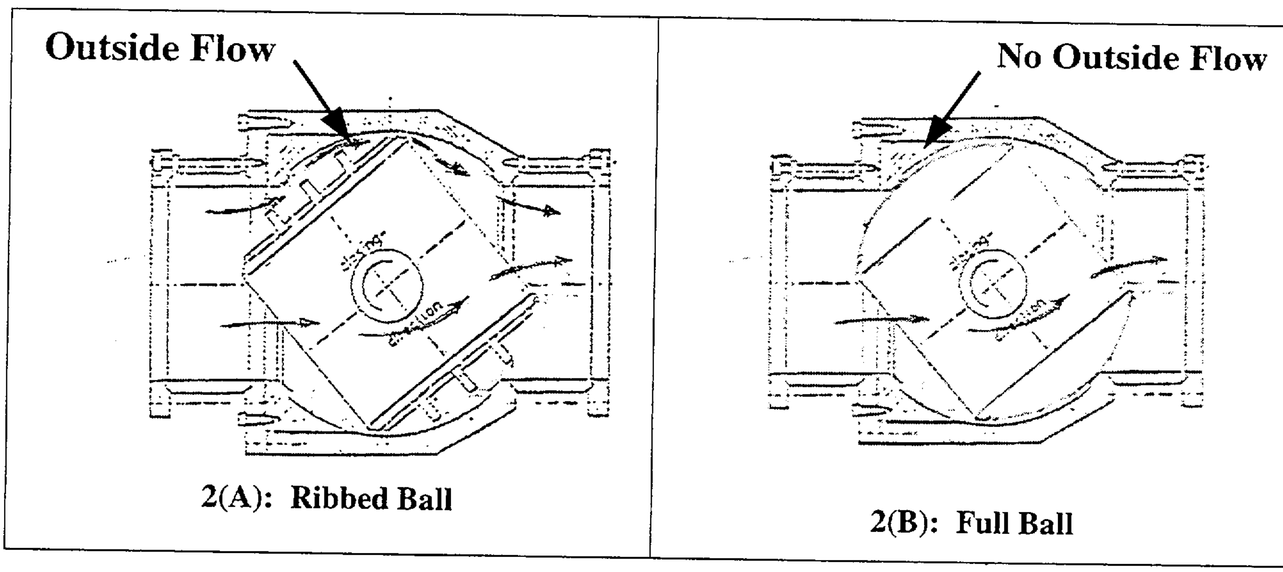


Figure 2: Geometry differences between the ribbed spherical ball [10] and full spherical ball designs significantly influence their hydrodynamic performance.

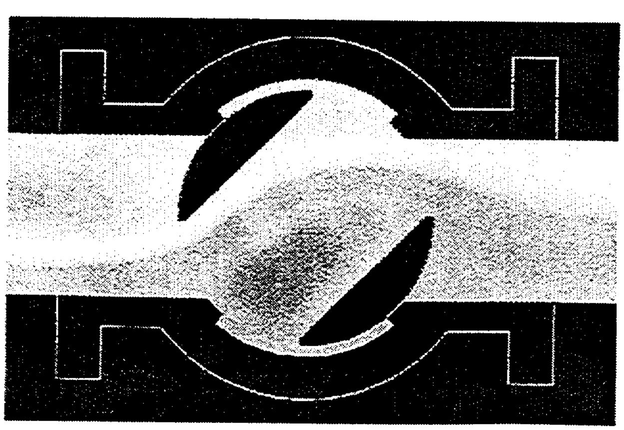
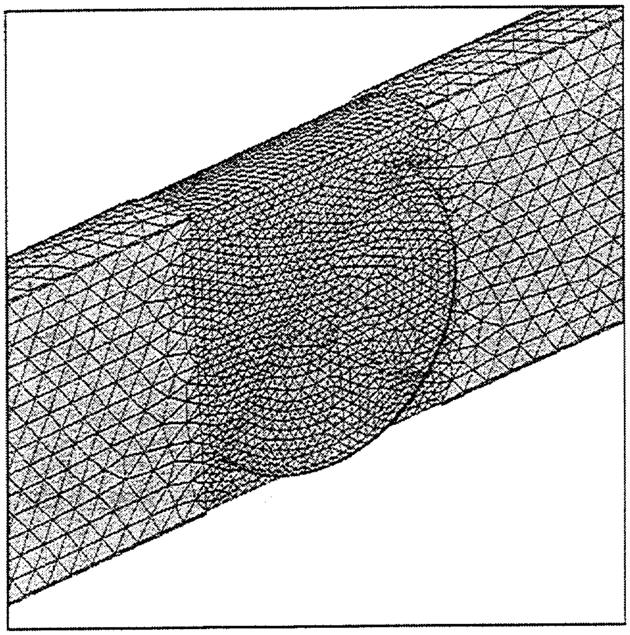


Figure 3 Typical CFD Analysis of a Full Ball/ Plug Valve



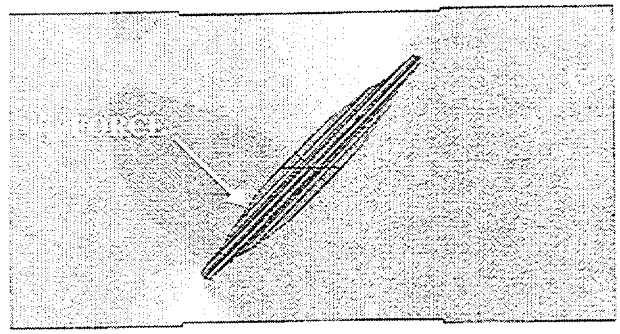


Figure 4 3–D CFD Model and Pressure Distributions for a Symmetric Disc Butterfly Valve

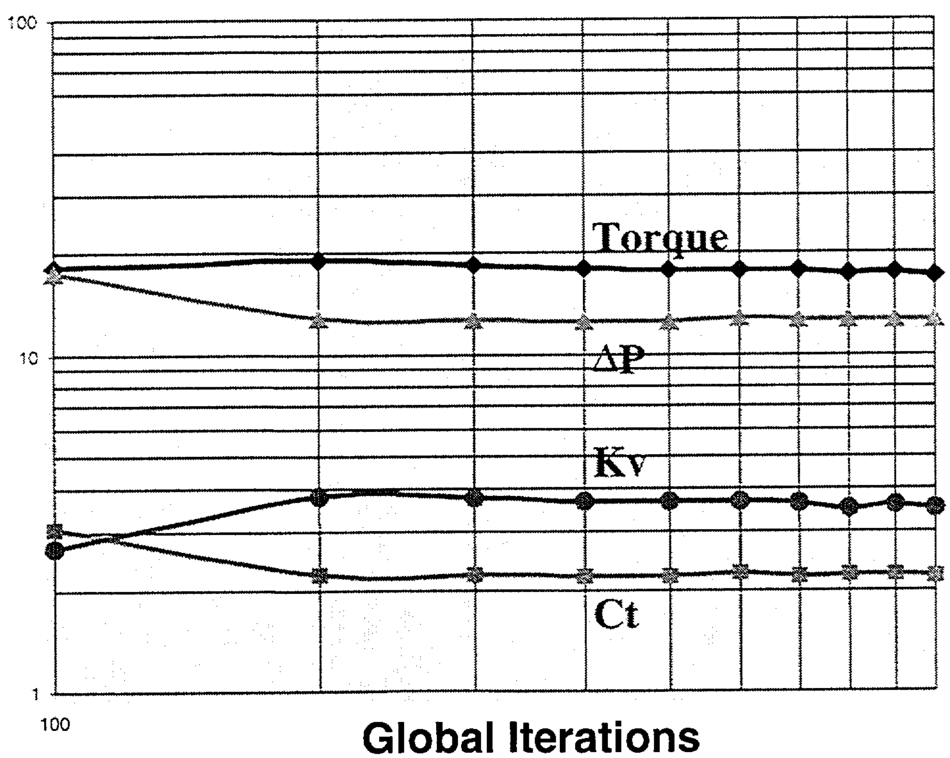


Figure 5 Stability and Convergence of CFD Solutions Confirmed by a Large Number of Iterations

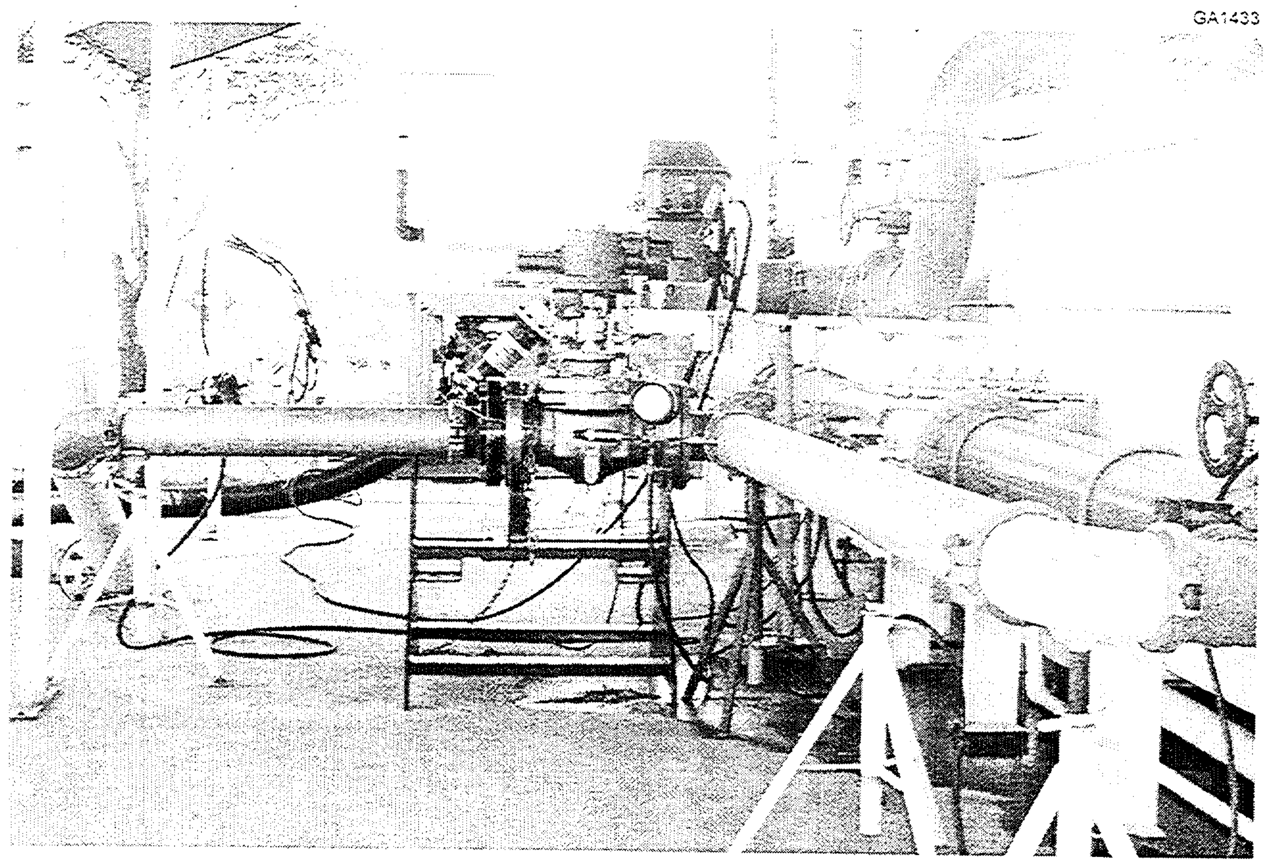


Figure 6 Flow Loop Testing of a Spherical Ball Valve with an Upstream Elbow In Progress

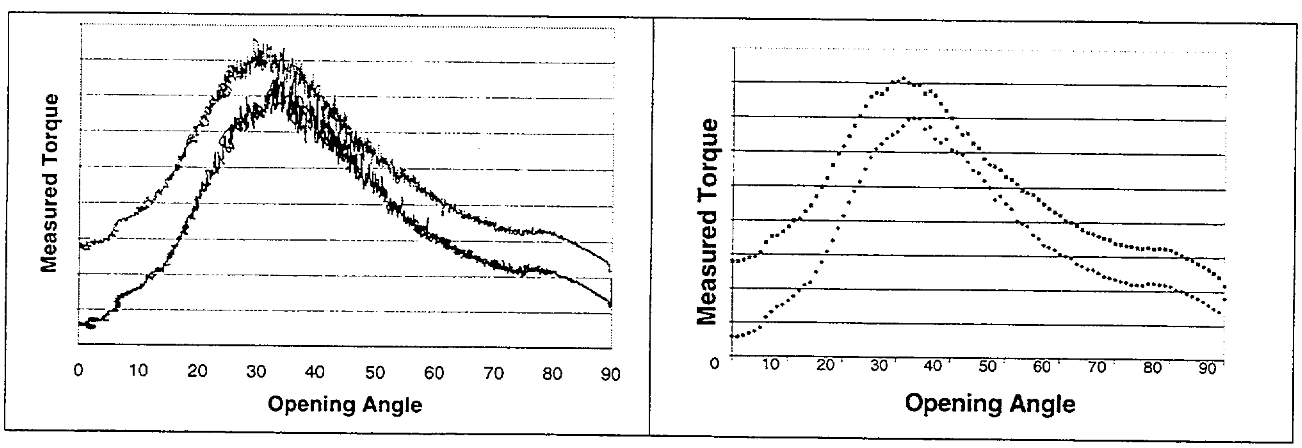
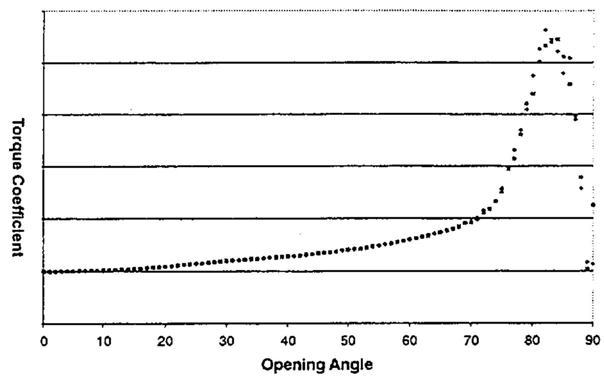
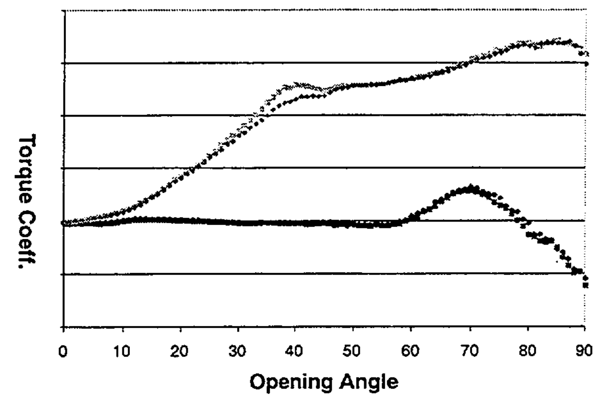


Figure 7 Typical Raw Data and Average Data (for each degree increment) for an Opening and Closing Stroke of a Full Ball Valve



8A



8B

Figure 8 Typical Torque Coefficients for (A) Full Ball and (B) Partial Ball Valves

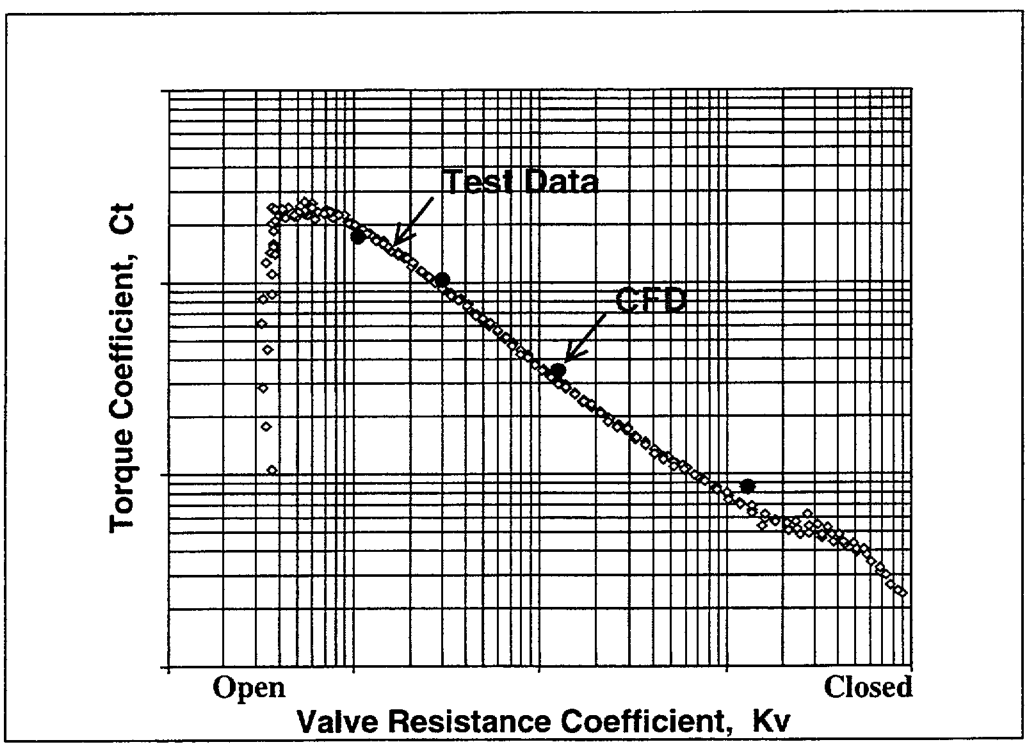


Figure 9 CFD Predictions for a Symmetric Disc Butterfly Valve Validated Against Test Data

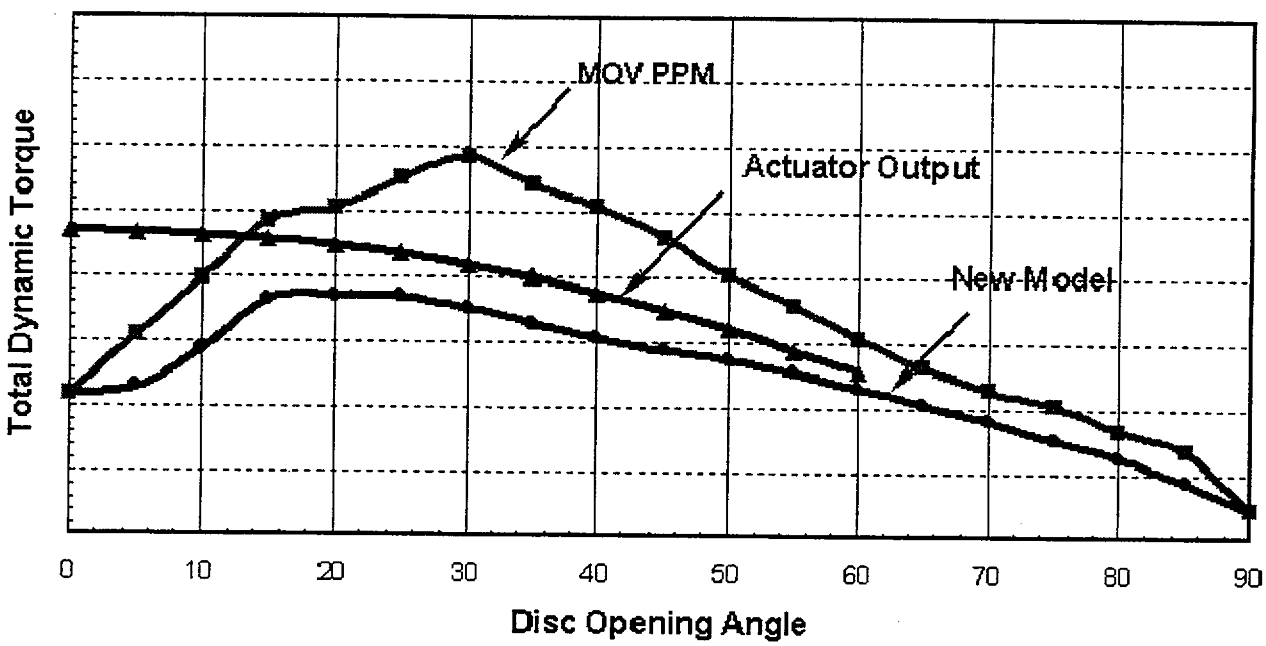


Figure 10 **New Butterfly Valve Models Eliminated Need for Modifications while Ensuring Reliable Operation of 16" Butterfly Valves**

Consideration of Mid-Stroke Effects in Sizing Air-Operated Valves

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Abstract

In many air-operated globe valves and quarter-turn valves, the dynamic loads peak at stroke positions other than fully open or fully closed. The current industry methodologies do not address margin and stability issues based upon mid-stroke effects. In several types of globe valves (e.g., parabolic plug shape globe valve, characterized skirt plug shape globe valve, and balanced plug globe valves), the plug force increases as the plug is lifted off the seat, reaches a maximum, and then drops off. This can happen in both flow-over-the-plug and flow-under-the-plug designs. The magnitude of the increase in the plug force as well as the negative plug force gradient (associated with the drop-off in the force magnitude) determine the actuator force margin and the stability of the actuator to hold a position in mid-stroke. In some air-operated valve (AOV) applications, this results in an undesirable stem-force-vs.-travel curve with a point of inflexion and too steep a negative plug force gradient. A high negative plug force gradient can cause actuator instability and continuous oscillations of the valve in mid-stroke position. The problem is caused by the interaction between the valve, actuator, and system flow characteristics, all of which need to be taken into consideration to ensure proper performance of the valve throughout the stroke.

With the diagnostic equipment available in the industry today, the stem thrust can be directly measured under dynamic flow conditions during normal plant operation. The stem thrust curve can also be indirectly estimated from the actuator air pressure by performing a quasi-static test. These data can be used to perform an evaluation of the AOV margin and stability under design basis conditions by properly accounting for the differences between test conditions and design basis conditions.

Instability can result in a rapid degradation of mechanical components (packing leakage, loosening of bolts and connections, premature fatigue failure of diaphragms, failure of bellows stem seals, etc.). This paper describes the basic approach to determine margins and stability of the AOV in mid-stroke and the criteria to eliminate problems related to these issues. Plant examples for balanced and unbalanced globe valves, as well as quarter-turn valves, are included.

Joint Owner's Group Air Operated Valve Program

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Abstract

Air Operated Valves (AOVs) have recently experienced increased scrutiny from industry and the USNRC. In 1997, the Institute of Nuclear Power Operations (INPO), and in 1998 the US Nuclear Regulatory Commission's (USNRC) Office for Analysis and Evaluation of Operational Data (AEOD) initiated activities associated with AOVs. Both identified engineering and maintenance issues that could potentially contribute to AOV failures. Concurrently, the Joint Owner's Group (JOG) AOV Committee developed an AOV Program providing the minimum requirements necessary to evaluate and maintain the performance of AOVs.

The JOG AOV Program

A review of "lessons learned" from Motor Operated Valve (MOV) programs indicates that AOV performance can be enhanced via improvements in valve actuator sizing, setup, testing and maintenance. In an effort to maximize the benefits of industry experience to address AOV issues, utilities have voluntarily formed a Joint Owner's Group (JOG). The JOG has determined that there are advantages to working together to develop a common industry AOV Program. These advantages include:

- Provides focused resources to develop consistent, technically sound methods;
- Leverages utility resources in addressing common AOV issues;
- Ensures thoroughness through a uniform approach;
- Minimizes regulatory uncertainty and plant-to-plant regulatory variations through a uniform approach;
- Provides a focal point for communication with the Nuclear Regulatory Commission (NRC) and other industry AOV groups;
- Utilizes benefits of MOV "lessons learned";
- provides a controlled environment for vendor/contractor interaction;
- Affords every utility the opportunity to participate in the JOG.

The objective of the JOG AOV Program is to provide an industry document that defines the minimum requirements of an AOV program that provides assurance of AOV capability. The program utilizes risk-informed methods to determine the in-scope AOV population.

The JOG AOV Program provides nine key elements identified as program requirements and program implementation:

- Scoping and Categorization;
- Setpoint Control;
- Design Basis Reviews;

- Testing;
- Preventive Maintenance;
- Training;
- Feedback;
- Documentation/Data Management;
- Tracking and Trending of AOV Performance.

The JOG AOV Program provides guidance on these elements. It is expected that utilities will develop a plant specific AOV Program to implement the requirements and methods provided.

Program Requirements

The initial step in establishing an AOV program is to identify and categorize the plant AOVs for evaluation. AOVs are screened for inclusion or exclusion from the JOG AOV Program. Those included in the program are placed in one of two categories (Categories 1 and 2) based on their contribution to safe plant operation and/or accident mitigation. The requirements of the JOG AOV Program are dependent on the category in which each AOV is assigned. These categories determine the extent of design review and testing activities to be performed.

Training, Feedback, Tracking and Trending, and Documentation/Data Management are general program requirements. In addition, all program AOVs require setpoint control and shall be included in a maintenance program. Setpoint control ensures that for each AOV, setpoints (e.g., preload, regulator setting, etc.) are maintained. For AOVs that are safety-related, active and have high safety-significance (Category 1), additional requirements are stipulated to provide added confidence in the functional capability of these AOVs. These requirements include Design Basis Reviews (DBRs), Baseline Testing, Periodic Testing and Post Maintenance Testing.

AOV Scope and Categorization

In general, nuclear power plants have a large population of AOVs with varying degrees of safety-significance. Therefore, to develop an effective AOV Program, it is essential to establish a method to clearly identify those AOVs with the highest contribution to safe plant operation. A risk informed approach provides a structured, systematic, and defensible method as well as providing a basis for program establishment and allocation of resources. The risk informed method endorsed by this program allows proper use of resources in the appropriate areas to increase safety focus, achieve appropriate risk reduction, and eliminate unnecessary conservatism and burden for the nuclear power industry.

Scope

All AOVs are considered for categorization, except isolation devices that are in duct work, i.e., dampers. This is consistent with Generic Letter 89–10, "Safety-Related Motor-Operated Valve Testing and Surveillance." Dampers typically are installed in low differential pressure applications. In these applications, static loads are significant compared to dynamic loads. A search of the Institute of Nuclear Power Operations (INPO) databases, i.e., Nuclear Plant Reliability Database System (NPRDS) and Equipment Performance and Information Exchange System (EPIX), did not identify any damper failures as a result of design basis issues; therefore, dampers are excluded from the scope of this program.

Categorization Process

Each plant shall determine the safety-significance of the AOV. Specific methods and screening criteria used to determine safety-significance is the responsibility of each plant. The AOVs within the scope of this program are classified into two categories.

Category 1: AOVs that are safety-related, active and have high safety-significance.

Category 2: AOVs that are safety-related, active and do not have high safety-significance, <u>or</u> AOVs that are non safety-related, have high safety-significance and are active.

AOVs not in Categories 1 or 2 are considered outside the scope of this program, as they are deemed not to be critical to plant safety. It is recognized that the AOVs outside the scope of this program may currently be included in other plant programs and activities such as: ISI/IST, LLRT, preventive maintenance, equipment qualification inspections, etc. It is expected that the JOG AOV Program will not impact these on-going activities. Additionally, the quality requirements of 10CFR50 Appendix B still apply to passive, safety-related AOVs.

Expert Panel

Each plant shall convene an expert panel to verify the scope and categorization of each plant's AOV program. This panel should include representatives from organizations such as operations, maintenance, engineering, safety analysis, licensing, and PSA. The expert panel shall give consideration to PSA, plant specific performance and deterministic considerations. The panel shall review the screening criteria to ensure plant specific AOV concerns are considered (e.g., passive AOVs that are credited to remain closed for which flow tends to open). The expert panel's qualification requirements, screening criteria and decisions shall be documented.

Determination of Safety-Significance

The safety-significance classification shall involve a blended process of risk ranking and plant expert panel evaluation. The expert panel should document and validate the results of the risk ranking to justify the process and results. Any one of the following is an acceptable method for ranking safety-significance and conducting the expert panel:

- ASME Code Case OMN–3, "Requirements for Safety-Significance Categorization of Components Using Risk Insights for Inservice Testing of LWR Power Plants."
- Topical Report NEDC 32264, "Application of Probabilistic Safety Assessment to Generic Letter 89–10 Implementation," in accordance with the NRC Safety Evaluation dated February 27, 1996 (for participating members of the BWR Owners' Group Integrated Risk-Based Regulation Committee (IRBRC)).
- Topical Report V–EC–1658–A, Rev. 2, "Risk Ranking Approach for Motor Operated Valves in Response to GL 96–05," in accordance with the NRC Safety Evaluation dated April 14, 1998 (for participating members of the Westinghouse Owners' Group).
- Regulatory Guide 1.160, Rev. 2, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants."

(Commonly referred to as the "Maintenance Rule")

- Regulatory Guide 1.174, Rev. 0, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," and Regulatory Guide 1.175, Rev. 0, "An Approach for Plant-Specific Risk-Informed Decision Making: Inservice Testing."

Other methods may be used to establish safety-significance as justified by the plant.

The plant IST program basis document, Updated Final Safety Analysis Report (UFSAR)/Final Safety Analysis Report (FSAR), Technical Specifications, design basis documents, and system operating procedures are acceptable sources for determining AOV function.

If improved safety-significance or risk ranking models are developed, or if plant configuration changes alter the safety-significance ranking, AOV categories may be affected resulting in an increase or decrease in category level or a complete removal from the program. Plant AOV programs should be updated to reflect these changes as appropriate.

Setpoint Control

Setpoint control is required for those setpoints affecting the active safety functions of the AOV. As a minimum, parameters to be maintained and documented as part of the plant specific setpoint control program, as applicable, are:

- Actuator air supply setting(s)
- Preload (bench set)
- Stroke length

For Category 1 valves, the above information is established as part of the design basis review. For Category 2 valves, the required information is typically obtained from the current specification.

Design Basis Reviews

The design basis review (DBR) is used to verify and document the adequacy of AOV sizing and setpoints, and in establishing conditions for verification testing. Specifically, the DBR consists of both a system level review and a component level review. The system level review determines the AOV's system (worst case) operating conditions within the licensing basis of the plant. The component level review, if required, establishes the AOV's required operating thrust/torque, actuator output capability, and available actuator capability margin.

Plants should consider the impact of NRC Generic Letter 95–07, "Pressure Locking and Thermal Binding of Safety-Related Power Operated Gate Valves," and NRC Generic Letter 96–06, "Assurance of Equipment Operability and Containment Integrity during Design-Basis Accident Conditions," on AOVs.

System Review

The system review identifies the worst case operating condition(s) under which an AOV must operate and maintain position within the licensing basis of the plant.

The system review identifies the following parameters:

- Upstream and downstream line pressures
- Process fluid
- Fluid temperature
- Flow direction (flow-to-open, flow-to-close)

- Fluid flow (as required to determine differential pressure or valve factor)
- Allowable seat leakage

The results of this step will be input for the component level review, if required, in order to establish the valve thrust/torque requirements.

Periodic Cycling

Existing site programs and normal plant operation could provide adequate demonstration of AOV capability via periodic cycling. Credit can be taken for this demonstration provided that the periodic cycling conditions meet or exceed the worst case operating conditions within the licensing basis of the plant. Conditions that should be considered are those items listed previously and the following:

- Actuating air pressure and source
- Air controlling devices
- Actuator exhaust paths

In these cases, component level DBRs are not required; however, assurance should be provided that the component and accessories are operating within allowable limits. The basis for satisfying the component level DBR requirement shall be documented.

Component Level Review

A component level review evaluates the actuator's ability to stroke the valve at the conditions determined previously. This is accomplished by:

1. Determining the valve's minimum required thrust/torque,
2. Assessing the actuator output capability,
3. Comparing the required thrust/torque with the actuator output capability to establish the resultant actuator capability margin, and
4. Evaluating allowable limits of the valve, actuator and its accessories.

The JOG AOV Program lists the critical inputs that may be required for the component level review and provides acceptable methods for their determination.

Minimum Required Thrust/Torque

Thrust and torque methods from approved Generic Letter 89–10 programs can be used for AOVs subject to confirming the methods' applicability to the specific AOVs to which they are applied. This confirmation of applicability should cover the technical basis of the methods used and the range of conditions (valve parameters, system parameters, etc.) associated with the data used to justify the methods.

The EPRI Performance Prediction Methodology (PPM) can be used for gate, globe and butterfly valves, subject to the adjustments specified by EPRI for applying the PPM to AOVs.

For several valve types such as caged balanced disk globe valves, pilot globe valves, double seat globe valves, 3-way valves, ball valves, plug valves, diaphragm valves, etc., vendor or first-principles methods should be used.

Actuator Output Capability

First principle methods for determining actuator capability should be used. The EPRI application guide for evaluation of actuator output capability for AOVs provides acceptable first principle equations. Vendor methods may also be used if determined to be appropriate by the plant.

The actuator capability margin calculation shall include allowances for uncertainties and known degradation. For degradation to be addressed by periodic testing, actuator capability margin should include the potential degradation anticipated during the interval between tests. For elements not addressed by periodic testing, actuator capability margin should address potential degradation anticipated during remaining AOV life.

The JOG AOV Program provides a comprehensive list of uncertainties and degradations to be considered in the actuator capability margin calculation. It also provides acceptable methods for combining these factors.

Actuator capability margin shall be calculated in the stroke direction(s) related to the AOV's safety-significant function. In some cases, the actuator force may change throughout the stroke; therefore, it may be necessary to determine actuator capability margin at more than one stroke position.

An actuator capability margin greater than 0% is acceptable.

Testing

Testing is performed to verify component functional capabilities and, where appropriate, validate design assumptions. All testing shall be performed utilizing plant approved test procedures and acceptance criteria for each type of testing performed. Current plant maintenance activities may satisfy the requirements for testing. Equipment and instruments used to measure and record test data within the scope of the JOG AOV Program shall be calibrated in accordance with the plant's quality assurance requirements.

Baseline Testing

Baseline testing shall be performed on all Category 1 AOVs, unless existing site programs and normal plant operation provide adequate demonstration of AOV capability via periodic cycling. Baseline testing is performed with the intent to:

- Verify the functional capability
- Validate DBR design inputs
- Confirm required operating setpoints
- Establish a reference for periodic testing

Each plant should determine the type of baseline testing, which can range from stroke time testing to dynamic testing with diagnostics, needed to satisfy the above requirements. Guidance in selecting the appropriate baseline test is provided in the JOG AOV Program.

Baseline testing is not required on Category 2 AOVs unless a DBR is required due to a generic issue identified through the Category 1 DBR process.

Periodic Testing

Periodic testing shall be performed on Category 1 AOVs to identify potential degradation except for those AOVs periodically cycled. The initial frequency of testing shall be at least once every 3 refueling outages or 6 years, whichever is longer, until sufficient data exists to determine a more appropriate test frequency.

Grouping of valve assemblies is encouraged. The number of valve assemblies tested from each group within the periodic test interval shall be a minimum of 30%; however, no less than two shall be selected from each group. The following shall be considered when grouping valve assemblies:

- AOV assemblies with identical or similar designs and with similar plant service conditions may be grouped.
- Individual AOVs in a group should be tested at consecutive intervals to monitor degradation rather than testing a different valve when the next test is due for the group.
- Generic issues that are identified during the performance of testing shall be reviewed for their impact on similar AOV assemblies within the scope of the JOG AOV Program.

Each plant should determine the method of periodic testing. Degradation parameters are addressed in the JOG AOV Program; however, this program does not add any periodic testing requirement for Category 2 AOVs beyond current plant requirements.

Post Maintenance Testing

Post maintenance testing shall be performed on Category 1 AOVs to re-baseline the DBR inputs and functional capability following replacement, repair, or maintenance that could affect valve performance. The post maintenance testing requirements are established by the individual plants and need not exceed the initial (baseline) testing requirements. This program does not require additional post maintenance testing for Category 2 AOVs beyond verification of the affected setpoints previously established.

Preventive Maintenance

Preventive Maintenance (PM) shall be performed for all program AOVs to provide a high level of confidence that AOVs will perform their intended design function. Safety-significance, duty cycle and environment should be considered when determining PM activities and frequency. It is the responsibility of the plant to establish and maintain a PM program.

Considerations for the PM program include:

- Vendor recommendations
- Licensing commitments
- Environmental qualification
- Equipment history
- Maintenance Rule

The AOV PM template in the EPRI Preventive Maintenance Basis Document provides an acceptable method for determining PM activities and frequencies.

Training

Training is critical to a successful AOV program. Industry feedback has shown that cross training of disciplines involved with AOVs is extremely effective. Individual plants shall be responsible for identifying and performing the appropriate plant specific training and documenting individual qualifications for specific tasks.

Recommended training areas include:

- Actuator, valve, and accessory design and function
- Setpoint control
- Test equipment use and evaluation
- Calculation processes

- Maintenance practices
- Lessons learned

Feedback

There are two types of feedback: plant specific feedback and industry feedback. Plant specific feedback is critical to ensure that plant operating, testing and maintenance experiences are appropriately incorporated into plant programs. Industry feedback is important to ensure that generic issues can be evaluated for inclusion into plant specific programs.

Plant Specific Feedback

Plant specific feedback shall ensure AOV test results and failures are incorporated into the appropriate plant programs. As a minimum, this feedback mechanism shall ensure that design basis calculations remain valid and lessons learned pertaining to design, maintenance and operations are evaluated for inclusion into the AOV program and plant PSA models. Credit should be taken for activities performed under other plant programs, such as the Maintenance Rule Program or root cause evaluation of failures.

Industry Feedback

There are several industry feedback mechanisms that currently exist, such as the 10CFR Part 21 process, NRC formal communications, NRC Notices and Bulletins, INPO Equipment Performance and Information Exchange System (EPIX) and the INPO Nuclear Network. Additionally, industry forums such as the Air Operated Valve Users' Group (AUG) meetings provide an opportunity for sharing information. These should be incorporated as the current feedback mechanisms for the plant's AOV program. Information that affects the content of this document should be communicated to the participating Owners' Groups.

Documentation & Data Management

Each plant shall develop a method for configuration control in accordance with their individual plant practices. Use of electronic formats (e.g., database) may facilitate data control and retrieval. Documents and information to be controlled, as applicable, are:

- Plant program document
- AOV scoping and categorization, criteria, bases and results
- System design basis reviews
- Actuator/Valve capability calculations
- Setpoints
- Test results
- Training records
- Tracking and trending reports

Tracking and Trending

Each plant shall track and trend AOV failures for all program AOVs. Additionally, critical AOV performance parameters obtained during periodic testing of Category 1 AOVs shall be tracked and trended. Examples of information that may be trended are:

- Stroke time
- Packing/running loads
- Setpoint pressure
- Preload or bench set range
- Seating/unseating loads
- Valve friction factors (if dynamically tested).

Credit may be taken for existing plant programs that provide this information.

Full Program Implementation

Individual plant AOV programs are considered fully implemented when the program elements presented are completed or established. An effective program is one that is updated, assessed, and periodically enhanced with new information and incorporates lessons learned even after full program implementation.

References

JOG, 1999, "Joint Owner's Group AOV Program," Duke Engineering & Services document 575.0.1.F10–01.

Program Element	Section	Category 1 Valves	Category 2 Valves
Setpoint Control	4.2	Yes	Yes
Design Basis Reviews	4.3	Yes	No
Baseline Testing	4.4.1	Yes	No
Periodic Testing	4.4.2	Yes	No
Post Maintenance Testing	4.4.3	Yes	No
Preventive Maintenance	4.5	Yes	Yes
Training	4.6	Yes	Yes
Feedback	4.7	Yes	Yes
Documentation & Data Management	4.8	Yes	Yes
Tracking and Trending	4.9	Yes	Yes

Figure 1. AOV Program Requirements

Session 3(B)

O&M Code Issues on Testing of Valves and Pumps

Session Chair
Adele M. DiBiasio
Curtiss-Wright Flow Control

Codes and Rules for Inservice Testing in Spain

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Abstract

Spain has always applied the codes and rules in the country of the main designer of the nuclear power plant. Since the majority of plants in Spain are from U.S.A. designers, basically the codes and rules required by the regulatory body in Spain, are the regulations required in U.S.A., although other codes and rules from European countries are applied.

The purpose of this paper is to describe how the codes and rules in the U.S.A. and other countries from Europe, are followed or applied in Spain: scope, particular subjects, differences with designs of other countries, specific requirements of the regulatory body in Spain, Consejo de Seguridad Nuclear (CSN), etc.

Introduction

There are 9 units in operation in Spain: 6 PWR with U.S.A. design, 1 PWR with German design, and 2 BWR with U.S.A. design. Considering that the regulatory body in Spain (CSN), requires the use of the codes endorsed in the reference plant or in the countries of the main designers, the basic code applied is the ASME OM Code. However, and especially in the case of inservice testing, other rules from Germany are applied for the PWR plant of German design.

Besides the use of the ASME OM Code, the plants in Spain perform a review of applicability of others requirements in the U.S.A., mainly coming from the U.S. Nuclear Regulatory Commission, like Generic Letters, Bulletins, NUREGs, etc.

International experiences reported through INPO are also evaluated for applicability, and in cases where it is recommended, the IST programs are modified in order to improve the program. This feedback of experiences is fundamental when the IST programs are performance-based or risk-informed, and these concepts are now the tendency in Spain.

Inservice Testing Programs

The inservice examination (ASME XI) and testing (ASME OM) programs are defined together within a document called Manual de Inspección en Servicio (MISI). This manual is updated every 10 years, as 10CFR50.55a requires in U.S.A., and the structure basically implements verifies the requirements and guidelines of ASME XI Appendix F and ASME OM Appendix A for the preparation of inspection plans.

This document containing the inservice inspection plans, preoperational or during the service life, is always reviewed and approved by the CSN. All the following revisions to include new rules or requirements, modifications, as well as the 10-year update, is also reviewed by the CSN.

There is a chapter with the description of all the applicable codes and rules, and also the scope of each one, including the limitations or modification that the U.S. NRC imposes in the 10CFR50.55a . This chapter is reviewed by the plant during the 10-year interval in order to include new codes and rules, such as Code Cases, NRC Bulletins, NRC Generic Letters or any backfit regulation of the U.S. NRC.

A normal chapter for a plant, and considering only the IST requirements, contains the application of the following codes and rules:

- 10CFR50.55a is considered in order to apply the approved editions of ASME OM, with the particular modifications and limitations for each one, and also for specific backfit requirements.
- 10CFR50.55a Appendix J, Option B
- ASME OM (At present applications are ASME OM parts 1, 4, 6 and 10 following references from ASME XI 1989 Edition)
- Generic Letters:
  - 89–04 Guidance in Developing Acceptable Inservice Testing Programs.
  - 90–06 Power-Operated Relief Valve and Block Valve Reliability, and Additional Low-Temperature Overpressure Protection for Light-Water Reactors.
  - 90–09 Alternative Requirements for Snubber Visual Inspection Interval and Corrective Actions.
  - 96–05 Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves.
- Operational Technical Specification of the particular plant

In the case of the German design plant, only the ASME/ANSI OM Part 1 for the safety and relief valves is implemented, and there is an specific written program for the rest of the valves and pumps, based in Technical Specifications and maintenance programs requirements.

For this German design plant, and in relation with the containment testing, there are specific German rules that are applied, with additional criteria from ANSI/ANS 56–8:

- KTA 3401.4 for the periodic inservice testing and inspection in the containment
- KTA 3405 for the integrated leakage rate testing (ILRT) method

The above rules require performance of the ILRT at a reduce pressure of 0.5 bar over the atmospheric pressure instead of the base accident pressure. The local leak test are only required in the valves in contact with the atmosphere of the containment. However the ANSI/ANS 56–8 is also applied to incorporate the criteria of performing a verification test in the ILRT, not specified by the KTA 3405. The frequencies for the ILRT are 4 years, after performing the first inservice ILRT in the first refueling outage after commercial operation.

Another chapter constitutes a description of the IST scope, with tables of components and piping and instrument diagrams (P&IDs). The P&IDs are reviewed in order to identify the valve categories, containment isolation valves and pumps within the IST scope.

The next chapter includes the particular testing programs specifying the valves with all the necessary information to identify and locate them in the P&IDs, and specific information related to the requirements of the ASME OM Code: safety function, fail position, testing frequency, testing procedure, etc. There is a particular program for each of the following test: exercising tests, leak tests and safety or relief valves tests. However, based on the goal of implementing, since the risk-based testing methodology becomes the goal, the testing programs for the following components' particular programs will be different in the near future: check valves, motor operated valves, air operated valves, safety and relief valves. Additionally, and of course, leak test are a different program that also includes 10CFR50 Appendix J requirements.

The last chapter is a table with all the technical procedures to perform each individual test.

When applying the ASME OM in Spain, there are requirements not considered because they are specific in the U.S.A. These requirements are in relation with the Authorized Inspection Agencies, Inspectors and Supervisors. The IST plans and the performance of examinations and tests are reviewed and supervised by staff of the regulatory body (CSN).

There is also a difference when applying the 10CFR50 Appendix J related to test procedure. The test method is the Mass Point, according to the ANSI/ANS 56–8, as well as the KTA–3405, in the case of the German design plant, but the time duration of the test is at least 8 hours, instead of the 24 hours specified by Appendix J.

Quality Assurance programs are developed by owners and the organizations and companies involve in IST activities fulfilling, in general, with the following rules and standards:

- 10CFR50 Appendix B
- ANSI/ASME NQA–1
- C.P. 50–C–QA from the IAEA (International Atomic Energy Agency)
- UNE–73–401 Garantia de Calidad en Centrales Nucleares, from AENOR in Spain
- Guias de Seguridad del CSN: (Safety Guides from the CSN)Translate)
- 10.1 Guia Basica de Garantia de Calidad para Instalaciones Nucleares, 25–2–99
- 10.5 Garantia de Calidad de ensayos, pruebas e inspecciones de instalaciones nucleares, Septiembre 1987.

Besides the ISI/IST Manual, where all the ISI/IST programs are defined, there are other documents not included in this Manual, that are also part of the ISI/IST management, and that are referenced in the ISI/IST Manual, like:

- Technical Procedures for each particular examination or test
- Interferences for non destructive examinations or test in each particular area(weld, support, valve, snubber...). It contains pictures with all the interferences, and it is reviewed during the service of the plant in order to incorporate new interferences.
- Before and during the Preservice Inspection: Design Review to verify the feasibility to perform all examinations and tests. In this document all the programs are reviewed, in order to avoid interferences, and to define recommendations or modifications in the design in order to allow the performance of examinations or tests

(test connections to do leak testing in the containment isolation valves, test circuits for functional testing of pumps, etc...).

- Calibration blocks, for the nondestructive examinations

However, during the service life, new interferences or code changes, require relief requests, or in some cases deferral justifications. The CSN reviews these requests, and case by case, the CSN approves or requires additional actions.

Besides the review of the ISI/IST Manual, the CSN reviews all the ISI/IST refueling outage programs, and after the outage, the ISI/IST result reports. The CSN performs periodic audits during the examination and testing activities, and all the ISI/IST documents mentioned above, are reviewed by the CSN.

The IST program included in the ISI/IST Manual is defined independently for each particular plant according to the codes and standards described above, and in compliance with the specific requirements of the CSN for any particular plant. Basically, all the IST programs are very similar because small differences between the plants, with the exception of the German design, where the IST activities are considered part of the maintenance and follows technical specifications instead of specific IST code or standard.

Although the IST Manuals are defined independently for each plant, the structure and the programs are very similar. At present, there is not any specific coordination between all the plants, but considering that the CSN reviews all the IST Manuals and the rest of the IST documents, there are always directions from the CSN with a unification objective.

In relation to the preparation of refueling outage ISI/IST programs and result reports, the content and structure are very similar because of the Safety Guides documents, mentioned above.

The IST staff in the plants have similar qualification, but vary from plant to plant in number, depending of the specific organization of the owner, and also depending on the volume of the contracted activities.

References

1. ASME OM Code
2. ASME XI Code
3. 10CFR50.55a Appendix J, Option B
4. Generic Letter 89–04 Guidance in Developing Acceptable Inservice Testing Programs.
5. Generic Letter 90–06 Power-Operated Relief Valve and Block Valve Reliability, and Additional Low-Temperature Overpressure Protection for Light-Water Reactors.
6. Generic Letter 90–09 Alternative Requirements for Snubber Visual Inspection Interval and Corrective Actions.
7. Generic Letter 96–05 Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves.
8. ASME/ANSI OM Part 1
9. ANSI/ANS 56–8
10. KTA 3401.4 "Periodic inservice testing and inspection of containment"
11. KTA 3405 "Integrated leakage rate testing method"

12. 10CFR50 Appendix B

13. ANSI/ASME NQA–1

14. C.P. 50–C–QA from the IAEA

15. UNE–73–401 Garantia de Calidad en Centrales Nucleares, from AENOR in Spain

16. Guias de Seguridad del CSN: translate

17. 10.1 Guia Basica de Garantia de Calidad para Instalaciones Nucleares, 25–2–99

18. 10.5 Garantia de Calidad de ensayos, pruebas e inspecciones de instalaciones nucleares, Septiembre 1987.

Assessing Component Performance and Compliance with the ASME Code for Inservice Testing of Pumps and Valves

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Abstract

The use of analysis to meet American Society of Mechanical Engineer (ASME) Code requirements for inservice testing (IST) of pumps and valves has greatly expanded from the most basic analysis activities of determination of component scope, test methodology, and test practicality. With the incorporation by reference into 50.55a of the *Code of Federal Regulations* of the ASME Code for Operation and Maintenance of Nuclear Power Plants (OM Code)–1995 edition through the 1996 addenda, U.S. utilities will be allowed to utilize analysis to a greater extent to meet the Code requirements. While analysis provides a means of optimizing test activities and potentially providing more meaningful information with regards to component degradation, it could also allow for erosion of safety margins if used improperly. This paper will identify the major analysis requirements in the recently endorsed OM Code. In addition, similar requirements in the 1989 Edition of ASME Boiler and Pressure Vessel Code, Section XI, which references earlier OM Standards, will also be identified as most U.S. plant IST programs are currently implemented to comply with this edition of the Code. Specific issues will also be discussed in the five major areas where analysis is applied: general requirements on pump and valve testing, motor-operated valve testing, safety and relief valve testing, and a new approach to check valve testing.

I. Introduction

The use of owner-derived requirements by means of qualitative or quantitative calculation, evaluation, or justification, have always been an integral part of the American Society of Mechanical Engineers (ASME) Code for inservice testing (IST) of pumps and valves. These activities are usually associated with the performance of an analysis of the component. The performance of this analysis is specifically referenced in recent ASME Code editions as a method to support continued operation of pumps and valves which have been declared inoperable because of a failure to meet the test acceptance criteria. However, the use of analysis should be viewed much more broadly to include programmatic requirements that are essential to develop and maintain a good

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IST program. For example, the determination of component scope, the method of testing to meet the Code requirements, and whether this testing is practical at a particular operating mode, are all qualitative analysis decisions that must be made before a plant IST program is implemented.

The use of analysis to meet certain Code requirements provides many potential benefits and possible drawbacks to component performance and ultimately plant safety. The U.S. Nuclear Regulatory Commission (NRC) recognizes that analysis has both a necessary and significant role in IST. However, the results of an analysis should not solely be used to determine that a component complies with the Code or technical specification requirements but that the component will perform its safety function over the required IST interval given its current condition. Analysis should combine the sum total of all the relevant information to allow the owner to make informed decisions on component functionality.

The 1995 Edition through the 1996 Addenda of the ASME Code for Operation and Maintenance of Nuclear Power Plants (OM Code) for inservice testing of pumps and valves, which was recently endorsed in 10 CFR 50.55a, has placed a greater emphasis on the use of analysis to assess component condition and satisfy Code requirements. U.S. operating plants will be required to update their IST program to this Code edition in their next ten-year update. This paper will identify the major analysis requirements in the recently endorsed OM Code. Specific issues will also be discussed in the five major areas where analysis is applied: general requirements on pump and valve testing, motor-operated valve (MOV) testing, safety and relief valve testing, and a new approach to check valve testing.

In this paper, similar requirements between the 1989 Edition of ASME Section XI Boiler and Pressure Vessel Code (BPV Code) and Subsections ISTB and ISTC of OM Code–1995 will also be identified as most U.S. plant IST programs are implemented to comply with this edition of the Code. The 1989 Edition of Section XI, Subsection IWP and IWV, references OM–1987 for IST of pumps and valves respectively. Pump requirements are located in OMa–1988, Part 6 (OM–6). General valve requirements are located in OMa–1988, Part 10 (OM–10). Finally, safety and relief valve requirements as referenced in OM–10 are required to comply with the requirements in ANSI/ASME OM–1–1981 (OM–1).

II. Analysis Requirements

The analysis requirements that are discussed in this paper were selected based on the following criteria:

> Analysis requirements are unspecified programmatic or component performance requirements that are complied with by use of either qualitative or quantitative calculation, evaluation, justification, or other means not specifically delineated in the Code.

As an example, evaluating compliance with the pump absolute alert acceptance criterion of 0.325 inches per second for overall bearing vibration does not require analysis because this is a specific performance parameter which can be measured by use of a calibrated instrument. By the same token, the limiting stroke time of an air-operated valve is assessed by reading a stop watch and comparing it with the owner-specified value. In contrast, analyzing pump parameters which are in the required action range, verifying the necessary check valve obturator movement by other positive means, and evaluating the ability of relief valves which do not comply with acceptance criteria to perform their intended function until the next test interval or maintenance opportunity are all examples which analysis, evaluation, and justification are used to comply with the Code requirements.

III. Analysis: Potential Benefits and Drawbacks

Much has been said by owners about the prescriptive nature of the test requirements in the Code. Owners have long requested alternatives which provide additional flexibility to assess whether their pumps and valves are degrading and what degraded condition renders these components unable to perform their intended safety functions. By allowing analysis to assess component performance, as opposed to a valve stroke time or a pump hydraulic limit based on pre-determined reference values, owners would be able to take advantage of more up-to-date technologies and reduce or eliminate unnecessary testing. This would allow a more logical and accurate assessment of component performance. However, analysis used without regard to safety can also weaken the Code requirements in assessing the condition of the component. The task for owners and the NRC staff is to determine whether the analysis, as documented, realistically assesses the importance of the components' condition and the capability to withstand any challenge to plant safety.

It is clear that analysis performed thoughtfully with the full intent of determining the condition of the component can enhance safety, optimize testing, and reduce component wear. Analysis performed with the sole purpose of meeting the Code requirements and the plant technical specifications without regard to the actual condition of the component has the potential to reduce safety margins, and might allow inoperable components to continue to remain in service and potentially further degrade. Clearly, there is an expectation that the analysis should be performed with the intent of determining the condition of the component, and elements of the decision process used to meet the analysis requirements are documented as required by the Code.

IV. Programmatic Analysis Requirements

There are many programmatic areas where qualitative analysis, evaluation, and justification activities are used to meet Code requirements for all pumps and valves in an IST program. The most important issues are determination of program scope, applicability, and component test practicability.

1. Program Scope and Applicability

The determination of whether a pump or valve is safety-related is the first and most fundamental Code required analysis activity engaged by the owner. A thorough, well documented determination of scope and applicability can aid in the determination of safety significance, test practicality, test methodology, and justification for inclusion (and exclusion) from the IST program. Generally speaking, owners that have extensive documentation of program scope (i.e., a basis document) have equally comprehensive IST programs.

The NRC has provided extensive guidance on program scope development in NUREG–1482, "Guidelines for Inservice Testing at Nuclear Power Plants." Because every plant variation could not be documented in this guidance, questions often arise regarding whether certain pumps and valves should have been included in an IST program. One reoccurring difficulty is the program scope of certain relief valves which is discussed in Section V.3 of this paper.

It is the owners' responsibility to determine the scope of their IST programs. It is to their benefit that this determination be documented appropriately. The NRC has provided guidance in this area and continues to facilitate public forums to discuss IST issues. The NRC oversight function allows inspection of this programmatic activity to verify compliance with the Code.

2. Component Test Practicability

Associated with IST program scope determination is the analysis of the practicability of testing a component during a particular plant mode of operation. The determination of whether testing is impracticable involves review of the affected systems, design basis documentation, plant procedures, technical specifications, and any other relevant documentation to determine if the testing is practicable to perform. The NRC relies in part on the documentation of the deferral in the owner's IST program to assess compliance with the Code.

Complete deferral of stroke-time testing from the "at-power" mode to cold shutdown or refueling outage is only applicable for valves. Valve test deferral in some cases appears to be highly subjective. One owner may regard a particular exercise test of a check valve as impractical at power although another might regard a check valve test in a similar system practicable to perform. In the documentation of the test deferral, it is important to note the specific reasons for the impracticability, supported by system performance parameters at specific plant operating modes and other information to support the deferral.

With the introduction of the OM Code–1995, certain pump test requirements include a practicability analysis. Further discussion is provided in Section V.1 below.

V. Specific Component Analysis Requirements

The OM Code–1995 Edition through 1996 Addenda includes five specific subsections, Code cases, and appendices, that are specifically related to component IST. Each of these separate portions of the Code contain specific analysis requirements for their respective components. The following sections include a brief discussion of general or specific topics on those component groups followed by a table specifying the analysis requirements for that component group and, where applicable, previous Code editions where these analysis requirements were specified.

1. OM Code 1995, Subsection ISTB: Inservice Testing of Pumps in Light-Water Reactor Power Plants

A significant safety improvement in the OM Code–1995 is the requirement to establish specific pump hydraulic reference values within ±20% of the pump design flow rate, where practicable. This flow test requirement provides the optimum reference range to assess pump degradation. The key analysis provision in this requirement is the assessment by the owner of when this requirement is practicable to perform. Temporary modifications, such as the installation of spool pieces or the construction of dykes, are practicable to perform on a refueling outage frequency as required by the Code. It is appropriate for licensees to propose alternate testing when the intent of the Code requirements will be met by their current testing. As an example, if the attainable pump test flow rate is a few percentage points below 80% of the pump design flow rate, the owner may be able to propose that the current testing is an acceptable alternative per 10 CFR 50.55a(a)(3)(i) and meets the intent of the Code test requirement. When such alternatives are submitted as required by the NRC regulations, they should include performance data to support the proposed alternative.

In addition to the above safety enhancement, new flexibility is also provided in Subsection ISTB by means of analysis of the test results. After declaring a pump inoperable, analysis is provided as an option to assess the condition of the pump and, if the performance is determined to be acceptable, assign new acceptance criteria. This analysis is not required to be submitted to the NRC for review or approval but must be documented in accordance with the Code requirements. Guidance for analysis of safety-related pumps and valves which are in the required action range and are determined to be degraded but operable is currently included in NRC Generic Letter (GL) 91–18, "Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded And Nonconforming Conditions And on Operability." The NRC staff has previously granted relief for licensees to use ISTB 6.2.2 because it is consistent with this guidance.

With regard to the application of analysis for the alert range, the Code requirements appear inconsistent. While ISTB 4.6 specifically details how new reference values can be established by analysis when the pump parameter is in the alert or required action range, ISTB 6.2.1 on alert range acceptance criteria makes no mention that analysis can be used when an acceptance criterion is in the alert range. Adjustment of the alert range by means of analysis appears to be appropriate within the context of the OM Code–1995. In other words, in order to perform analysis to modify the alert range, the owner would have to request to update the IST program to incorporate OM Code–1995, Subsection ISTB, in its entirety. The remaining portions of the subsection are regarded as related requirements because this analysis is directly applicable to the test information derived from more optimum testing which is required in the Code.

By allowing the alert or required action range values to be changed by use of analysis comes the potential danger of stair-stepping pump performance down to the pump operating limits. This could lead to operating a pump below its required performance limits or catastrophic failure. It is expected that these provisions will be used infrequently and that each instance will be documented as required by the Code for potential review in a future NRC inspection.

2. OM Code–1995, Subsection ISTC: Inservice Testing of Valves in Light-Water Reactor Power Plants

OM Code–1995, Subsection ISTC, includes general requirements for all valves in the IST program with the exception of Category C safety and relief valves, which are included in mandatory Appendix I and are discussed in Section V.3 of this paper. Valves are divided into two basic groups: power-actuated (or power-operated) and self-actuated.

Power-operated valves include valves which are motor-operated, air-operated (discussed in Section VI), solenoid-operated, and hydraulically-operated. The acceptance criteria for power-operated valves employed by the Code continue to compare a change in the measured stroke-time against the reference and the owner defined limiting values. Code Case OMN–1 provides alternate requirements for MOVs and is discussed in Section V.4.

The major analysis requirements that were included in the 1989 Edition of the ASME BPV Code, Section XI, and continue to be in place for power-operated valves are focused on stroke time reference values and assessing the results of stroke time tests. The requirements include:
1) establishing reference values when the valve is known to be operating acceptably; 2) assessing when to implement new reference values; 3) analyzing valves which do not meet stroke time acceptance criteria; and 4) analyzing valves in regular use to determine if they meet the Code requirements.

Check valves, which are considered self-actuated valves, have always presented a challenge in determining a test methodology and developing associated acceptance criteria which monitor degradation of the check valve. The NRC has provided guidance in GL 89–04, "Guidance on Developing Acceptable Inservice Testing Programs," Positions 1, 2, 3, and 4, which discuss testing and examination of check valves. Verification of the test acceptance criteria, especially one which uses "other positive means" to verify check valve obturator movement that owners employ has always yielded unique methodologies. Some of these methodologies were determined not to meet the intent of the Code during NRC inspections.

Sample disassembly and inspection of check valves is now provided in the OM Code–1995 as an alternative if flow testing is impractical and is similar to guidance provided in Position 2 of GL 89–04. The analysis requirements in disassembly and inspection of check valves are numerous, from assessing the similarity of the group to evaluating the condition of the components. These issues have not changed with this addition to the Code but have reduced the burden of having to submit to the NRC a request for relief from the Code requirements.

Analyses using non-intrusive test methods which provide quantitative data on the performance of check valves allow owners to make an informed assessment on the condition of the check valve. These methods must be qualified prior to use, but provide an analysis of the condition of the component that is superior to simple flow testing which is discussed in the current NRC guidance.

The Code and regulatory analysis requirements with regard to bi-directional testing and implementation of Appendix II, "Condition Monitoring Program," for check valves are discussed in Section V.5.

3. OM Code–1995, Appendix I: Inservice Testing of Pressure Relief Devices in Light-Water Reactor Power Plants

Test requirements for safety and relief valves are referenced, depending on the Code edition, to ASME Performance Test Code 25.3–1976, OM–1–1981 Standard, or Appendix I to OM Code–1995. Analysis requirements for relief valves have always been a significant part of their testing requirements. Critical analysis requirements are the evaluation of valve test failure and the need to expand the testing sample and test for generic concerns.

One issue that continues to be problematic is the effect of ambient temperature on set pressure and the use of vendor supplied correlation information to adjust the set pressure for an ambient temperature set pressure test so that the valve will open at its required set pressure at its operating temperature. Currently, the Code requires that correlation testing be performed to establish the appropriate set pressure to use when periodic testing is to be performed using test fluids or temperature different from operating fluids or operating temperatures. After numerous attempts to draft new Code language that would permit ambient temperature testing of some valves using correlations provided by manufacturers based on engineering judgement and not the current Code required test data, the committees have not arrived at a consensus on this issue. Owners have also attempted to perform their own correlation tests to satisfy Code requirements for alternate test fluid temperature testing. Until that time, owners should ensure that the intent of this Code analysis requirement is met.

As stated previously, relief valve scope determination continues to be a challenge. An NRC inspection in February of 2000 at a Region I plant revealed that the owner had excluded 52 relief valves from their program. The Code has provided specific requirements addressing this issue. Code Interpretation 95–9 states that Class 2 and Class 3 pressure relief valves are required to be tested if their only overpressure protection function is to protect isolated components from fluid expansion caused by changes in fluid temperature provided they are within the scope of the OM Code. Owners can use this information to help ensure that the scope of all relief valves in their IST program is in compliance with the Code.

A comparison between OM Code–1995, Appendix I, and OM–1–1981 has not been included in the following table because of the substantial differences in the format and text of the two codes.

4. OM Code–1995, Code Case OMN–1: Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light-Water Reactor Power Plants

ASME Code Case OMN–1 allows an alternative program of periodic diagnostic testing and exercising in lieu of quarterly stroke time testing of MOVs. The analysis requirements in OMN–1 benefit from an extensive MOV design basis and periodic verification program and allow licensees to use the activities in these programs to meet the Code requirements. Provisions of OMN–1 are superior to the stroke time testing requirements for power-operated valves currently specified in the Code. Owners may apply OMN–1 to some or all of their MOVs in their IST program.

The reader is referred to the extensive guidance in GL 89–10, GL 96–05 and industry documents.

5. OMa Code–1996, Appendix II: Check Valve Condition Monitoring Program

Two significant changes to IST of check valves were included in the ASME OMa Code–1996 Addenda to: (1) correct certain anomalies in the way exercising of check valves is currently being implemented, and (2) to codify a process for monitoring the valve's operating condition and performance. This integral two-part improvement to the Code provides interrelated requirements. ISTC 4.5.2, "Exercising Requirements," and ISTC 4.5.4, "Valve Obturator Movement," were changed to require a bi-directional test to improve the detection of valve degradation and failure. The related ISTC 4.5.5, "Condition Monitoring Program," change allowed the use of a codified condition monitoring process as an alternative to the exercising and testing requirements of ISTC 4.5.1 through ISTC 4.5.4.

The condition monitoring process is defined in Appendix II, "Check Valve Condition Monitoring Program." The condition monitoring process allows the owners certain flexibility in establishing the types of test, examination, and preventive maintenance activities and their associated intervals, when justified based on the valve's performance and operating condition. Owners who elect not to implement the ISTC 4.5.5 alternative Condition Monitoring Program in their IST Plan, are required to use ISTC 4.5.1 through ISTC 4.5.4 which are the default testing and examination requirements.

The condition monitoring program is the culmination of a trend in the ASME Code to provide more flexibility to owners through the use of analysis. The test, examination, and preventive maintenance activities will go beyond the simple "demand challenge" test previously required by the Code. The analysis requirements call for the owner to determine and justify the test methodology and test interval based on a documented history of performance. Check valves are appropriate for this type of approach due to the difficulty in developing test acceptance criteria that provides meaningful information on the condition of the component.

In the statement of considerations of the amendment to 10 CFR 50.55a (64 FR 51388), the NRC stated it would "favorably consider a request by a licensee under §50.55a(f)(4)(iv) to apply Appendix II in advance of incorporating the 1995 Edition with 1996 Addenda of the ASME OM Code as its Code of Record if the licensee's request justifies: (1) the modifications to Appendix II contained in the rule have been satisfied, and (2) all portions of the 1995 Edition with the 1996 Addenda of the OM Code that apply to check valves are implemented for the remaining check valves not included in the Appendix II program."

The Condition Monitoring Program approach of Appendix II, for check valve IST with the modifications in the amendment to 10 CFR 50.55a, to be a significant improvement over the current Code requirements. Owners are encouraged to implement Appendix II. The use of the ISTC 4.5.5 alternative IST program provides the licensee with knowledge of the valve's operating condition, informed and verified expectations of the valve's performance over extended intervals, and a process to reduce the burden of unnecessary IST. To date, the NRC has approved requests for the implementation of Appendix II for 12 plants.

VI. Future Analysis Requirements

In a future revision of the Code, it is anticipated that the test requirements for air-operated valves (AOVs) will be supplemented. This will provide an opportunity for Owners who have performed extensive design basis and periodic verification of AOVs to take advantage of their work to optimize testing, similar to MOVs in Code Case OMN–1. Development of these provisions and their ultimate inclusion in the ASME Code is expected in the next couple of years.

VII. Conclusion

Analysis requirements have always been a part of IST of pumps and valves. More recent editions of the ASME OM Code have provided new analysis requirements which have allowed owners greater flexibility in the methods used to determine the extent of degradation of safety-related components and to establish acceptance criteria to meet the Code requirements. Indeed, analysis requirements are considered significant improvements over prescriptive Code test requirements.

Used appropriately, analysis provides a means of flexibility from certain prescriptive requirements. However, misuse of the analysis provisions might allow a component to degrade to the point of failure and not be capable of performing its safety function. As we venture into a new regulatory environment, we all need to be supportive of the use of appropriate analysis to satisfy the Code requirements and verify component functionality while being cognizant of the potential to misrepresent the results of any Code test methodology assessed by analysis.

VIII. References

Codes and Standards

Performance Test Codes, PTC 25.3–1976, "Safety and Relief Valves," New York, 1976.

American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI), Operations and Maintenance Standards, New York, 1987.

Part 1 (OM–1), "Requirements for Inservice Performance Testing of Nuclear Power Plant Pressure Relief Devices," 1981 and 1987.

Part 6 (OM–6), "Inservice Testing of Pumps in Light-Water Reactor Power Plants," 1988 Addenda and 1989 Addenda.

Part 10 (OM–10), "Inservice Testing of Valves in Light-Water Reactor Power Plants," 1988 Addenda.

ASME Code for Operation and Maintenance of Nuclear Power Plants (ASME OM Code–1995), New York, 1995.

Subsection ISTB, "Inservice Testing of Pumps in Light-Water Reactor Power Plants," ASME OM Code–1995 and OMa Code–1996 Addenda

Subsection ISTC, "Inservice Testing of Valves in Light-Water Reactor Power Plants," ASME OM Code–1995 and OMa Code–1996 Addenda

Code Case OMN–1, "Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light Water Reactor Power Plants," ASME OM Code–1995, Subsection ISTC.

Appendix I, "Inservice Testing of Pressure Relief Devices in Light-Water Reactor Power Plants," ASME OM Code–1995.

Appendix II, "Check Valve Condition Monitoring Program," ASME OMa Code–1996.

ASME OM Code–1995 Interpretation 95–9, Testing of Thermal Relief Valves.

Generic Letters

Generic Letter 89–04, "Guidance on Developing Acceptable Inservice Testing Programs," April 3, 1989.

Generic Letter 89–10, "Safety-Related Motor-Operated Valve Testing and Surveillance," June 28, 1989.

Generic Letter 91–18, "Information to Licensees Regarding Two NRC Inspection Manual Sections on Resolution of Degraded and Nonconforming Conditions and on Operability," November 7, 1991

Generic Letter 96–05: "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," September 18, 1996.

NUREG

NUREG–1482, "Guidelines for Inservice Testing at Nuclear Power Plants," published April 1995.

Table 1: Pump Analysis Requirements		
OM Code–1995 ISTB	**Analysis Requirement**	**OMa–1988 Part 6**
1.1	Determine whether pump within scope of Code.	1.1
1.2	Determine if exclusions applicable.	1.2
4.3(e)(2)	Determine practicality of testing within ±20% of pump design flow rate.	none
4.4	Determine if reference values affected by repair, replacement, or routine service. Evaluate deviations between old and new reference values.	4.4
4.5	In establishing an additional set of reference values, analyze results of Group A or comprehensive pump test and determine if operation acceptable per ISTB 6.2.	4.5
4.5(b)	Justify an additional set of reference values for positive displacement pumps.	none
4.6	When pump test parameters in alert or required action range, reference value changes can be supported by use of an analysis.	none
4.7.1(a)	Accuracy requirements for parameters determined by analytical methods.	none
6.2.2	Analysis of pump test parameter which is in required action range. Allows potential establishment of new reference values in lieu of corrective action.	none
7.3(f)	Analysis of deviations included in record of tests.	7.3(f)

Table 2: General Valve Analysis Requirements		
OM Code–1995 ISTC	**Analysis Requirement**	**OMa–1988 Part 10**
1.1	Determine whether valve in scope of program.	1.1
1.2	Determine if valve excluded from scope of Code.	1.4
1.4	Evaluate valve function to determine proper category.	1.4
2(b)	Ensure application, method, and capability of each non-intrusive technique is qualified.	2
3.1(a)	Any valve which has undergone maintenance that could affect its performance subject to ISTC 3.4	3.1(a)
3.3	Reference values shall be established only when valve known to be operating acceptably. If measured parameter affected by other related conditions, then these conditions shall be analyzed.	3.3 3.3
3.4	Repair, replacement, or maintenance requires new reference values if these activities affect reference values. Deviations between new and old reference values shall be analyzed.	3.4 3.4
3.5	For additional reference values established by reasons other than covered in 3.4, reconfirm old reference values or, if impractical, analyze at new reference values.	3.5
4.1	Allows use of other indications for local observation.	4.1
4.2.2(a) through 4.2.2(e)	Determination of practicality of valve testing at power, during cold shutdowns, and refueling outages.	4.2.1.2(a) through 4.2.1.2(e)
4.2.3	Determination of valve obturator movement by means other than control room indication lights or stem travel.	4.2.1.3
4.2.4(a)	Specify limiting values of full-stroke time of each power-operated valve.	4.2.1.4(a)
4.2.4(c)	Evaluation of abnormal or erratic action of power operated valve stroke testing to determine need for corrective action.	4.2.1.4(c)
4.2.5	Analysis of valves in regular use to determine if operation meets Code requirements.	4.2.1.5
4.2.9(b)	Valves that do not meet stroke time acceptance criteria shall be analyzed.	4.2.1.9(b)
4.2.9(c)	Valves declared inoperable may be analyzed to determine the deviation and the valve shown to be operating acceptably.	4.2.1.9(c)
4.3.1	Valves which identified during plant operations that fully demonstrate adequate seat leak-tightness need not be additionally tested.	4.2.2.1
4.3.3(b)(4)	Permits leakage tests involving pressure differentials lower than functional differential pressure.	4.2.2.3(b)(4)
4.3.3(e)	Compare actual leakage rates with permissible rates.	4.2.2.3(e)
4.5.2(a) through 4.5.2(e)	Determination of practicality of check testing at power, during cold shutdowns, and refueling outages.	4.3.2.2(a) through 4.3.2.2(e)

Table 2 continued		
OM Code–1995 ISTC	**Analysis Requirement**	**OMa–1988 Part 10**
4.5.3	Check valves in regular use need not be additionally exercised if required observations made and analyzed.	4.3.2.3
4.5.4(a)	Check valve obturator movement verified by other positive means.	4.3.2.4(a)
4.5.4(b)	Reference values used shall be obtained when check valve known to be operating properly.	4.3.2.4(b)
4.5.4(c)	Use of a sample disassembly examination program for check valves for which are impractical to test quarterly or during cold shutdowns. Assess need for testing after maintenance.	none
4.5.4(c)(1)	The grouping of check valves shall be technically justified.	none
4.5.4(c)(2)	Examine obturator which has been disturbed prior to disassembly to determine if a condition exists that could prevent full opening or reclosure of the obturator.	none
4.5.4(c)(4)	Determine practicality of full or part stroke exercise of a check valve after reassembly.	none
4.5.6	Retest check valve which fails to exhibit required change in obturator movement to show acceptable performance prior to return to service. Check valves which are disassembled to meet Code requirements which cannot be exercised or have unacceptably degraded internals shall be analyzed.	4.3.2.6 none
6.2(d)	Document justification for deferral of testing in test plans.	6.2(d)
6.3(f)	Document analysis of deviations.	6.3(f)

Table 3: Relief Valve Analysis Requirements	
OM Code–1995 Appendix I	**Analysis Requirement**
1.1	Determine whether pressure relief device within scope.
1.1.2(a)	For parameters being tested which are not specifically addressing installed operating and test conditions shall be comparable or proven correlations applied.
1.3.1(e) 1.3.2(c)	Prepare written acceptance criteria.
1.3.3(c) 1.3.5(c)	Owner to evaluate why valves failed to meet acceptance criteria. Owner to evaluate need for testing to meet generic concerns.
1.3.7	Consider historical data to assess the need to conduct more frequent leak testing of containment relief valves and containment vacuum relief valves.
3.3.1(b) 7.3.1(b) 3.3.2(b) 7.3.2(b) 3.3.3(b) 7.3.3(b) 3.3.5(b) 7.3.5(b) 7.3.6(b)	Test may be a quantitative or qualitative determination primarily for gross determination of as found seat tightness.
3.4.1(e) 7.4.1(d) 3.4.2(d) 7.4.2(d) 3.4.3(d) 7.4.3(d) 3.4.5(d) 7.4.5(d) 3.4.7(d) 4.5.6(d)	Evaluate ability of relief valves which do not comply with acceptance criteria to perform their intended function until the next test interval or maintenance opportunity. Determine appropriate corrective actions to ensure operability.
4.1.1(a)	Alternate compressive fluids may be used as the test media if correlation data between the alternate fluid and steam have been established.
4.1.1(e) 8.1.1(e) 4.1.2(e) 8.1.2(e) 4.1.3(e) 8.1.3(e)	If the effect of ambient temperature on set pressure can be established for a particular valve type, then the valve may be set-pressure tested using an ambient temperature differential from the operating ambient temperature.
4.3.1 8.3.1 4.3.2 8.3.2	Owner shall ensure that correlation established for using alternate media will be of sufficient accuracy to comply with the valve acceptance criteria.
5.1(g) 9.1(g)	Maintain records of analysis test which do not meet acceptance criteria or evaluation of test anomalies.
5.4 9.4	Document alternate test media correlation test procedure.

Table 4: Motor Operated Valve Analysis Requirements	
OM Code–1995 Code Case OMN–1	**Analysis Requirement**
1.1	Determine whether motor-operated valve in scope.
3.1	Design basis verification test to be conducted at conditions as close to design basis conditions as practicable.
3.1(b)	If design basis test done at test facility, perform analysis documenting that supports applicability to in situ conditions.
3.1(c)	Justification at conditions other than design basis and grouping like MOVs shall be documented by evaluation or testing.
3.1(d)	Validation of design basis test after modifications of MOV, application, or system shall be justified by evaluation or test.
3.4	Deviations between new and previous inservice tests shall be identified and analyzed.
3.5	Grouping may be justified by evaluation or test.
3.5(b)	Test results shall be evaluated and justified for all valves in the group.
3.5(d)	Number of MOVs tested determined using appropriate statistical methodology.
3.5(e)	Test results for MOV will be analyzed and evaluated.
3.6.1	Longer exercise intervals may be used if justified by successful operation experience.
3.6.2	Consider more frequent exercising for MOVs with higher risk, infrequently operated MOVs with higher risk, harsh environment or service, and abnormal characteristics.
3.7	Risk based criteria for MOV testing allowed. Owner will consider acceptable basis for risk determination, develop screening criteria and applicability from expert panel.
5.4	Collect data required to analyze functional margin.
6.2	Analyze data to determine if performance acceptable. Consider all relevant operating conditions. Include qualitative review to identify anomalous behavior, analyze anomalous behavior identified, and complete any required corrective action.
6.3	Owner will determine which evaluation methods suitable for each MOV and application.
6.4	Owner will demonstrate that adequate functional margin exists.
6.4.1.1(b)	Design basis stem factor can, with justification, be estimated by analytical methods.
6.4.1.2	Design basis stem torque for quarter-turn MOVs can, with justification, be estimated by analytical methods.
6.4.2.2	For MOVs where inservice testing does not sufficiently load the MOV to cause torque switch trip, available stem torque based on the current torque switch setting may be determined analytically from test data.
6.4.4	MOV functional margin will be evaluated to account for anticipated time related changes in performance to determine test interval.
9.2	Document analysis of Section 6 of OMN–1.

Table 5: Check Valve Condition Monitoring Program Analysis Requirements	
OM Code 1996 Addenda Appendix II	**Analysis Requirement**
2(b)	Groupings based on analysis of test results.
3	Perform analysis of test and maintenance history in order to establish the basis for inservice testing, maintenance, and preventative maintenance activities.
4(a)(1) through 4(a)(3)	If insufficient info available to analyze as required in II 3, then perform tests, examinations, and other types of analysis, as applicable, at sufficient intervals over the next 5 years or 3 refueling outages, whichever less. Conduct activities until sufficient info obtained or the end of the interim period.
4(a)(4)	Review results of activities performed in 4(a)(1) through 4(a)(3) to determine if any changes to the program are required.
4(b)(1) through 4(b)(3)	If sufficient information available, identify applicable preventative maintenance, examination, and test activities and their associated intervals and revise the condition monitoring program to perform these activities.
4(b)(4)	Review results of activities performed in 4(b)(1) through 4(b)(3) to determine if any changes to the program are required. If there are significant changes, repeat applicable requirements of Sections II 2, II 3, and II 4.
5	If corrective maintenance performed, analysis used to formulate the basis of the activities reviewed to determine if any changes are required. If there are significant changes, repeat applicable requirements of Sections II 2, II 3, and II 4.
6(d)	Document the analysis forming the basis for the program.

Implementation of ASME Inservice Testing at Sizewell B

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Sizewell B Power Station

Abstract

The nuclear power program in the UK spans three generations of technology since the 1950s. The technologies are the early Magnox gas cooled graphite moderated natural uranium reactor design, the later Advanced Gas Cooled graphite moderated enriched uranium reactor design, and the most recent SNUPPS based PWR station located at Sizewell in Suffolk and entered full commercial operation in 1995.

Sizewell B is the first nuclear power station in the UK to implement inservice testing as a stand alone program. This paper includes a description of the reasons for the route taken towards inservice testing at Sizewell B and the overall strategy in working to the requirements of the ASME OM Code outside of the United States regulatory requirements.

The approach taken to those issues which were not carried across directly is discussed, e.g., the management/control of:

- Relief requests
- Cold Shutdown Justifications
- Metrication

The paper discusses these application issues as well as the strategy for resourcing the performance testing and program management.

In conclusion, the paper looks forward to the future for program management at Sizewell B, as the plant moves to a different phase in its life when the program becomes more dynamic as plant ageing takes place and preparations are put in place for the first 120 month review.

Introduction

The construction of Sizewell B in the UK represented a significant departure for the UK nuclear industry. The UK nuclear industry had been based on gas cooled reactor technology developed within the UK. As for many countries the nuclear program started with reactors designed to manufacture weapons grade material, the generation of electricity became a natural progression for the need to remove the heat generated in the process. The first natural uranium gas cooled reactors for the purpose of selling electricity were designed, built and operated by the nationalized electricity supply industry company the Central Electricity Generating Board (CEGB) in the 1950s and 60s.

These first generation reactors were known as Magnox reactors because of the Magnesium non-oxidizing material used for the natural uranium fuel cladding. Nine twin reactor Magnox stations were built until it was realized that in order to keep up with modern turbine technology higher temperature and pressure steam conditions were required. The Magnox reactors were very limited due to the low melting point of the fuel materials. From this need the Advanced Gas Cooled Reactor (AGR) design was developed using stainless steel fuel cladding and enriched uranium fuel. The AGR reactors were designed to supply superheated steam to modern 500 and 660 MW turbine generating sets identical to those used in the conventional oil and coal fired power stations. Six twin reactor AGR stations were constructed in the 1970s and 1980s with the last stations commissioned in 1985/6.

In the early 1980s the CEGB was in the process of developing the long term strategy for electricity supply in the UK. There was a need to plan for the end of the life of the Magnox stations and many of the conventional power stations which were ageing. A strategy was developed to build a family of large coal fired stations and a family of next generation nuclear stations. As a forerunner to this program a project team had been given the task of deciding which nuclear option the UK should follow, i.e. develop the UK AGR technology with its advantages of on-load refuelling, or adopt another country's technology, i.e. French PWR technology or U.S. SNUPPS design. The conclusion was to adopt the SNUPPS reference design as successfully implemented at Wolf Creek and Callaway.

The CEGB established a PWR Project Management Team as a joint venture between the CEGB and its nuclear architect engineering contractor (NNC). The remit was to construct a family of four PWRs starting with Sizewell B; following a public inquiry Government consent for Sizewell B was granted in 1986. First civil works started in September 1987, the station initial criticality was achieved on the 31st of January 1992, and full commercial operation was achieved in June 1995. In the middle of the journey (November 1989) the UK Government decided to put a hold on the build program and only Sizewell B survived.

Station Commissioning

In order to capitalize on previous experience the PWR Project Group (PPG) station commissioning team was resourced from commissioning engineers from the U.S. As commissioning work progressed so the organization looked towards requirements for Pre-Service examination and Pre-Service testing. There was a wealth of Inspection knowledge within the organization and ASME expertise also which was necessary to support construction; however, the project had not needed any PST/IST expertise and so some of the U.S. Commissioning resource was diverted to develop the Pre-Service/Inservice Test Programme.

Why Implement Pre-Service and Inservice Testing

During the Sizewell B public inquiry, the CEGB committed to following "best international practice" and committed to following the requirements of the ASME code. In order to address the different legislation arrangements an ASME adaptation document was developed which allowed the intent of the ASME code to be met but within the UK legal framework.

The extent of PST/IST commitment for Sizewell B was limited in scope to:

- Part 1 Requirements for Inservice Performance Testing of Nuclear Power Plant Relief Devices.
- Part 6 Inservice Testing of Pumps in Light-Water Reactor Power Plants
- Part 10 Inservice Testing of Valves in Light-Water Reactor Power Plants

The reference ASME code for Sizewell B is as follows:

ASME Boiler and Pressure Vessel Code—1989 Edition and 1990 addendum, Subsection IWP and IWV.

ASME OM Standards 1987 including 1988 addenda.

Where does the Programme Fit in the Station Administration

The PST/IST program at Sizewell B has been established as one of the Technical Specifications related programs. The program has its own Surveillance Requirements with Limiting Conditions of Operation (LCOs) which must be entered in the event of a test failure.

Each IST test is a Surveillance Test Procedure within the suite of Technical Specification Test Procedures. Scheduling and tracking of test performance is performed within the stations overall work management system (Passport). All operational related IST test procedures are performed by the plant operators, all of the maintenance/inspection IST procedures are performed by either station maintenance craft personnel or maintenance contractors.

All completed test procedures are returned to the IST Programme Co-ordinator for review and confirmation that the requirements of the test have been satisfied.

Within the IST program there are 37 pumps and 740 valves. The program generally includes all safety related pumps and valve, i.e. identified as safety category 1 within the station design.

IST Programme Maintenance Resource

During the commissioning of Sizewell B there was a considerable amount of resource required to prepare the suite of surveillance test procedures, however, in the operational phase the IST Programme Co-ordinator role is managed on a part time basis by a System Engineer within the NSSS Systems Group of Systems Engineering.

The IST Programme Co-ordinator is the nominated person for all IST procedures, this means that procedures can not be changed without his approval.

The IST Programme interfaces heavily with the Motor Operated Valves Testing program (MOVATS) and with the Containment Local Leak Rate Testing program. These programs are also managed within Systems Engineering, but under a different Group. Each program has its own Programme Co-ordinator.

Units of Measurement

The intent at the outset was that Sizewell B would follow metric units wherever practical. This even extended to Westinghouse designed components were manufactured under license in the UK to engineering drawings which had the measurements converted from imperial to metric units.

The Inservice Test program uses the following units:

- Speed—revolutions per minute (rpm)
- Vibration—displacement—microns
- Vibration—velocity—mm/second
- Pressure—bar
- Flow—meters cubed per hour

Independent Monitoring of the Inservice Test Program and the Regulators Involvement

British Energy appoint an Authorized Nuclear Independent Inspector (ANII) resident engineer to provide a monitoring role with regard to the application of ASME for ISI, the ASME Repair and Replacement Procedure and for Inservice Testing.

The Nuclear Installations Inspectorate (NII) also have a resident inspector at the station, the NII site inspector provides an on site arrangements monitoring role and has access at any time to personnel and records.

Management of Program Updates

The Inservice Test Program Co-ordinator is responsible for the correct status of all IST documentation. He is responsible for approving all procedure changes and for initiating all program changes.

Changes to the Inservice Test program at Sizewell B are managed under the same arrangements as for other safety case documentation, e.g. the Station Safety Report. If a change is considered necessary, e.g. Relief Request or Cold Shutdown Justification, a proposal is prepared under the modifications process, unless the change was a major change the modification would be categorized as category 2 and would proceed as follows. The proposal will be subject to on site and off-site review. The off-site review will be performed by company headquarters safety case specialists who are perform an independent assessment specifically with respect to safety case compliance and nuclear safety issues. Once approved the change can be implemented and would be retrospectively reported to the NII for information.

This level of change has not been required to date. This is because all of the testing was performed during commissioning under the scope of pre-service testing. Therefore all Cold Shutdown Justifications were incorporated into the first issue of the program.

Experience So Far

During construction and commissioning of Sizewell B there was a significant emphasis placed on adopting best practices and learning from the successful nuclear power plants. There were many travel exchanges in order to bring in the most effective knowledge and expertise to give Sizewell B the best chance of safe and reliable operation.

Once all arrangements were in place, and on site staff numbers were reduced to the core team, emphasis became focused on maintaining generation and refuelling outage work. The consequence has been that the IST program has stood still while the successful plants from which the organization learnt have moved on.

In early 2000 the Sizewell B IST program was subject to the first external review since it was first established. The review was performed under two main criteria, namely compliance with the arrangements in place, and comparison with best U.S. practice, the review was performed by a U.S. contractor who is active in the U.S. IST programs.

In general, the findings were that although the program has many strengths it represented the methods and characteristics of the early 1990s and had not evolved along with best US practice. The detail findings concluded that the original implementation document contained areas of Code non-compliance yet there are no relief requests, also the cold shutdown and refuelling justification basis are not as complete as would be required in a U.S. plant. These are areas of deficiency which the organization were not aware of as a result of the isolation between the UK implementation and U.S. practice. The experience gained from the external review has provided valuable learning and as a result of the issues identified, a program of work has been developed and incorporated into the Station Business Plan to bring the Sizewell B Inservice Test Program closer to best practice.

The 120 Month Update

In line with U.S. practice Sizewell B will undertake the 120 month update of the IST program. Following the Spring 2000 review a level 1 program to achieve the 120 month update by mid 2003 has been incorporated into the Station business plan.

The 120 month update will in some areas increase the scope of testing, e.g. pump full flow tests, however, at the same time there will be many areas where it will be possible to reduce testing in line with some practices which have become standard practice in the U.S. since 1994 when the Sizewell B IST program was established.

In parallel with the 120 month update of the IST program, Sizewell B will also perform the 120 month review of the ISI program, and on a larger scale, the Station Safety Reported is also subject to a similar review. There will therefore be a significant amount of interfacing for these projects and possibly shared resource.

The Future for the Program

In September 2000 Sizewell B will enter its fourth refuelling outage. In Fuel Cycle five it is currently planned to review the overall management of the Technical Specification related programs, but in particular the MOVATS, IST and LLRT programs. It is understood that many U.S. plants bring these programs together under one team, and this will be considered.

It is recognized that Sizewell B needs to reconsider how to maintain progress with best U.S. practice, and to this end increased participation in events such as ASME Code committee meetings has begun.

The role of the IST program co-ordinator at Sizewell B to date has been relatively straight forward because the plant has not been subject to significant wear ageing. As degradation takes place so the demands upon the IST program co-ordinator are likely to increase.

The vision of British Energy is to become a World Class Energy Company. One of the enablers towards achieving this vision is for its power plants to achieve the operating standards equivalent to that of INPO level 1. There is therefore the continuous drive to look for opportunities to incorporate the world's best practices in a manner which supports commercial operation. The Spring 2000 IST review showed that there is still much to learn, but there is every incentive to be involved and achieve our goal.

References

1. ASME Boiler and Pressure Vessel Code—1989 Edition and 1990 addendum, Subsection IWP and IWV.

2. ASME OM Standards 1987 including 1998 addenda.

3. U.S. Nuclear Regulatory Commission —Generic letter 89–04 Guidance on Developing Acceptable Inservice Testing Programs including "Minutes of the Public Meetings on Generic Letter 89–04" dated April 3, 1989 and October 25, 1989.

4. NUREG–1482, Guidelines for Inservice Testing at Nuclear Power Plants, April 1995.

Voluntary Industry Initiatives in Lieu of Regulatory Actions

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Abstract

The Commission by a staff requirements memorandum (SRM) dated May 27, 1999, requested the staff to work with industry and other stakeholders to develop the process and guidelines for use of Voluntary Industry Initiatives in the regulatory process. The staff sent a paper to the Commission in May 2000. Following Commission review, comment, and approval, the guidelines will be issued for final public comment. Comments from stakeholders have been that the "ad hoc approach" between the industry and the NRC with regard industry initiatives is adequate. The staff has prepared a set of guidelines\process that allows the NRC to entertain Industry Initiatives (II) that may substitute for or complement a regulatory action, may be for information gathering or address a non-safety concern of interest to the industry. The guidelines\process allows the flexibility desired by industry but add some structure to ensure consistency and efficiency in implementation. The paper contains the decision-making process to be utilized by the staff and industry in initiating and pursuing a particular II. The proposed guidelines account for the tracking of commitments made in IIs, as well the inspection and enforcement of IIs consistent with existing regulatory processes. The enforcement criteria are consistent with the proposed reactor oversight process improvements and will be communicated to the industry and other stakeholders after these proposed guidelines are reviewed and approved by the Commission. The proposed guidance addresses how licensees could be subject to related inspection and enforcement. The proposed guidelines identify to the public that IIs in the regulatory process can and will provide effective and efficient resolution of issues, will be controlled and monitored by the staff to ensure plant safety is not compromised, and does not represent a reduction in NRC's commitment to safety and sound regulation.

This paper was prepared by staff of the U.S. Nuclear Regulatory Commission. It may present information that does not currently represent an agreed-upon NRC staff position. NRC has neither approved nor disapproved the technical content.

Impact of the Recent IST Rulemaking and the Future of the OM CODE

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Abstract

This paper will discuss the most recent change to 10CFR50.55a regarding the update to the Codes and standards referenced for use for inservice testing at nuclear power plants and the future directions of the ASME Operation and Maintenance Code committees.

Introduction

The U.S. Nuclear Regulatory Commission in the *Code of Federal Regulations,* 10CFR50.55a, requires by law implementation of an inservice testing program for Class 1, 2, and 3 pumps and valves. The regulations specify which Code editions and addenda are to be used and requires an update of the IST program every 10 years to the latest Code incorporated by referenced in the regulations. Since August of 1992, the regulations have referenced the 1989 Edition of ASME Section XI, which references the ASME OM Standards 1, 6, and 10 for inservice testing of pumps and valves. Soon after the publication of this regulation, the NRC undertook an effort to include the newly published ASME Operation and Maintenance Code in the regulations, after numerous delays and after more than 7 years, the NRC revised the regulation to include the ASME O&M Code. In September of 1999, 10CFR50.55a was revised to reference the 1995 edition of the OM Code including the 1996 Addenda. There are numerous Code changes included in this edition and addenda that will be discussed. As part of the rulemaking effort, each Code change was evaluated by the NRC for its impact on the safety, radiation exposure, critical path of the licensee's plants, record keeping, and cost. The changes were tabulated by Code paragraph and Code year and are attached to this paper.

With regards to the current rule, in the original proposed rulemaking sent out for public comment, the NRC had retained the 10 year update provision. Numerous comments were received to delete this provision, and after deliberation by the staff, it was decided to consider this issue separately and to publish a supplement to the proposed rulemaking. The NRC staff had made a recommendation to the Commission to delete the 10-year update provision and to require one last update to the 1996 Addenda. On April 13, 2000, the Commission disapproved the staff's recommendation and the 10-year update will remain in the rule. In addition, the Commission commented that the staff should improve the timeliness in issuing updates to 10CFR50.55a.

Discussion

In 1990, the ASME published the first edition of the Operation and Maintenance Code. This first edition was simply a transferral of the applicable requirements in Section XI Subsections IWA, IWP, IWV, and IWF related to snubbers. The committee was directed to make be no technical changes in this Edition. However, there were a number of concerns that there were technical changes regarding snubber testing and inspection, however this issue is outside the scope of the paper. There were a number of editorial and minor changes of an administrative nature regarding the transferral of IWA requirements into ISTA of the OM Code. See Table 1 for a summary of the changes related to pumps and valves. There were no addenda published in 1990, 1991, nor in 1993.

The 1992 Addenda included three O&M Code Committee letter ballots, all revising provisions in ISTD (Snubbers) only, and one errata, i.e., a correction related to publishing such as a typographical error or omission from what the committees had approved. The 1994 Addenda included 16 actions, with four involving ISTD only. The most noteworthy of the twelve changes related to pumps and valves in the 1994 Addenda are the addition of the comprehensive pump test and use of analysis to revise pump reference values in ISTB, and the addition of a sample disassembly and inspection program and non-intrusive testing for check valves in ISTC. The 1995 Edition of the OM Code incorporates the changes in the 1992 and 1994 Addenda into the 1990 Edition, with a number of errata in ISTB and Appendix I. The changes related to pumps and valves are included in Table 2.

Although, addenda to the OM Code are normally published every year, in 1995 ASME decided not to publish addenda the years that the editions were published. Therefore, none was published. The 1996 Addenda contains 13 actions affecting pump and valve testing. This addenda includes the addition of a check valve condition monitoring program in lieu of exercising (Appendix II), requiring check valves to be exercised in both directions regardless of their safety function, provisions for testing check valves in series, and a Code Case on motor-operated valve testing (Case OMN−1). Table 3 details the changes related to pumps and valves in the 1996 Addenda.

The NRC has not included any Addenda after the 1996 in the recently published rulemaking. The NRC has recently initiated an action to include the 1997, 1999, and possibly the soon to be published 2000 addenda, and 1998 Edition. Given the direction by the Commission for the staff to approve Code changes more expeditiously, the hope is that rulemaking to incorporate these Addenda will be forthcoming. The rulemaking plan states that it will take approximately 2 years to incorporate these addenda/edition.

Table 4 summarizes the 1997 Addenda pump and valve changes. This addenda deletes the ANII involvement with inservice testing and decreases the time between successive relief valve openings to 5 minutes. Use of these two changes has been requested by utilities in relief requests.

The 1998 Edition, in addition to including the technical changes from the 1996 and 1997 addenda, includes a substantial reformatting of the Code, in which all the paragraphs have been renumbered. I mention this because if Owners would like to use the provisions of a later Code change, the difference in paragraph numbering may cause significant confusion. The 1998 Code provides specific requirements for specific components. For example, ISTC now includes separate requirements, i.e., paragraphs, for manual, solenoid, and hydraulically operated valves. In addition this edition includes a

Code Case on thermal relief valves, the risk-informed safety classification Code Case, additional requirements for valve test instrumentation, clarification on the use of mechanical exercisers for check valve testing, defines vertical line shaft pumps, and addresses the test frequency for extended shutdowns. As discussed above, there was no addenda published in 1998.

The 1999 Addenda includes three Code Cases addressing: digital instruments, testing relief valves without insulation, and concerning risk-informed check valve testing. This addenda also addresses manual valves and requires an exercise every 5 years unless adverse conditions justify more frequent testing, and adds metric units for the international Code users.

Future Directions of the OM Code

The ASME OM Code has in recent years been very active in revising and supplementing the Code. As discussed above, significant changes and improvements have been produced. The ASME OM Main Committee has in the recent past, placed risk-informed testing as the top priority. Since that effort is coming to conclusion, the future direction of the Code committees has been actively discussed. Code maintenance is of high importance, in that the Code committees need to be responsive to the users of the Code. Maintenance includes preparing responses to Code inquiries and revising the Code as inadequacies, inconsistencies, and issues come up with Owners implementing a yet unused Code. One utility has recently voluntarily updated to the 1995 OM Code, instead of to the 1989 Edition of Section XI as allowed by the regulations for this plant. This utility has determined that the improvements in the later Code justify the update, in particular they have noted the improvements to Appendix I, and the addition of check valve condition monitoring and comprehensive pump test. Other utilities have volunteered via relief requests to use portions of later Codes, however, this is the first wholesale use of the later Code.

Another issue receiving considerable attention is the use of performance based testing. That is testing where the scope and frequency are based on the results of the tests. In the 1996 Addenda, check valve condition monitoring was introduced to the Code, which is performance based. Condition monitoring is now being pursued by the Code committees to address pump vibration issues. For example, smooth running pumps are currently penalized by the Code since corrective action is based on a relative increase, and for these pumps the reference vibration is very low. Condition monitoring of the pumps is proposed in lieu of taking corrective actions. This approach has already been accepted by the NRC at one utility via a relief request. There is some concern at the Code committees regarding codifying condition monitoring, which is often considered maintenance activities. Inspection by the regulators may be difficult due to the increased reliance on engineering evaluations.

In an attempt to produce products that are useful to the industry, the committees have recently been reorganized to focus on our product line, i.e., specific codes and standards. Additionally, the ASME ballot process has been redesigned to make it more efficient and more responsive to the users. The Code Committees encourage participation by the users of the Code, and strongly recommend that users who have questions or inquiries attend committee meetings to help expedite their requests.

Especially now that the issue of the NRC endorsing later Code editions has been resolved. The committees are a volunteer organization. I would encourage everyone involved in inservice testing to attend the now biennial Code meetings, as they prove to be a cost-effective training tool. Additionally, there is an increased reliance on the use of technology to get ASME business done, i.e., E-mail and teleconferencing requiring less of a time commitment by committee members. The Codes are best improved by having as many individuals and companies involved in their development.

Table 1. Summary and Evaluation of ASME OM Code Changes[1], 1990 Edition

"Subsection ISTA[2]" 11May95 Draft

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors[3]	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
001	1.1	The OM Code does not identify provisions for accessibility and inspectability, examination procedures, and reports in the scope.	E	The Section XI scope includes these requirements [IWA-1100(a)], however, since the scope does not provide requirements, this difference is insignificant.						
002	1.2	The OM Code jurisdiction does not cover complete power plants.	L	Section XI covers complete power plants as well as individual components that have met all the requirements of the construction code (Section XI, IWA-1200). However, since the OM Code addresses components, not systems, this difference is insignificant.	N	N	N	N	N	N
003	1.3.1	The OM Code refers to testing and examination.	E	Section XI refers to inspection and testing (IWA-1310).						
004	1.3.2	The OM Code does not discuss components classified to a higher class than required by the group classification criteria, piping that penetrates a containment vessel, nor non-nuclear safety class systems.	L	Section XI includes these requirements in IWA-1320. There is no significant impact, however, because it is the responsibility of the Owner to determine the appropriate Code class (OM Code, ISTA 1.4).	N	N	N	N	N	N
005	1.4	The OM Code does not include preparation of diagrams and system drawings identifying the extent of the areas of components subject to examination; maintenance of inspection records, such as diagrams, drawings, and evidence of personnel qualifications; and retention of inspection records; as responsibilities of the Owner.	L	Although Section XI, IWA-1400, includes these requirements, there is no significant impact. Specific diagrams or drawings identifying the areas subject to examination are not necessary. Snubber examinations are performed using design drawings (OM Code, ISTD 4.1). The OM Code requires retention of inspection records in ISTA 3. The OM Code requires personnel to be qualified in accordance with the Owner's QA program (ISTD 1.8).	N	N	N	N	N	N
006	1.5	The OM Code provisions for accessibility do not specifically include the following considerations: sufficient space for removal and storage of structural members, shielding and insulation; installation and support of handling machinery; and performance of alternate examinations in the event structural defects or indications are revealed which may require such examinations.	E	The OM Code does, however, require access for the Inspector and examination personnel and equipment necessary to conduct the test or examination, which would cover these specifics identified in Section XI, IWA-1500.						
007	1.6	The OM Code references the 1988 Addenda of ANSI/ASME N626.	L	Section XI references the 1987 Addenda. The only difference between the 1987 and 1988 Addenda is that the 1988 Addenda requires the ANII supervisor to be qualified as an "ANI supervisor".	N	N	N	N	N	N

[1]i.e., changes in requirements in the ASME OM Code 1990 Edition from existing requirements in Section XI 1989 Edition and Standard Technical Specifications.

[2]Compared with Section XI, Subsection IWA.

[3]The impact of each item has been evaluated to be high (H), medium (M), low (L), editorial (E), or errata (ER). Each of the factors - safety, occupational exposure, exposure to the public, critical path, records, and cost - has been determined to increase (I), decrease (D), or not change (N) for each high, medium, or low item.

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTA (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
008	2.1.1	The OM Code does not address the Inspector duties to perform the following: -review the examination plan and any revisions to the plan during the preservice interval; -verify visual examinations, VT-3, have been performed and the results recorded; -verify that the examinations are performed by personnel employed by the Owner or the Owner's agent and are qualified; -require requalification of procedures or operators if the requirements are not being met; and -certify examination records after verifying the requirements have been met and records are correct.	L	Section XI, IWA-2110 includes these requirements. Safety may decrease due to decreased ANII involvement.	D	N	N	N	N	N
009	2.1.3	The OM Code requires the Owner to notify the Inspector when specific tests or examinations will be performed.	E	Section XI, IWA-2130 requires the Owner to keep the inspector informed of the progress of the preparatory work necessary to permit inspections.						
010	N/A	The OM Code does not include the surface replication methods and surface cleaning requirements.	L	Surface replication methods are generally not used for snubber visual examinations. Cleaning is performed under the Owner QA program.	N	N	N	N	N	N
011	N/A	The OM Code does not provide for alternative examination methods.	L	Alternate examination methods are generally not used for snubber visual examinations.	N	N	N	N	N	N
012	N/A	The OM Code deletes the VT-3 visual examination requirements for snubber testing and VT-3 personnel qualification. The licensee is required by the Code to qualify test personnel in accordance with his procedures or in accordance with an approved QA program.	M	Licensees are currently required by the regulations to perform snubber examinations in accordance with ASME Section XI. Section XI requires a VT-3 examination method. There may be a slight increase in plant risk as a result of potential inadequacies in training and qualifying personnel in accordance with licensee specific requirements in lieu of a industry standard. Additionally, there may be a decrease in the cost to the licensees due to the decrease in training, documentation, and required education levels. The qualification and training of personnel performing snubber inspections is, however, still required. Licensee qualification programs may meet, or even exceed, the VT-3 requirements. Additionally, the licensee would still be required to train and certify personnel that perform examinations required by Section XI (e.g., examinations of pump casings and valve bodies, reactor vessel interiors, and supports) in accordance with VT-3 requirements. There would be a limited increase in the NRC inspection burden due to the implementation of licensee specific qualification requirements versus the use of an industry standard.	D	N	N	N	D	D
013	2.2.1	The OM Code does not explain "related requirements".	E	Section XI, IWA-2411, Footnote 3 addresses related requirements.						
014	2.2.1	The OM Code requires the initial inservice test interval to comply with the edition and addenda of this section adopted by the regulatory authority 12 months prior to the issuance of the operating license.	L	The OM Code complies with the requirements in 10CFR50.55a(f)(4)(i).	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

"Subsection ISTA (continued)"

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
015	2.2.2	The OM Code does not specify the requirements for the preservice test interval plan.	L	Preservice test interval plans are required and it is assumed that ISTA 2.2.2 will be used in their preparation.	N	N	N	N	N	N
016	2.2.3	The OM Code has deleted Inspection Program A.	L	Although, Section XI allowas an Inspection Program A, the impact is low based on the OM Code test and examination frequencies which are independent of the length of the interval. Additionally, no US utilities are currently using Program A.	N	N	N	N	N	N
017	2.2.4	The OM Code does not address the use of Code Cases during the preservice examination or test intervals.	L	Code cases can be used as allowed by Regulatory Guide 1.147.	N	N	N	N	N	N
018	3.2.1	The OM Code has deleted the Section XI Owner responsibility to prepare summary reports for Class 1 and 2 snubbers, pumps and valves, Form NIS-1 for Class 1 and 2 snubber examinations, and preservice plans, schedules and records.	L	The OM Code requires documentation of examinations and tests. This documentation is available to the enforcement and regulatory authorities.	N	N	N	N	D	D
019	3.2.2	The OM Code does not address the cover sheet requirements for schedules.	E	Schedules are part of Plans in accordance with 2.2.2 and cover sheet requirements are specified.						
020	3.3.1	The OM Code states that records shall be maintained for the service lifetime of the component.	E	ISTA 1.4(k), Owner's Responsibility, however, states that the records shall be maintained for the service lifetime of the system, as required by Section XI, IWA-6310.						
021	3.3.3	The OM Code does not address the requirement for maintaining test reports and schedules, pump and valve reports, and NDE procedures.	E							
022		The OM Code does not reference Section XI, IWA-4000 or 7000 for repairs and replacements of snubbers, pumps and valves.	L	Licensees are currently using Section XI rules and it is anticipated that this practice would continue in the absence of other rules. Therefore, all factors are no change.	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

"Subsection ISTB[1]"

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
023	1.1	The OM Code scope is not limited to Class 1, 2, or 3 pumps. The OM Code scope includes additional safety-related pumps.	L	Although the OM scope includes safety-related components, the regulations require the application of the ASME Codes to Class 1, 2, and 3 components. The proposed amendment does not include a change to the scope of the regulations for pumps and valves.	N	N	N	N	N	N
024	4.6.2(b)	The OM Code requires that when measuring differential pump pressure, a differential pressure gage or 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 shall be used.	E	Although Section XI states that the different methods of determining differential pressure may be used, there is no significance to this change.						
025	Remaining ISTB paragraphs	There are no differences, besides format, between the OM Code and Section XI.	E							
"Subsection ISTC[2]"										
026	1.1	The OM Code scope is not limited to Class 1, 2, or 3 valves. The OM Code scope includes additional safety-related valves.	L	Although the OM scope includes safety-related components, the regulations require the application of the ASME Codes to Class 1, 2, and 3 components. The proposed amendment does not include a change to the scope of the regulations for pumps and valves.	N	N	N	N	N	N
027	Remaining ISTC paragraphs	There are no differences, besides format, between the OM Code and Section XI.	E							
"Subsection ISTD[3]"										
028	1.1	The OM Code requirements apply only to Class 1, 2, and 3 and MC component snubbers.	L	The current regulations, § 50.55a, address only Class 1, 2, and 3 components. The Technical Specifications, however, apply to all safety-related snubbers. The Standard Technical Specifications and many Technical Specifications for newer plants apply to all snubbers, except those that are installed in non safety-related systems, and then only if their failure or the failure of the system on which they are installed has no adverse effect on any safety-related system. A change to the scope of the regulations is proposed to address all safety-related snubbers. This will result in no impact.	D	D	N	D	D	D

[1]Compared with Section XI, Subsection IWP.

[2]Compared with Section XI, Subsection IWV.

[3]Compared with existing requirements [i.e., Section XI 1989 Edition, NUREG-0452, "Standard Technical Specifications for Westinghouse Pressurized Water Reactor," Revision 4, November 1981 or Revision 4a, 1987 (STS), and selected individual plant Technical Specifications (TS)].

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

'Subsection ISTD (continued)'

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
029	1.2	The OM Code specifically addresses Owner responsibilities.	L	The TS do not specifically address Owner responsibilities. However, there is no significant change in Owner responsibilities, as they are currently covered under the Owner Appendix B QA program.	N	N	N	N	N	N
030	1.3.1	The OM Code ensures "operational readiness" of snubbers.	E	The STS and individual TS ensure "operability."						
031	1.3.2	The OM Code allows exemptions of certain snubbers if technical justification is provided in the inspection plan filed with the enforcement and regulatory authority.	M	The STS do not address snubber exemptions. Exemptions from the TS may, however, be authorized by the NRC. The Regulations [10CFR50.55a(a)(3)(i), (a)(3)(ii), (f)(6)(i), and (g)(6)(i)] require NRC authorization if relief from the Code requirements is sought. Some plant TS specifically state that snubber exemptions may be granted by the Commission. One older plant TS exempts snubbers greater than 50,000 lb. capacity and snubbers that are identified as "especially difficult to remove" or in "high radiation zones" from functional testing, provided they have been demonstrated operable during the previous tests. This plant has only four snubbers greater than 50,000 lb. capacity (used on reactor coolant pumps) and the licensee currently tests these snubbers. Additionally, the licensee has not exempted any safety-related snubbers based on removal difficulties or radiation. Although the licensee could exempt certain snubbers from testing and examination without prior Commission approval, the licensee has to provide technical justification for the exemptions and it is assumed that the exemptions would be approved by the Commission. A modification has been included to not allow exemptions under this paragraph, which will result in no impact.	D	D	N	N	D	D
032	1.4	The OM Code definition of repair and replacement is not consistent with Section XI.	L	There is no impact because the two codes are used independently.	N	N	N	N	N	N
033	1.5	The OM Code requires applicable design and operating information be available for use during the program.	E	This information is available in accordance with the Owner QA program.						
034	1.6, 1.7, 2.2, 3.3	The OM Code has specific documentation requirements for examination, test, maintenance and repair procedures and instructions and examination and test results.	L	There would be no significant change. Procedures, instructions, and results are covered under the QA program, although the specific requirements are not specified in the TS, they are included in most Owner programs.	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

"Subsection ISTD (continued)"

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
035	1.8	The OM Code only requires personnel qualification in accordance with the Owner procedures or a QA program approved by the Owner.	L	Licensees are currently required by the regulations to perform snubber examinations in accordance with ASME Section XI. Section XI, paragraphs IWF-5200 (a) and 5300 (a) specifically require a VT-3 examination method. There may be a slight increase in plant risk as a result of potential inadequacies in training and qualifying personnel in accordance with licensee specific requirements in lieu of an industry standard. Additionally, there may be a decrease in the cost to the licensees due to the decrease in training, documentation, and required education levels. The qualification and training of personnel performing snubber inspections is, however, still required. Licensee qualification programs may meet, or even exceed, the VT-3 requirements. There would be a limited increase in the NRC inspection burden due to the implementation of licensee specific qualification requirements versus the use of an industry standard.	D	N	N	N	D	D
036	1.9	The OM Code requires instrumentation and test equipment to have the range and accuracy to demonstrate conformance to specific examination or test requirements and be calibrated and controlled in accordance with the Owner procedures or a QA program approved by the Owner.	L	These requirements are also contained in Section XI. They are not, however, addressed in the TS. They are addressed, however, in the Owner Appendix B QA program.	N	N	N	N	N	N
037	1.9	The OM Code does not address test equipment failure.	L	The STS and many individual TS address test equipment failure. Test equipment failure may invalidate testing and allow testing to resume at a later time provided all snubbers tested with the failed equipment are retested. The Owner QA program, however, addresses nonconforming test equipment.	N	N	N	N	N	N
038	1.10	The OM Code states that snubbers shall not be subjected to maintenance or repair specifically to meet the examination or testing requirements prior to examination or testing.	L	Section XI only requires testing to be performed in the as-found condition to the extent possible. The STS do not address this requirement. One plant TS does not allow prior maintenance specifically for the purpose of meeting functional test requirements. Owner's procedures typically require testing in the as-found condition. There would be a small increase in safety because all tests and examinations would reflect the as-found condition.	I	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
039	1.10	The OM Code requires replaced or modified snubbers to be tested in accordance with the applicable preservice examination and inservice examination and test requirements.	L	Section XI requires the inservice examination and testing acceptance criteria to be satisfied (OM, Part 4, 1.5.7). Additionally, Section XI (IWA-7530) requires a preservice examination in accordance with IWF-2200. Many plant TS require functional tests for replacement snubbers prior to installation in the unit. Mechanical snubbers are required to meet the acceptance criteria subsequent to their most recent service and a freedom-of-motion test must have been performed within 12 months before being installed in the unit. The TS do not specifically address "modified" snubbers. There is no significant impact. The TS and Owner QA procedures require tests and inspections to verify that activities have been satisfactorily accomplished and components are operable.	N	N	N	N	N	N
040	1.10	The OM Code requires an evaluation of the effects of maintenance and repair activities on the snubbers intended function. If the activities could alter the snubber ability to perform its intended function, the snubbers shall be tested and examined to ensure the function is verified to be acceptable.	L	The STS and many individual TS require functional tests if repair activities might affect the functional test results before installation in the unit. There would be an increase in documentation requirements as a result of the required maintenance or repair evaluation. There would be no significant impact on safety because Owner tests and QA programs require verification that components are returned to operable status.	N	N	N	N	I	I
041	1.11	The OM Code requires replacement or modified snubbers have a proven suitability for the application and environment, and be examined and tested in accordance with the Codes.	L	There is no significant impact. Many plant TS and the STS require functional tests for replacement snubbers prior to installation in the unit. Additionally, the requirements of Section XI, IWA-7220, "Verification of Acceptability," would apply.	N	N	N	N	N	N
042	1.12	The OM Code addresses snubbers deleted based on analysis. If the deleted snubber is unacceptable, the remaining snubbers in the failure mode group (FMG) are subject to corrective action. Unacceptable deleted snubbers shall be used in determining the next examination interval or additional testing requirements.	L	There is no significant change. Although the TS does not address deleted snubbers, corrective action is based on the number of unacceptable snubbers. The wording of the OM Code has been changed but the intent of the requirements is the same as in Section XI [OM Part 4, paragraph 2.3.5.4 and 3.2.5.1(d)].	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
043	1.13	The OM Code addresses transient dynamic events and requires the affected systems and snubbers be reviewed and corrective action taken if the event may affect snubber operability. Any actions taken are independent of the Code examination and testing requirements (e.g., additional tests, examination intervals). There are no implementation schedule requirements.	L	Section XI does not address transient dynamic events. The STS and many individual TS discuss transient event inspections. The TS specify that only snubbers attached to sections of systems that have experienced unexpected, potentially damaging transients be visually inspected within 6 months of the transient. One plant TS requires the inspection during the next scheduled visual inspection. One plant TS requires the inspection within 72 hours for accessible areas and 6 months for inaccessible areas. Many older plant TS do not address transient events. There would be a small increase in safety and record keeping because all plants snubber programs would address transient events. Most plant procedures, however, currently address transient event evaluations.	I	N	N	N	I	I
044	1.13	The OM Code does not address snubbers that appear inoperable during post-maintenance inspections and area walkdowns.	L	Some plant TS state that snubbers that appear inoperable during post-maintenance inspections, area walkdowns or transient event inspections shall not be considered inoperable when determining subsequent test intervals, provided the cause is established and remedied for any generally susceptible snubbers. There is no significant impact because most plants would consider this to be outside the scope of the Code.	N	N	N	N	N	N
045	1.14	The OM Code requires an evaluation of the system or component for possible damage when a snubber is unacceptable.	L	There is no significant impact. The STS's Limiting Conditions of Operation (LCO) require, within 72 hours, the inoperable snubber be restored to operable status and an engineering evaluation on the attached component be performed, or declare the attached system inoperable. Older individual TS require plant shutdown if the snubber cannot be restored with 72 hours. Some plant TS require an evaluation to justify continued operation with an unacceptable snubber. If continued operation cannot be justified the TS action requirements shall be met.	N	N	N	N	N	N
046	1.15	The OM Code specifies which records are to be maintained and controlled.	L	The OM Code includes test equipment identification which is not included in Section XI. There is no significant impact. Although the TS do not specifically address these records, they are addressed in the Owner QA program.	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
047	2.1	The OM Code limits the examination boundary from snubber pin to pin, inclusive.	L	Section XI, paragraph IWF-5200 (c) and 5300 (c), however, additionally requires examination of other snubber parts (i.e., integral and nonintegral attachments for snubbers, including lugs, bolting, pins, and clamps). The STS require an inspection to ensure the attachments to the foundation or supporting structure, and fasteners for attachment of the snubber to the component and snubber anchorage are functional. In addition to the requirements of the OM Code, a limited number of snubber mechanical attachments will be examined in accordance with Section XI, IWF-2000 (i.e., 25% of Class 1, 15% of Class 2, and 10% of Class 3). However, there would be a decrease in safety, because all snubber attachments to the supporting structure and component would no longer be required to be examined by Section XI or the Technical Specifications.	D	D	N	N	N	D
048	3.1	The OM Code requires testing at a load sufficient to verify the operating parameters. Testing at less than rated load must be correlated to operability parameters at rated load.	L	The TS do not specify test loads. There would be an increase in safety and record keeping due to testing at rated load and preparing an evaluation.	I	N	N	N	I	I
049	3.2	The OM Code allows correction factors to be used when the installed operating and test conditions differ. Test results must be correlated to operating conditions.	L	The TS do not address test conditions. Safety would increase based on evaluating test results which are correlated to operating conditions.	I	N	N	N	I	I
050	4 and 5	The OM Code specifies preservice examination and operability test requirements.	L	The TS do not address preservice tests and examinations. 10CFR50.34, App. A and App. B, as well as Regulatory Guide 1.68, address plant startup testing. However, these requirements do not include specifics. Safety would increase as a result of uniform preservice test and examination requirements.	I	N	N	N	N	N
	4.1	The OM Code specifies preservice examination requirements, including damage or impaired operability, snubber installation in accordance with design drawings and specifications, adequate swing clearance, fluid levels, structural connection installation.								
	4.2	The OM Code requires reexamination if the initial system preoperational test exceeds the preservice examination by more than 6 months.								
	4.3	The OM Code requires preservice thermal movement examinations. *(continued on next page)*								

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

"Subsection ISTD (continued)"

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
050	5.2	The OM Code preservice test includes the same parameters as the inservice tests.								
	5.3	The OM Code differentiates between design and other deficiencies and specifies how they are to be corrected.								
051	6.1	The OM Code objective is to require a visual examination to identify physical damage, leakage, corrosion, or degradation from environmental exposure or operating conditions. The OM Code additionally requires an examination of external features that may indicate snubber operability.	E	The STS require verification that (1) there are no visible indications of damage or impaired operability, (2) attachments to the foundation or supporting structure are functional, and (3) fasteners for attachment of the snubber to the component and to the anchorage are functional.						
052	6.2	The OM Code allows the categorization of snubbers as accessible and inaccessible for examinations. The OM Code limits this categorization to inservice examinations.	E	Section XI allows this categorization to also apply to preservice examinations. The STS provides additional clarification that the snubber is inaccessible during reactor operation.						
053	6.3.1	The OM Code requires snubbers to be installed such that when activated, they are capable of restraining movement. Snubbers that are incapable shall be unacceptable. The OM Code requires an evaluation of conditions that might interfere with proper restraint of movement.	L	Section XI requires snubbers to be installed so that they can carry the load. Section XI, as well as the OM Code, require observation of loose fasteners, deformed members, and disconnected components. The STS require verification that (1) there are no visible indications of damage or impaired operability, (2) attachments to the foundation or supporting structure are functional, and (3) fasteners for attachment of the snubber to the component and to the anchorage are functional. Additionally, the 1980 vintage STS and many individual TS require manually induced snubber movement to verify freedom of movement (if the snubber does not have to be disconnected to exercise). For those plants whose TS require manually stroking snubbers as part of the inservice examination, there would be a small decrease in safety and radiation exposure for test personnel.	D	D	N	N	N	D
054	6.3.2	The OM Code requires snubbers to be installed such that thermal movement is not restricted which could cause overstressing of the pipe or equipment.	E	The TS require no visible indications of damage or impaired operability.						
055	6.3.3	The OM Code requires snubbers to be free of defects that may be generic to particular designs as may be detected by visual examinations such as observation of fluid supply or content. If the fluid level is less than the minimum amount, a test may be performed to change the classification from unacceptable to acceptable. The test shall be performed with the piston in the as-found setting and in the extension (tension) direction. The OM Code also allows the test to be performed in a mode that closely resembles the operating and design requirements of the snubber in lieu of testing in the extension direction.	L	The TS require visual examinations. Some individual TS require, when the fluid port of a hydraulic snubber is found uncovered, the test is to be performed with the piston in the as-found setting, extending the rod in the tension mode direction. One TS allows the steam generator snubbers to be inspected independently if inoperability is due to excessive fluid leakage from external tubing. The STS and many individual TS require snubbers connected to an inoperable common fluid reservoir to be counted as inoperable snubbers. One plant TS allows inoperable snubbers connected to a common reservoir to represent one failure unless multiple individual failures are evident.	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

"Subsection ISTD (continued)"

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
056	6.4	The OM Code allows snubbers that are unacceptable as a result of visual examinations to be tested and recategorized as acceptable, provided the testing can show that the unacceptable condition did not affect operability. The OM Code does not require the cause of the rejection to be remedied for generally susceptible snubbers.	L	The STS and most individual TS additionally require that the cause of the rejection be clearly remedied for that snubber and other snubbers, irrespective of type, that may be generically susceptible.	D	D	N	D	D	D
057	6.5.1	The OM Code requires the initial inservice examination to be started not less than 2 months after 5% power operation, and to be completed within 12 months after 5% power operation.	L	The STS and numerous individual TS require the first inservice visual inspection to be performed after 4 months, but within 10 months of commencing power operation (i.e., >5% rated thermal power). One TS required the initial visual inspections to be performed after 4 months but within 6 months of initial criticality.	N	N	N	N	N	N
058	6.5.2	The OM Code requires subsequent examinations at 18-month intervals unless unacceptable snubbers are found. Then the interval is decreased with increasing number of unacceptable snubbers in accordance with Table ISTD 6.5.2-1. The OM Code allows an alternate schedule if technical justification is accepted by the regulatory authority.	L	Generic Letter 90-09 provides an alternate interval schedule to the OM Code/Section XI which is based on the number of unacceptable snubbers in relation to the snubber population and a fuel cycle up to 24 months. Many individual TS have incorporated this alternate schedule. The STS and most plant TS follow the same interval schedule as the OM Code.	N	N	N	N	N	N
059	6.5.3	The OM Code requires the time to subsequent examination not be lengthened more than one increment at a time.	L	Section XI, the STS, and most individual TS also contain this requirement. If a generic problem has been identified and corrected, the STS and some individual TS allow the interval to be lengthened one step the first time and two steps thereafter, provided no inoperable snubbers of that type are found. One plant TS allows the interval to be lengthened up to two steps per inspection. The impact is low and no factors change because the OM Code allows snubbers to be assigned to failure mode groups (FMGs) and the examination intervals are determined for each FMG and not the total snubber population.	N	N	N	N	N	N
060	6.6.1	The OM Code requires examination of all snubbers of all groups (accessible and inaccessible) for the initial examination.	E	Section XI, the STS, and most individual TS also contain this requirement.						
061	6.6.2	The OM Code requires subsequent examination of all snubbers of all groups. The OM Code allows the sample size to be reduced after two successful examination intervals at the maximum time interval (18 months), provided the Owner justifies the reduction and it is accepted by the regulatory authority. The OM Code also allows the sample size to be reduced after two successive intervals at 12 months for plants on annual refueling cycles.	L	The STS do not allow the sample size to be reduced. There is no impact because, although the OM Code allows sample size reduction, NRC acceptance is required.	N	N	N	N	N	N
062	6.7	The OM Code requires the cause of unacceptable snubbers to be determined, and for snubbers to be categorized into examination FMGs. The OM Code and Section XI specify the FMG to be used (e.g., design/manufacturing, application induced) and the FMG boundaries.	L	Although the TS do not address "FMGs", there is no significant impact because the STS and most individual TS require that the cause of the rejection be clearly established and remedied for that snubber and other snubbers, irrespective of type, that may be generically susceptible.	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
063	6.8	The OM Code provides FMG corrective actions including the impact on the subsequent examination schedule. It allows snubbers to be categorized as acceptable for the purpose of establishing the next examination interval by replacing or modifying all susceptible snubbers.	L	The TS allow snubbers that are unacceptable as a result of visual examinations to be tested and recategorized as acceptable, provided the testing can show that the unacceptable condition did not affect operability. The STS and most individual TS additionally require that the cause of the rejection be clearly established and remedied for that snubber and other snubbers, irrespective of type, that may be generically susceptible. Although the OM Code does not require testing, all susceptible snubbers will be replaced or modified.	N	N	N	N	D	D
064	7.1	The OM Code requires snubbers to be tested to verify the breakaway or drag force or both as required by the Owner procedures.	L	The STS and many individual TS require breakaway and drag tests for mechanical snubbers only. Some plant TS, however, do not specifically limit drag and breakaway tests to mechanical snubbers. Additionally, one plant TS and the 1980 vintage STS require the drag force not to increase more than 50% of previously measured values. One plant TS states that an increase of 50% is an indication of impending failure. There is no significant impact because, although the TS require breakaway and drag tests for mechanical snubbers only, the OM Code requires these tests only if required by the Owner procedures. The Code Committee is considering a change to limit these tests to mechanical snubbers. The test acceptance criteria is established by the Owner.	N	N	N	N	N	N
065	7.1	The OM Code requires snubbers to be tested to verify the activation velocity or acceleration, bleed or release rate, and for units designed not to displace under continuous load; the ability to withstand load without displacement.	L	Some individual TS do not require demonstration of the ability to withstand load without displacement for those snubbers designed not to displace under continuous load. One individual TS only requires bleed/release tests for hydraulic snubbers. One plant TS does not specifically address what functional tests are to be performed. One plant TS also requires a verification of the snubber fasteners for snubbers selected for functional tests. There would be an increase in testing requirements and safety for some plants.	I	I	N	I	N	I
066	7.2.1	The OM Code requires the snubbers to be tested as found, to the fullest extent practicable.	L	Although, the TS do not specify this requirement, plants typically require this. There would be a small increase in safety because all tests would reflect as-found conditions.	I	N	N	N	N	N
067	7.2.2	The OM Code requires that the test methods shall not alter the snubber condition to the extent that the results are not representative of the parameters before the test.	L	The TS do not specify this requirement. There would be an increase in safety because the test results would reflect the snubber condition.	I	N	N	N	N	N
068	7.2.3, 7.2.4	The OM Code allows in-place or bench testing, provided the reinstalled snubbers undergo a limited preservice examination (ISTD 4.1(e)).	L	The TS allow either method of testing but do not address preservice examinations of "reinstalled" snubbers. There is no impact because the Owner QA program assures that reinstalled snubbers are installed correctly.	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
069	7.2.5	The OM Code allows the testing and examination of snubber subcomponents when limitations, due to size, test equipment or accessibility, prevent in-place or bench testing.	L	The TS do not address testing and examination of snubber subcomponents. This allowance will reduce the number of exemptions.	N	N	N	N	D	D
070	7.2.6	The OM Code allows the correlation of indirect measurements.	E	Section XI, the STS, and most individual TS also allow the correlation of indirect measurements.						
071	7.2.7	The OM Code requires each snubber of a parallel or multiple installation be identified and counted individually.	L	Although the TS do not specifically address this, the TS require each snubber to be demonstrated operable.	N	N	N	N	N	N
072	7.2.8	The OM Code requires fractional sample sizes to be rounded up.	E	The TS do not specifically address this.						
073	7.3	The OM Code allows qualitative testing in lieu of quantitative testing, provided the justification is acceptable to the regulatory authority. The OM Code requires the Owner to obtain data to demonstrate the ability of the parameter in question to be within the specification over the life of the snubber.	L	Section XI also allows qualitative testing. Section XI requires the Owner to justify the ability of the parameter to be within the specification. The TS do not address this option. However, there is no significant impact. Regulatory authority acceptance is required. 10CFR50.55a has allowed alternate testing that provides an acceptable level of quality and safety through the submittal of relief requests.	N	N	N	N	N	N
074	7.4	The OM Code requires testing a sample of snubbers at least every refueling outage.	E	The STS require testing a sample at least once per 18 months during shutdown. Some individual TS require testing once per cycle or each refueling outage.						
075	7.5	The OM Code requires unacceptable snubbers to be evaluated to determine the cause of the failure and categorized into test Failure Mode Groups (FMG).The OM Code FMG includes all unacceptable snubbers with a given failure mode and all other snubbers with similar potential for similar failure.	L	Section XI FMG includes all unacceptable snubbers with a given failure mode and all other snubbers subject to the same failure mode. The OM Code and Section XI specify the FMGs to be used (e.g., design, application induced) and the test boundaries. There would be no significant change. Although the STS and most individual TS do not address the use of test "FMGs", an engineering evaluation of each failure is required to be made to determine the cause of the failure. The results of the evaluation are used to determine the snubbers to be tested, irrespective of type, which may be subject to the same failure mode. One of the plant TS reviewed allowed snubbers to be categorized into test FMGs and separated for continued testing apart from the general population. The TS, however, does not specify the FMGs to be used.	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
076	7.6	The OM Code requires snubbers that do not meet the operability or qualitative test acceptance criteria (ISTD 7.1 or 7.3) to be subjected to corrective actions with their indicated impact on continued testing. The OM Code also requires the provisions of ISTD 1.10 and 1.11 to apply (Snubber Maintenance or Repair).	L	Section XI requires only those snubbers that have been found unacceptable by operability testing (OM Part 4, 3.2.1.1) to be subject to the 10%, 37 or 55 Sample Plans corrective actions with their indicated impacted on continued testing. The TS require snubbers which fail the functional test criteria to be repaired or replaced and additional snubbers tested. There is no significant change because the TS currently require snubbers which fail the functional test criteria to be repaired or replaced and additional snubbers tested.	N	N	N	N	N	N
077	7.7.1	The OM Code allows either the 10% or 37 testing sample plan.	L	Section XI and some individual TS also allow the 55 testing sample plan in addition to the 10% and 37 plans. Many individual TS specify only the 10% plan. There may be a decrease in the number of snubbers tested for those plants which can only utilize the 10% Plan, (they will now be able to use the 37 plan which requires fewer snubbers to be tested when the defined test group has more than 370 snubbers). Although there are individual TS that include the 55 plan. Those TS that include the 55 plan, however, also include a reject line in the 37 plan. Without the reject line, as in the OM Code version of the 37 plan, the 55 plan would require more testing and probably would not be chosen. There are two plants that utilize alternate sample plans. One utilizes an 88 sample plan and another utilizes a 105 sample plan. Alternate plans may be authorized by 50.55a(a)(3).	D	D	N	D	D	D
078	7.7.2, 7.7.4	The OM Code requires the plan used for each defined test plan group (snubber type for the TS) to be selected before testing for a given test interval begins, and that the selected plan be used through the test interval.	E	Individual TS that have multiple sample plans also contain this requirement. Section XI does not address this.						
079	7.7.2	The OM Code requires the Owner to file the plans and schedules with the enforcement and regulatory authority [ISTA 1.4(c)]. The OM Code does not require the Owner to file the test plan selected with the NRC prior to the test period.	L	Individual TS require the Owner to notify the NRC Regional Administrators in writing of the plan selected for each snubber type prior to the test period, or the sample plan used in the prior test period shall be implemented.	N	N	N	N	N	N
080	7.7.3	The OM Code requires the defined test plan group to encompass all snubbers and shall be based on similarities of design or application. The snubbers may be grouped by size, type, design, application or other means determined by engineering evaluation.	L	Section XI and the TS do not specify "defined test plan groups." The TS, however, require a representative sample from each type of snubber (i.e., same design and manufacturer).	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
081	7.8.1	<u>10% Test Plan</u> The OM Code requires a representative, random sample of 10% of the snubbers in the defined test plan group (snubbers may be grouped by size, type, design, application, or other means).	L	Section XI requires a representative, random sample of 10% of the snubbers in the general population. The STS require a representative, random sample of 10% of each type (i.e., same design and manufacturer, irrespective of capacity). Some individual TS require a sample of 10% of hydraulic and 10% of mechanical snubbers. The OM Code, Section XI, STS and individual TS specify the sample to include various configurations, operating environments, sizes and capacity, as practical. Therefore, there is no significant change.	N	N	N	N	N	N
082	7.8.1	Additionally, the OM Code requires the first sample lot to be a composite based on the ratio of each particular category to the total number of snubbers in the defined test plan group.	E	Section XI requires the ratio to be based on the total number of snubbers installed in the plant. The STS and individual TS require the sample tested to be representative.						

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
083	7.8.2	The OM Code requires for any snubber(s) determined to be unacceptable as a result of testing, an additional sample of at least one-half the size of the initial sample until the total number tested is equal to the initial sample size multiplied by (1+C/2), where C is the total number of snubbers found to be unacceptable. The OM Code allows testing to cease when all the snubbers in the FMG have been tested.	M	The STS and many individual TS require, for each unacceptable snubber of a type (i.e., same design and manufacturer), an additional 10% of that type be tested until no more failures are found or all snubbers of that type have been tested. If the additional sampling is required due to failure of only one type of snubber, the test results shall be reviewed to determine if the additional samples should be limited to that type of snubber. Some individual TS require an additional 5% of that type be tested for each unacceptable snubber until there are no more failures found, or all snubbers of that type have been tested. For each unacceptable snubber, an additional 5% of the initial defined test plan group sample size would be required to be tested instead of 10% of the number of snubbers of the type that was unacceptable. The licensees are able to designate more defined test plan groups, containing smaller numbers of snubbers, than groups of snubber "types". Licensees would be required to test substantially less snubbers if unacceptable snubbers are found. Additionally, based on SNUG data from 1975-1988, there were numerous unacceptable mechanical snubbers due to failure to lockup. The Code change would have resulted in significantly less inspections/tests. There may be an increase in plant risk for those plants whose Technical Specifications require testing of an additional 10% for each unacceptable snubber, due to the decreased number of snubbers periodically tested and examined, and the potential for component failure due to a undetected snubber failure. There would be no increase in risk for the many plants whose Technical Specifications require an additional 5% for each unacceptable snubber. The occupational exposure would be reduced due to the reduction in testing and examinations. There would be a substantial decrease in cost. The average plant has 730 snubbers and has 5 snubbers that fail the functional test each outage[*]. Assuming a test cost of $2,000/snubber[**] and an average of 1.5 years between refueling outages, the average decrease in cost per plant would be $240,000 per year (5/1.5 x 10%/2 x 730 snubbers x $2,000). [*]NUREG/CR-5386, "Basis for Snubber Aging Research: Nuclear Plant Aging Research Program," D. Brown, G. Palmer, E. Werry, January, 1990. [**]NSAC 104 "Guidelines for Reducing Snubbers on Nuclear Piping Systems," Electric Power Research Institute, July, 1986.	D	D	N	N	D	D

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
084	7.8.3	The OM Code specifies the composition of the additional test lots required as a result of unacceptable snubbers.	L	Many plant TS and the STS require the engineering evaluation of each failure be used in selecting snubbers to be tested. There is no significant change. The OM Code simply identifies the elements of an engineering evaluation.	N	N	N	N	N	N
085	7.8.4	The OM Code requires subsequent test interval snubbers to be selected in accordance with paragraph ISTD 7.8.1, 2, and 3.	M	The STS and most individual TS require snubbers placed in the same locations as snubbers which failed the previous test to be retested [but they cannot be included (counted) in the sample plan]. The OM Code has deleted the Technical Specification requirement of most plants to test snubbers placed in the same location as snubbers which failed the previous functional test, without counting them in the sample plan. Licensees would be required to modify their snubber selection procedures and would test less snubbers. There may be an increase in plant risk due to potential snubber and ultimately component failure which may be caused by the snubbers operating environment or by a failure mode for which the corrective action was ineffective. The occupational exposure would be reduced due to the reduction in testing and examinations. There would be a small decrease in cost. The average plant has 730 snubbers and has 5 snubbers that fail the functional test each outage. Assuming a test cost of $2,000 per snubber and an average of 1.5 years between refueling outages, the average decrease in cost per plant would be $6,700 per year (5/1.5 x $2,000). A modification to the OM Code to require testing snubbers in the same location as snubbers that failed the previous functional test has been included to address this safety concern.	D	D	N	D	D	D
086	7.9	The OM Code provides corrective action requirements or FMGs and the impact on determining additional testing lots. One option for Design, Manufacturing, Maintenance, Repair, Installation, and Application Induced FMGs includes replacing or modifying all snubbers in the test FMG and declaring them operable in lieu of replacing or modifying only the unacceptable snubbers and determining additional test lots based on the number of unacceptable snubbers. The OM Code requires snubbers to be replaced or modified in accordance with paragraph ISTD 1.11.	L	Section XI, paragraph IWF-5400 references paragraph IWA-7000 which provides rules for replacements. Section XI explicitly states for application induced or isolated FMGs, the unacceptable snubbers that are reclassified as acceptable are not counted for the purpose of determining the number of additional sample lots. This could be implied in the OM Code. The TS require only inoperable snubbers to be replaced or restored and there is no provisions for recategorizing them as operable. One plant TS that addresses FMGs requires the number of unacceptable snubbers be used in determining additional test lots. It does not address recategorizing snubbers as acceptable [ISTD 7.9.1 (a) and (c)]. The OM Code allows replacing or modifying all susceptible snubbers in lieu of performing additional tests which would result in less testing, however, more replacements and modifications. Therefore, the result would be no impact.	N	N	N	N	N	N

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
087	7.10	37 Test Plan The OM Code requires an initial random sample of 37 snubbers from the defined test plan group. Additional samples shall be randomly selected from the remaining population of the defined test plan group.	L	Section XI and one individual TS require samples from the general snubber population. The STS and many individual TS require samples from each type (i.e., same design and manufacturer) of snubber. Section XI also addresses subsequent test intervals sample selection [OM Part 4, 3.2.3.2(d)]. This change would result in testing more snubbers initially, if the Owner chose to identify more defined test plan groups than snubber "types". 37 snubbers per type or defined test plan group are required to be tested. However, the 37 test plan would probably not be chosen by the Owner because more snubbers would be required to be tested. Therefore, there is no significant change.	N	N	N	N	N	N
088	7.11	The OM Code requires a supplemental test lot for each independent FMG from the defined test plan group (general population). The OM Code states that failures in the supplemental test lot require additional testing in the defined test plan unless an engineering evaluation indicates that another grouping is appropriate.	L	Section XI requires continued testing in any separate FMG be performed in accordance with paragraph 3.2.2 of OM, Part 4 (Inservice Operability Test Frequency). The STS do not address FMGs. Additional test lots are required for each unacceptable snubber. The Plant TS that does address FMGs requires that each FMG be counted as one unacceptable snubber for additional testing in the general population, and any additional unacceptable snubbers be counted for continued testing only for that FMG. This change may result in less additional snubbers required to be tested as a result of unacceptable snubbers in FMGs that contain a limited number of snubbers.	D	D	N	D	D	D
089	7.12	The OM Code requires testing to satisfy the inequality [N≥36.49+18.18C]. The OM Code redefines the variables N and C for independent FMGs.	L	Section XI and the individual TS that have a 37 plan also include a reject inequality, which requires all snubbers to be tested if the criteria is exceeded. Section XI and one plant TS require FMGs, but do not provide an explanation on applying the inequality (i.e., the Figure) to FMGs. The TS do not address FMGs. Although there is no "reject line" in the OM Code, the OM Code requires 100% testing if the "accept line" is not crossed. The reject line is crossed when ≥5.5% of snubbers fail. This failure rate will most likely result in extended testing.	D	D	N	D	D	D
090	7.12	The OM Code requires each snubber to be evaluated in its assigned order in the random sample.	L	Section XI requires the evaluation at the end of each lots testing. The STS require an evaluation at the end of each day testing. This change allows in process evaluation, allowing testing to stop once the inequality is satisfied. There is no change because most Owners discontinue testing for the day once the equality is satisfied.	N	N	N	N	N	N

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Appendix I (continued)

Item No.	Paragraph, Figure, Table	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
091	7.13	The OM Code provides corrective action requirements for each FMG and the impact on determining additional testing requirements. Either all snubbers in the FMG must be replaced or modified or only the unacceptable snubbers must be repaired.	L	The STS do not address FMGs. The STS and the individual TS, however, require the inoperable snubbers to be replaced or restored, or declare the supported system inoperable. Therefore, there would be no significant change.	N	N	N	N	N	N
092	N/A	The OM Code does not address service life monitoring.	H	The STS and most individual TS require a snubber service life monitoring program to ensure that the service life is not exceeded between surveillance intervals. Since this change is rated high, these factors are discussed in more detail in the "Analysis of a Significant Revision" in the front part of this Appendix. The proposed amendment includes a modification to require a service life monitoring program.	D	D	I	D	D	D

Table 2. Summary and Evaluation of ASME OM Code Changes*, 1992 & 1994 Addenda & 1995 Edition

Subsection ISTB

11Apr95 Draft

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors**	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
001	1.3	94	Adds definitions of Group A and B pumps, preservice test, reference point, and trending. Revises definitions of instrument accuracy, operational readiness, preservice test period, and reference values.	E	Definitions do not provide requirements.						
002	3.1	94	Requires Owner to categorize and identify pumps as Group A or B.	L	Group A pumps are those that are routinely operated. Group B pumps are those that are not routinely operated (i.e., standby pumps). Owners would be required to categorize pumps and include this information in their IST plans.	N	N	N	N	N	N
003	3.2	94	Revises to address Group A and B tests. Bypass loop may be used for Group B tests provided bypass loop can accommodate flow rate and time limitations for minimum flow. For Group A or comprehensive tests, it requires +/- 20% of design flow.	L	Bypass/test loops would have to be modified to accommodate the higher flowrates for a limited number of pumps or relief requests would have to be submitted (e.g., containment spray pumps in most PWRs).	I	I	N	I	I	I
004	4	94	Adds introduction to paragraph. Allows substitution of tests with more stringent requirements.	L	This allows flexibility in testing.	N	N	N	N	N	N
005	4.1	94	Revises preservice testing to require establishment of reference curves for centrifugal and vertical line shaft pumps.	L	Additional testing to develop pump curves would be required.	I	I	N	I	I	I
006	4.1-1 Table	95	"Differential" corrected to "differential pressure" in Note 1.	ER							
007	4.2	94	Adds reference to Groups A, B, and comprehensive tests for inservice test requirements.	E							
008	4.3	94	Requires reference values be established within ±20% of pump design flow for comprehensive test and when practical for Group A and B tests.	L	Bypass/test loops would have to be modified to accommodate the higher flowrates for a limited number of pumps or relief requests would have to be submitted (e.g., containment spray pumps in most PWRs).	I	I	N	I	I	I
009	4.4	94	Requires comprehensive or Group A test after replacement, repair, or maintenance.	E	No change to existing test requirements.						
010	4.5	94	Allows the establishment of an additional set of reference values based on previously developed pump curves.	L	Allows extrapolation between data points.	N	D	N	N	D	D

*The changes from requirements in the 1990 Edition of the ASME OM Code are summarized.

**The impact of each item has been evaluated to be high (H), medium (M), low (L), editorial (E), or errata (ER). Each of the factors - safety, occupational exposure, exposure to the public, critical path, records, and cost - has been determined to increase (I), decrease (D), or not change (N) for each high, medium, or low item.

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

"Subsection ISTB (continued)"

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
011	4.6	94	Adds new paragraph to allow analysis to be used for justifying a new set of reference values even though pump may be in alert or action range.	L	The prior Addenda implicitly allowed analysis to be used for new reference values.	N	N	N	N	N	N
012	4.5	95	Reference to ISTB 6.1, Trending, corrected to ISTB 6.2, Acceptance Criteria.	ER							
013	4.7	94	Prior Paragraph 4.6, "Instrumentation," renumbered and renamed to 4.7, "Data Collection."	E							
014	4.7.1(a)	94	Allows parameters to be determined by analytical method.	L	ISTB 4.6.5 currently allows flow rate to be determined analytically.	N	N	N	N	N	N
015	4.7.1-1 Table	94	Requires more accurate pressure instruments for comprehensive and preservice tests.	L	Some pressure instruments may have to be replaced.	N	I	N	I	I	I
016	4.7.1(b)(2)	94	Replaces "shall not" with "does not".	E							
017	4.7.2,4.6.3, 4.7.4,4.6.5	94	"Measurement" deleted from titles and other minor rewording.	E							
018	5.1	94	Requires biennial tests as well as quarterly.	L	The biennial comprehensive test may be performed in lieu of the more limited quarterly test per ISTB4.	N	N	N	N	N	N
019	5.2	94	Subdivides paragraph to address Group A, B and comprehensive tests separately.	E	The impact of each subparagraph is given below through Item No. 19.						
020	5.2.1(a),5.2.2(a) 5.2.3(a)	94	Allows ±1% variance in pump speed.	L	Most utilities factor in some variance.	N	N	N	N	N	N
021	5.2.1(b),5.2.3(b)	94	Requires determination of flow after discharge pressure is equal to reference point for positive displacement pumps.	L	No change in most plants test procedures.	N	N	N	N	N	N
022	5.2.1(e),5.2.3(e)	94	New paragraph explains that vibration measurements are to be compared to both relative and absolute acceptance criteria.	E	Requirements currently contained in Table 5.2-2.						
023	5.2.1(e),5.2.2(d) 5.2.3(e)	95	Reference to ISTB 6.1, Trending, corrected to ISTB 6.2, Acceptance Criteria.	ER							
024	5.2.2(b)	94	Requires measurement of either pressure or flowrate for Group B tests. Only flowrate is required for positive displacement pumps.	L	Test requires less data to be taken.	D	D	N	N	D	D
025	5.2.3-1 Table	95	Second test parameter, Δ, corrected to ΔP.	ER							
026	5.3	94	Revision limits paragraph on pumps in regular use to Group A pumps.	E	Group B pumps are not normally operating.						

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Subsection ISTB (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
027	5.4	94	Within 3 months "of placing the system" is replaced with "before the system is placed" in an operable status.	E							
028	5.5	94	Limits this paragraph on pumps lacking required fluid inventory to Group B pumps.	E	Pumps that lack the required fluid inventory are never Group A pumps.						
029	5.6	94	Eliminates requirement for the pumps to be run at least 2 minutes for the Group B test.	L	Stable conditions must be established before taking measurements.	N	N	N	N	N	N
030	6.1	94	New Paragraph: Requires trending of parameters in Table 4.1-1.	L	Most licensees currently use trending programs. The change does not specify what to do with the results of trending.	N	N	N	N	N	N
031	6.2	94	Old Paragraph 6.1 renumbered and broken down into three subheadings	E							
032	6.2.1	94	New paragraph on Alert Range.	E	Same requirement as before with additional Table identified.						
033	6.2.2	94	New paragraph on Action Range which allows analysis to be used to determine new reference values.	L	Prior addenda implicitly allowed analysis to be used for new reference values.	N	N	N	N	N	N
034	6.2.3	94	New paragraph on Systematic Error which allows retest for systematic error during testing.	L	Only instrument recalibration was addressed previously.	N	N	N	N	N	N
035	7.2	94	Adds to IST Plan records: identification of pumps subject to testing and pump category.	L	Additional information would be included in the IST Plan.	N	N	N	N	N	N
036	4.1-1 Table	94	Revises existing Table 5.2-1 to address preservice, Group A, Group B and comprehensive tests.	M	Affects Group B test only. Measurement of vibration has been deleted, and either ΔP or flowrate is required for this test.	D	D	N	N	D	D
037	5.2.1-1 Table	94	Replaces existing Table 5.2.-2a and adds clarification for non-reciprocating, positive displacement pumps.	L	Currently there are no vibration acceptance criteria for positive displacement pumps other than reciprocating.	N	N	N	N	N	N
038	5.2.1-2 Table	94	Replaces existing table 5.2.-2b.	E							
039	5.2.2a Table	92	Corrects inequality.	ER							
040	5.2.2-1 Table	94	Modifies existing hydraulic acceptance criteria for Group B positive displacement and vertical line shaft pump test.	L	Alert range has been deleted and the required action criteria is less stringent, resulting in less pumps requiring increased testing or corrective action.	D	D	N	D	D	D
041	5.2.3-1 Table	94	Modifies existing hydraulic acceptance criteria for comprehensive test.	L	The high required action criteria is more stringent for all pumps. The alert range is more stringent for centrifugal pumps. Therefore, this results in more pumps entering the alert and required action range.	I	I	N	I	I	I
Subsection ISTC											

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Subsection ISTB (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
042	1.3	94	Adds definition of non-intrusive testing.	E	Definitions do not provide requirements.						
043	2	94	Adds requirement for Owners to qualify non-intrusive techniques and include in plant design provisions necessary to comply with subsection.	L	10CFR50, Appendix B requires owners to qualify "special processes". The regulations provide design and access provision requirements.	N	N	N	N	N	N
044	4.5.4(a)	94	Adds non-intrusive testing as another example of positive means used for observing obturator movement.	L	Generic Letter 89-04, Position 1 allows non-intrusive means.	N	N	N	N	N	N
045	4.5.4(c)	94	Allows sample disassembly and inspection in lieu of disassembling every valve every refueling outage.	L	Generic Letter 89-04, Position 2 allows a sampling technique. The code change reflects the criteria of the Generic Letter, except that the code allows an inspection interval of 8 years (as opposed to 6 yrs.). This change reflects the industry shift from 18 mo. refueling cycles to 24 mo. cycles. One valve will still be tested every refueling outage.	N	N	N	N	N	N
046	4.5.6	94	Revises corrective action to address sample disassembly and inspection program.	L	Change reflects Generic Letter 89-04, Position 2 criteria.	N	N	N	N	N	N
047	6.2(e)	94	Adds sample disassembly and inspection program documentation requirements.	L	No additional documentation is required over that specified in Generic Letter 89-04.	N	N	N	N	N	N
			Subsection ISTD								
048	1.1	94	Expands scope of ISTD to include all safety-related snubbers.	L	Plant Technical Specifications are not limited to ASME Code Class 1, 2, or 3 and require testing and examination of all safety-related snubbers. Therefore, there is no impact.	N	N	N	N	N	N
049	1.3	94	Deletes reference to Class 1, 2, 3, and MC.	L	See ISTD 1.1	N	N	N	N	N	N
050	1.4	92	Definition of "Examination Group" has been deleted.	E	Examination Groups are only referred to in the existing requirements in Table ISTD 6.5.2-1 (note 1), which has been replaced.						
051	1.4	94	Definitions for activation, defined test plan group, drag force, isolated failure, and unexplained failure have been revised and the definition for transient dynamic event failure has been added.	E	Definitions do not provide requirements.						
052	1.10.1	94	Clarifies with no change in requirements.	E							
053	1.10.2	94	Requires repaired or maintained snubbers to undergo preservice examination and testing instead of inservice examination and testing.	L	There is no significant change between the preservice and inservice requirements.	N	N	N	N	N	N

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

"Subsection ISTD (continued)"

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
054	1.12	92	As a result of analysis of the affected piping system, the unacceptable deleted snubbers are now required to be included in the examination population and examination category, in addition to the failure mode group (FMG), for determining the corrective actions. The example has been deleted.	L	This revision clarifies the intent of the Code and industry practice.	N	N	N	N	N	N
055	5.2	94	Item (a) on breakaway force and drag force has been revised and renumbered as (c) and (d). The new version separately discusses these parameters for mechanical (c) and hydraulic snubbers (d). Breakaway is no longer required for hydraulic snubbers. Hydraulic snubbers are required to have a drag test only if required to verify proper reassembly.	L	The STS and many plant TS do not require breakaway or drag verification for hydraulic snubbers. Therefore, there will be no impact for most plants.	N	N	N	N	N	N
056	6	92	Clarifies with no change in requirements.	E							
057	6.1	92	Replaces "operability" with "operational readiness" and other minor editorial changes.	E							
058	6.2	92	Clarifies that all snubbers may be considered as one population or categorized as accessible and inaccessible separately for examination. The revision adds the requirement that the classification must be chosen prior to an examination schedule and cannot be changed. Later, if decided to recombine into one population, the shorter interval of the categories shall be used.	L	These additional constraints on the decision of selecting the snubber population or categories will not significantly impact the current industry practices.	N	N	N	N	N	N
059	6.3	92	Clarifies with no change in requirements.	E							
060	6.4	92	Clarifies with no change in requirements.	E							
061	6.5.1	92	Clarifies with no change in requirements.	E							
062	6.5.2	92	Combines existing paragraphs 6.5.2 and 6.5.3. There is a change in the subsequent examination intervals after the initial examination at the time of first reactor power operation. The second examination is required to be conducted at the first refueling outage, rather than the existing requirement of 18 months. The third examination shall be conducted at the second refueling outage, irrespective of the outcome of the second examination. The subsequent examination interval will follow Table ISTD 6.5.2-1.	L	Changes in the inservice inspection intervals have relaxed the existing requirements. This will reduce the radiation exposure to workers, the cost, and recording efforts.	N	D	N	N	D	D

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
063	6.5.2-1 Table	92	This Table is completely revised. In addition to the number of unacceptable snubbers, the visual examination intervals also are dependent on the population or sizes of each category. The new requirements allow the next visual inspection interval to be twice, the same, or reduced by as much as two-thirds of the previous interval, depending on the number of unacceptable snubbers for various population sizes.	M	The existing code requirement reduces the examination interval from 18 months to 6 months when 2 unacceptable snubbers are found, irrespective of the size of the population. The new requirement, in addition to a maximum reduction of two-thirds of the previous interval, also allows doubling the previous interval for the next examination (not to exceed 48 months). Based on industry experience, an average plant will have a typical 24-48 month visual examination interval for all its snubbers. This less frequent examination schedule will reduce the operating cost, radiation exposure to workers and critical path. The revised code duplicates the alternate requirements provided in Generic Letter 90-09. Numerous licensees have incorporated this Generic Letter. For these licensees, there would be no impact.	N	D	N	D	D	D
064	6.6	92	Requires all snubbers, based either on the whole population or on the accessible categories, to be subject to inservice examination.	L	The existing code allows the sample to be reduced if justified and approved by the NRC. Therefore, the impact is minimal.	N	N	N	N	N	N
065	6.7	92	The concept of categorizing unacceptable snubbers into examination FMGs is eliminated. This eliminates paragraphs 6.7.1 to 6.7.4. However, the root cause evaluation of all unacceptable snubbers is still required.	L	Since the examination intervals based on the new Table are not as stringent when compared to the existing requirements, the concept of categorizing unacceptable snubbers into various FMGs has very little impact on the failure evaluation.	N	N	N	N	N	N
066	6.8	92	Since the use of FMGs for the unacceptable snubbers has been eliminated from the visual examination requirements, this section is revised entirely. Subsections 6.8.1 to 6.8.3 are removed. The Code requires that all unacceptable snubbers shall be adjusted, repaired, modified, or replaced.	L	Since the concept of FMGs has been eliminated as discussed above, corrective actions on each FMG are no longer required. The impact due to this is change marginal.	N	N	N	N	N	N
067	7	94	Replaces "operability" with "operational readiness" and makes other minor changes for clarification.	E							
068	7.1	94	Replaces "operability" with "operational readiness". Breakaway and drag force verification is no longer required for hydraulic snubbers.	L	The STS and many plant TS do not require breakaway or drag verification for hydraulic snubbers. Therefore, there will be no impact for most plants.	N	N	N	N	N	N
069	7.2	94	Paragraphs 7.2.4 and 7.2.5 are revised to include additional inspections as given in paragraph 4.1 during reinstallation and reassembly after testing. Additionally, there are a number of editorial changes.	L	Additional inspection activities are typically performed by the utilities as a good engineering practice.	N	N	N	N	N	N
070	7.3	94	Clarifies with no change in requirements.	E							
071	7.4	94	Clarifies with no change in requirements.	E							

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
072	7.5	94	Existing paragraph 7.7.3 is revised and relocated to ISTD 7.5. It has three subparagraphs 7.5.1 to 7.5.3. The selection of snubbers or snubber groups for testing is described in detail. Those snubbers subject to corrective action as a result of an examination are exempt from testing. Revision adds the requirement that snubbers for steam generators and reactor coolant pumps for PWR plants shall be at least one separate group.	L	This group selection criteria may have some minor impact on plant procedures, if the plant has a different strategy in choosing the test groups.	N	N	N	N	N	N
073	7.6	94	Relocates existing paragraphs 7.7.1, 7.7.2, and 7.7.4 and clarifies with no change in requirements. The new non-mandatory Appendix E is referred to for selecting the snubber testing plans.	E							
074	7.7	94	Relocates and revises existing paragraph 7.5. Clarifies snubbers failure inclusion in DTPG and the use of mathematical expressions for completing the test schedule. Isolated or unexplained failures have been removed from and transient dynamic events have been added to the list of FMGs.	L	There is no change in the requirements (including the number of additional tests as a result of unacceptable snubbers) for these FMGs.	N	N	N	N	N	N
075	7.8	94	Relocates the existing paragraph 7.6 and clarifies with no change in requirements.	E							
076	7.9	94	Relocates existing paragraph 7.8.	E							
077	7.9.1	94	Relocates and revises the existing paragraph 7.8.1. The initial sampling may include snubbers concurrently scheduled for seal replacement or similar activity related to service life monitoring.	L	This may result in less snubbers being tested. Previously the entire sample had to be random.	N	D	N	N	D	D
078	7.9.2	94	Relocates existing paragraph 7.8.2 and clarifies with no change in requirements.	E	ISTD 7.11 now contains the test completion mathematical expression.						
079	7.9.3	94	Relocates and revises existing paragraph 7.8.3. The additional sample is now required to be selected from the DTPG.	L	This should have minimal impact on the current industry practices.	N	N	N	N	N	N
080	7.9.4	94	This new paragraph requires random additional sample selection from a FMG. The existing paragraph 7.8.4 is eliminated.	L	This should have minimal impact on the current industry practices.	N	N	N	N	N	N
081	7.10	94	Relocates existing paragraph 7.9 with no change in requirements.	E							
082	7.10.1	94	Relocates existing paragraph 7.9.3 on unexplained failure group and clarifies with no change in requirements.	E							
083	7.10.2	94	Relocates existing paragraph 7.9.2 on isolated failure group and clarifies with no change in requirements.	E							

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
084	7.10.3	94	Relocates and revises the existing paragraph 7.9.1(a) and (c) and addresses design or manufacturing and application-induced FMGs only.	L	Snubbers in maintenance, repair and installation FMGs are no longer allowed to be recategorized as acceptable for the purpose of determining additional testing provided all snubbers in the FMG are replaced or modified. Additional snubbers would be required to be tested as a result of failures in these FMGs. However, there is no change in impact based on the requirement to perform additional tests versus replacing or modifying all snubbers in the FMG.	N	N	N	N	N	N
085	7.10.4	94	Relocates and revises existing para. 7.9.1(b).	E	The impact is discussed below for ISTD 7.11.						
086	7.10.5	94	This new paragraph addresses transient dynamic event FMG. No additional tests are required, however, the operational readiness of all snubbers in this FMG must be evaluated by stroking or testing.	L	ISTD 1.13 currently requires the affected snubbers to be reviewed and any appropriate corrective action taken.	N	N	N	N	N	N
087	7.11	94	Revises the 10% testing sample plan additional testing requirements. It contains mathematical expressions to determine additional samples when unacceptable snubbers are found for each DTPG, as well as FMG.	L	This mathematical expression is consistent with the existing requirement in para. 7.8.2, for the DTPG. This revision also addresses additional testing in FMGs. If a FMG has a limited number of snubbers, this revision could result in less additional snubbers being tested. The 10% plan is now consistent with the 37 plan.	N	D	N	D	D	D
088	7.12	94	Relocates existing paragraph 7.10 and clarifies with no change in requirements.	E							
089	7.12.1	94	Relocates existing paragraph 7.10.1 and clarifies with no change in requirements.	E							
090	7.12.2	94	This new paragraph addresses the additional sample size.	E	The requirements already exist in ISTD 7.12.1						
091	7.12.3	94	Relocates existing paragraph 7.10.2 and clarifies with no change in requirements.	E							
092	7.13	94	Recognizes the various FMGs and duplicates the additional testing requirements of the 10% Plan for the 37 Plan.	L	This should not impact the current industry practices.	N	N	N	N	N	N
093	7.13.1	94	Provides requirements for additional testing for unexplained failures.	L	This does not change the number of snubbers that would be tested.	N	N	N	N	N	N
094	7.13.2	94	This applies to those snubbers under the isolated failure groups. The revision does not require additional testing for this FMG.	L	This would result in less snubbers being tested as a result of failures.	N	D	N	N	D	D
095	7.13.3	94	This applies to those snubber failures attributed to design or manufacturing and application-induced FMGs. The revision does not require additional testing for these FMGs.	L	This would result in less snubbers being tested as a result of failures. However, all affected snubbers are corrected such that additional failures will not occur.	N	D	N	N	D	D

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Subsection ISTD (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
096	7.13.4	94	Clarifies the additional testing requirements.	E							
097	7.13.5	94	The new paragraph applies to those snubber failures which are categorized in the transient dynamic event FMG.	E	These requirements already exist in ISTD 1.13.						
098	7.14	94	Relocates existing paragraph 7.12 and clarifies with no change in requirements. The existing subparagraph 7.12.2, concerning snubber evaluation sequence, has been eliminated.	L	This should not impact the current industry practices.	N	N	N	N	N	N
099	7.15	94	This is a new paragraph on the retest requirements for previously unacceptable snubbers.	L	This should not impact the current industry practices. Most Technical Specifications currently contain this requirement.	N	N	N	N	N	N
100	7.14.1-1 Figure	94	Relocation of existing Fig. ISTD 7.12.1-1.	E							
			Appendix I								
101	1.1	94	Scope is revised to make consistent with ISTC scope.	E							
102	Throughout Appendix	94	Changes "set pressure" to "set-pressure."	E							
103	1.1.2	94	Clarifies with no change in requirements.	E							
104	1.2	94	Reference for other definitions is changed to ANSI/ASME PTC 25.3. Definitions for gag and overpressure protection are revised. The definition for reactor criticality is deleted and definitions on owner, power-actuated relief valve and valve group are added.	E	Definitions do not provide requirements.						
105	1.3.1(b)	94	Clarifies with no change in requirements.	E							
106	1.3.1(c)	94	Clarifies with no change in requirements.	E							
107	1.3.1(e)	94	Adds new paragraph on the establishment and documentation of acceptance criteria.	L	Owner already required to prepare written acceptance criteria (I 1.3.2(a)(3)).	N	N	N	N	N	N
108	1.3.2	94	Deletes paragraph on Owner responsibility to prepare and maintain records and on Test Supervisor responsibilities.	L	Owner is required to prepare and maintain records in ISTA 3.2. Test Supervisor responsibilities for test personnel qualification, instrument calibration and compliance with procedures are now assigned to Owner. ISTC 6.3 covers the signing and dating of results.	N	N	N	N	N	N
109	1.3.3(a)	94	The initial 5-year test interval is revised and combined with the subsequent test schedule.	L	The initial 5 year period test schedule (Table I 1.3.3-1) has been deleted, however, all valves must still be tested within 5 years, with a minimum of 20% within 24 months.	N	N	N	N	N	N

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Appendix I (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
110	1.3.3(b)	94	Relocates existing 1.3.3(c) and clarifies with no change in requirements.	E							
111	1.3.3(c)	94	Relocates and revises existing 1.3.3(d) and (e). The acceptance criteria includes the Owner's established set-pressure criteria, as well as ±3% of nameplate set-pressure. Other changes are editorial.	L	This gives the Owner the option of establishing acceptance criteria. This may result in fewer valves being declared inoperable. However, based on the requirements in 1.3.1(e), there should be no affect on safety as the acceptance criteria is based on the system/valve design basis or Technical Specification. Additionally, the -3% acceptance criteria will result in more valves being declared inoperable.	N	N	N	N	N	N
112	1.3.5(a)	94	The initial 10 year test interval is revised and combined with the subsequent test schedule.	L	The initial 10 year period test schedule (Table I 1.3.5-1) has been deleted, however, all valves must still be tested within 10 years, with a minimum of 20% within 48 months.	N	N	N	N	N	N
113	1.3.5(b)	94	Relocates existing 1.3.5(c) and clarifies with no change in requirements.	E							
114	1.3.5(c)	94	Relocates and revises existing 1.3.5(d) and (e). The acceptance criteria is revised to include the Owner established set-pressure criteria and -3% of name plate set pressure, as well as +3% of nameplate set-pressure. Other changes are editorial.	L	This gives the Owner the option of establishing acceptance criteria. This may result in fewer valves being declared inoperable. However, based on the requirements in 1.3.1(e), there should be no affect on safety as the acceptance criteria is based on the system/valve design basis or Technical Specification.	N	D	N	N	D	D
115	1.3.6	94	Clarifies with no change in requirements.	E							
116	1.3.7(a)	94	Changes containment vacuum relief valve test frequency from 6 months to 2 years or at refueling, whichever is sooner.	L	Less testing is required by the Code unless historical data indicates a requirement for more frequent testing. Based on this requirement for trending, safety should not be impacted. Containment vacuum breakers are explicitly covered by the BWR Technical Specifications. Therefore, this change will only affect PWRs.	N	D	N	D	D	D
117	1.3.7(b)	94	Clarifies with no change in requirements.	E							
118	1.4.1(a)	94	Clarifies with no change in requirements.	E							
119	1.4.1(b)	94	Requires the overall set-pressure instrument combined accuracy not to exceed ±1% of indicated pressure.	L	The current requirement is +1% and -2%. Instruments currently used by most Owners comply with this requirement.	N	N	N	N	N	N
120	2, 6	94	Replaces valves of the same manufacturer and type with valve group, and inspection with examination.	E							

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Appendix I (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
121	3.1.1	94	The sequence of testing MSRVs before installation is revised. Accessories are required to be tested before the seat tightness test.	L	This will result in less radiation exposure to test personnel and cost. The normal practice is to perform the seat leakage test as the final test, after reinstallation. The current requirements may cause the Owners to perform the seat leakage test twice.	N	D	N	N	N	D
122	3.1.5, 3.1.6, 3.1.7, 3.2	94	Clarifies with no change in requirements.	E							
123	3.2.1	94	Requires testing before initial power generation to be performed at reduced or normal system pressure.	L	The Code previously required testing at both reduced and normal system pressure. However, industry practice is to perform the test at one pressure.	N	N	N	N	N	N
124	3.2.2	94	Requires MSRVs without auxiliary actuating devices to have their set-pressure verified within 6 months before criticality.	L	The Code previously did not require functional testing. This will result in additional testing.	I	N	N	N	I	I
125	3.2.4, 3.2.6	94	Requires nonreclosing pressure relief valves to pass a visual examination after installation, but before initial power generation.	L	This will require an additional examination.	I	N	N	N	I	I
126	3.2.5	94	Clarifies with no change in requirements.	E							
127	3.2.7(a)	94	Clarifies with no change in requirements.	E							
128	3.3	94	References control ring adjustment requirements in other paragraph of the Code.	E							
129	3.3.1	94	Clarifies that maintenance or set-pressure adjustments may be performed following the visual exam, seat tightness determination, and set-pressure determination; and before the accessory and seat tightness test. Additionally, the seat tightness test is moved to after the accessory tests. Footnote 1 is added to clarify the intent of the seat tightness determination (Code Interpretation 92-3).	L	The Code previously required all the testing to be performed prior to adjustment or maintenance. This will reduce the time it takes to test because the valve may be adjusted to meet the set-pressure criteria prior to removing it from the test stand. The accessory tests should not affect the set-pressure. Additionally, this will result in less radiation exposure to test personnel and cost. The normal practice is to perform the seat leakage test as the final test, after reinstallation. The current requirements may cause the Owners to perform the seat leakage test twice.	N	D	N	N	N	D
130	3.3.2	94	Changes the test sequence. The determination of operation and electrical characteristics of position indicators is required to be performed prior to the seat tightness test.	L	The normal practice is to perform the seat leakage test as the final test, after reinstallation. The current requirements may cause the Owners to perform the seat leakage test twice.	N	D	N	N	N	D

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Appendix I (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
131	3.3.3	94	Clarifies that maintenance or adjustments may be performed following the visual exam, seat tightness determination, and set-pressure determination; and before the remaining tests. Additionally, the seat tightness test is now the last test performed.	L	The Code previously required all the testing to be performed prior to adjustment or maintenance. This will reduce the time it takes to test because the valve may be adjusted to meet the set-pressure criteria prior to removing it from the test stand. The accessory tests should not affect the set-pressure. Additionally, the normal practice is to perform the seat leakage test as the final test, after reinstallation. The current requirements may cause the Owners to perform the seat leakage test twice.	N	D	N	N	N	D
132	3.3.4	94	References requirements from paragraph I 1.3.4 and requires a visual examination in accordance with the Owner examination, and not the receipt inspection procedure.	L	Both the receipt inspection and examination procedures are developed by the Owner, and may be identical.	N	N	N	N	N	N
133	3.3.5	94	Clarifies that maintenance or adjustments may be performed following the visual exam, seat tightness determination, and set-pressure determination; and before the remaining tests. Additionally, the seat tightness test is now the last test performed.	L	The Code previously required all the testing to be performed prior to adjustment or maintenance. This will reduce the time it takes to test because the valve may be adjusted to meet the set-pressure criteria prior to removing it from the test stand. The accessory tests should not affect the set-pressure. Additionally, the normal practice is to perform the seat leakage test as the final test, after reinstallation. The current requirements may cause the Owners to perform the seat leakage test twice.	N	D	N	N	N	D
134	3.3.6	94	References requirements from paragraph I 1.3.6 and requires a visual examination in accordance with the Owner examination, and not the receipt inspection procedure.	L	Both the receipt inspection and examination procedures are developed by the Owner, and may be identical.	N	N	N	N	N	N
135	3.3.7, 3.4	94	Clarifies with no change in requirements.	E							
136	3.4.1(a), (b), (c)	94	Clarifies with no change in requirements.	E							
137	3.4.1(d)	94	Clarifies that actuation may be performed at reduced or normal system pressure before resumption of power generation following maintenance.	L	The Code previously required the test to be conducted at reduced pressure. This clarifies the intent of the Code.	N	N	N	N	N	N
138	3.4.1(e), 3.4.2(d), 3.4.3(d), 3.4.5(d), 3.4.7(d)	94	This new paragraph allows the component not to be immediately maintained to comply with its acceptance criteria, provided that the ability of the valve to perform its function until the next test or maintenance opportunity is evaluated.	L	This will allow valves with minor set-pressure deviations to be accepted until the next test. This will reduce the number of corrective actions for minor deviations. However, based on the evaluation, the number of records is not affected. The OM Code already allows the Owner to analyze the stroke times of valves in lieu of repair or replacement (ISTC 4.2.9).	N	D	N	N	N	D

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Appendix I (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
139	3.4.2(a), (b), (c), 3.4.3(a), (b), (c), 3.4.5(a), (b), (c), 3.4.7(a), (b), (c),	94	Clarifies with no change in requirements.	E							
140	3.4.4, 3.4.6	94	References requirements from paragraphs I 1.3.4, 1.3.6 and requires a visual examination in accordance with the Owner examination, and not the receipt inspection procedure.	L	Both the receipt inspection and examination procedures are developed by the Owner, and may be identical.	N	N	N	N	N	N
141	4.1.1(a), (c), 4.1.2(c)	94	Clarifies with no change in requirements.	E							
142	4.1.1(b), 4.1.2(b)	94	The specific minimum accumulator volume requirements are replaced with the volume "shall be sufficient to determine the valve set-pressure."	L	The Owner now must determine the minimum volume.	N	N	N	N	N	N
143	4.1.1(d), 4.1.2(d), 4.1.3(d)	94	Allows direct or indirect temperature measurements when establishing thermal equilibrium. It also does not require verification of thermal equilibrium when valves are tested at ambient temperature using a test medium at ambient temperature.	L	This will not change how licensees perform tests.	N	N	N	N	N	N
144	4.1.1(f), 4.1.2(f), 4.1.3(f)	94	Clarifies with no change in requirements.	E							
145	4.1.1(g), 4.1.2(g)	94	Adds requirement to return adjusted control ring to their proper position prior to return to service.	L	Most licensees programs already include this requirement, as IE Notice 92-64 alerted them to this concern.	N	N	N	N	N	N
146	4.1.2(a)	94	Allows air or nitrogen to be substituted at the same temperature without the additional testing requirements of I 4.3.	L	This will result in less testing.	N	N	N	N	D	D
147	4.1.3(b)	94	Clarifies with no change in requirements.	E							
148	4.1.3(c)	94	Prohibits the use of assist devices for liquid service pressure relief valves.	L	Previously, the Code did not recommend the use of these devices. Generally assist devices are not used for these valves.	N	N	N	N	N	N
149	4.1.3(h)	94	Deletes the requirement that any subsequent openings at the same set point adjustment be within acceptance criteria, and that valve opening be determined when the valve is flowing at the rate of 40 cc/min.	L	This deletes the quantitative criteria for determining valve opening and allows a qualitative assessment. There should be no impact on the testing.	N	N	N	N	N	N
150	4.2	94	Clarifies with no change in requirements.	E							
151	4.2.2, 4.2.3	94	Replaces "may" with "shall."	L	This will not affect the methods or acceptance criteria used by licensees.	N	N	N	N	N	N
152	4.3.2	94	Clarification and correcting the reference to other paragraphs.	E							

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

Appendix I (continued)

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
153	5.1	94	Additional records that the Owner must maintain are added.	L	These records are currently required by ISTC 6.1 and 6.3.	N	N	N	N	N	N
154	5.2	94	Adds the requirement for the Owner to implement a schedule of testing to be performed.	L	I 1.1.1(b) currently requires the Owner to establish a program that defines and implements the requirements of this Appendix.	N	N	N	N	N	N
155	5.3	94	Deletes the requirement for procedures to include special test requirements and acceptance criteria, and minor editorial rewording.	L	I 1.3.2(b) and (c) requires preparation of test procedures and written acceptance criteria.	N	N	N	N	N	N
156	5.5.1	94	Clarifies with no change in requirements.	E							
157	6	95	Reference to I 1.7 corrected to I 7.1.	ER							
158	7.1.1, 7.1.2	94	Revises the sequence of testing safety valves and power actuated relief valves before installation. Accessories are required to be tested before the seat tightness test.	L	The normal practice is to perform the seat leakage test as the final test, after reinstallation. The current requirements may cause the Owners to perform the seat leakage test twice.	N	D	N	N	N	D
159	7.1.4, 7.1.5, 7.1.6, 7.1.7	94	Clarifies with no change in requirements.	E							
160	7.2.1	94	Requires set-pressure verification 6 months before initial reactor criticality.	L	The Code previously required set-pressure verification within 6 months of initial fuel load. This change will affect the test schedule for plants that have not begun electric power generation.	N	N	N	N	N	N
161	7.2.2	94	Clarifies with no change in requirements.	E							
162	7.2.4, 7.2.6	94	Requires nonreclosing pressure relief valves to pass a visual examination.	L	This will require an additional examination.	I	N	N	N	I	I
163	7.2.5	94	Allows the Main Steam safety valves to be set-pressure and seat leak tested either before or after installation, but within 6 months before initial reactor criticality.	L	The Code previously required the tests after installation and system heatup , but before initial reactor criticality. This will affect the test schedule for plants that have not begun electric power generation.	N	N	N	N	N	N
164	7.2.7(a)	94	Clarifies with no change in requirements.	E							
165	7.3	94	References control ring adjustment requirements in another paragraph of the Code.	E							

Table 2. Summary and Evaluation of ASME OM Code Changes, 1992 & 1994 Addenda & 1995 Edition (Continued)

"Appendix I (continued)"

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
166	7.3.1, 7.3.2, 7.3.3, 7.3.5, 7.3.6,	94	Clarifies that maintenance or adjustments may be performed following the visual exam, seat tightness determination, and set-pressure determination; and before the remaining tests. Additionally, the seat tightness test is now the last test performed.	L	The Code previously required all the testing to be performed prior to adjustment or maintenance. This will reduce the time it takes to test because the valve may be adjusted to meet the set-pressure criteria prior to removing it from the test stand. The accessory tests should not affect the set-pressure. Additionally, the normal practice is to perform the seat leakage test as the final test, after reinstallation. The current requirements may cause the Owners to perform the seat leakage test twice.	N	D	N	N	N	D
167	7.3.4, 7.3.7, 7.4.4, 7.4.7	94	References requirements from paragraphs I 1.3.4, 1.3.6 and requires a visual examination in accordance with the Owner examination, and not the receipt inspection procedure.	L	Both the receipt inspection and examination procedures are developed by the Owner, and may be identical.	N	N	N	N	N	N
168	7.3.8, 7.4	94	Clarifies with no change in requirements.	E							
169	7.4.1(a), (b), (c),	94	Clarifies with no change in requirements	E							
170	7.4.1(d), 7.4.2(d), 7.4.3(d), 7.4.5(d), 7.4.6(d)	94	This new paragraph allows the component not to be immediately maintained to comply with its acceptance criteria, provided that the ability of the valve to perform its function until the next test or maintenance opportunity is evaluated.	L	This will allow valves with minor set-pressure deviations to be accepted until the next test. This will reduce the number of corrective actions for minor deviations. The OM Code already allows the Owner to analyze the stroke times of valves in lieu of repair or replacement (ISTC 4.2.9).	N	D	N	N	N	D
171	7.4.2(a), (b), (c), 7.4.3(a), (b), (c), 7.4.5(a), (b), (c), 7.4.6(a), (b), (c), 7.4.8(a), (b)	94	Clarifies with no change in requirements.	E							
172	8.1.1(a)	94	Minor rewording with clarification that safety valves designed for saturated steam service that are installed on a water filled loop seal are to be tested with saturated steam.	E	This incorporates intent interpretation91-1.						
173	8.1.1(b), 8.1.2(b)	94	The specific minimum accumulator volume requirements have been replaced with the volume "shall be sufficient to determine the valve set-pressure."	L	The Owner now must determine the minimum volume.	N	N	N	N	N	N
174	8.1.1 (c), 8.1.2(c)	94	Clarifies with no change in requirements.	E							

Table 1. Summary and Evaluation of ASME OM Code Changes, 1990 Edition (Continued)

'Subsection ISTD (continued)'

Item No.	Paragraph, Figure, Table	Year	Description	Im pact	Explanation of Impact and Factors	Saf ety	Occ Exp	Pub Exp	Crit Path	Rec ord	Cost
175	8.1.1(d), 8.1.2(d), 8.1.3(d)	94	Allows direct or indirect temperature measurements when establishing thermal equilibrium. It also does not require verification of thermal equilibrium when valves are tested at ambient temperature using a test medium at ambient temperature.	L	This will not change how licensees perform tests.	N	N	N	N	N	N
176	8.1.1(f), 8.1.2(f), 8.1.3(f)	94	Clarifies with no change in requirements.	E							
177	8.1.1(g), 8.1.2(g)	94	Adds requirement to return adjusted control rings to their proper position prior to return to service.	L	Most licensee programs already include this requirement, as IE Notice 92-64 alerted them to this concern.	N	N	N	N	N	N
178	8.1.2(a)	94	Allows air or nitrogen to be substituted at the same temperature without the additional testing requirements of I 8.3.	L	This will result in less testing.	N	N	N	N	D	D
179	8.1.3(b)	94	Clarifies with no change in requirements.	E							
180	8.1.3(h)	94	Deletes the requirement that any subsequent openings at the same set point adjustment be within acceptance criteria, and that valve opening be determined when the valve is flowing at the rate of 40 cc/min.	L	This deletes the quantitative criteria for determining valve opening and allows a qualitative assessment. There should be no impact on the testing.	N	N	N	N	N	N
181	8.2	94	Clarifies with no change in requirements.	E							
182	8.2.3	94	Replaces "may" with "shall."	L	This will not affect the methods or acceptance criteria used by licensees.	N	N	N	N	N	N
183	8.3.1	94	Clarifies with no change in requirements.	E							
184	8.3.2	94	Clarifies and corrects the reference to other paragraphs.	E							
185	9.1	94	Adds additional records that the Owner must maintain.	L	These records are currently required by ISTC 6.1 and 6.3.	N	N	N	N	N	N
186	9.2	94	Adds the requirement for the Owner to implement a schedule of testing to be performed.	L	I 1.1.1(b) currently requires the Owner to a establish a program that defines and implements the requirements of this Appendix.	N	N	N	N	N	N
187	9.3	94	Deletes the requirement for procedures to include special test requirements and acceptance criteria, and minor clarification rewording.	L	I 1.3.2(b) and (c) requires preparation of test procedures and written acceptance criteria.	N	N	N	N	N	N
188	9.5.1	94	Clarifies with no change in requirements.	E							

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
1	ISTA 1.1	518	Add preservice to the scope of the subsection.	E							
2	ISTA 1.4(c)	518	Delete specific requirement for preparation of schedules.	E	"Plans," by the definition in ISTA 2.2.2, includes schedules.						
3	ISTA 1.7	585	Add definition of skid-mounted component and component subassembly.	E	Definitions do not provide requirements.						
4	ISTA 2.1.1(2)	518	Add to duties of inspectors, test plan revision review during preservice test period.	L	Inspector is already required to review the test plan.	N	N	N	N	N	N
5	ISTA 2.1.1(4)	518	Delete specific requirement to verify "inservice" tests and examinations, to clarify that Inspector must verify both preservice and inservice tests and examinations.	E							
6	ISTA 2.2.1(a)	518	Replace "preservice test interval" with "preservice test period."	E							
7	ISTA 2.2.2	518	Clarify that these test plan requirements also apply to the preservice test period.	E	Paras. ISTA 3.3.3(b) and 2.1.1(a)(1) refer to para. ISTA 2.2.2 for preservice test plans.						
8	ISTA 2.2.4(a)	518	Clarify that test plans must include Code Cases used during all tests or examinations, not just inservice.	E							
9	ISTA 3.2	518	Delete specific requirement for preparation of schedules and clarify that Owner is responsible for preservice plans and records preparation.	E							
10	ISTA 3.3.1	518	Add record retention for the service lifetime of the system or component.	E	ISTA 1.4(k) requires the Owner to retain records for the service lifetime of either system or component.						

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
11	ISTA 3.3.3(b)	518	Delete preservice test plan and only refer to an inservice test plan.	E	Inservice test plan, as defined in ISTA 2.2.2, includes plans for the preservice and inservice test periods.						
12	ISTB 1.1	570	Replace "cold shutdown" with "safe shutdown."	L	Many plants are only licensed to achieve hot standby or hot shutdown. The Code previously required testing of components that may not be safety related at all plants. NUREG-1482, Section 2.2 addressed this issue, and allows these plants to only include those component required to achieve safe shutdown.	N	N	N	N	N	N
13	ISTB 1.2(c)	585	Add exclusion of skid-mounted component and component subassembly, provided they are tested adequately as part of the main component.	L	Most licensees already do not include these components in their IST Programs. NUREG-1482, Section 3.4 states that it is acceptable to test these components during the test of the major component.	N	D	N	N	D	D
14	ISTB 4.7.4	571	Clarify that the measurements are to be taken approximately in the orthogonal direction.	L	The intent of the Code had been previously clarified in Code Interpretation 95-03.	N	N	N	N	N	N

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
15	ISTC 1.1	570	Replace "cold shutdown" with "safe shutdown."	L	Many plants are only licensed to achieve hot standby or hot shutdown. The Code previously required testing of components that may not be safety related at all plants. NUREG-1482, Section 2.2 addressed this issue, and allows these plants to only include those component required to achieve safe shutdown.	N	N	N	N	N	N
16	ISTC 1.2	585	Add exclusion of skid-mounted component and component subassembly, provided they are tested adequately as part of the main component.	L	Most licensees already do not include these components in their IST Programs. NUREG-1482, Section 3.4 states that it is acceptable to test these components during the test of the major component.	N	D	N	N	D	D
17	ISTC 1.2	571	Add exclusion for exercising and position verification of Category A and B safety and relief valves.	M	This change was added to address the ADS valves in BWRs. Many plants currently are required to exercise these valves quarterly (although many have relief requests) and perform the requirements of Appendix I. This change would result in less records (i.e., relief requests and records of tests) and less testing. The testing requirements of App. I are adequate to ensure safety. (Reference NUREG-1482, Section 4.3.4 and NUREG/CR-6396, Section 2.1.2)	N	D	N	N	D	D

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
18	ISTC 4.3.2	544	Para. 4.3.2 was clarified to state that Para. 4.3.3 applies to CIVs with a seat leakage requirements based on other functions that include, but may not be limited to, RCS pressure isolation function.	L	This clarification was previously provided in NUREG-1482, Section 4.4.8.	N	N	N	N	N	N
19	ISTC 4.3.3	544	Wording was changed to be consistent with Para. 4.3.2	E							
20	ISTC 4.5.1	545	Para. 4.5.1 was revised to include the new reference to the condition monitoring program para. 4.5.5, and the renumbering of para. 4.5.6.	M	See discussion under ISTC 4.5.5						
21	ISTC 4.5.2, 4.5.4(a)	545	This change was made to require a bi-directional test for all check valves, regardless of their safety function. The test interval is based on when it is practical to perform both tests. For valves with only a safety function in the closed position, a partial stroke is allowed. For valves with a safety function in the open direction, partial stroke tests are no longer required. The test must be performed when the valve can be fully open (or to the required position to perform its function).	M	This change will result in increased test intervals. However, the bi-directional test should provide increased confidence in the operational readiness of check valves, resulting in no change in risk or safety.	N	L	N	N	L	L
22	ISTC 4.5.4(c)(4), App. J.	545	Revise wording and reference non-mandatory Appendix J for guidance on testing following reassembly.	E							

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
23	ISTC 4.5.5, App. II	545	Para. 4.5.5 was relocated to 4.5.6. The new para. 4.5.5 permits the use of a condition monitoring (CM) program for check valves (Mandatory App. II), in lieu of the testing or examination requirements of ISTC 4.5.1 through 4.5.4. The CM program allows the Owner to determine the appropriate preventative maintenance, tests, and examinations (including frequency), based on an analysis of the valves' test and maintenance history.	M	In addition to testing check valves in accordance with the ASME Code, plants have additional programs to monitor their performance (e.g., SOER 86-03 and the Maintenance Rule). This Code change allows plants to take credit for these programs and to potentially eliminate the quarterly exercising. The valve's test and maintenance history must be analyzed, and the results used to determine the preventative maintenance, test and examination activities required (including frequency). This alternative may result in less testing, however, the analysis of data and specific potential failure mechanisms, which is not currently required, should maintain or improve the level of safety.	N	D	N	N	I	I
24	ISTC 4.5.6	545	Para. 4.5.6 was relocated to 4.5.8. Change "being full-stroke exercised" to "full-stroke movement."	E							
25	ISTC 4.5.7, 4.5.8, 6.2 (f)	551	Add para. to address check valves in series without provisions to verify individual reverse flow closure.	L	Identical guidance was provided in NUREG-1482, Section 4.1.1. This Code change, however, will eliminate the need for licensees to submit a relief request.	N	N	N	N	D	D

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
26	ISTC 4.5.8	551	This new para. includes the two para. previously found in 4.5.6. and a new para., which addresses corrective action when check valves are tested in series, was added.	L	Identical guidance was provided in NUREG-1482, Section 4.1.1.	N	N	N	N	D	D
27	ISTC 6.2(e)	545	Change "part-stroke exercise" to "an exercise to at least a partially open position."	E							
28	ISTC 6.2(f)	551	The basis for testing valves in series was added to requirements for test plans.	L	Similar guidance was provided in NUREG-1482, Section 4.1.1 for documentation.	N	N	N	N	D	D
29	ISTD TITLE	520	Title revised to reflect contents of subsection, which includes preservice, as well as, inservice testing and examination of snubbers.	E							
30	ISTD 1.2	520	Delete para. ISTD 1.2, Owner Responsibility.	E	These responsibilities are already included in ISTA 1.4.						
31	ISTD 1.3	520	Delete para. ISTD 1.3, Limitations.	L	Para. 1.3.1, Operation Readiness, did not include any requirements and the commentary is also included in ISTD 1.1, Scope. Para 1.3.2, Exemptions, allowed the exemption of certain snubbers from examination and testing requirements, provided the Owner filed the justification with the enforcement and regulatory authority. The Commission took exception to this allowance in 10CFR50.55a(b).	N	N	N	N	N	N

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
32	ISTD 1.4	558 524	Delete breakaway force and revise drag force definitions. Add diagnostic testing, service life, service life population.	E	Definitions do not provide or change requirements.						
33	ISTD 3.4, App. H	583	Add para. to provide guidance for establishing functional test methods by referencing non-mandatory App. H.	E							
34	ISTD 5.2 (c), 7.1(c)	558	Delete from the mechanical snubber test requirements breakaway force, if required by the test procedure. The measurement of drag force is now required for all mechanical snubbers.	L	Breakaway force is generally measured at only one stroke location, which, in most cases, is not the location of peak resistance force. Measurement of drag force, throughout the anticipated thermal movement stroke, is a more comprehensive measure of the overall resistance to thermal movement. The current practice at most plants is to only measure drag force and not to measure breakaway force. However, for those plants that may only measure breakaway force, test procedure revision will be required. Existing test equipment should be able to be utilized for either test method.	I	N	N	N	N	I

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
35	ISTD 8 and App. F	524	Add new requirement for service life monitoring. Service lives of snubbers are required to be predicted and evaluated to ensure that the service life will not be exceeded before the next scheduled RFO. Specific requirements have been provided for snubbers tested without applying a load to the snubber piston rod, in response to Generic Issue 113, on testing large bore hydraulic snubbers (Reference NUREG/CR-5416).	M	Most plants are currently required to have a service life monitoring program, as required by their Technical Specifications. There may be some increase for those few plants, whose Technical Specifications do not require such a program. However, these requirements simply formalize preventative maintenance practices currently found in most plants. The specific requirements in ISTD 8.4 for large bore snubbers that cannot be tested by applying a load to the piston rod (e.g., steam generator snubbers), however, are not addressed in plant Technical Specifications and represent an increase in the requirements, resulting in an increase in cost and an increased confidence in detecting internal degradation and ensuring the seal's pressure retaining integrity.	I	I	N	N	I	I
36	I 1.1	574	Change title from "Scope" to "Applicability"	E							
37	I 1.3.5(a)	574	Add ", if they exist" to last line of first paragraph.	E							

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
38	I 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.7, 7.1.1, 7.1.2, 7.1.3, 7.1.5	574	Replace Owner's receiving or receiving inspection procedures to inspection procedures.	E							
39	I 3.2.5, 7.2.3	574	Add: "the device shall pass visual examination in accordance with the Owner's inspection procedure." (Change will make it consistent with I 3.2.3)	E							
40	I 3.3.1, 3.3.2, 3.3.3, 3.3.5, 7.3.1, 7.3.2, 7.3.3, 7.3.5, 7.3.6	571	Delete requirement to perform tests, other than the visual examination, seat tightness determination, and set-pressure determination, in sequence.	L	This should reduce some of the scheduling burdens associated with testing. The sequence of these tests does not affect their ability to assess the operational readiness of the valves.	N	N	N	N	N	N
41	I 4.1.2(a), 4.1.3(a), 8.1.2(a), 8.1.3(a)	574	Revise to read "and different temperature may be used."	E							
42	I 4.1.2(g), 8.1.1(g), 8.1.2(g),	574	Revise to read "prior to return to service."	E							
43	I 5.4	574	Add: "and documentation of results of tests performed." (Change will make it consistent with I 9.4)	E							
44	I 5.5.1	574	Replace "performed" with "made to."	E							
45	I 7.2.4, 7.2.6	574	Add: "Functional testing is not required." (Change will make it consistent with I 3.2.4, 3.2.6)	E							

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
46	I 8.3.3	574	Add "shall".	E							
47	I 9.3	574	Add "or both".	E							
48	Tables I 4.2.2-1 and 8.2.2-1	574	Add series of dots to Air/Gas-Volumetric or Weight Measurement entry.	E							

Table 3-Summary and Evaluation of ASME OM Code Changes, 1996 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
49	Code Case OM-N-1	582	Add alternate rules for periodic testing of MOVs.	L	The use of this code case is voluntary. If a licensee chooses to use OM-N-1, the exercise frequency for MOVs may be increased from quarterly to once every refueling cycle. No stroke time measurement is required for this exercise. Additionally, once every 10 years (or less), a test to determine available stem torque is required using non-intrusive techniques. A periodic test has been required by Generic Letter 96-05. Therefore, this represents no increase in requirements over those currently required. The one-time design basis verification test required by the code case has been performed by licensees as part of the Generic Letter 89-10 implementation. Therefore, the only change in requirements in implementing this code case is the deletion of stroke time measurements and an increased exercise test interval. The additional requirements of Generic Letters 89-10 and 96-05 assure that this change will not adversely affect safety.	N	N	N	N	D	D

Table 4-Summary and Evaluation of ASME OM Code Changes, 1997 Addenda

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
1	ISTÅ 1.1	616	Revise scope of section to include the scopes of the various subsections and Appendix I.	E							
2	ISTA 1.3.1	574	Delete requirement for the enforcement authorities to review selection of components subject to IST.	L	The authorized inspector (AI) generally does not have the training, experience or education to determine the selection of components subject to IST. Selection of components is the responsibility of the Owner, and is subject to review by the staff.	N	N	N	N	N	N
3	ISTA 1.4(e)	591	Delete requirement to verify "qualification to required level" and add requirement to qualify test and inspection personnel in accordance with Owner's QA program.	L	The OM Code, unlike Section XI, does not require qualification levels (e.g., Level II UT examiner). This requirement is a remnant from the Section XI/OM separation. Licensee's QA programs already require qualification of personnel.	N	N	N	N	N	N
4	ISTA 1.4	574	Delete para. (f) concerning the requirement to possess an arrangement with an authorized inspection agency, and renumber the following paragraphs.	L	Deleting the requirement for an AI to inspect IST activities should not affect the safety of the plant, since inspectors, typically, only verify that the documentation is in order. This activity is also performed by the Owner's QA/QC departments and by periodic inspections by the staff, therefore, safety should not be affected.	N	N	N	N	N	D
5	ISTA 1.5	574	Delete the requirement for accessibility to be provided for the Inspector.	L	Access for inspection is no longer required with the deletion of AI's involvement.	N	N	N	N	N	N
6	ISTA 2	574	Delete Inspection from the title.	E							

Table 4-Summary and Evaluation of ASME OM Code Changes, 1997 Addenda (Continued)

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
7	ISTA 2.1	574	Delete this para. which addresses duties and qualifications of Inspectors, and accessibility.	L	The AI is no longer required to review the IST plan, verify that tests are complete and results recorded, verify examinations are performed in accordance with written procedures. The inspector's qualification and access requirements have also been deleted.	N	N	N	N	N	N
8	ISTA 2.2	574	Renumber para.	E							
9	ISTA 2.2.4(c), (e), 2.2.5(b)	574	Delete "and enforcement."	L	The inservice test plan is no longer required to be filed with or approved by the enforcement agencies.	N	N	N	N	N	N
10	ISTA 2.2.7	591	Add new para. to ISTA to address test and examination procedures.	L	These requirements were contained in ISTD 1.6, and are required by the Owner's QA programs.	N	N	N	N	N	N
11	ISTA 3.2.3	591	Add new para. to address test and examination result records.	L	These requirements have been relocated from Subsections ISTB, ISTC, and ISTD.	N	N	N	N	N	N
12	ISTA 3.2.4	591	Add new para. on record of corrective actions.	L	These requirements have been relocated from Subsections ISTB, ISTC, and ISTD.	N	N	N	N	N	N
13	ISTA 3.3.1	574	Delete "in a manner which will allow access by the Inspector."	L	Access for inspection is no longer required with the deletion of AI involvement.	N	N	N	N	N	N
14	ISTA 3.3.3 (c)	591	Combine para. (c)-(f) into (c).	E							
15	ISTA 3.3.3(d)	591	Add new para. to require records of corrective action to be retained.	L	This revision does not add any new requirements over what a licensee's QA program would require.	N	N	N	N	N	N

Table 4-Summary and Evaluation of ASME OM Code Changes, 1997 Addenda (Continued)

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
16	ISTB 1.1	616	Delete generic discussions found in ISTA 1.1.	E							
17	ISTB 3.1	591	Add reference to ISTA 1.4	E							
18	ISTB 7.2, ISTC 6.2	591	Add reference to ISTA 2.2.2 and 2.2.7, and delete duplicate requirements.	E							
19	ISTB 7.3, ISTC 6.3	591	Delete para.	E	These requirements may now be found in ISTA 3.2.3.						
20	ISTB 7.4, ISTC 6.4	591	Delete para.	E	These requirements may now be found in ISTA 3.2.4.						
21	ISTC 1.1	616	Delete generic discussions found in ISTA 1.1.	E							
22	ISTC 2	591	Add reference to ISTA 1.4	E							
23	ISTD 1.1	616	Delete generic discussions found in ISTA 1.1.	E							
24	ISTD 1.2	591	Delete para.	L	Requirements are now covered by ISTA 1.4(e) and (l), ISTA 2.2.7.	N	N	N	N	N	N
25	ISTD 1.4	605	Revise definition of unexplained failure to bé failures that have not been, instead of can not be, determined.	L	This definition does not change any requirements.	N	N	N	N	N	N

Table 4-Summary and Evaluation of ASME OM Code Changes, 1997 Addenda (Continued)

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
26	ISTD 1.4	592	The definition of service life has been broadened to be the period of time between all maintenance activities, and not just the replacement of parts, lubricant replacement or similar activity necessary to renew service life.	L	The service life monitoring program should not be affected by the change in definition.	N	N	N	N	N	N
27	ISTD 1.6	591	Delete para.	L	The requirement for written procedures may now be found in ISTA 2.2.7. Specific procedure requirements are included in the Owner's QA program, and are not necessary in the Code.	N	N	N	N	N	N
28	ISTD 1.7	591	Delete para. (b) through (g), add reference to ISTA 3.2.3.	L	The deleted requirements are now contained in ISTA 3.2.3 and 3.2.4.	N	N	N	N	N	N
29	ISTD 1.8	591	Delete para.	E	Personnel qualification requirements are now covered by ISTA 1.4(e).						
30	ISTD 1.15	591	Delete para.	L	ISTA 3.3.1 addresses maintenance of records required by the Code. The Owner's QA Program provides for the control of these and other QA records.	N	N	N	N	N	N
31	ISTD 2.2	591	Delete para.	L	These requirements are covered by ISTA 3.2.3.	N	N	N	N	N	N
32	ISTD 3.3	591	Delete para.	L	These requirements are covered by ISTA 3.2.3.	N	N	N	N	N	N

Table 4-Summary and Evaluation of ASME OM Code Changes, 1997 Addenda (Continued)

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
33	ISTD 7.2.5	592	Add reference to ISTD 8.4.	E							
34	ISTD 7.7	605	Add reference to ISTD 7.11 or 7.14, renumber para. 7.7 to 7.7.1, replace the second and third 'shall' in 7.7.11(b) with 'should,' replace 'shall' with 'should' in first sentence of ISTD 7.7.2.	L	This change allows the licensee to perform the required additional testing prior to completing the root cause analysis. The determination and use of failure mode groups (FMG) is no longer a requirement, but is now only a recommendation. Additional testing may be performed in the general snubber population, instead of limiting the additional testing to a limited population based on the common potential for failures. By deleting this requirement, the same number, or more additional snubbers will be required to be tested, depending on the size of the FMG, thereby, resulting in an equivalent level of quality and safety. The licensee may realize a decrease in cost and critical path as a result of delaying the root cause analysis and determining all the other susceptible snubbers, especially for a small number of failures.	N	N	N	D	N	D
35	ISTD 7.7.1-7.7.4	605	Renumber to ISTD 7.7.2 to 7.7.5.	E							
36	ISTD 7.8	605	Delete requirement for failed snubbers to be evaluated to establish failure mode groups.	L	See discussion above for ISTD 7.7.						
37	ISTD 7.10.4(a)	605	Revise reference to ISTD 7.7.1.	E							

Table 4-Summary and Evaluation of ASME OM Code Changes, 1997 Addenda (Continued)

Item No.	Paragraph, Figure, Table	BNCS Ballot	Description	Impact	Explanation of Impact and Factors	Safety	Occ Exp	Pub Exp	Crit Path	Record	Cost
38	ISTD 8.4	592	Replace "shall include both" with "shall consider the results" and replace the terms verification and verified in (b) with monitoring or monitored.	E							
39	I 1.1	616	Delete generic discussions found in ISTA 1.1, and last sentence concerning recommended performance data.	L	The applicability statements do not provide requirements.	N	N	N	N	N	N
40	I 4.1.1(h), 4.1.2(h), 4.1.3(g), 8.1.1(h), 8.1.2(h), 8.1.3(g)	597	Revise the time required between successive relief valve openings from 10 min. to 5 min.	L	The data presented with this code change, reflected minimal effect with a change of hold times, therefore there should be no affect on safety.	N	N	N	N	N	N
41	I 5.1, 9.1	591	Delete second para.	L	Requirements covered by ISTA 3.2.	N	N	N	N	N	N
42	I 5.2, 9.2	591	Delete para.	L	Requirements covered by ISTA 3.2.1(a).	N	N	N	N	N	N
43	I 5.3, 9.3	591	Delete para.	L	Requirements now covered by ISTA 2.2.7.	N	N	N	N	N	N
44	I 5.4, 9.4	591	Delete general requirements found in ISTA, add reference to ISTA 3.2.3, revise title.	E							
45	I 5.5, 9.5	591	Revise titles, add reference to ISTA 3.2.4.	E							

Valve and Pump Testing in the UK Nuclear Power Programme—A Regulator's View

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Abstract

The use of valves and pumps is widespread in nuclear plant and they are component parts of process, control and protection systems. A large modern reactor might have 20,000 valves and 100 pumps. These items will be of different types with different operational and environmental conditions.

The testing of pumps and valves in inaccessible spaces requires a special approach to cold set pressure and set pressure. Their use with radioactive and toxic fluids imposes further restraints on the usefulness of testing for full flow capability unless extra subsystems are in place. Recent experience with safety relief valves in British reactors has revealed drift over short periods together with the need to amend procedures for both testing and re-setting. This experience is examined for new and older reactor systems.

Relevant legislation in the UK and Europe is described as it affects nuclear pumps and valves. In particular, the regulatory regimes for nuclear and industrial safety in valve and pump testing and requirements are discussed. Design codes from ASME and Europe have been used in the UK with differing specification. One major specification needs to be that of the environmental qualification, but maintenance and ageing must be taken into account with some sort of condition monitoring. Each can and does affect the capability for testing and the usefulness of the results.

The possible role of education in the design for safety and testing of pressurised systems, pumps and valves is explored.

Introduction

The use of pumps and valves is widespread in nuclear plant where they are component parts of process, control and protection systems. A large modern reactor of the non-passive types will have about 20,000 valves and hundred of pumps.

My organization is the regulator of health and safety on nuclear licensed sites and my job is to make specialized assessments and inspections of mechanical engineering systems, structures and components in power reactors. The Unit in which I work deals with large gas cooled reactors and the PWR reactor at Sizewell B.

Functions of pumps and valves

The pumps provide boiler feed water, condensate, instrument air, coolants and lubricating oil to main, ancillary and auxiliary systems. The valves facilitate flow control, stopping and starting, safety and pressure relief, diversion and logic sequencing.

They have varied duties as main or standby items, isolation or constant use.

They need maintenance, monitoring and inspection of different types and comprehensiveness. Regular refurbishment and overhaul are essential for most pumps and for larger valves such as the safety and relief valves. Different duties—such as main, stand by or emergency—might justify different inspection and maintenance regimes.

Regulation in the United Kingdom

The regulation of the nuclear industry for health, safety and environment in the United Kingdom is enforced by the Health and Safety Executive (HSE) and by the environmental agencies.

The Health and Safety at Work, etc. Act of 1974 (HSWA74)—reference 1—is the principal legislation that created and empowers the HSE and the Health and Safety Commission, to regulate health, safety and the protection of the environment from work activities. HSWA74 places a duty of care on employers and employees to do all that is reasonably practicable to protect health and safety. The Act applies to nuclear and non-nuclear industries alike. The policy of the HSE towards enforcement is stated in reference 2. The principles of enforcement policy are proportionality in applying the law and securing compliance; consistency in approach; targeting of enforcement action; and transparency about how the regulator operates and what those regulated may expect.

Although it has been on the statute book for longer than the HSWA74, the Nuclear Installations Act of 1965 (NIA65, reference 3) is subsidiary to it. Under the NIA65 and its amendments, the Nuclear Installations Inspectorate (NII) is empowered to regulate the safety of nuclear power plant sites, nuclear chemical plant sites and certain other nuclear installations. Through NII, which is part of its Nuclear Safety Directorate, HSE operates a licensing regime for these nuclear installations. By means of site license conditions that it attaches to a license, NII is able to regulate and enforce the maintenance of standards of safety, health and the protection of the environment on licensed sites. The licensing regime is not prescriptive; it is essentially a regime of goal setting.

The Environmental Protection Act 1990 (EPA90 reference 4) is the principal legislation that created and empowers the Environment Agency (for England and Wales) and the Scottish Environmental Protection Agency to regulate the control of discharges of noxious effluents to the environment. To enable better co-ordination of regulation, there are official memoranda of understanding between the regulatory bodies. Matters of mutual interest include incidents that might lead to discharges to the environment. These could come from the spurious operation of relief valves.

Of more recent origin, but of direct relevance are the European Council Directives. These are given effect in the United Kingdom by Acts and Regulations made by Parliament. For example, the Basic Safety Standards Directive 80/836/Euratom lays down the basic safety standards for the health protection of the general public and workers against the dangers from ionizing radiation.

The Pressurized Equipment Directive (reference 5) has led to the Pressure Equipment Regulations 1999 (reference 6) which apply to the placing onto the market or the putting into service of equipment after November 1999. Consequently, these regulations will apply to the replacement of SRVs and pumps, and any modifications to their systems.

Also of direct relevance, the Pressurized Systems Safety Regulations 2000 (reference 7) have been made under the HSWA74 and in general address the design and construction, installation and operation of pressure systems at work.

Clearly, the operator of a pressurized reactor needs to take notice of several systems of regulations. These are statutory requirements and are in addition to his commercial and in-house constraints and obligations.

Nuclear Industry Regulation

The intent and wording of site license conditions varied greatly between those for power stations and those for other types of installation, and also between power stations of similar type. In 1977, the public inquiry was held by the late Sir Frank Hayfield QC into the application to build a PWR at Sizeable B. NII was requested by the Inspector to consider codifying its approach to the assessment of safety at installations and thereby to facilitate the comparison of an operator's safety guidelines with the safety principles of the regulator. Also recommended by the Inquiry was the publication by HSE for discussion of its thinking on risk issues, which led to reference 8.

In 1992, NII published its revised safety assessment principles or SAPs (reference 9) for nuclear installations. They are intended for use by NSD in the assessment of new plants, but can be used for existing plants. Then in 1992, NII introduced the standard model license with 35 (now 36) standard conditions for all types of licensed nuclear installations.

In line with the goal setting approach, site license conditions require the licensee to make and to implement arrangements adequate for the effective management and control of the different aspects of his activities. Those activities can range from the design of plant and equipment through to its decommissioning.

NII or the Nuclear Installations Inspectorate

From August 1, 2000, NSD is organized into four divisions, two of which address the operators of the two major British reactor types and the third of which addresses the other licensees. Division 1 deals with the eight sites of the British Energy Group (BEG). Division 2 deals with the sites of British Nuclear Fuels Limited who operate Magnox reactors and fuel processing plants. Division 3 deals with the varied sites of defense installations, research reactors and fuel plant. Division 4 deals with the formulation of strategy and the pursuit of research. NII is the regulatory part of the directorate and it comprises the appropriate staff within the directorate.

With the exception of the PWR at Sizewell B, the reactors on BEG sites are of an advanced gas-cooled and graphite moderated type known as AGRs. The AGR reactors have been in operation since before the revised SAPs and the standard license came into effect. Therefore, the assessment of the safety of the plant and equipment requires judgement when using the revised SAPs.

The original design of the plant was predicated on the assumptions that its components would retain their functionality and reliability. The design of the reactors and their component items was undertaken to achieve a balance between functional requirements and the constraints of cost, materials properties and certification, codes and analyses, manufacturing methods and QA, inspection and testing, etc. That balance is not the same as today's balance would be because of improvements in materials properties, computerized methods of analyses, electronic monitoring of component condition, and accumulated operational experience. The reliability of the components will be maintained through the life of the reactor only if comprehensive and appropriate programs of inspection, testing and maintenance are devised and followed.

Consequently, the regulation of the reactors, systems, procedures, plant and components relies heavily on the experience and judgement of the inspectors, and on the use of national and international feedback and guidance. In order not to expect the operators of existing plant to upgrade it continuously, the law looks for improvements to safety, etc., to be made that are reasonably practicable. In other words, the benefits for safety, health and the environment from improvements to work activities should not be pursued by regulators if they are achievable only at grossly disproportionate cost in resources or money.

Safety assessment

Through license condition 15, a licensee is required to undertake a review of the validity of the safety case for the plant. A Periodic Safety Review or PSR aims to review the operating history to identify any factors which could limit the safe operating life of the reactor; to make comparisons with current standards and to identify any improvements which are reasonably practicable to implement; and to examine all the relevant mechanisms of ageing in order to confirm the safe period of operation will continue until the next PSR. A major part of the work of the review is a comparison against modern standards and although the review is not a safety case, it is assessed by NSD against the SAPs.

To provide a transparent framework for consistent assessment and inspection of nuclear plant, NII published its set of revised safety assessment principles (reference 9). The SAPs document contains a long section devoted to the engineering principles that should be applied when assessing plant and equipment. To help inspectors to follow the enforcement policy, NSD has provided guidance documents such as reference 10. Additional guidance is available in the Safety Series of documents from the IAEA. Typical of these are the documents on in-service maintenance (reference 11) and inspection (reference 12).

From the SAPs, the following selection is from those that can appertain to pumps and valves.

Categorization and classification

SAP P69 looks for the categorization of each structure, system and component (SSC) by taking account of the consequences of their potential failure and of the requirements on failure frequency that are placed on them by the safety analysis.

Each SSC is capable then of having a standard of design and analysis, of monitoring, of construction and fabrication, of inspection, of QA allocated to it.

For the majority of UK pumps and valves in reactors, the design work predates the use of categorization and therefore only their maintenance can be subject to this discipline, unless the component is to be replaced or modified.

Maintenance, inspection and testing

SAP P329 expects that the requirements for inservice testing, inspection or other maintenance procedures and the frequencies for which specific claims have been made in the safety case are identified and included in a maintenance schedule. The schedule is such an important document that a licensee is required by license condition (28) to make arrangements for the preparation of the maintenance schedule.

Equipment qualification

SAP P90 seeks for procedures for equipment qualification that ensure the recording and retrieval of lifetime data from the manufacture, testing, inspection and maintenance of safety SSCs. The intention is that a demonstration can be made to show that the assumptions in the safety case remain valid throughout the design life of the plant.

Owner's criteria

Each AGR was designed by a consortium comprised of companies with expertise in reactor engineering, civil engineering, turbo-alternator engineering, equipment and plant manufacture, etc. The owner provided design safety guidelines which addressed the deterministic and later the probabilistic engineering safety criteria. Most of the pumps and valves were purchased to British Standard Specifications and some to ASME standards, but all were purchased to the overarching company specifications of the owner.

At periods of 10 years, an operator will conduct a review of the plant and safety case. This is known as a Periodic Safety Review (PSR) and it is required under license condition 15. Under the circumstances of regulatory licensing, the pumps and valves of pre-SAP reactors are subject to inspections and reviews of their fitness for continuing purpose. The maintenance and testing activities assume increasing importance as the items age. Increased availability from a reactor causes the pumps and valves to be used more often or harder.

Pumps and valves

Primary coolant safety and relief valves

Each AGR has either three or four safety relief valves of the spring loaded full lift type in the primary circuit. The earlier AGRs have their valves on a manifold and each has a pilot valve and isolating valve. The later AGRs have two manifolds having a pair of valves, each with an isolating valve. Any one valve is capable of preventing the pressure raising to greater than 110% of the maximum operating pressure of the pre-stressed concrete pressure vessel (PCPV).

The absolute limits on vessel pressure are set between the maximum safe limit of the PCPV and the highest fault pressure. Between these two limits are set the maximum design pressure of the PCPV. Hence the set lift pressures (maximum and minimum) can be chosen, with small allowances for the error in setting and for drift.

The nature of the heat transfer properties of the coolant gas carbon dioxide is such that it is desirable to maintain pressure in the primary coolant circuit in order to continue cooling the fuel in the core. Therefore, there is a need for the SRVs to be set with high confidence that a valve will not open spuriously at pressures close to the normal operating pressure of the reactor and to reseat promptly and effectively.

Site license condition 30 requires that each reactor be shut down every 3 years for maintenance, testing and repair. These statutory outages enable the operator to undertake work that cannot be done with the reactors pressurised. License condition 28 requires arrangements for the examination, inspection, maintenance and testing of equipment that might affect safety.

When the reactor is shut down for its statutory outage, each SRV is pop tested to determine its set pressure, usually with several tests. The test figures are used to check the drift of set pressures away from the specified pressures. One SRV is overhauled fully at each statutory outage. In the workshop, the refurbished SRV is pop tested for leak tightness and its freedom of movement is checked. Once re-installed in the reactor circuit, the SRV is pop tested and adjusted until its set pressure is achieved with three consecutive tests.

Each SRV is tested for pressure relief at every outage (normally, every year). Otherwise, pop testing is used to check set pressure at ambient temperatures and tests of freedom of movement are made.

The regular testing for pressure lift and for lift heights has provided some data for the operator about drift in the values of set pressure. However, there appears to be no systematic reason for the drifts. The latest drift of note was a 1.9 bar downward drift in a SRV set for 47 barg. This figure is within the normal distribution of set values that underpin the licensee's choice of operating limits, but it is outside the allowances for drift or instrumentation error. The setting procedures have been amended. The concern currently with drift is that it has occurred sometimes within a few months of the setting of the SRV. Because the SRVs are in radiation areas, they cannot be set unless the reactor is in a powered down state, and this means that the valve is cooler than normal operations and the system pressures are not as usual because of its isolation from the circuit. Both effects are possible contributors to drift in set pressures.

Lift heights when measured have been found to be well above the minimum required for safety, though sometimes they have been found to be below the specified range. The main cause of the lift height setting problem was the machining of components that cumulatively diminished the set height of the lift limiting devices. This problem caused the temporary down rating of AGRs and it was reported widely by BEG to industry.

Sizewell B PWR

On March 6, 1999 while shut down for refueling, the PWR at Sizewell B underwent the opening of a safety relief valve on a line from the primary coolant system in the reactor containment building —an incident that was rated at level 1 on the INES scale. At the time, the valve was being tested (reference 13). The test was being performed to a written procedure to determine the pressure setting of the safety relief valve. However, the relief valve did not reseat fully, possibly because of the small margins between circuit pressure and the set pressure, simmer pressure and the reseat pressure of the valve. The situation was brought under control although 20 tons of circuit water had entered the relief tank and sumps.

Aging of Valves

The ageing mechanisms of valves for nuclear service are addressed in the integrity assessment of ageing components (INTACT) program of the European Commission. The INTACT project is a part of the 4th Framework Program of the European Commission on Nuclear Fission Safety. Reference 14 provided an overview of the ageing studies and a report (reference 15) is being drafted to bring up to date the topic of motorized valves. Although the particular type of valve is the motor operated valve, the problems of the valve itself are identical to the non-motorized valve. Amongst the tests described in the recent reports are functional tests of the flow capacity and tests of the operability of the valve components e.g., the stem, the motor. Monitoring of the ageing of the valves can be achieved by measurements of torque, current to the motor, stem forces, delay times.

Pumps

A typical AGR reactor has one main 100% boiler feed pump (MBFP) and 2 starting and standby 50% feed pumps (SSBFPs). For shut down conditions, there is the decay heat boiler feed system with 4 pumps of 50%. Backing these up in the event of failure are emergency boiler feed pump systems (EBFPs). The EBFPs number 4 and provide 2.5% of normal boiler feed.

The pumps are of different types and are driven by different means. MBFPs are driven by turbine with steam bled from the main turbine HP cylinder. The SSBFPs are electrically driven and are used to feed the boilers until sufficient steam is available to drive the MBFP. The EBFPs are driven by electric motors that draw electrical supply from a different source than do the SSBFPs.

Pumps with a safety duty are tested every 3 years, increased from 2 years because of maintenance optimization. The exceptions are Emergency Cooling Water pumps that are removed and stripped every two years because of the possibility of erosion and corrosion by seawater. Later centrifugal pumps have been designed to API610 and from comparisons with earlier standards, it is believed that the extra tests and monitoring required by the API610:1995 code are capable of being met by the older designs.

Testing in service of these varied pumps is achieved by the use of leak off circuits provided for this purpose. The MBFPs do not have a safety duty and these are tested by use of the usual feed piping and the boilers. Again, test data are available to enable trends to be determined. The use of different regimes for main and standby pumps is being considered for these large rotating machines and consequential effects on their reliability would be monitored. A pump that is intended only for standby use will receive starting checks and endurance tests, with condition monitoring. Performance checks will be compared with the characteristic curves to look for any deterioration.

Education of engineers

The engineers who deal with the design and the operation of pumps and valves are encouraged to seek their continuing professional development as a normal part of their careers. It needs to be addressed in two ways, depending on the nature of the project.

For existing reactor systems such as those of the United Kingdom, the engineers need access to feedback of operational experience. To place it in a useful framework, the feedback should be presented in the form of descriptive text of failure incidents in addition to trending curves. To study only successful work is not as instructive, as Henry Petroski has made clear in reference 16.

For new and forthcoming designs, the engineer needs to take a systems approach. In this approach, the simulation of pumps and valves as electrical analogies should provide a useful insight into the function and nature of the different types. The simulation of unit operations as part of the design of refineries or chemical plant could be used to help develop new or improved design features for the valve and the pump.

For all engineers, health and safety should be a required module in a course of study. Unfortunately, there is only one degree-level course in the United Kingdom on health and safety for engineers. The Health and Safety Commission and Executive have provided written support to the Engineering Council in the United Kingdom in its attempt to strengthen this aspect of the formation of professional engineers.

Conclusion

In the United Kingdom, the nuclear power stations are subject to regulation by health and safety and environment regulators. Most regulation is of goal setting form and some is prescriptive; the major pieces of legislation are being reviewed in some respect.

The pressurized components of reactors are addressed by several systems of detailed regulations. Although some regulations have been in existence since before the reactors were designed and constructed, they have been amended since. Further systems have been introduced in accordance with European directives.

The design principles are known in most cases and there are available reports of the operational history and experience. Maintenance and inspection regimes are being revised to suit the different required duties of identical items.

Therefore, the testing of pumps and valves is a matter of dealing with equipment that is of "older" design in a framework of modern goal setting legislation. This requires engineers and others with the training, experience and knowledge to use sound professional engineering judgement in testing, maintaining, inspecting and regulating. They need guidance and feedback.

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Session 4

Regulatory Activities Update

Session Chair
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Performance of Safety-Related Motor-Operated Valves

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Abstract

Many fluid systems at nuclear power plants depend on the successful operation of motor-operated valves (MOVs) in performing their system safety functions. As a result of problems with MOV performance in nuclear power plants, the U.S. Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 89–10, "Safety-Related Motor-Operated Valve Testing and Surveillance," and GL 96–05, "Periodic Verification of the Design-Basis Capability of Safety-Related Motor-Operated Valves," requesting that U.S. nuclear power plant licensees verify initially and periodically the design–basis capability of MOVs in safety-related systems. The NRC has reviewed GL 89–10 and GL 96–05 programs as part of the preparation of safety evaluations and during inspections. In addition, several owners groups have developed a Joint Owners Group (JOG) program for the periodic verification of the design-basis capability of safety-related MOVs. The NRC has accepted the JOG program as an industry-wide response to GL 96–05 with respect to age-related valve degradation. The NRC issued GL 95–07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves," requesting that licensees ensure that safety-related power-operated gate valves (including MOVs) susceptible to pressure locking or thermal binding are capable of performing their safety functions. As a result of weaknesses in the information provided by static stroke-time testing performed as part of inservice testing programs, the NRC revised the regulations on September 22, 1999, to require that licensees supplement quarterly MOV stroke-time testing with a program to verify MOV design-basis capability on a periodic basis when implementing the American Society of Mechanical Engineers *Code for Operation and Maintenance of Nuclear Power Plants* (1995 Edition with 1996 Addenda). The NRC continues to monitor the efforts of the U.S. nuclear power industry to ensure proper performance of safety-related MOVs.

I. Introduction

Many fluid systems at nuclear power plants depend on the successful operation of motor-operated valves (MOVs) in performing their system safety functions. MOVs must be capable of operating under design-basis conditions, which may include high differential pressure and flow, high ambient temperature, and degraded motor voltage. The design of the MOV must apply valid engineering equations and parameters to ensure that the MOV will operate as intended during normal plant operations and design-basis events. Manufacturing, installation, preoperational testing, operation, inservice testing (IST), maintenance, and replacement must be

This paper was prepared by staff of the U.S. Nuclear Regulatory Commission. It may present information that does not currently represent an agreed-upon NRC staff position. NRC has neither approved nor disapproved the technical content.

conducted by trained personnel using proper procedures. Surveillance must be performed and testing criteria must be applied on a soundly based frequency in a manner that suitably detects questionable operability or degradation. Moreover, these activities must be monitored by a strong quality assurance program.

The regulations of the U.S. Nuclear Regulatory Commission (NRC) require that components that are important to the safe operation of a U.S. nuclear power plant be treated in a manner that ensures their performance. Appendix A, "General Design Criteria for Nuclear Power Plants," and Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 50) contain broadly based requirements in this regard. In 10 CFR 50.55a, the NRC has required U.S. nuclear power plant licensees to implement provisions of the American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code (B&PV Code) for testing of MOVs as part of their IST programs. On September 22, 1999, the NRC revised 10 CFR 50.55a to require that, when implementing the 1995 Edition with the 1996 Addenda of the ASME *Code for Operation and Maintenance of Nuclear Power Plants* (OM Code), licensees supplement the quarterly MOV stroke-time testing specified in the ASME Code with a program to verify MOV design-basis capability on a periodic basis.

Operating experience at nuclear power plants in the 1980s and 1990s revealed weaknesses in many activities associated with MOV performance. For example, some engineering analyses used in the original sizing and setting of MOVs did not adequately predict the thrust and torque required to open and close valves under design-basis conditions. Both regulatory and industry research programs later confirmed the weakness in the initial design and qualification of MOVs. Shortcomings in maintenance programs, such as inadequate procedures and training, also resulted in poor MOV performance. Further, testing of MOVs to measure valve stroke times under zero differential-pressure and flow conditions was shown not to detect certain deficiencies that could prevent MOVs from performing their safety functions under design-basis conditions.

II. Verification of MOV Design-Basis Capability

In response to weaknesses in MOV performance, the NRC staff issued Generic Letter (GL) 89–10 (June 28, 1989), "Safety-Related Motor-Operated Valve Testing and Surveillance." In GL 89–10, the NRC staff requested that licensees ensure the capability of MOVs in safety-related systems to perform their intended functions by reviewing MOV design bases, verifying MOV switch settings initially and periodically, testing MOVs under design-basis conditions where practicable, improving evaluations of MOV failures and necessary corrective action, and trending MOV problems. The NRC staff requested that licensees complete the GL 89–10 program within approximately three refueling outages or 5 years of the issuance of the generic letter.

In support of the industry effort to respond to GL 89–10, the Electric Power Research Institute (EPRI) developed the EPRI MOV Performance Prediction Methodology (PPM) to predict dynamic thrust and torque requirements for gate, globe, and butterfly valves. On March 15, 1996, the NRC staff issued a safety evaluation (SE) accepting the EPRI MOV

PPM with certain conditions and limitations. On February 20, 1997, the NRC staff issued a supplement to the SE on general issues and two unique gate valve designs. NRC Information Notice (IN) 96–48 (August 21, 1996), "Motor-Operated Valve Performance Issues," alerted licensees to lessons learned from the EPRI MOV program. Among the lessons learned were the following: (1) the thrust requirements to operate some gate valves under pump flow and blowdown conditions were higher than predicted by the manufacturers; (2) a potential exists for gate valves to be damaged when operating under blowdown conditions such that the thrust requirements can be unpredictable; (3) the effective flow area in some globe valves can be larger than expected and can cause thrust requirements to be higher than predicted; and (4) the friction coefficients for sliding surfaces in gate valves can increase with service before reaching a plateau.

Nuclear power plant licensees implemented the recommendations of GL 89–10 through a combination of design-basis reviews, revision of MOV calculations and procedures, static and dynamic diagnostic testing, industry-sponsored research programs, and trending of test results. The industry expended significant resources to resolve the deficiencies in the design, qualification, and application of safety-related MOVs that led to the issuance of GL 89–10. The NRC staff has evaluated the MOV program at each nuclear plant through onsite inspections of the design-basis capability of safety-related MOVs. The NRC staff has closed its review of GL 89–10 for every (except one) U.S. nuclear power plant.

III. Long-Term Aspects of MOV Performance

On September 18, 1996, the NRC staff issued GL 96–05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," to provide recommendations for the long-term verification of MOV design-basis capability. In GL 96–05, the NRC staff requested that licensees establish a program, or ensure the effectiveness of their current program, to verify on a periodic basis that safety-related MOVs continue to be capable of performing their safety functions within the current licensing basis of the facility. The guidance in GL 96–05 supersedes the guidance in GL 89–10 on long-term MOV programs.

In GL 96–05, the NRC staff noted five attributes of effective programs for periodic verification of safety-related MOV design-basis capability at nuclear power plants:

(1) A risk-informed approach may be used to prioritize valve test activities, such as frequency of individual valve tests and selection of valves to be tested.

(2) The valve test program provides adequate confidence that safety-related MOVs will remain operable until the next scheduled test.

(3) The importance of the valve is considered in determining an appropriate mix of exercising and diagnostic testing. In establishing the mix of testing, the benefits (such as identification of decreased thrust output and increased thrust requirements) and potential adverse effects (such as accelerated aging or valve damage) are considered when determining the appropriate type of periodic

verification testing for each safety-related MOV.

(4) All safety-related MOVs covered by the GL 89–10 program are considered in the development of the periodic verification program. The program includes safety-related MOVs that are assumed to be capable of returning to their safety position when placed in a position that prevents their safety system (or train) from performing its safety function; and the system (or train) is not declared inoperable when the MOVs are in their nonsafety position.

(5) Valve performance and maintenance are evaluated and monitored, and the periodic verification program is periodically adjusted as appropriate.

In response to GL 96–05, several U.S. nuclear power plant owners groups developed an industry-wide Joint Owners Group (JOG) Program on MOV Periodic Verification to obtain benefits from the sharing of information between licensees on MOV performance. The participating owners groups are the Boiling Water Reactor Owners Group (BWROG), the Babcock & Wilcox Owners Group (B&WOG), the Combustion Engineering Owners Group (CEOG), and the Westinghouse Owners Group (WOG). Elements of the JOG program include (1) an "interim" MOV periodic verification program for applicable licensees to use in response to GL 96–05; (2) a dynamic testing program over the next 5 years to identify potential age-related increases in required thrust and torque to operate gate, globe, and butterfly valves under dynamic conditions; and (3) a long-term MOV diagnostic program based on information from the dynamic testing program. On October 30, 1997, the NRC staff issued an SE accepting the JOG Program on MOV Periodic Verification with certain conditions and limitations. Most licensees have committed to implement the JOG program as part of their response to GL 96–05. The NRC staff meets periodically with JOG to discuss the status and results of the JOG program.

Licensees are applying risk insights in implementing their long-term MOV programs. In Topical Report NEDC 32264, "Application of Probabilistic Safety Assessment to Generic Letter 89–10 Implementation," BWROG describes a methodology to rank MOVs according to their relative importance to core damage frequency and other considerations to be applied by an expert panel. On February 27, 1996, the NRC staff issued an SE accepting the BWROG methodology for risk ranking MOVs with certain conditions and limitations. On June 2, 1997, WOG submitted Engineering Report V–EC–1658 (Revision 1) describing an MOV risk-ranking approach for Westinghouse-design nuclear plants. On April 14, 1998, the NRC staff issued an SE accepting the WOG methodology for risk ranking MOVs with certain conditions and limitations.

As the JOG program focuses on potential increases in MOV operating requirements, licensees address potential degradation in the output of MOV motor actuators by their plant-specific programs. In Limitorque Technical Update 98–01 (May 15, 1998) and Supplement 1 (July 17, 1998), Limitorque Corporation provided updated guidance for the prediction of the output capability of its ac-powered motor actuators. The NRC issued Supplement 1 to IN 96–48 on July 24, 1998, to alert licensees to this new information on MOV motor actuator output. In its technical update, Limitorque also indicated that updated guidance for predicting the output capability of dc-powered motor actuators would be issued. BWROG has recently developed such guidance for dc–powered motor actuators based on an evaluation of available test information. The NRC staff is considering the need to prepare a supplement to IN 96–48 to alert licensees to the updated guidance for predicting the output capability of dc-powered MOVs.

The NRC staff is preparing an SE to document its review of the response to GL 96–05 by each U.S. nuclear power plant licensee. If a licensee commits to implement the JOG program, the NRC staff relies to a significant extent on that commitment in preparing the SE without the need for plant-specific inspection activity in most instances. The NRC staff reviews GL 96–05 programs of licensees that have not committed to the JOG program by a separate process of submittals and inspections, as appropriate.

IV. ASME Code Improvements for MOV Inservice Testing

The ASME Code specifies that stroke-time testing of MOVs be conducted as part of the IST programs of nuclear power plants on a quarterly frequency where practical. The NRC and the industry have long recognized the limitations of stroke-time testing as a means of monitoring the operational readiness of MOVs. In the recent revision to 10 CFR50.55a, the NRC requires U.S. nuclear power plant licensees implementing the 1995 Edition with the 1996 Addenda of the ASME OM Code to supplement the quarterly MOV stroke-time testing specified in the Code by a program to verify MOV design-basis capability on a periodic basis.

In response to concerns about the adequacy of MOV stroke-time testing, the ASME Operations and Maintenance Code Committee developed ASME Code Case OMN–1, "Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor Operated Valve Assemblies in LWR Power Plants, OM Code 1995 Edition; Subsection ISTC." As an alternative to frequent stroke-time testing, ASME Code Case OMN–1 allows periodic exercising of all safety-related MOVs once per cycle and periodic diagnostic testing under static or dynamic conditions, as appropriate, on a frequency determined by margin and degradation rate. In GL 96–05, the NRC staff noted that the method in ASME Code Case OMN–1 could be used as part of a licensee's response to the generic letter.

In the recent revision to 10 CFR 50.55a, the NRC endorsed the use of ASME Code Case OMN–1 as an acceptable alternative to the quarterly MOV stroke–time testing specified in the ASME OM Code with certain conditions. In the rule, the NRC stated that, where a selected test interval for an MOV under ASME Code Case OMN–1 exceeds 5 years, the licensee must evaluate information obtained from valve testing during the initial 5-year period to validate assumptions made in justifying the longer test interval. The NRC also specified that licensees must evaluate the potential increase in risk associated with extending the quarterly exercise frequency for MOVs identified as having a high safety significance. In the background discussion of the rule, the NRC noted that, as part of implementing ASME Code Case OMN–1, licensees need to consider the benefits (such as identification of decreased thrust output and increased thrust requirements) and potential adverse effects (such as accelerated aging or valve damage) when determining appropriate testing for each MOV. Also in the background discussion of the rule, the NRC noted that the provisions of ASME Code Case OMN–1 would satisfy the regulatory requirements for supplementing quarterly MOV stroke-time testing with the conditions specified in the rule.

Currently, ASME is working to incorporate ASME Code Case OMN–1 directly into the ASME OM Code. The NRC staff is also preparing a regulatory guide to endorse the use of ASME Code Case OMN–1 as an alternative to the MOV stroke-time test provisions of the ASME B&PV Code.

V. Pressure Locking and Thermal Binding of Gate Valves

Pressure locking can occur in flexible-wedge and double-disk gate valves when pressure in the bonnet is higher than the line pressure on both sides of a closed disk and the valve actuator is not capable of overcoming the additional thrust required as a result of the differential pressure. Thermal binding is generally associated with a solid- or flexible-wedge gate valve that is closed at high temperature and is allowed to cool before reopening is attempted such that mechanical interference occurs because of contraction of the valve body on the disk wedge. The nuclear industry and NRC have issued numerous generic communications on the potential for gate valves to experience pressure locking and thermal binding.

On August 17, 1995, the NRC issued GL 95–07, "Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves," to request that licensees perform, or confirm that they had previously performed, (1) evaluations of the operational configurations of safety-related, power-operated (including motor-, air-, and hydraulically operated) gate valves for susceptibility to pressure locking and thermal binding; and (2) further analyses, and any needed corrective actions, to ensure that safety-related power-operated gate valves that are susceptible to pressure locking or thermal binding are capable of performing their safety functions within the current licensing basis of the facility.

Testing sponsored by the NRC Office of Nuclear Regulatory Research at the Idaho National Engineering and Environmental Laboratory (INEEL) to study pressure locking and thermal binding of gate valves. The test valves included a six-inch Walworth flexible-wedge gate valve and a six-inch Anchor/Darling double-disc gate valve. Both valves were determined to be susceptible to pressure locking. Heatup of the valve caused the bonnet to pressurize slowly until leakage was overcome and then to pressurize rapidly. Air pockets were found to remain trapped in the valve bonnet after both heatup and subsequent cooldown. No significant increase in thrust requirements was found during thermal binding tests for these valves. A previous test program had revealed a significant increase in unseating load under thermal binding conditions. The study is described in NUREG/CR–6611 (May 1998), "Results of Pressure Locking and Thermal Binding Tests of Gate Valves."

Commonwealth Edison (ComEd) has developed a methodology to predict the thrust required to open flexible-wedge gate valves under pressure locking conditions. As discussed in the evaluations of licensee responses to GL 95–07 applying the ComEd methodology, the NRC staff considers the ComEd methodology to provide a technically sound basis for assuring that flexible-wedge gate valves susceptible to pressure locking are capable of performing their intended safety-related function with certain conditions. For example, the staff agrees with the ComEd provision of minimum margins to be available between calculated pressure locking thrust and actuator capability when applying its methodology. Further, licensees using the ComEd methodology are responsible for ensuring that the thrust values calculated to overcome pressure locking for their valves remain valid after implementation of any revisions or enhancements to the ComEd pressure locking prediction methodology. Certain other licensees have developed pressure locking methodologies that have been evaluated on a plant-specific basis.

The NRC staff prepares an SE to discuss its review of the response to each licensee to GL 95–07. As part of this review, the staff determines whether the licensee has performed appropriate evaluations of the operational configurations of safety-related power-operated gate valves to identify valves that are susceptible to pressure locking or thermal binding and have taken, or is scheduled to take, the appropriate corrective actions to ensure that these valves are capable of performing their intended safety functions. The NRC staff has completed its review of GL 95–07 for almost all U.S. nuclear power plants.

VI. Conclusions

The U.S. nuclear power industry has completed the verification of the design-basis capability of safety-related MOVs in response to GL 89–10 (with the exception of one facility). Substantial NRC and licensee resources were required to resolve deficiencies in the design, qualification, and application of safety-related MOVs that led to the issuance of GL 89–10. Licensees are implementing long-term MOV periodic verification programs in response to GL 96–05. Most licensees have committed to implement the JOG Program on MOV Periodic Verification as part of their response to GL 96–05. The NRC staff relies to a significant extent on licensee commitments to the JOG program in closing its review of GL 96–05 to minimize the need for plant inspection activity. In a rulemaking on September 22, 1999, the NRC endorsed ASME Code Case OMN–1 as an alternative to the quarterly MOV stroke-time testing specified by the ASME OM Code. The NRC staff is preparing a regulatory guide to endorse ASME Code Case OMN–1 for use by licensees applying the ASME B&PV Code. In the recent rulemaking, the NRC also directed that licensees implementing the ASME OM Code must supplement the quarterly MOV stroke-time testing in their IST programs with a program to periodically verify MOV design-basis capability. In GL 95–07, the NRC staff requested that licensees take actions to ensure that valves susceptible to pressure locking or thermal binding are capable of performing their safety functions within the current licensing basis of the facility. The NRC staff has completed its review of GL 95–07 for almost all U.S. nuclear power plants. The NRC continues to monitor the efforts of the U.S. nuclear power industry to ensure proper performance of safety-related MOVs.

Performance of Air-Operated Valves Important to Plant Safety and Other Inservice Testing Issues

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Abstract

On September 22, 1999, the regulations were revised to incorporate by reference the 1995 Edition of the American Society of Mechanical Engineers (ASME) *Code for Operation and Maintenance of Nuclear Power Plants* with the 1996 Addenda. This Code edition and addenda contain several changes which enhance safety and reduce requirements. The most beneficial change to the Code with respect to safety is the periodic requirement to test safety-related pumps within ±20% of their design flow rate where practicable. The comprehensive test will provide for an optimum performance point to determine degradation in safety-related pumps over the life of the plant. Some of the reduced requirements in the Code include elimination of thermal equilibrium verification for safety and relief valves testing under ambient conditions using a test medium at ambient conditions, relaxed accumulator volume requirements, and provisions for check valve sample disassembly and inspection.

The Nuclear Regulatory Commission staff and industry have also worked to develop an industry-wide approach to verify the design basis capability of power-operated valves. This paper discusses the industry initiatives in developing an air-operated valve (AOV) program, recent AOV performance issues and inspection results, and closure of Generic Safety Issue (GSI) 158 as documented in Regulatory Issue Summary (RIS) 2000–03, "Resolution of Generic Safety Issue 158: Performance of Safety-Related Power-Operated Valves Under Design Basis Conditions."

I. Introduction

During the past several years, activities of the Nuclear Regulatory Commission (NRC) staff (the staff) have resulted in changes to inservice testing requirements. The 1995 Edition of the American Society of Mechanical Engineers (ASME) *Code for Operation and Maintenance of Nuclear Power Plants* (OM Code) up to and including the 1996 Addenda, was incorporated by reference into the *Code of Federal Regulations* (10 CFR 50.55a). With this rulemaking came revised requirements for inservice testing. Several of the changes which enhance safety and reduce requirements are discussed in this paper.

In addition to revising the regulations, the staff and industry have worked to develop an industry-wide approach to verify the design basis capability of power-operated valves. This paper discusses the industry

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initiatives in developing an air-operated valve (AOV) program, recent AOV performance issues and inspection results, and closure of Generic Safety Issue (GSI) 158 as documented in Regulatory Issue Summary (RIS) 2000–03, "Resolution of Generic Safety Issue 158: Performance of Safety-Related Power-Operated Valves Under Design Basis Conditions."

II. General Inservice Testing Issues

On September 22, 1999, the staff's endorsement of the 1995 Edition of the ASME OM Code up to and including the 1996 Addenda, was published in the Federal Register (Vol. 64, No. 183). The 1995 Edition contains several changes which enhance safety and reduce requirements. Prior to publication of the NRC's final rule on the Section 10 CFR 50.55a amendment in the *Federal Register,* the staff received requests and approved alternatives to use portions of the 1995 Edition of the Code including the related requirements. The staff approvals were based on required adherence to the provisions of the final rule. The code changes which appear to have the most positive affect on burden reduction involve set pressure testing of safety and relief valves and sample disassembly and inspection of check valves.

Set Pressure Testing of Safety and Relief Valves

Thermal Equilibrium

The 1989 Edition of ASME Section XI references OM–1987, Part 1 (OM–1) for testing of safety and relief valves. OM–1 paragraphs 4.1 and 8.1 contain requirements for verifying temperature stability prior to set pressure testing of safety and relief valves. It states that the test method shall be such that the temperature of the valve body be known and stabilized before commencing set pressure testing, with no change in measured temperature of more than 10 °F in 30 minutes. For valves which are tested at ambient temperature using a test medium at ambient temperature, verification of thermal equilibrium is unnecessary. This has been reflected in the 1995 Edition of the Code, Appendix I paragraphs I 4.1.1(d), I 4.1.2(d), I 4.1.3(d) for set pressure testing of boiling water reactors, and I 8.1.1(d), I 8.1.2(d), I 8.1.3(d) for set pressure testing of pressurized water reactors. The 1995 Edition of the OM Code states that verification of thermal equilibrium is not required for valves that are tested at ambient temperature using a test medium at ambient temperature. Several licensees have requested to use the 1995 Edition's thermal equilibrium requirements. The staff approved these alternatives in the following safety evaluations:

- Palo Verde Nuclear Generating Station Units 1, 2, and 3 dated July 8, 1999
- Oconee Nuclear Station Units 1, 2, and 3 dated September 20, 1999
- McGuire Nuclear Station Units 1 and 2 dated February 3, 2000

Time Between Valve Openings

Both the 1989 and 1995 Edition with the 1996 Addenda of the OM Code require a minimum of 10 minutes to elapse between successive valve openings during set pressure testing. The purpose of the hold time requirement between successive openings is to allow time for the valve to return to thermal equilibrium. However, it is not clear that this is necessary for valves which are tested under ambient conditions using a test medium at ambient conditions since insignificant temperature deviations occur during testing. As discussed above, the 1995 Edition added the provision that verification of thermal equilibrium is not required for valves tested at ambient temperature using a test medium at ambient temperature. On this basis, several licensees have requested and been authorized to delete the 10-minute hold time requirement for these valves.

In addition, the hold time requirement between successive valve openings has been reduced to 5 minutes in the 1998 Edition of the Code. For valves tested at other than ambient conditions, several licensees have requested to reduce the hold time to 5 minutes. These requests have also been authorized in the following safety evaluations:

- Oconee Nuclear Station Units 1, 2, and 3 dated September 20, 1999
- McGuire Nuclear Station Units 1 and 2 dated February 3, 2000

Accumulator Volume

OM–1 paragraphs 4.1 and 8.1 require a minimum accumulator volume below the valve inlet for set pressure testing. The minimum volume is calculated by multiplying the valve capacity by the time it is open and dividing by 10. The accumulator volume requirement was changed in the 1995 Edition, paragraphs I 4.1.1(b), I 4.1.2(b) for boiling water reactors and I 8.1.1(b) and I 8.1.2(b) for pressurized water reactors. The 1995 Edition of the OM Code requires that the volume of the accumulator drum and pressure source flow rate be sufficient to determine the valve set pressure. The minimum volume calculation has been removed and it is left to the owner to determine what combination of accumulator volume and pressure source flow rate is needed. The following licensees have requested and been authorized to use this alternative testing method:

- Palo Verde Nuclear Generating Station, Units 1, 2, and 3 in safety evaluation dated July 8, 1999
- Nine Mile Point Nuclear Station Unit 1 in safety evaluation dated December 14, 1999
- Nine Mile Point Nuclear Station Unit 2 in safety evaluation dated April 2, 1999
- Arkansas Nuclear One Unit 2 in a safety evaluation dated March 31, 2000

Instead of requesting to apply the requirements of selected paragraphs of Appendix I of the 1995 Edition of the OM Code, the licensee for the Perry Nuclear Power Plant requested to use Appendix I in its entirety as an alternative to OM–1. The staff authorized this alternative method for testing safety and relief valves in a safety evaluation dated March 31, 1999.

Check Valve Sample Disassembly and Inspection

Part 10 of the ASME/ANSI OM–1987 Standard with the 1988 Addenda, paragraph 4.3.2.4(c) allows disassembly of check valves every refueling outage as an alternative means to verify their operability. Instead of disassembling each check valve every refueling outage, in Generic Letter 89–04, "Guidance on Developing Acceptable Inservice Testing Programs," the staff gave licensees the option of using of a sample disassembly and inspection plan for groups of identical valves in similar applications. Guidelines for this plan are contained in Appendix A of NUREG 1482, "Guidelines for Inservice Testing at Nuclear Power Plants." Since use of a sampling plan is a deviation from the Code requirements, the staff reviews these alternatives as relief requests.

The 1995 Edition of the OM Code, paragraph ISTC 4.5.4(c) contains a provision for a sample disassembly examination program for instances when other means of verifying check valve operability are impractical. Requirements for the program are contained within the Code and state in part that the sampling program shall group check valves of similar design, application, and service conditions. The grouping shall be technically justified and consider as a minimum, valve manufacturer, design, service, size, materials of construction, and orientation.

This is a relaxation of requirements because not only is a sample disassembly and inspection plan allowed by the Code, but the requirements are more permissive than the recommendations of GL 89–04. The Code requires that the valves within a group be similar and the grouping be technically justifiable, whereas the GL 89–04 sample disassembly and inspection program limits the group to four valves and recommends that each valve in the group be of the same design (manufacturer, size, model number, and material of construction) and have experienced the same service conditions including orientation. Further, the GL 89–04 sampling plan recommends the testing of a different valve from the four sample group valves during each refueling so that all valves are tested within a 6-year interval, based on an 18-month fuel cycle, and corrective action is required on all four sample valves if any valve in the group fails during testing.

The staff approved an alternative based on ISTC 4.5.4(c) requirements for Fermi 2 in a safety evaluation dated February 17, 2000. Detroit Edison proposed a grouping of four swing check valves in the emergency equipment cooling water system. The four valves have the same manufacturer, are the same model, are oriented the same way in the system, and are subject to the same service conditions. However, three are 6 inch valves and the other is an 8 inch valve. The licensee was able to substantiate the validity of this grouping by reviewing inspection results from 6 refueling cycles and finding that no failures or significant degradation had ever been identified for these valves. This is an example of where a small size difference within a group of valves, that are subject to the same service conditions, can be justified and determined to be appropriate based on the performance experience.

Pump Test Enhancement

The most beneficial aspect of 1995 Edition of the OM Code with respect to safety is the periodic requirement to test safety-related pumps within ±20% of their design flow rate where practicable. The comprehensive test will provide for an optimum performance point to determine degradation in safety-related pumps over the life of the plant as compared with the requirements in the 1989 Edition of ASME Section XI which did not specify a specific performance point where pumps should be tested. The new test requirement is more rigorous than the guidance in GL 89–04, Position 9, and it will supercede this guidance when licensees adopts the 1995 Edition of the OM Code.

One point of discussion in the future will be the definition of the term "practicable" with regard to the comprehensive test. In the recently submitted Seabrook 10-year update to the 1995 Edition of the OM Code, the licensee proposes an alternative for testing the containment spray pumps at 68% of design flow rate. In the basis for relief, the licensee states that it is not necessary to install a spool piece and construct a temporary dyke to test these pumps when the current level of testing is at substantial flow conditions and is on a stable portion of the pump curve and therefore provides meaningful data concerning pump degradation. These temporary modifications are viewed by the licensee, and the staff, to be practicable to perform. Nonetheless, it is appropriate for licensees to propose alternative testing when the intent of the Code requirements will be met by the current testing. When such reliefs are submitted, performance data should be included to demonstrate acceptability of the proposed testing.

III. Performance of Air-Operated Valves Important to Safety

In addition to endorsing the 1995 Edition up to and including the 1996 Addenda of the ASME OM Code, the staff issued RIS 2000–03 to address the closure of GSI–158. The RIS contains the status of efforts by both the NRC and the commercial nuclear power industry to determine whether safety-related POVs are capable of performing their safety functions.

Background of GSI–158

GSI–158 was initiated because static testing of POVs has been shown to be insufficient for demonstrating consistent performance under design basis conditions. The POVs contained in GSI–158 include motor-operated, solenoid-operated, air-operated, and hydraulically-operated valves.

Resolution of this generic safety issue produced several generic communications. Concerns over motor-operated valve performance resulted in the issuance of Generic Letter (GL) 89–10, "Safety-Related Motor-Operated Valve Testing and Surveillance," and GL 96–05, "Periodic Verification of Design Basis Capability of Safety-Related Motor-Operated Valves." RIS 2000–03 addressed concerns with the remaining types of POVs.

NRC staff made a presentation to the Advisory Committee on Reactor Safeguards (ACRS) indicating its intention to close GSI–158 because no changes or additions to the *Code of Federal Regulations* were required to address the issues. The ACRS expressed concerns with the closure because the staff had not adequately addressed whether POVs are able to perform their intended functions under design basis dynamic conditions. The ACRS also expressed skepticism that an optional industry program would address these issues effectively and felt that the only method to achieve resolution was proactive involvement by the NRC. After interactions with the ACRS, during which the staff committed to take additional regulatory action if the functionality of POVs under design basis dynamic conditions are not adequately address by industry actions, the staff closed GSI–158. The closure of GSI–158, however, does not minimize the seriousness of the need to verify the design capability of POVs and to provide some means of long term periodic verification. Rather, the closure signifies that no additions to the *Code of Federal Regulations* are required to resolve this issue.

On March 15, 2000, the NRC issued RIS 2000–03 addressing the closure of GSI–158 and detailing NRC and industry activities concerning the remaining groups of power-operated valves (POVs). The RIS is a current summary of the status of efforts by both the NRC and the commercial nuclear power industry to determine whether safety-related POVs are capable of performing their safety functions.

While GSI–158 addresses all POVs, recent activities on verification of valve design basis capability have focused on air-operated valves (AOVs). Activities by both the NRC and industry to further characterize the scope of concern and provide solutions to address the issue are described below.

Recent AOV Performance and Safety Significance

The results of seven site visits to 11 U.S. light water reactors conducted in 1997 and 1998, combined with a review of AOV operating experience, are documented in NUREG–1275, Vol.13, "Evaluation of Air-Operated Valves at U.S. Light-Water Reactors," and its companion document, NUREG/CR–6654, "A Study of Air-Operated Valves in U.S. Nuclear Power Plants." For the sites visited by NRC staff and its contractors, 167 safety-related, high-risk-significant AOVs were identified. The number of these AOVs ranged from high of 36 to low of 4 per site. In addition, two licensees identified 15 AOVs that were not safety-related but high-risk-significant. The major safety concern identified was a simultaneous common-cause failure of AOVs which disable redundant trains of a system important to safety (e.g., during an accident or transient, AOVs in redundant trains of a safety system fail when subjected to pressure, temperature, and flow conditions different from those seen during normal operation or testing).

Industry Initiatives

The majority of POVs are AOVs. Solenoid-operated valves (SOVs) are generally considered a part of the AOV assembly. The four nuclear steam supply system owners' groups funded a joint owners group on air-operated valves (JOG AOV). The final product of this effort, the JOG AOV Program, provides guidance for verifying valve performance at design conditions and a framework for long-term periodic verification of safety-related AOVs categorized as high-risk-significant. The risk significance of AOVs that are within the scope of the program may be determined by any justifiable method. However, it is generally being performed by identification of risk significant systems in conjunction with compliance with 10 CFR 50.65 (the maintenance rule), evaluation of the individual plant examination (IPE), and convening of a separate expert panel for classification of risk significance. AOVs which are either safety-related but low-risk-significant or are not safety-related but are high-risk-significant, are subject to a less rigorous verification of valve functionality (no initial or periodic verification of design basis). A copy of the JOG AOV program document was submitted to the NRC in a letter dated July 19, 1999, from the Nuclear Energy Institute (NEI) which facilitated the JOG AOV effort.

One point discussed in the NEI letter to the NRC was that the industry did not want the JOG AOV program to be considered a voluntary industry initiative which would entail compliance by all U.S. commercial nuclear utilities. The NRC provided comments to NEI in a letter dated October 8, 1999, emphasizing the need for a comprehensive implementation strategy by stating that industry-wide implementation would achieve a uniform level of consistency which would provide increased confidence in the design basis capabilities of high-risk-significant AOVs in nuclear power plants. In addition to the issue of implementation, other limitations of the program were stated in the letter.

Specifically, 1) there were no requirements for any design basis verification of safety-related low-safety-significant AOVs; 2) non-safety-related, high safety-significant AOVs did not require design basis verification even though it was recognized that these valves were safety-significant regardless of the licensing basis of the plant; and 3) there were no specific requirements in the JOG AOV program with respect to air system monitoring. A total of 17 comments were provided.

RIS 2000–03 Summary and Discussion of Voluntary Initiatives

As stated earlier, RIS 2000–03 documented the closure of GSI–158 because the current regulations provide adequate requirements to ensure verification of the design basis capability of POVs and no new regulatory requirements need to be developed. The staff committed to work with industry groups on an industry-wide approach to the POV issue and to provide timely, effective, and efficient resolution of the concerns regarding POV performance.

Although there is no requirement for licensees to establish an AOV program, those that implement the JOG AOV program may wish to consider the comments contained in the NRC's letter to NEI dated October 8, 1999. In addition, as an attachment to RIS 2000–03, the NRC listed attributes derived from lessons learned from GL 89–10 and NRC site visits. Licensees who choose to develop plant-specific programs may also wish to consider these lessons learned, as they are considered by the NRC to be characteristics of a successful POV design basis capability and long-term periodic verification program.

Verification of POV Design Basis Capability

Licensees are required by 10 CFR 50.65 to monitor the performance of structures, systems, or components (SSCs) in a manner sufficient to provide reasonable assurance that such SSCs (e.g., systems with safety-related and high-safety-significant AOVs) are capable of fulfilling their intended functions. The NRC committed to monitor licensees' activities to ensure that POVs are capable of performing their specified safety–related functions under design basis conditions. One method of monitoring is through inspections. As a part of the effort to develop NRC inspection procedures for the new inspection process, a specific module is being developed to verify that POVs are capable of performing their design basis functions. One inspection of this nature was conducted earlier this year and is summarized below.

Engineering Inspection at Limerick Generating Station

As a follow–up to issues discussed in RIS 2000–03, the design basis capability of certain AOVs were evaluated during an NRC engineering inspection at Limerick Generating Station on February 7–11, 2000, and is documented in Inspection Report 50–352&353/2000–01 dated April 21, 2000. The inspectors evaluated plant modifications to the emergency service water (ESW) system that impacted air-operated valves. In addition, the inspectors participated in extensive discussions with PECO Energy Company (the licensee) on details of their AOV program, and reviewed the licensee's response to GL 88–14, "Instrument Air Supply System Problems Affecting Safety-Related Equipment" and current practices with respect to maintaining air-system air quality.

The documented findings include: 1) a generic modification for solenoid valve replacement did not include consideration of changes in valve stroke time; and, 2) stroke times of the ESW air-operated gate valves were not consistent. In one of the licensee's condition reports, it states that "one reason for these inconsistencies is that there are currently no absolute set-up criteria for the valve actuator, i.e., benchset or air regulator...which may allow these valves to be set up differently every time...." Another finding of the inspection was that design calculations were not performed for a generic modification to address AOV failures in the ESW system attributed to corrosion of carbon steel components. This finding was not included in the inspection report because design basis verification activities in the Limerick AOV program were addressing this deficiency. Discussions with the air system manager and a review of documentation of the actions in response to GL 88–14 appeared to comply with the original guidance provided in the generic letter on air system air quality.

Conclusion

The NRC is committed to work with industry groups to develop an industry-wide approach to verify the design basis capability of POVs. The industry has provided an approach that will address some of the issues related to AOVs but does not provide for an industry-wide implementation of the effort. In addition, the industry actions on POVs should also address solenoid operated and hydraulically operated valves. The staff would be receptive to a voluntary industry initiative to resolve any further POV issues and to verify design basis capability of POVs. Until there is a systematic, industry-wide implementation of verification of design basis of safety related POVs, this issue will continue to be subject to review by NRC inspectors and technical staff.

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Current Rulemakings Involving ASME OM Code

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Abstract

The regulations in Section 50.55a of Title 10 of the *Code of Federal Regulations* (10 CFR 50.55a) establishes the requirements for applying codes and standards to nuclear power plant components in the United States. The U.S. Nuclear Regulatory Commission (NRC) recently issued a final rule that incorporates by reference the 1995 Edition and 1996 Addenda of the ASME *Code for Operation and Maintenance of Nuclear Power Plants* into paragraph (b) of 10 CFR 50.55a. The NRC staff is currently developing several rulemakings to other portions of §50.55a that directly relate to inservice testing (IST) of pumps and valves. In this paper, the author will discuss these current rulemakings and their potential impact on IST requirements.

Introduction

The regulations in 10 CFR 50.55a provide the requirements for design, IST, and inservice inspection (ISI) of nuclear power plant components. The mechanism for endorsing the ASME Code has been to incorporate by reference the ASME Code rules into §50.55a. Paragraph (b) of §50.55a cites the specific Edition and Addenda to the ASME Code that are approved for incorporation by reference. Section 50.55a is updated periodically to reference the latest Edition and Addenda.

On December 3, 1997, the NRC published a proposed rule for public comment to amend §50.55a to incorporate by reference the 1995 Edition and 1996 Addenda to the ASME *Boiler and Pressure Vessel Code* (BPV Code) and the ASME *Code for Operation and Maintenance of Nuclear Power Plants* (OM Code). The NRC staff completed its review of the public comments and developed a revision to the rule in response to the comments. Several public comments suggested eliminating the requirement for licensees to update their IST and ISI programs every 120 months to the latest ASME Code incorporated by reference in §50.55a. Because of the significance of this proposed change, the NRC staff issued a supplement to the proposed rule on April 27, 1999, requesting public comments specifically on the possible elimination of the 120-month update requirement. The NRC held a public workshop on May 27, 1999, to discuss this proposed supplement. In a staff requirements memorandum dated June 24, 1999, the Commission directed the staff to proceed with the completion of the December 1997 proposed rule and to address the elimination of the 120-month update requirement in a separate rulemaking.

This paper was prepared by staff of the U.S. Nuclear Regulatory Commission. It may present information that does not currently represent an agreed-upon NRC staff position. NRC has neither approved nor disapproved the technical content.

The NRC staff completed the final rule and issued it in the *Federal Register* on September 22, 1999 (64 FR 51370). In addition, the staff completed a policy paper on the 120-month update requirement, and received further guidance from the Commission on this issue. The details of these two issues will be discussed in the following paragraphs of this paper. In addition, the paper will discuss two additional rulemaking issues that the staff is currently preparing that relate to IST provisions for pumps and valves. These two issues are: (1) incorporation by reference of the 1998 Edition of the ASME Code, and (2) revision to footnote 6 of 10 CFR 50.55a regarding regulatory guides on the use of ASME Code cases.

September 22, 1999, Final Rule

On September 22, 1999, the NRC issued a final rule to amend its regulations in 10 CFR 50.55a to incorporate by reference more recent Editions and Addenda of the ASME BPV Code and the ASME OM Code. Previously, 10 CFR 50.55a incorporated by reference the 1989 Edition of the ASME BPV Code. The final rule incorporated by reference all subsequent Editions and Addenda of the ASME BPV Code up to and including the 1995 Edition and the 1996 Addenda. It also, for the first time, incorporated by reference the 1995 Edition up to and including the 1996 Addenda of the ASME OM Code. The final rule also included several new modifications to and limitations in the use of the ASME Codes as well as a deletion of a previous modification, and permits the use of several alternative requirements on a voluntary basis. A few of the more significant final rule issues pertaining to IST are discussed below.

The proposed rule contained, in part, one new modification [§50.55a(b)(3)(ii)] pertaining to motor-operated valve stroke time testing requirements and two provisions [§§50.55a(b)(3)(iii) and 50.55a(b)(3)(iv)] pertaining to voluntary implementation of alternatives to specific OM Code requirements on pump and valve testing. The first provision involved implementation of ASME Code Case OMN–1, "Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light-Water Reactor Power Plants," in lieu of stroke time testing as required in Subsection ISTC, with a modification. The second provision involved implementation of a check valve condition monitoring program under Appendix II as an alternative to the testing or examination provisions contained in Subsection ISTC, with three modifications.

Motor-Operated Valve Stroke Time Testing:

> §50.55a(b)(3)(ii) Motor-Operated Valve stroke-time testing. Licensees shall comply with the provisions on stroke time testing in OM Code ISTC 4.2, 1995 Edition with the 1996 Addenda, and shall establish a program to ensure that motor-operated valves continue to be capable of performing their design basis afety functions.

The final rule contains a modification (§50.55a(b)(3)(ii)) pertaining to supplementing the stroke-time testing requirement of Subsection ISTC of the OM Code applicable for motor-operated valves (MOVs) with programs that licensees have previously committed to perform for demonstrating the design-basis capability of MOVs. Stroke-time testing of MOVs is also required by Section XI of the ASME BPV Code. Since 1989, it has been recognized that the quarterly stroke-time testing requirements for MOVs in the

Code are not sufficient to provide assurance of MOV operability under design-basis conditions. For example, in Generic Letter (GL) 89 10, "Safety-Related Motor-Operated Valve Testing and Surveillance," the NRC stated that ASME Section XI testing alone is not sufficient to provide assurance of MOV operability under design-basis conditions. Therefore, in GL 89 10, the NRC staff requested licensees to verify the design-basis capability of their safety-related MOVs and to establish long-term MOV programs.

The NRC subsequently issued GL 96 05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," to provide updated guidance for establishing long-term MOV programs. Licensees have made licensing commitments pursuant to GL 96 05 that are being reviewed by the NRC staff. Most licensees have voluntarily committed to participate in an industry-wide Joint Owners Group (JOG) Program on MOV Periodic Verification. This program will help provide consistency among the individual plant long-term MOV programs.

At this time, the OM Code committees are working to update the Code with respect to its provisions for quarterly MOV stroke-time testing. For example, the ASME is considering incorporating Code Case OMN−1, "Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light-Water Reactor Power Plants," into the OM Code. These provisions would allow users to replace quarterly MOV stroke-time testing with a combination of MOV exercising at least every refueling outage and MOV diagnostic testing on a longer interval.

The final rule supplements the Code requirements for MOV stroke-time testing with a provision that licensees periodically verify MOV design-basis capability. The changes to §50.55a(b)(3)(ii) do not alter expectations regarding existing licensee commitments relating to MOV design-basis capability. Without being overly prescriptive, the final rule allows licensees to implement the regulatory requirements in a manner that best suits their particular application. The rulemaking does not require licensees to implement the JOG program on MOV periodic verification. The final rule in §50.55a(b)(3)(iii) allows licensees the option of using ASME Code Case OMN 1 to meet the requirements of §50.55a(b)(3)(ii).

Code Case OMN−1:

> §50.55a(b)(3)(iii) *Code Case OMN−1.* As an alternative to §50.55a(b)(3)(ii), licensees may use Code Case OMN−1, "Alternative Rules for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in Light Water Reactor Power Plants," Revision 0, 1995 Edition with the 1996 Addenda, in conjunction with ISTC 4.3, 1995 Edition with the 1996 Addenda. Licensees choosing to apply the Code case shall apply all of its provisions.
>
> (A) The adequacy of the diagnostic test interval for each valve must be evaluated and adjusted as necessary but not later than 5 years or three refueling outages (whichever is longer) from initial implementation of ASME Code Case OMN−1.
>
> (B) When extending exercise test intervals for high risk motor-operated valves beyond a quarterly frequency, licensees shall ensure that the potential increase in core damage frequency and

risk associated with the extension is small and consistent with the intent of the Commission's Safety Goal Policy Statement.

Section 50.55a(b)(3)(iii) of the final rule permits the voluntary implementation of ASME Code Case OMN−1 in lieu of stroke time testing as required for MOVs in Subsection ISTC. In particular, Code Case OMN−1 permits licensees to replace quarterly stroke-time testing of MOVs with a program of exercising on intervals of one year or one refueling outage (whichever is longer) and diagnostic testing on longer intervals. As indicated in Attachment 1 to GL 96 05, the Code case meets the intent of the generic letter, but with certain limitations which were discussed in the generic letter. For MOVs, Code Case OMN−1 is acceptable in lieu of Subsection ISTC, except for leakage rate testing (ISTC 4.3) which must continue to be performed. In addition, OMN−1 contains a maximum MOV test interval of 10 years, which the NRC supports. However, the NRC believed it prudent to include the modification requiring licensees to evaluate the information obtained for each MOV, during the first 5 years or three refueling outages (whichever is longer) of use of the Code case, to validate assumptions made in justifying a longer test interval. These conditions on the use of OMN−1 were included in the final rule [§50.55a(b)(3)(iii)(A)].

Paragraph 3.7 of OMN−1 discusses the use of risk insights in implementing the provisions of the Code case such as those involving MOV grouping, acceptance criteria, exercising requirements, and testing frequency. For example, Paragraph 3.6.2 of OMN−1 states that exercising more frequently than once per refueling cycle shall be considered for MOVs with high risk significance. In its reviews of plant-specific requests to use OMN 1, the NRC staff has determined that a clarification in the final rule was appropriate regarding the provision in the Code case for the consideration of risk insights if extending the exercising frequencies for MOVs with high risk significance beyond the quarterly frequency specified in the ASME Code. In particular, licensees should ensure that increases in core damage frequency and/or risk associated with the increased exercise interval for high-risk MOVs are small and consistent with the intent of the Commission's Safety Goal Policy Statement (51 FR 30028; August 21, 1986). The NRC also considers it important for licensees to have sufficient information from the specific MOV, or similar MOVs, to demonstrate that exercising on a refueling outage frequency does not significantly affect component performance. The information may be obtained by grouping similar MOVs and staggering the exercising of MOVs in the group equally over the refueling interval. This clarification is provided in §50.55a(b)(3)(iii)(B) of the final rule.

Thus, Code Case OMN 1 is acceptable as an optional alternative to MOV stroke-time test requirements with (1) the modification that, at 5 years or three refueling outages (whichever is longer) from initial implementation of Code Case OMN−1, the adequacy of the test interval for each MOV must be evaluated and adjusted as necessary; and (2) the clarification of the provision in OMN−1 for the establishment of exercise intervals for high risk MOVs in that the licensee will be expected to ensure that the potential increase in core damage frequency and risk associated with extending exercise intervals beyond a quarterly frequency is small and consistent with the intent of the Commission's Safety Goal Policy Statement.

In addition, as noted in GL 96 05, licensees are cautioned that, when implementing Code Case OMN 1, the benefits of performing a particular test should be balanced against the potential adverse effects placed on the valves or systems caused by this testing. Code Case OMN–1 specifies that an IST program should consist of a mixture of static and dynamic testing. While there may be benefits to performing dynamic testing, there are also potential detriments to its use (i.e., valve damage). Licensees should be cognizant of this for each MOV when selecting the appropriate method or combination of methods for the IST program.

The final rule does not require the use of Code Case OMN–1. Licensees will be allowed the option of using the Code case as an alternative to the Code-required provisions for MOV stroke-time testing with the specified limitation and clarification. The voluntary use of Code Case OMN–1 by a licensee (in accordance with the rule and GL 96 05) would resolve weaknesses in the Code requirements for quarterly MOV stroke-time testing, and would also address the need to establish a long-term MOV program in response to GL 96 05.

It should also be noted that the amendment does not limit the diagnostic test interval in Code Case OMN–1 for MOVs to 5 years or three refueling outages. In endorsing the allowable use of Code Case OMN–1, the amendment states that the adequacy of the test interval for each MOV shall be evaluated and adjusted as necessary but not later than 5 years or three refueling outages (whichever is longer) from initial implementation of Code Case OMN–1. In other words, the amendment requires when applying Code Case OMN 1, prior to extending diagnostic test intervals for a specific MOV beyond 5 years (or three refueling outages), that the licensee evaluate test information on similar MOVs to ensure that the aging mechanisms are sufficiently understood such that the MOV will remain capable of performing its safety function over the entire diagnostic test interval. After evaluating the test information on similar MOVs, a licensee can extend the diagnostic test interval on other MOVs beyond 5 years or three refueling outages up to 10-year limit specified in Code Case OMN 1.

Appendix II

§50.55a(b)(3)(iv) *Appendix II.* The following modifications apply when implementing Appendix II, "Check Valve Condition Monitoring Program," of the OM Code, 1995 Edition with the 1996 Addenda:

(A) Valve opening and closing functions must be demonstrated when flow testing or examination methods (nonintrusive, or disassembly and inspection) are used;

(B) The initial interval for tests and associated examinations may not exceed two fuel cycles or 3 years, whichever is longer; any extension of this interval may not exceed one fuel cycle per extension with the maximum interval not to exceed 10 years; trending and evaluation of existing data must be used to reduce or extend the time interval between tests.

(C) If the Appendix II condition monitoring program is discontinued, then the requirements of ISTC 4.5.1 through 4.5.4 must be implemented.

Paragraph ISTC 4.5.5 of Subsection ISTC permits the owner to use Appendix II, "Check Valve Condition Monitoring Program," of the OM Code as an alternative to the testing or examination provisions of ISTC 4.5.1 through ISTC 4.5.4. If an owner elects to use Appendix II, the provisions of Appendix II become mandatory per OM Code requirements. However, upon reviewing the appendix, the NRC determined that the requirements in Appendix II must be supplemented in three areas.

The first area is testing or examination of the check valve obturator movement to both the open and closed positions to assess its condition and confirm acceptable valve performance. Bi-directional testing of check valves was approved by the ASME OM Main Committee for inclusion in the 1996 Addenda to the Code. The NRC agrees with the need for a required demonstration of bi-directional exercising movement of the check valve disc. Single direction flow testing of check valves, as an interpreted requirement, will not always detect degradation of the valve. The classic example of this faulty testing strategy is that the departure of the disc would not be detected during forward flow tests. The departed disc could be lying in the valve bottom or another part of the system, and could move to block flow or disable another valve. Although the ASME's Working Group on Check Valves (OM Part 22) is considering Code rules for bi-directional testing of check valves, Appendix II does not presently require it. Hence, the modification in § 50.55a(b)(3)(iv)(A) was included so that an Appendix II condition monitoring program includes bi-directional testing of check valves to assess their condition and confirm acceptable valve performance (as is presently required by the OM Code).

The second area needing supplementation is the length of test interval. Appendix II would permit a licensee to extend check valve test intervals without limit. Under the current check valve IST program, most valves are tested quarterly during plant operation. The interval for certain valves has been extended to refueling outages. The NRC has concluded that operating experience exists at this time to support longer test intervals for the condition monitoring concept. A policy of prudent and safe interval extension dictates that any additional interval extension must be limited to one fuel cycle, and this extension must be based on sufficient experience to justify the additional time. Condition monitoring and current experience may qualify some valves for an initial extension to every other fuel cycle, while trending and evaluation of the data may dictate that the testing interval for some valves be reduced. Extensions of IST intervals must consider plant safety and be supported by trending and evaluating both generic and plant-specific performance data to ensure the component is capable of performing its intended function over the entire IST interval. Thus, the modification (§50.55a(b)(3)(iv)(B)) limits the time between the initial test or examination and second test or examination to two fuel cycles or three years (whichever is longer), with additional extensions limited to one fuel cycle. The total interval is limited to a maximum of 10 years. An extension or reduction in the interval between tests or examinations would have to be supported by trending and evaluation of performance data.

The third area in Appendix II which the NRC determined should be supplemented is the requirement applicable to a licensee who discontinues a condition monitoring program. A licensee who discontinues use of Appendix II, under Subsection ISTC 4.5.5, is required to return to the requirements of Subsection ISTC 4.5.4. However, the NRC has concluded that the requirements of ISTC 4.5.1 through ISTC 4.5.4 must be also met. Hence, if the monitoring program is discontinued, the modification [§50.55a(b)(3)(iv)(C)] specifies that licensees implement the provisions of ISTC 4.5.1 through ISTC 4.5.4.

The NRC staff considers the Condition Monitoring approach of Appendix II for check valves to be a significant improvement over present Code requirements, and encourages licensees to implement Appendix II. Where a licensee's Code of record is an earlier edition or addenda of the ASME Code, the regulations in §50.55a(f)(4)(iv) allow the licensee to implement portions of subsequent Code editions and addenda that are incorporated by reference in the regulations subject to the limitations and modifications listed in the rule, and subject to Commission approval. The NRC staff also noted in the final rule that it will favorably consider a request by a licensee under §50.55a(f)(4)(iv) to apply Appendix II, in advance of incorporating the 1995 Edition with the 1996 Addenda of the ASME OM Code as its Code of record, if the licensee justifies the following in its submitted request: (1) the modifications to Appendix II contained in the rule have been satisfied; and (2) all portions of the 1995 Edition with the 1996 Addenda of the OM Code that apply to check valves are implemented for the remaining check valves not included in the Appendix II program.

Clarification of Scope of Safety-Related Valves Subject to IST:

§50.55a(f) *Inservice testing requirements.*

(1) For a boiling or pressurized water–cooled nuclear power facility whose construction permit was issued prior to January 1, 1971, pumps and valves must meet the test requirements of paragraphs (f)(4) and (f)(5) of this section to the extent practical. Pumps and valves which are part of the reactor coolant pressure boundary must meet the requirements applicable to components which are classified as ASME Code Class 1. Other pumps and valves that perform a function to shut down the reactor or maintain the reactor in a safe shutdown condition, mitigate the consequences of an accident, or provide overpressure protection for safety-related systems (in meeting the requirements of the 1986 Edition, or later, of the Boiler and Pressure Vessel or OM Code) must meet the test requirements applicable to components which are classified as ASME Code Class 2 or Class 3.

The previous language in §50.55a(f)(1) had been interpreted by some licensees as a requirement to include all safety-related pumps and valves regardless of ASME Code Class (or equivalent) in the IST program of plants whose construction permits were issued before January 1, 1971. The NRC proposed to revise this paragraph in the draft rule amendment to clarify which safety-related pumps and valves are addressed by 10 CFR 50.55a. The intent of the revision was to ensure that the IST scope of pumps and valves for these earlier-licensed plants was similar to the scope for plants licensed after January 1, 1971. A corresponding revision was also proposed for §50.55a(g)(1) for ISI requirements. The staff believes that the scope of pumps and valves to be included in an IST program should be dependent on the safety-related function of the component rather than the function of the system. That is, a safety-related system might include many pumps and valves. However, not all of the pumps and valves might have a safety-related function. For example, some valves in a safety-related system might be used for maintenance purposes only although they might be classified as safety-related because they are part of the safety-related system pressure boundary. Accordingly, these valves would not need to be tested under the IST program, but the welds connecting the valve to the piping might be required to be examined under the ISI program.

For this reason, the NRC further concluded that, unlike the scope issue that arose in §50.55a(f)(1) for IST, the scope issue did not apply to ISI, and a modification to the language of §50.55a(g)(1) pertaining to ISI was not appropriate. Therefore, the existing language of §50.55a(g)(1) remained unchanged. However, the staff found that there was a need to modify the language for IST requirements. The final rule revised §50.55a(f)(1) to ensure that the scope of inservice testing of pumps and valves in earlier plants is consistent with the scope applicable to later plants. This was accomplished by making the language of §50.55a(f)(1) consistent with the scope of Paragraph 1.1 in Subsections ISTB and ISTC of the OM Code. Hence, §50.55a(f)(1) in the final rule specifies that those pumps and valves that perform a specific function to shut down the reactor or maintain the reactor in a safe shutdown condition, mitigate the consequences of an accident, or provide overpressure protection for safety-related systems must meet the test requirements applicable to components which are classified as ASME Code Class 2 and Class 3 to the extent practical. The new language establishes the scope of pumps and valves that are to be included in an IST program based on the safety-related function of the pump or valve. The requirements for pumps and valves that are part of the reactor coolant pressure boundary have not been changed. This change in the regulation will clarify the scope of IST for earlier-licensed plants resulting in a more consistent scope in pump and valve IST programs for all nuclear power plants.

120-Month Code Update Requirement

The NRC regulations require nuclear power plant licensees to update their inservice inspection (ISI) and inservice testing (IST) programs every 120 months to meet the requirements of the latest ASME Code incorporated by reference in 10 CFR 50.55a. The NRC issued a proposed rule on April 27, 1999, to request public comment on a proposed modification to eliminate this update requirement. The NRC staff held a public workshop on May 27, 1999, to discuss the need for the 120-month update requirement. The staff received numerous comments on the proposed rule from the ASME, the Illinois Department of Nuclear Safety, the Nuclear Energy Institute (NEI), nuclear utilities, and private citizens. The comments varied widely from keeping the 120-month update requirement to eliminating the 120-month update requirement and baselining the Code to the 1989 Edition. The NRC staff reviewed the public comments from both internal and external stakeholders and prepared a Commission policy paper (SECY–00– 0011, dated January 14, 2000) in which the NRC staff identified three options with respect to updating ISI and IST programs. These three options were as follows:

(1) Replace the 120-month ISI/IST update requirement with a baseline of ISI and IST requirements and allow voluntary

updating to entire subsequent NRC-endorsed ASME Code editions and addenda without prior NRC approval unless the baseline is revised in accordance with 10 CFR 50.109, where the initial baseline will consist of one of the following three possible sets of ISI and IST requirements:

(A) The 1989 Edition of the ASME BPV Code for ISI of ASME Code Class 1, 2, and 3 components (including supports) and for IST of ASME Code Class 1, 2, and 3 pumps and valves; the 1992 Edition with the 1992 Addenda of Subsections IWE and IWL of the ASME BPV Code for ISI of Class MC and Class CC components and their integral attachments; the 1995 Edition with the 1996 Addenda of Appendix VIII of the ASME BPV Code, Section XI, with limitations and modifications specified in 10 CFR 50.55a (as discussed in the proposed rule dated April 27, 1999);

(B) The 1995 Edition with the 1996 Addenda of the ASME Code with the limitations and modifications specified in the NRC regulations, or

(C) A later version (e.g., the 1998 Edition) of the ASME Code with appropriate limitations and modifications.

(2) Retain the current 120-month ISI/IST update requirement and the current regulatory provision that allows licensees to use portions of NRC-endorsed ASME Code editions or addenda provided that all related requirements of the respective editions are met.

(3) Retain the 120-month ISI/IST update requirement and the current provision for use of portions of NRC-endorsed ASME Code editions or addenda, but develop explicit guidance for plant-specific alternatives to the ISI/IST update requirement.

Varied opinions existed among stakeholders, including the NRC staff, regarding the need for a mandatory ISI/IST update requirement. The staff found that no particular option had an overwhelming advantage over the other options.

Based on consideration of the Commission's performance goals, the staff recommended to the Commission that Option 1.B, as described in this paper, be implemented. The staff recommendation was based principally on (1) the incorporation by reference of the 1995 Edition and 1996 Addenda of the ASME Code into the regulations on September 22, 1999, and (2) the substantial improvements to the ASME Code since 1989 identified by staff review and public comments.

The NRC staff met with the Commission on March 24, 2000, to discuss the 120-month update requirement. In addition, representatives from the ASME, NEI, and the NRC's Advisory Committee on Reactor Safeguards also presented their views on this issue.

On April 13, 2000, the Commission issued a staff requirements memorandum in which it disapproved the NRC staff's recommendation and instead approved Option 2 of SECY−00−0011 which maintains the current requirement that licensees update their ISI and IST programs every 120-months to the latest edition of the ASME Code that is incorporated by reference in 10 CFR 50.55a. The Commission's decision was based on several considerations including (1) the inappropriateness to freeze Code requirements at the 1995 level in light of license renewal which will allow some plants to operate well into the 21st century, (2) doubts about the practicality of backfitting new Code improvements on licensees, (3) the adverse impact on licensee and NRC resources that would result from the added complexity caused by greater customization of ISI and IST programs.

Incorporation By Reference of the 1998 Code Edition

As a result of the Commission's decision to maintain the 120-month update requirement, the NRC staff is currently preparing a rulemaking package to incorporate by reference the 1998 Edition of both the ASME BPV Code and the ASME OM Code including the 1997, 1999, and 2000 Addenda. Specifically, the staff plans to initiate rulemaking in order to amend the regulations in 10 CFR 50.55a to incorporate by reference (1) the 1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of Division 1 rules of Section III, "Rules for Construction of Nuclear Power Plant Components," of the ASME BPV Code; (2) the 1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of Division 1 rules of Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," of the ASME BPV Code; and (3) the 1997 Addenda, 1998 Edition, 1999 Addenda, and 2000 Addenda of the ASME OM Code. In those cases where significant differences exist between the ASME Code requirements and staff positions or where the ASME Code requirements may not be complete, the staff may impose limitations and modifications to the Code requirements.

Because the proposed amendment to 10 CFR 50.55a is not expected to impose any new rules on licensees, the impact on the licensees is expected to be minimal. The estimated cost for licensees to update their IST programs is approximately $300,000 to $500,000 every 120 months. Adoption of the proposed amendment would permit the use of the improved methods for construction, inservice inspection, and inservice testing which will save licensees and the NRC staff both time and effort by providing uniform detailed criteria against which the staff could review any single submittal.

The rulemaking process is expected to be completed in approximately two years.

Footnote 6 to 10 CFR 50.55a

Footnote 6 to 10 CFR 50.55a states:

> ASME Code cases that have been determined suitable for use by the Commission staff are listed in NRC Regulatory Guide 1.84, "Design and Code Case Acceptability—ASME Section III Division 1," NRC Regulatory Guide 1.85, "Materials Code Case Acceptability—ASME Section III Division 1," and NRCRegulatory Guide 1.147, "Inservice Inspection Code Case Acceptability—ASME Section XI Division 1." The use of other Code cases may be authorized by the Director of the Office of Nuclear Reactor Regulation upon request pursuant to §50.55a(a)(3).

The purpose of footnote 6 is to permit licensees of nuclear power plants to use alternative provisions (i.e., ASME Code cases) that have been approved by the NRC staff in lieu of requirements in the ASME Code, Sections III and XI. The staff was initially planning to update footnote 6 to add revisions numbers to the regulatory guides and to include a new regulatory guide that would endorse OM Code cases. However, certain legal complications arose that caused the staff to consider a different approach to endorsing Code cases than using footnote 6.

Before discussing the complications to the rulemaking, it is important to explain the meaning of "incorporation by reference." The term "incorporation by reference" was established by statute and allows Federal agencies to meet the requirement to publish regulations in the *Federal Register* by referring to materials already published elsewhere. For an incorporation to be valid, the Director of the *Federal Register* must approve it. The legal effect of incorporation by reference is that the material is treated as if it were published in full in the *Federal Register*. This material, like any other properly issued regulation, has the force of law. The Director of the *Federal Register* will approve an incorporation by reference only when the requirements of 1 CFR part 51 are met.

The need to revise footnote 6 became apparent to the NRC's legal staff when the NRC was planning to issue the next revisions to Regulatory Guides 1.84, 1.85 and 1.147. Until now, the three regulatory guides as presented in footnote 6 did not include the revision numbers. Because these three regulatory guides endorse ASME Code cases that may be used in lieu of Code requirements (rather than providing guidance in interpreting how Code requirements may be met), the Code cases themselves, when implemented, effectively become Code requirements. It would be inappropriate to use a regulatory guide as a vehicle to endorse Code cases without the regulatory guide (or Code cases themselves) being incorporated by reference into the regulations. 1 CFR part 51 requires that incorporation by reference of a publication be limited to the edition of the publication that is approved. 1 CFR part 51 also states that future amendments or revisions of the publication are not included. It was the intent of footnote 6 to incorporate by reference the ASME Code cases approved by the NRC staff in Regulatory Guides 1.84, 1.85, and 1.147. If the regulatory guides were incorporated by reference into the regulations, it would be appropriate for licensees to use the Code cases in lieu of the requirements of the ASME Code. However, 1 CFR 51.1(f) requires the inclusion of the publication's revision, and, until now, footnote 6 did not include the revision numbers of the regulatory guides. 1 CFR 51.7(b) further states that the Director of the Office of Federal Register will assume that a publication produced by the same agency that is seeking its approval (in this case, NRC's regulatory guides) is inappropriate for incorporation by reference unless the publication possesses other unique or highly unusual qualities.

Because of the above complications, the NRC staff decided it would not be appropriate to continue using footnote 6 to reference regulatory guides to endorse Code cases. Instead, the NRC staff is considering listing the approved Code cases directly in the regulations. The staff is planning to eliminate footnote 6 altogether and develop a new Appendix U to Part 50. The new Appendix U would contain a list of all approved Code cases and any conditions in their use. Appendix U would be updated periodically to include later Code cases.

The NRC staff is also planning to add to this proposed Appendix U, a list of approved OM Code cases. Until 1990, the requirements for IST of pumps and valves were contained in ASME Code, Section XI, Subsections IWP (OM Part 6—pumps) and IWV (OM Part 10—valves). In 1990, ASME published the initial edition of the OM Code which provided rules for IST of pumps and valves. Subsequent to the publication of the 1990 OM Code, ASME's Board on Nuclear Codes and Standards (BNCS) transferred responsibility for maintenance of these rules on IST from the ASME Code, Section XI to the OM Code Committee. The NRC issued a final rule on September 22, 1999 (64 FR 51370) requiring, for the first time, the use of the 1995 Edition including the 1996 Addenda to the OM Code for IST of pumps and valves. In addition, the final rule permits licensees to voluntarily adopt OM Code case OMN–1, "Alternative Rule for Preservice and Inservice Testing of Certain Electric Motor-Operated Valve Assemblies in LWR Power Plants," with certain limitations. This OM Code case was included in the final rule because a regulatory guide endorsing OM Code cases did not yet exist, and the need for regulatory endorsement of OM Code cases did not exist until the OM Code was incorporated by reference into the regulation.

ASME's OM Main Committee has issued six OM Code cases and is developing several other Code cases that will address risk-informed IST methods for pumps and valves. The NRC staff anticipates that industry and ASME will be seeking NRC action to endorse these new OM Code cases in the near future. Staff endorsement of these OM Code cases will be necessary in order to establish a regulatory framework for allowing an efficient implementation of risk-informed IST programs. Therefore, the NRC staff is planning to include endorsement of OM Code cases in the proposed Appendix U.

Conclusions

This paper discussed four current rulemakings related to 10 CFR 50.55a involving the ASME OM Code. These rulemakings included (1) the September 22, 1999, final rule that incorporated by reference the 1995 Edition and 1996 Addenda to the ASME OM Code, (2) the proposed supplemental rule to eliminate the 120-month update requirement, (3) a proposed rule to incorporate by reference the 1998 Edition up to and including the 2000 Addenda of the ASME Code, and (4) a proposed revision to footnote 6 of 10 CFR 50.55a. These rulemakings are not expected to impose any new requirements on licensees. The staff believes that the rulemakings will provide a more efficient regulatory process, maintain safety, and permit licensees to use the latest technological improvements in the performance of inservice testing of pumps and valves.

References

Code of Federal Regulations, Title 10, "Energy," Part 50, "Domestic Licensing of Production and Utilization Facilities."

Code of Federal Regulations, Title 1, "General Provisions," Part 51, "Incorporation by Reference."

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.84, "Design and Code Case Acceptability—ASME Section III Division 1."

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.85, "Materials Code Case Acceptability—ASME Section III Division 1."

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability—ASME Section XI Division 1."

U.S. Nuclear Regulatory Commission, SECY–00–0011, "Evaluation of the Requirement for Licensees to Update Their Inservice Inspection and Inservice Testing Programs Every 120 Months," January 14, 2000.

U.S. Nuclear Regulatory Commission, Staff Requirements Memorandum, "Evaluation of the Requirement for Licensees to Update Their Inservice Inspection and Inservice Testing Programs Every 120 Months," April 13, 2000 (ML003702722).

American Society of Mechanical Engineers, "*Code for Operation and Maintenance of Nuclear Power Plants*," 1995 Edition up to and including the 1996 Addenda, New York, New York.

Study of Air-Operated Valves in Nuclear Power Plants

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1 Introduction

In July 1997 the Nuclear Regulatory Commission initiated a study of air-operated valves (AOVs) to help the NRC determine if additional attention was needed to be focused on AOVs. The NRC and the Idaho National Engineering Laboratory, (INEEL) engineers performed a comprehensive review of AOV operating experience, and made visits to 7 U.S. light water reactor sites at which there are 11 operating reactors. Two NRC reports, NUREG 1275 Vol. 13, "Evaluation of Air-Operated Valves at U.S. Light-Water Reactors," and its companion document, Idaho National Engineering and Environmental Laboratory report NUREG/CR–6654, "A Study of Air-Operated Valves in U.S. Nuclear Power Plants." present the details of the study. This paper presents the highlights of the study.

2 Use and Application of Air-Operated Valves

AOVs are used in all U.S. LWRs. They are used in a wide variety of applications. Some AOVs perform important functions in safety and nonsafety-related systems which could affect initiating event frequencies, accident mitigation, and radiological releases.

Table 1 contains a listing of the AOV populations at the 7 sites (11 plants) visited during this study. The licensees visited stated that their plants had between 418 and 2800 AOVs. Each of the plants visited has categorized between 42 and 410 AOVs as "safety-related," "high safety-significance," "important-to-safety," or a combination thereof. The remaining AOVs (the majority of AOVs at each plant) were determined to have little or no safety-significance. The majority of AOVs at U.S. LWRs are nonsafety-related and are generally associated with the non-nuclear balance of plant. Nonetheless, two of the plants visited identified a number of "important" or "risk important" AOVs which had been classified as nonsafety-related.

3 Air-Operated Valve Issues

The primary issues of concern with AOVs are those design deficiencies, maintenance deficiencies, and pneumatic system deficiencies which may result in simultaneous common-cause failures (CCF) of more than one valve. For example, similar to the situation with MOVs which prompted issuance of GL 89–10, high differential pressure across the valve disk, seen during accident or transient conditions, may cause friction forces beyond the capacity of the valve operator. Since it is expected that the valves in both trains of a safety system would be subject to the same conditions, both trains of a safety system could fail at the same time.

Table 1 Populations of Air-Operated Valves in Plants Visited					
Plant Name	**Safety-Related AOVs**	**Category 1 AOVs**	**Category 2 AOVs**	**Category 3 AOVs**	**GL 89–10* MOVs**
Palo Verde 1-2-3	41 + 131 = 172 AOVs per plant are classified by the licensee as safety-related. See Category 1 and 2.	41 AOVs per plant are classified by the licensee as Category 1. The licensee refers to active safety-related AOVs as Category 1.	131 AOVs per plant are classified by the licensee as Category 2. The licensee refers to nonactive safety-related AOVs as Category 2.	Approximately 2628 AOVs per plant are classified by the licensee as Category 3. The licensee refers to nonsafety-related AOVs as Category 3.	There are 831 MOVs on site (3 plants) of which 336 are in the GL 89–10 program.
Fermi 2	29 AOVs in Category 1 and 34 AOVs in Category 2 (63 total) are safety-related according to the program plan draft. In addition, 370 AOVs for scram inlet and outlet valves. (There are also 2482 solenoid-operated valves (SOVs) of which 1442 are classified by the licensee as QA1.)	410 AOVs are classified by the licensee as Category 1. The licensee refers to AOVs having "high safety-significance" as Category 1. Included are 370 SCRAM inlet and outlet valves, 29 safety-related valves, and 11 AOVs that perform a nonsafety-related risk significant function.	84 AOVs are classified by the licensee as Category 2 including 34 safety-related AOVs. The licensee designates as Category 2 those less safety-significant AOVs that support safety-related functions or have relatively high economic consequences if they should fail.	Category 3 AOVs are those "having little or no safety-significance or economic consequences." (Note: The original 1995 rough outline for development of the Fermi 2 AOV program lists a total of 2058 AOVs of which 598 were considered safety- related valves or dampers, and 1460 were considered nonsafety-related valves or dampers.)	147 MOVs are in the GL 89–10 program.
Palisades	191 AOVs	111 AOVs. Valves in this category are safety-related with active safety functions, important-to-safety based on their probabilistic safety assessment (PSA), risk significance, or included based on Expert Panel determinations.	42 AOVs are classified by the licensee as Category 2. These AOVs are safety-related but of low risk-significance or nonsafety-related but used in "critical" applications.	Approximately 561 AOVs which are not Category 1 or 2 are classified by the licensee as Category 3 AOVs.	There are 54 MOVs in the plant of which 30 are covered by GL 89–10.
LaSalle 1-2	84 for both units. In addition, 370 control rod drive hydraulic valves in each unit are classified by the licensee as safety-related.	AOVs having high safety significance. Number not provided.	AOVs having low safety significance. Number not provided.	AOVs having high economic significance. Number not provided. (LaSalle categorizes AOVs with no or limited safety/economic significance as Category 4.) (There are 1575 nonsafety-related AOVs for both units.)	There are 200 MOVs in the GL 89–10 program for both units.

Plant Name	Safety-Related AOVs	Category 1 AOVs	Category 2 AOVs	Category 3 AOVs	GL 89–10* MOVs
TMI 1	98 AOVs are classified as safety-related (designated "Q-class" or "Class 1") by the licensee.	98 AOVs are categorized as Class 1 by the licensee. These are AOVs with an active safety function.	328 AOVs are categorized as Class 2 by the licensee. These are AOVs with an EOP function or operational economic significance.	484 AOVs are categorized as Class 3 by the licensee. These are AOVs not categorized 1 or 2. There are a total of 910 AOVs at TMI–1.	There are 81 MOVs in the GL 89–10 program for this plant.
Indian Point 3	263 AOVs are classified as safety-related by the licensee.	The licensee did not classify AOVs as Category 1, 2, or 3. [215 AOVs were classified by the licensee as being within the scope of the Maintenance Rule, 10 CFR 50.65 (Ref. 1)]	The licensee did not classify AOVs as Category 1, 2, or 3.	The licensee did not classify AOVs as Category 1, 2, or 3. There are 578 AOVs in the plant, therefore: 578–263 = 315 AOVs are nonsafety-related.	89 MOVs are within the scope of GL 89–10.
Turkey Point 3-4	The licensee classified 191 AOVs (total for both units) as safety-related.	174 AOVs (98 active, 76 passive, total for both units) are classified by the licensee as Category 1.	53 (34 active, 19 passive, total for both units) are classified by the licensee as Category 2.	There are 836 AOVs in both units. It is not known if the licensee specifically designated some AOVs as Category 3.	111 MOVs (total for both units) are within the scope of GL 89–10.

*Generic Letter (GL) 89–10, "Safety-Related Motor-Operated Valve Testing and Surveillance 10 CFR 50.54(f)," June 28, 1989 (Ref. 2). This column is included for comparison purposes.

NOTE: The category designations in the table vary from plant-to-plant. The use of the categories for each plant is explained with the entry.

There may be SOVs in the plants that are classified as part of AOVs. Figures for SOVs were included if separate data was provided.

the same time. As noted in Section 15.4 and Table 7 in the INEEL AOV draft report, "A Study of Air-Operated Valves at U.S. Nuclear Power Plants, "NUREG/CR–6654," the inability of one particular AOV to operate at one of the plants visited could cause an increase in plant core damage frequency (CDF) of 61 percent (Risk Achievement Worth[1] = 1.61), whereas a common-cause failure (CCF) of that AOV and its counterpart in another train would result in an increase in plant CDF of about 4600 percent (Risk Achievement Worth = 47). The licensee at a different plant found that common-cause failures of other AOVs would result in a risk achievement worth of 202.

[1]Risk achievement worth is the ratio of the plant's CDF calculated when the component of interest has a failure rate of one divided by the plant's base case overall CDF.

3.1 Design Capability Versus Operability and Operational Readiness

As noted in recent NRC and industry communications, and as observed during our plant visits [NUREG 1275, Volume 13, and NUREG/CR–6654], licensees have found several instances of AOVs which were capable of performing satisfactorily during normal plant operations but were not capable of performing satisfactorily during design-basis transient or accident conditions. In many cases, the AOVs successfully passed inservice or surveillance testing to be declared operable, but further analysis or diagnostic testing indicated that the AOVs did not have adequate margins to operate successfully during the more severe design-basis conditions. There have been numerous cases where the AOV design specifications did not account for the more severe transient or accident conditions. There have been cases where the AOV manufacturers' design assumptions or analyses were found to be incorrect. As a result of these types of design deficiencies, some AOVs have been found to have little or no operating margins. In addition, as explained below, there have been cases where inservice or surveillance testing did not reveal the AOVs' small or nonexistent margin for performing their design-basis functions. Inservice or surveillance testing does not necessarily replicate the more harsh transient or accident conditions. Successful completion of inservice or surveillance testing is generally viewed as having demonstrated "operability." However, because of differences between the "test" and "design basis" conditions, inservice or surveillance testing of AOVs does not necessarily verify that the AOVs have the "design capability" to assure that they would function satisfactorily during design basis events. Table 7 of the INEEL study NUREG/CR–6654 lists about 30 events and conditions during the last 5 years where AOVs or their components where the design basis was not met and/or not known.

3.2 Supporting Instrument Air Systems

AOVs are finely tuned systems which are susceptible to failure from contaminants such as moisture, dirt particles, and oil which may be introduced through the pneumatic supply system. Water in contact with carbon steels can lead to the formation of rust particles. Excessive use of threadlockers can lead to the formation of "foreign unidentified sticky substances" (FUSS) when they come in contact with lubricants, elastomers, or other chemicals in the AOVs' piece-parts (SOVs), thereby preventing the AOVs from functioning properly. Dirt particles and rust particles can block the small passageways within the AOVs' piece-parts and prevent them from functioning properly—SOVs, converters, and regulators are especially prone to this phenomena. Oil contamination can result in the formation of varnish-like deposits on the heated surfaces of SOVs, thereby preventing them from changing position. Operating experience confirms that intrusion of moisture, oils, and other particles via the pneumatic system has been a source of AOV failures. Because many AOV piece-parts have tight clearances and tolerances, they are vulnerable to CCFs from contaminants introduced by the pneumatic system.

Another CCF vulnerability of concern is that of excessive pneumatic system pressure due to pressure regulator failure. Pressures in excess of the SOVs' (AOV piece-parts) maximum operating pressure differential (MOPD) may prevent the SOVs from functioning properly and thereby cause failure of their associated AOVs.

Recognizing the importance of rapidly detecting and eliminating moisture contamination from pneumatic systems, current industry standards and guides for pneumatic equipment and systems recommend continuous or frequent (shiftly or daily) dewpoint monitoring [Instrument Society of America, (ISA)–S7.0.01–1996, "Quality Standard for Instrument Air," (Ref. 5) ASME OMa–S/G–1998 Guide Part 17, "Performance Testing of Instrument Air Systems in Light-Water Reactor Power Plants," and Electric Power

Research Institute (Nuclear Maintenance Applications Center) (EPRI/NMAC), NP–7079, "Instrument Air Systems—A Guide for Power Plant Maintenance Personnel" (Ref. 7)].

4 Site Visits

Seven site visits were conducted between October 1997 and March 1998. Each visit lasted 2 days. Table 2 lists the plant name, the dates of the visit, the reactor manufacturer, the architect engineer, and the year the plant began commercial operation.

4.1 AOV Programs at Sites Visited

All of the plants visited had AOV programs in place. All of the programs were aimed at improving AOV performance. However, there were many differences in the status and the depth of the programs at each station (see Table 3). NUREG/CR–6654 provides details of the programs at the stations visited.

The AOV programs at all of the stations visited had been or were in the process of surveying, categorizing, and ranking their AOV populations. Table 1 contains a summary of the categorizations and ranking efforts at each of the seven stations visited. The methodologies used to categorize and rank the AOVs at the plants visited included: review of plant operating experience, consideration of the results of plant PSAs, the use of expert panels, consideration of plant responses to transients and design basis events, and review of emergency procedures. Frequently these activities were part of licensee implementation of the maintenance rule. Many licensees' evaluations utilized IPE and IPEEE methodologies and results. Many licensees' categorizations considered risk achievement worth, Fussell-Vesley, or other risk importance measures.

In order to analyze their AOVs, many of the utilities canvassed[2] have had to purchase design information and analyses from the AOV manufacturers since that information was not provided with the valves. It appears that some of the original AOV design information may have been

[2]Plants canvassed include the seven stations visited plus others that had representatives at AOV industry meetings.

Table 2 Site Visits

Plant Name	Dates of Visits	Plant Description/ Architect Engineer	Year Commercial Operation Began
Palo Verde 1–2–3	10/28–29/97	Combustion Engineering, two loop, System 80 (no power-operated relief valves [PORVs]) PWR/Bechtel	1986
Fermi 2	11/03–04/97	General Electric BWR 4/Detroit Edison	1988
Palisades	11/18–19/97	Combustion Engineering, two loop PWR/Bechtel	1971
LaSalle 1–2	12/17–18/97	General Electric BWR 5/Sargent & Lundy	1984
TMI 1	02/12–13/98	Babcock and Wilcox, lowered loop PWR/ Gilbert Associates	1974
Indian Point 3	03/10–11/98	Westinghouse, four loop PWR/United Engineers and Constructors	1976
Turkey Point 3–4	03/24–25/98	Westinghouse, three loop PWR/Bechtel	1972

Table 3 Status of Air-Operated Valve Programs at Time of Site Visits			
Plant	**Categorization Status**	**Diagnostic Testing* Being Done**	**Findings**
Palo Verde	Complete	Static and Dynamic	Low margins— replaced or modified AOVs
Fermi	Nearing Completion	To be determined	Calculations planned
Palisades	Complete	Static and Dynamic	Low margins— replaced or modified AOVs
LaSalle	Complete	Static	Low margins— replaced or modified AOVs. Found generic effective diaphragm area problem described in Information Notice (IN) 96–68.
TMI 1	Complete	Static planned.	Low margins—modified AOVs
Indian Point 3	Complete	Static	Low margins—replaced or modified AOVs
Turkey Point	Complete	Static	Focusing on maintenance and operations. Limited testing of problem AOVs.
*Dynamic testing: testing conducted with system pressure and/or flow. Static testing: testing conducted at ambient conditions without system pressure or flow.			

provided to the architect-engineers but the utilities were not privy to many of the details of the AOVs' design analyses or available margins. Recently, there have been several cases in which utilities evaluated their AOVs and found errors in the AOV manufacturers' design calculations as well as errors in the valve designs (e.g., Crane-Aloyco, Fisher, Anchor-Darling/ACF/WKM/ BS&B [described in References 3 and 4). In addition, many AOV manufacturers have not provided sufficient guidance or instructions for AOV maintenance or changeout. Similarly, regarding SOVs which are important piece-parts of AOVs, NUREG–1275, Vol. 6, "Operating Experience Feedback Report Solenoid-Operated Valve Problems," U.S. Nuclear Regulatory Commission Office for Analysis and Evaluation of Operational Data, February 1991, noted many cases where SOV manufacturers did not provide utilities with sufficient guidance for maintenance and change-out of SOVs, many of which control AOVs.

AOV programs at the stations visited either were using or were planning to use AOV diagnostic testing equipment. In addition to the plants visited, feedback from industry meetings indicates that plants have had favorable results using AOV diagnostic testing equipment to diagnose and fix specific AOV problems. In many cases, as a result of using diagnostic testing equipment, the utilities have made modifications to AOVs to improve their operation. Some plants indicated that they use AOV diagnostic testing equipment routinely to confirm that AOVs have been set up correctly.

Some plants have performed AOV diagnostic testing under prototypic dynamic conditions. However, most plants' AOV diagnostic testing has been done statically, and not under prototypic design loading conditions. In some cases, successful static diagnostic testing may not provide the assurance that an AOV will be able to perform its safety function under design loading conditions.

5 Operating Experience

The reader is referred to the NRC report NUREG 1275 Volume 13 "Evaluation of Air-Operated Valves at U.S. Light Water Reactors," Section 5.1, for summaries of selected common-cause air-operated valve events. The reader is also referred to INEEL report, NUREG/CR–6654, which has an extensive list of recent AOV events (Tables 2, 3, and 4) [These reports document a total of 159 events, 79 of which occurred during the last 5 years]. In addition, NUREG/CR–6654 contains a table (Table 7) of recent events (within the last 5 years) or conditions involving AOVs or air-operated components where the design basis was not met or were not known.

6 Air-Operated Valve Failures and Risk

Recognizing the application of the single failure criterion and defense in depth, failure of a single AOV would generally not be a cause of concern. However, all licensees visited identified "important" AOVs based on a variety of methods including plant specific probabilistic risk assessments, individual plant examinations, or maintenance rule expert panel reviews. Many licensees identified individual AOVs whose failure would result in increased risk as indicated by high risk achievement worth or high Fussell Vesely risk rankings.

Licensees for three nuclear stations performed calculations of the risk achievement worth assuming CCF of redundant AOVs in certain safety systems. These are tabulated in Table 6 of NUREG/CR–6654 which shows risk achievement worths which range from slightly over 1 up to 202.

6.1 Simultaneous Failure of Air-Operated Valves Which Disable Safety Systems.

The major safety concern of this study from a risk perspective is the simultaneous CCF of AOVs, which disable redundant trains of a safety system. The scenario of most concern is that during an accident or transient, AOVs in redundant trains of a safety system fail when subjected to pressure, temperature, and flow conditions different from those seen during normal operation or testing. Similar to the situation with MOVs which led to issuance of GL 89–10, errors in design parameters, such as valve factors, and other design, manufacturing, or maintenance errors could result in lower than expected AOV valve operator force or greater than expected valve friction. Normal testing or routine operation of these valves, if performed under pressure, temperature, flow conditions different from those expected during an accident or transient, may not reflect the actual capability of the valve to perform during an accident or transient.

Several instances from operating experience are noted in this study where AOVs were shown to be unable to operate under the conditions expected during an accident or transient. These were usually found through diagnostic testing methods similar to those utilized to verify MOV operability in response to GL 89–10 and its supplements. Current inservice testing and technical specification operability tests may not assure AOV capability for pressure and flow conditions during an accident or transient.

Another safety concern is the potential simultaneous failure of two or more AOVs in important safety systems due to contamination from the pneumatic system or from fabrication and maintenance activities. Rust, dirt, or water in the air system can affect many valves. Fabrication and maintenance activities can introduce excessive thread locker or other contaminants which cause sticking or binding. Elastomers deteriorate with age. AOV failures from these conditions are expected to be more random than the design errors and fabrication errors described above, but could still have the impact of disabling multiple trains of a safety system.

The study and its companion report describe over 150 AOV events. Many of the events are CCFs which resulted in degradation of important safety systems. If the plant had experienced an accident or transient while these failures existed, plant safety may have been challenged.

Risk calculations are generally done based on the assumption that components perform in a probabilistic sense under accident conditions. For those situations where AOVs in redundant trains of a safety system are not capable of operating due to pressure, temperature, or flow conditions expected during an accident or transient, those assumptions are negated. A truer risk analysis would account for this type of failure mechanism by assigning a failure probability of 1.0 for those valves for the particular accident or transient in which the valves are incapable of performing as needed.

6.2 Sensitivity of Core Damage Frequency to Air-Operated Valve Failures

A recently completed sensitivity study, INEEL report, "Generic Issue 158: Performance of Safety-Related Power-Operated Valves Under Operating Conditions," NUREG/CR–6644, September 1999, provides insights into the sensitivities of seven different U.S. nuclear reactors to the performance of their power-operated valves, (i.e., AOVs, SOVs, and HOVs). The study was performed for NRC to address Generic Safety Issue 158, "Performance of Safety Related Power-Operated Valves Under Design Basis Conditions." The results show wide variations in the plants' sensitivities to valve failures. At some plants, common-cause AOV failures can have a significant effect on the risk as measured by CDF. Furthermore, CDF sensitivity is dominated by the likelihood for CCF (quantified by the beta factor).

6.3 Important or Risk Significant AOVs

At each of the plants visited utility personnel provided lists of AOVs that were considered to be important at their plants. At many plants the selections were based on the AOVs' effect on CDF, as determined from the plants' PRAs, (i.e., the AOVs' risk achievement worth). Another subset of risk information that licensees at many of the plants visited deemed to be important was the AOVs' effect on large early release frequency. In addition, the licensees determination of the risk importance of AOVs considered the specific functions that the AOVs were required to perform as outlined in the plants' emergency, off-normal, abnormal recovery procedures, etc. Table 4 lists the systems, functions, or components that were determined by the licensees to have risk important AOVs at the plants visited and the number of risk significant AOVs at each station. In addition, the reader is directed to Table 6 in the INEEL AOV study NUREG/CR–6654 which lists the

Table 4 Systems, Functions or Components Having Risk-Significant Air-Operated Valves at Plants Visited		
Plants Visited	**Systems, Functions, or Components Having Risk Significant Air-Operated Valves**	**Number of Risk Significant Air-Operated Valves**
Palo Verde Units 1–2–3	Charging system, ADVs, feedwater isolation, steam generator isolation	51
Fermi Unit 2	Main Steam (MSIVs), scram discharge volume vent and drain, drywell floor drain, condensate polishing demineralizer, condensate emergency supply, reactor feed pump, general service water, emergency equipment cooling water, emergency equipment service water, standby gas treatment, reactor building HVAC, standby gas treatment to torus air purge valve, torus vent	29
Palisades	SDC heat exchanger, condensate inlet containment isolation, steam generator, SDC to LPSI, containment sump isolation to engineered safeguards room, steam generator steam dump	11
LaSalle Units 1–2	Containment vent valves, ADS, RHR room coolers, SW pump coolers, feed-water regulator valve, drywell venting	14
Three Mile Island Unit 1	ADVs, Containment isolation (coolant return lines)	4
Indian Point Unit 3	AFW, Main steam to auxiliary boiler, condensate storage tank to condenser, condensate polisher inlet stop valve, heater drain tank to condenser bypass, ADVs, pressurizer PORVs	40
Turkey Point Units 3–4	Steam generator blowdown control, auxiliary feedwater, CCW to emergency containment coolers, Instrument air combined header crosstie, charging pump suction.	33
	TOTAL	182

182 AOVs that were determined by the licensees to be risk significant at the seven sites visited. Two of the licensees found nonsafety-related AOVs that were risk significant. The Fermi plant found 11 "nonsafety-related AOVs that perform a risk significant function" and Indian Point Unit 3 found 4 nonsafety-related AOVs that were risk significant.

7 Findings and Conclusions

7.1 AOV Program Practices

- Licensees visited have implemented AOV programs.
- Licensee maintenance rule scope generally includes AOVs, both "safety-related" and "nonsafety-related."
- Licensees have identified risk significant and "important" AOVs, both "safety-related" and "nonsafety-related."
- Significant variations exist in the scope and focus of current licensee AOV programs.
- Air-operated dampers have been are excluded from most current and proposed AOV programs without full consideration of their risk importance.

7.2 Air-Operated Valve Performance Under Accident or Transient Conditions

- Current testing methods may not assess AOV performance under certain accident or transient conditions, similar to the earlier situation with MOVs.
- Several licensees that have begun using diagnostic equipment similar to that used for MOVs have found AOVs

which would not perform as expected under certain accident or transient conditions.

- Several licensees that have reanalyzed AOVs' capability using updated design and valve factor information have found AOVs which would not perform under certain accident or transient conditions.

7.3 Air-Operated Valve Common-Cause Failure Experience

- Design and manufacturing errors.
- Aged and degraded elastomers and other piece parts.
- Contamination from the pneumatic system and fabrication materials.

7.4 Air-Operated Valve Risk Considerations

- Licensees have identified AOVs which they consider to have risk significance based on high risk achievement worth and other risk analysis methods. These usually address the risk of a single valve failure.
- The primary risk concern regarding AOVs found in this study is the potential for simultaneous CCF of both trains of a safety system during an accident or transient due to design, manufacturing, maintenance, and testing deficiencies which do not properly account for pressure, temperature, and flow conditions expected to occur during accidents or transients.
- Another concern is the potential for simultaneous CCF mechanisms introduced by air system contamination, other contaminants, or ageing of elastomeric parts.

8 Recommendations

The implementation of an effective AOV program, incorporating the use of analysis, diagnostic testing, and lessons learned from operating experience, can minimize the likelihood of AOV failures resulting in risk significant events. Such a program would:

- Identify safety related AOVs which are normally in a non-safety position and are expected to move to their safety position during accidents or transients. (These will subsequently be referred to as safety related active AOVs.)
- Identify safety related active AOVs which contribute the most to risk should they fail to operate, using plant-specific application of appropriate risk-ranking methodologies. For those valves with unconfirmed design margin and unrepresentative diagnostic testing, risk calculations which consider failures of redundant valves in both trains of a system may be appropriate.
- Establish confidence that risk significant safety related active AOVs will operate as required, subject to the actual pressures, temperatures, and flows during transient and accident conditions, by application of accepted and verified analysis or diagnostic testing methods. Assure continued operability of these valves through periodic testing.
- Establish operations and maintenance practices which prevent introduction of contaminants to the pneumatic system or to the valves and their sub-

components and replace aging elastomers as appropriate.

- Identify nonsafety-related valves which have high risk significance and apply similar analysis or diagnostic techniques.

9 Epilogue: AOV Activities and Programs

In 1997, U.S. LWR licensees formed the JOG–AOV. JOG–AOV's stated mission is "to develop a common and cost-effective U.S. nuclear utility AOV program which defines the minimum elements necessary to enhance safe and reliable AOV performance and allow timely address of industry and regulatory AOV issues." The JOG–AOV initiatives are voluntary.

On June 3, 1999, a public meeting was held at NRC headquarters to discuss industry activities regarding AOVs. NRC staff met with representatives from NEI, JOG–AOV, Institute of Nuclear Power Operations, AUG, and EPRI to discuss AOV issues, including the JOG–AOV Program and JOG–AOV Program document. The meeting discussions about the JOG–AOV program and program document were limited because the NRC had not received copies prior to the meeting. NRC attendees noted that the industry programs appeared to be positive voluntary initiatives. However, the JOG–AOV program did not address several items which the NRC staff thought were important. The following list is a representative tally of those items not fully addressed:

1. Air system quality.
2. Risk significant nonsafety-related AOVs.
3. Quarter-turn AOVs (dampers).
4. Licensee commitments and schedules for implementation.

On July 19, 1999, NEI transmitted the JOG–AOV Program document to the NRC (Ref. 10). In the transmittal letter, NEI stated that the NRC was not requested to review or endorse JOG AOV's program document and that industry does not want credit for such industry activities in the context of SECY–99–063, "The Use by Industry of Voluntary Initiatives in the Regulatory Process." On October 8, 1999 (Ref. 11), NRC responded to NEI's July 19, 1999, letter, providing comments on the JOG–AOV program document. Appendix A of this report contains the NRC comments that were transmitted to NEI.

Subsequent to publication of the NRC and INEEL AOV studies, NRC issued Regulatory Issue Summary (RIS) 2000–03 (Ref. 12). RIS 2000–03 informs stakeholders of the NRC's actions regarding power operated valves (AOVs, SOVs and HOVs) and of the staff's intent to continue to work with industry groups to monitor their activities to ensure that safety-related POVs are capable of performing their specified functions under design basis conditions.

10 References

1. U.S. Nuclear Regulatory Commission, 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants."
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3. U.S. Nuclear Regulatory Commission, NUREG 1275, Volume 13, "Evaluation of Air-Operated Valves at U.S. Light-Water Reactors," February 2000.

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11. Imbro, E., U.S. Nuclear Regulatory Commission, letter to D. Modeen, Nuclear Energy Institute, "Comments on Joint Owners' Group Air-Operated Valve Program Document," October 8, 1999.

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Appendix A

NRC Comments on Joint Owners Group Air-Operated Valve Program Document

Following are NRC comments which were transmitted to NEI as an attachment to NRC letter dated October 8, 1999.

1. In Section 1.5, Instrument Air Systems, the Joint Owners Group Air-Operated Valve (JOG AOV) program (the Program) states the following:

    > It is the responsibility of individual plants to assure that pneumatic supply systems are appropriately maintained and operated consistent with plant commitments.

    The importance of the quality of the air supply in the proper operation of AOVs during design-basis events is well recognized. Poor quality air can lead to CCF scenarios that will result in the failure of the AOVs to move to either their desired or fail-safe position. These conditions can prevent an AOV from performing its design-basis function, regardless of the extent of analysis and testing performed on the AOV assembly.

    GL 88–14, "Instrument Air Supply System Problems Affecting Safety-Related Equipment," requested licensees to review NUREG–1275, Volume 2, "Operating Experience Feedback Report-Air System Problems," and to perform a design and operations verification of their instrument air systems. GL 88–14 did not provide guidance on periodic verification of air systems. Therefore, as part of the JOG AOV program it is recommended that licensees review their evaluations of air supply systems performed in response to GL 88–14 to assure themselves that the air systems have been appropriately maintained and operated.

2. In Section 2.0, Definitions, the staff has the following comments:

    The term "setpoint" should be defined because it is required for all AOVs, and is the key verification and testing method for AOVs defined in the program as Category 2. As an example, the following definition is currently being considered in the risk-informed AOV Code case being developed by the ASME Operations and Maintenance Committee on Pneumatically- and Hydraulically-Operated Valves and is viewed by the NRC staff to be acceptable:

    > A point or set of points that would be set by a technician so that the valve assembly would meet its design function. Examples of setpoints would be bench set values or pressure regulator values.

3. In Section 4.1.2, Scope, the program excludes air-operated dampers based on treatment of motor-operated dampers in GL 89–10, "Safety-Related Motor-Operated Valve Testing and Surveillance." The justification for

exclusion of dampers from the motor-operated valve (MOV) programs under GL 89–10 may not be appropriate for exclusion of air-operated dampers from the JOG AOV program. The program should specify that individual licensees will assess the design-basis functions and operating experience for their air-operated dampers. Each licensee would be responsible for developing plant-specific justifications for excluding any air-operated dampers from the program.

4. In Section 4.1.2, Scope, the program should ensure that licensees consider AOVs that are placed in their non-safety position for activities, such as maintenance or testing, where the train is assumed to remain operable during that time. Similar to what was stated in GL 96–05, "Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves," the program should include safety-related AOVs that are assumed to be capable of returning to their safety position when placed in a position that prevents their safety system (or train) from performing its safety function; and the system (or train) is not declared inoperable when the AOVs are in their nonsafety position.

5. In Section 4.1.3, Categorization Process, consideration of high risk-significant AOVs that might not be classified as safety-related is a positive risk-informed attribute of the JOG AOV program. However, the program only specifies that these AOVs be considered as Category 2. NRC Regulatory Guide 1.175 (Revision 0), "An Approach for Plant Specific Risk-Informed Decision Making: Inservice Testing," states that the licensee's Risk-Informed Inservice Testing program should include non-Code components that the licensee's integrated decision making process categorized as high safety significant components. For such components, the benefits in risk reduction from ensuring their capability could be substantial, while the burden in verifying their capability may be relatively minor. Therefore, we would recommend the program include treatment of these high-safety significant AOVs as part of a more extensive capability evaluation, similar to Category 1 AOVs. JOG AOV indicated at a public meeting with the NRC staff on June 3, 1999, that there likely would be few AOVs in this group.

6. In Section 4.1.3.2, Determination of Safety-Significance:

   a. The program lists several methodologies that may be used to categorize AOVs by their safety significance. Presentations at AUG meetings suggest that the actual categorization process will be focused on the use of information from the individual plant's maintenance program supplemented by risk insights from the plant specific IPE and use of an additional integrated decision-making process (i.e., expert panel). In order to establish consistency in AOV safety significance categorization, the program should include a typical list of AOVs to be evaluated for inclusion in the program for each major plant design. The list should also specify those AOVs that are typically categorized as high risk (This was done by the Boiling-Water Reactor Owners Group as part of their follow-up to GL 89–10). It is recognized that not all AOVs in these typical lists would need to be included in a individual AOV program, or categorized as high risk, because of plant-specific design considerations. However, the licensee should have a reasonable basis for excluding such AOVs from its program or categorizing them as low risk.

b. It is noted that one acceptable method for ranking safety significance and conducting an expert panel evaluation is contained in RG 1.160, Revision 2, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." This regulatory guide does not provide the necessary guidance for risk ranking AOVs at the component level. Therefore, its use alone might not be appropriate for its intended purpose.

7. In Section 4.1.4, Mispositioning, the program states that mispositioning or inadvertent operation of an AOV is not considered based on GL 89–10, Supplements 4 and 7, which considered the safety significance of mispositioning of MOVs in BWRs and PWRs, respectively. Both supplements concluded that the evaluation of MOV mispositioning could be removed from the scope of GL 89–10 programs based, in part, on studies by Brookhaven National Laboratory (BNL) of the safety significance of inadvertent operation of MOVs in safety-related systems. Nevertheless, GL 89–10, Supplement 7, indicated that consideration of valve mispositioning benefits safety. The JOG AOV program should not base the exclusion of considering AOV mispositioning on the GL 89–10 program, but rather should provide guidance for licensees to evaluate the susceptibility of their AOVs to mispositioning. For example, AOVs may be more susceptible to inadvertent operation depending on the quality of the air system, the flow direction, and the application.

8. In Section 4.2, Setpoint Control, the program states the following:

   Setpoint control is required for those setpoints affecting the active safety function of the AOV. As a minimum, parameters to be maintained and documented as part of the plant specific setpoint control program, as applicable, are:

   - Actuator air supply setting(s)
   - Preload (bench set)
   - Stroke length

   For Category 1 valves, the above information is established as part of the design basis review (Section 4.3). For Category 2 valves, the required information is typically obtained from the current specification.

The program appears to establish reasonable guidelines for ensuring the design-basis capability of Category 1 AOVs. The program should provide for the application of lessons learned from the detailed evaluation of Category 1 AOVs to other safety-related AOVs. Although limited in details, maintenance of setpoints might provide reasonable assurance of the capability of low safety significant (Category 2) AOVs where sufficient information is obtained from Category 1 or selected

Category 2 AOVs. The program should provide additional guidance to ensure that licensees establish adequate setpoint control methods. For example, a definition of setpoint should be included in the JOG–AOV program document (see comment to Section 2). Additional clarification should be provided as to the type of information that should be obtained to establish setpoints for Category 2 valves. The information should come from either current vendor information or the results of diagnostic testing. In addition, the establishment of setpoints should apply accurate information on valve packing loads and other parameters that may affect the capability of the AOV. A verification interval no greater than 10 years should be established to verify the setpoints of AOVs. These enhancements should ensure that the setpoints of Category 2 valves are established such that they will be capable of performing their safety functions.

9. In Section 4.3.3.2, Actuator Output Capability, the program should state that the actuator output capability must be verified by test information.

10. In Section 4.3.3.3, Actuator Capability Margin and Allowable Limits, the program states the following:

> Valve and actuator limits need not be evaluated if the current setpoints are within the original equipment manufacturer's (OEM) specified setpoints. As the equipment was procured as safety-related, the normal design process is expected to ensure the OEM established setpoints are within the design ratings of the valve and actuator assembly.

As discussed at the June 3, 1999, public meeting, the validity of industry data used to establish setpoints for AOVs needs to be ensured. As stated in comments on Section 4.2, the program should specify that setpoints need to be based on current vendor information or the results of diagnostic testing. In addition, the establishment of setpoints should apply accurate information on valve packing loads and other parameters that may affect the operation of the AOV.

With respect to the allowable actuator capability margin, the staff agrees with JOG AOV that the margin must be greater than 0%. The acceptability of an actuator capability margin which approaches 0% would depend on the assumptions associated with the margin calculation. In any inspection activity associated with AOVs, the staff would pay particular attention to margins that approach 0%.

11. In Section 4.4.1, Baseline Testing, the program states the following:

> Baseline testing is performed with the intent to:
>
> - Verify the functional capability
> - Validate design inputs in accordance with Appendix A [of the program]
> - Confirm required operating setpoints
> - Establish a reference for periodic testing
>
> Each plant should determine the type of baseline testing, which can

range from stroke time testing to dynamic testing with diagnostics, needed to satisfy the above.

Static stroke-time testing does not ensure design-basis capability of each tested AOV. Therefore, it should not be included as a baseline test option. Further, the program does not specify when dynamic or static diagnostic periodic testing is needed. The licensee should obtain sufficient information to ensure the design-basis capability of safety-related AOVs and those high-risk AOVs that might not be categorized as having safety-related functions.

12. In Section 4.4.2, Periodic Testing, the program should specify that test data need to be evaluated over the first 5 years (or 3 refueling cycles) to support extended test intervals. Further, the verification interval should not exceed 10 years because of the absence of long-range performance information.

13. In Section 4.4.3, Post Maintenance Testing, the program should ensure that the guidance for post maintenance testing of Category 2 valves in the program is consistent with quality assurance requirements of 10 CFR 50 Appendix B to ensure that safety-related AOVs can perform their safety functions.

14. In Section 4.6, Training, the program should include specific guidance on training to incorporate lessons learned from other valve programs.

15. In Section 4.7.2, Industry Feedback, it is not clear how feedback of industry information on AOV performance will be accomplished in light of plans to disband the JOG AOV and the absence of a specific AUG program. Although general mechanisms such as the INPO Equipment Performance and Information Exchange System (EPIX) and NRC communications may help in this regard, an AOV specific approach has not been identified.

16. In Section 4.9, Tracking and Trending, the program should include quantitative and qualitative trending of AOV performance, such as review of diagnostic data, and maintenance and condition reports. These trends should be periodically reviewed.

17. In Appendix B, Uncertainties and Potential Degradations, the program should address measurement uncertainty of AOV diagnostic test methodologies. Although this could be considered in the overall assessment of uncertainties, special attention should be given to diagnostics in the AOV program because of the history of challenges with diagnostics during implementation of MOV programs. The program should include a discussion of AOV diagnostic uncertainties and their relationship to other specific uncertainties discussed in the program. In addition, the program should emphasize that the diagnostic equipment must meet quality assurance requirements.

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The 2000 Symposium on Valve and Pump Testing, jointly sponsored by the Board on Nuclear Codes and Standards of the American Society of Mechanical Engineers and by the U.S. Nuclear Regulatory Com mission, provides a forum for exchanging information on technical and regulatory issues associated with the testing of v alves and pumps used in nuclear power plants. The symposium provides an opportunity to discuss the need to improve that testi ng in order to help ensure the reliable performance of valves and pumps. The participation of industry representatives , regulators, and consultants ensures the discussion of a broad spectrum of ideas and perspectives regarding the improvem ent of testing programs and methods at nuclear power plants.

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