IV-1000 INTRODUCTION

IV-1100 APPLICABILITY

This Mandatory Appendix establishes the requirements for Preservice and Inservice Testing, as defined in para. ISTA-2000, to assess the operational readiness of active pneumatically operated valves (AOVs) in reactor power plants.

IV-1200 SCOPE

Active Pneumatically Operated Valves and Pneumatically Operated Power Operated Relief Valves (PORVs) within the scope of para. ISTA-1100.

IV-1300 Exemptions

In addition to the exemptions specified in para. ISTC-1200, the following are excluded from this Mandatory Appendix:
(a) Pneumatically operated dampers
(b) Pneumatically operated check valves
(c) Category C check valves and safety/relief devices

IV-1400 Owner’s Responsibility

In addition to the requirements of paras. ISTA-1500 and ISTC-1400, it is the Owner’s responsibility to:

(a) Establish Performance Assessment Test acceptance criteria (para. IV-6100) and technical basis, including margin, that provides reasonable assurance the pneumatically operated valve is capable of performing its specific function(s) as defined in para. ISTA-1100. Performance Assessment Test acceptance criteria that

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1 (This Mandatory Appendix contains requirements to augment the rules of Subsection ISTC, Inservice Testing of Valves in Light-Water Nuclear Reactor Nuclear Power Plants.)
meet the requirements of this Mandatory Appendix, but were established before implementation of this Mandatory Appendix may be used where documented.

(b) Define the level of testing required prior to and after replacement, repair, modification or maintenance activities per para. IV-3520.

(c) Specify the limiting value(s) of full-stroke time of each valve per para. IV-3420.

(d) Determine if the risk ranking approach per para. IV-3800 will be used to implement this Appendix.

IV-2000 SUPPLEMENTAL DEFINITIONS

_Pneumatically Operated Valve (AOV)_ - A valve and its associated actuator, including pneumatically operated PORVs as defined in para. ISTC-2000, that uses air/gas as the motive force, including all subcomponents required for the valve assembly to perform its specific function as defined in para. ISTA-1100, except those exempted by para. IV-1300. For simplicity, this type of valve is referred to as an AOV throughout this Mandatory Appendix.

_AOV Functional Margin_ - The increment or percentage by which an AOV's available as tested capability exceeds the thrust/torque load required to operate the AOV under worst-case operating conditions (also referred to as field margin or post-test margin).

_Fail Safe_ - Characteristic of a valve and its actuator, which upon loss of actuating energy supply, will cause a valve obturator member to be fully closed, fully open, or remain in the last position, as necessary to satisfy the specific function as defined in para. ISTA-1100.

_Fail Safe Test_ - A test of an AOV with fail-safe functions, performed by observing the operation of the actuator upon loss of valve actuating power.

_Stroke Test_ - Exercising (as defined in para. ISTA-2000) the AOV by operating one complete open and close cycle and testing that includes a full-stroke time (as defined in para. ISTC-2000).

_Inservice Test Value(s)_ - Measured parameters that consist of Inservice Performance Assessment Test, Inservice Stroke Test and Leak Test results.

_Performance Assessment Test_ - Performance Testing (as defined in para. ISTA-2000) consisting of the measurement and assessment of applicable test parameters. This test is normally performed at ambient conditions without system pressure or flow.

_Test Parameter(s)_ - Parameters, or combination of parameters, which may be determined from data obtained during testing and are important to monitor to ensure the specific functional capability of the valve assembly. This includes, for example, bench set, spring pre-load, spring rate, full-stroke time, valve travel, total friction (which is the sum of packing friction, valve internal friction, and actuator friction), torque, thrust, seat
load, maximum available pneumatic pressure, and minimum pneumatic pressure
required to accomplish the specific function(s) of the valve assembly as defined in para. ISTA-1100.

IV-3000 GENERAL TEST REQUIREMENTS

IV-3100 RESERVED

IV-3200 RESERVED

IV-3300 PRESERVICE TESTING

Each AOV shall be tested during the preservice test period as required by this paragraph. These tests shall be conducted under conditions as near as practicable to those expected during subsequent Inservice Testing. Testing that meets the requirements of this Mandatory Appendix but was performed before implementation of this Mandatory Appendix may be used.

Each of the following tests shall be performed for each AOV during the preservice period:

(a) A Performance Assessment Test.

(b) A Stroke Test.

(c) A Fail Safe Test, if applicable

(d) Leak Testing in accordance with paras. ISTC-3600 and ISTC-5000, as applicable.

(e) Position Verification Testing, for valves with remote position indicators, in accordance with para. ISTC-3700.

Only one Preservice Test of each valve is required with the exception that any AOV that has undergone maintenance that could affect its performance after the Preservice Test shall be tested in accordance with para. IV-3520.

IV-3400 INSERVICE TESTING
Inservice Testing shall commence when the AOV is required to be operable to fulfill its specific function(s) as defined in para. ISTA-1100 and shall be sufficient to assess changes in AOV functional margin consistent with para. IV-6400. These tests shall be conducted under conditions as near as practicable to those expected during subsequent Inservice Testing. Each of the following tests shall be performed for each AOV:

(a) A Performance Assessment Test in accordance with para. IV-3410.

(b) A Stroke Test in accordance with para. IV-3420.

(c) A Fail Safe Test in accordance with para. IV-3430.

(d) Leak Testing in accordance with paras. ISTC-3600 and ISTC-5000, as applicable.

(e) Position Verification Testing, for valves with remote position indicators, in accordance with para. ISTC-3700, as applicable.

### IV-3410 PERFORMANCE ASSESSMENT TESTING

Performance Assessment Testing shall be performed as follows:

(a) For pre-2000 plants, an initial Performance Assessment Test shall be performed within three refueling cycles or 5 years (whichever is longer) following implementation of this appendix to assess functional margin. For post-2000 plants, an initial Performance Assessment Test shall be performed to assess functional margin prior to plant startup, or during plant startup activities.

The Preservice Performance Assessment Test may be used to meet this requirement. In addition, activities that were performed as part of a plant’s legacy AOV Program can be used to satisfy the initial Performance Assessment Test provided the requirements of IV-1400(a) have been met and the basis is documented.

(b) The interval for periodic Performance Assessment Tests shall be determined in accordance with para. IV-6400. If insufficient test data exists from an applicable AOV or AOV group to determine the Performance Assessment Test interval in accordance with para. IV-6400, then Performance Assessment Testing shall be conducted every three refueling cycles or 6 years (whichever is longer) until sufficient data exist, from an AOV or AOV group, to justify a longer Inservice Test interval.

(c) AOVs may be grouped for periodic Performance Assessment Testing as described in para. IV-3600.
(d) If maintenance activities are scheduled concurrent with an AOV’s periodic Performance Assessment Test, then the Performance Assessment Test shall be conducted prior to the maintenance activity, where practicable. See para. IV-3520 for guidance on the effects of AOV replacement, repair, modification or maintenance.

(e) For AOV’s that operate in the course of plant operation, periodic Performance Assessment Testing, other than the initial test per para. IV-3410(a), may be satisfied by the following, provided that:

1) The conditions during exercise of the AOV meet or exceed the worst-case operating conditions,
2) The required observations are made and analyzed during such operation and recorded in the plant record.
3) The observation is performed at least once every 24 months.
4) The valve exhibits the required change in obturator position.
5) A stroke test can be performed quarterly.

Credit may be taken for operation at less than design conditions with proper justification. The basis shall be documented by engineering evaluation. The engineering evaluation shall be reviewed and updated, as required, if an AOV application is changed, the AOV is physically modified, or the system is modified in a manner that invalidates the evaluation.

(f) Alternative risk-informed Performance Assessment Test intervals may be applied in accordance with para. IV-3800.

(g) The periodic Performance Assessment Test interval shall not exceed 10 years for each AOV.

(h) Any abnormality or erratic action shall be recorded (see para. IV-9000), and an evaluation shall be made regarding need for corrective action.

(i) The Owner shall consider more frequent Performance Assessment Testing for AOVs in any of the following categories:

1) AOVs with severe service conditions (temperature, radiation, fluid process, etc.).
2) AOVs with any abnormal characteristics (operational, design or maintenance conditions).
3) AOVs with low margin according to the Owner’s program.
IV-3420 STROKE TESTING

Stroke Testing shall be performed as follows:

(a) All AOVs, within the scope of this Mandatory Appendix, shall have a Stroke Test performed quarterly if practicable as follows:

1) If the testing is not practicable during operation at power, it may be limited to testing during cold shutdowns.
2) If the testing is not practicable during operation at power or cold shutdown, it may be limited to testing during refueling outages.
3) For test intervals of Cold Shutdown or Refueling, Testing is not required if the time period since the previous test is less than 3 months. During extended shutdowns, valves that are required to perform their specific function as defined in para. ISTA-1100 shall be Tested every 3 mo, if practicable.
4) Testing during cold shutdown shall commence within 48 hour of achieving cold shutdown and continue until all testing is complete or the plant is ready to return to operation at power. For extended outages, testing need not be commenced in 48 hour, provided all valves required to be tested during cold shutdown will be tested before or as part of plant start-up.
5) All testing required to be performed during a refueling outage shall be completed before returning the plant to operation at power.

(b) Stroke Testing includes stroke time measurement as follows:

1) The limiting value(s) of full-stroke time of each valve shall be specified by the Owner.
2) The stroke time of all valves shall be measured to, at least, the nearest second.
3) Any abnormality or erratic action shall be recorded (see para. IV-9000), and an evaluation shall be made regarding need for corrective action.
4) Where para. IV-3410 (e) is used to validate valve function, a Stroke Test shall be performed quarterly.

(c) Stroke Testing should be performed prior to Performance Assessment Testing when these tests are scheduled concurrently. This action ensures that the Stroke Test and its associated trendable parameters are performed under repeatable conditions to the extent practicable.

(d) Valve obturator movement shall be determined in accordance with para. ISTC-3530.

(e) See para. IV-7100 for acceptance criteria.
IV-3430 FAIL SAFE TEST

All AOVs with fail-safe actuators, within the scope of this Mandatory Appendix, shall have a Fail Safe Test performed in accordance with the frequency of para. IV-3420(a). The Fail Safe Test is performed by observing the operation of the actuator upon loss of valve actuating power.

IV-3500 TEST PARAMETERS

IV-3510 INSERVICE STROKE TEST REFERENCE VALUES

For post-2000 plants (as defined in Subsection ISTA) or new (i.e., new or replaced) AOVs in pre-2000 plants (as defined in Subsection ISTA), Inservice Stroke Test reference values shall be determined from the results of Preservice Testing. For pre-2000 plants, Inservice Stroke Test reference values may be determined from the results of Inservice Testing. These tests shall be performed under conditions as near as practicable to those expected during subsequent Inservice Testing. Reference values shall be established only when the valve is known to be operating acceptably. If the particular parameter being measured can be significantly influenced by other related conditions, then these conditions shall be analyzed.

IV-3520 EFFECT OF AOV REPLACEMENT, REPAIR, MODIFICATION OR MAINTENANCE

When an AOV is replaced, repaired, modified or undergoes maintenance that could affect the valve's performance, new Inservice Test values shall be determined or the previously established Inservice Test values shall be reconfirmed or the activities performed shall be evaluated along with the results of post replacement/repair/modification/maintenance testing to determine if new Inservice Test values are warranted before the AOV is returned to service. If the AOV was not removed from service, Inservice Test values shall be immediately determined or confirmed. This testing is intended to demonstrate that test parameters, which could be affected by the replacement, repair, modification or maintenance, are within acceptable limits. The Owner's program shall define the level of testing required prior to and after replacement, repair, modification or maintenance activities. Other attributes (such as functional margin) may be considered when defining the level of testing required prior to and after replacement, repair, modification or maintenance activities, where the basis is properly justified and documented by an engineering evaluation. Deviations between the previous and new Inservice Test values shall be identified and analyzed. Verification that the new Inservice Test values represent acceptable operation shall be documented as described in para. IV-9000.
IV-3530 ESTABLISHMENT OF ADDITIONAL SET OF INSERVICE STROKE TEST REFERENCE VALUES

If it is necessary or desirable for some reason, other than stated in para. IV-3520, to establish additional Stroke Test reference values, an Inservice Stroke Test shall first be run at the conditions of an existing set of reference values, or, if impractical, at the conditions for which the new reference values are required, and the results analyzed. If operation is acceptable in accordance with the applicable requirements of para. IV-7000, a second test shall be performed under the new conditions as soon as practicable. The results of the second test shall establish the additional reference values. Whenever additional reference values are established, the basis shall be justified and documented in the record of tests (see para. IV-9000).

IV-3600 GROUPING OF AOVs FOR PERFORMANCE ASSESSMENT TESTING

AOVs may be grouped for periodic Performance Assessment Testing. Grouping AOVs shall be documented and justified by an engineering evaluation, alternative testing techniques, or both. The following shall be satisfied when grouping AOVs:

(a) AOVs with identical or similar actuators and valves with similar plant service conditions may be grouped together.

(b) Test results shall be evaluated for all AOVs in the group.

(c) All valve assemblies in a group shall have Inservice Performance Assessment Testing performed within the maximum test interval.

(d) The number of valve assemblies tested from each group shall be determined using appropriate statistical methodology.

(e) The same valve assembly shall not be selected for the periodic Performance Assessment Test consecutively for a group.

IV-3700 RESERVED

IV-3800 RISK-INFORMED AOV INSERVICE TESTING
Risk-informed AOV Inservice Testing that incorporates risk insights in conjunction with functional margin to establish AOV grouping, acceptance criteria, exercising requirements and testing intervals may be implemented.

**IV-3810 RISK-INFORMED CONSIDERATIONS**

The Owner shall perform the following when incorporating risk insights in the Inservice Testing of AOVs:

(a) Develop an acceptable risk basis for AOV risk determination,

(b) Develop AOV screening criteria to determine each AOV’s contribution to risk,

(c) Finalize risk category by a documented engineering evaluation from a Plant Expert Panel, and

(d) Review PRA changes and/or plant modeling changes and apply to risk ranking as applicable.

**IV-3820 RISK-INFORMED METHODOLOGY**

Each AOV shall be evaluated and categorized using a documented risk ranking methodology. Subsection ISTE provides an acceptable method of risk ranking that may be used to categorize AOVs.

This Mandatory Appendix provides test requirements for High and Low Safety Significant Component (HSSC/LSSC) categories. If an Owner established more than two risk categories, then the Owner shall evaluate the intermediate SSCs and select HSSC or LSSC test requirements for those intermediate SSCs.

**IV-3821 HSSC AOVs**

HSSC AOVs shall be tested as follows:

(a) An initial Performance Assessment Test shall be performed to assess functional margin. The Preservice Performance Assessment Test may be used to meet this requirement.

(b) Periodic Performance Assessment Testing, in accordance with para. IV-3410, is required for HSSC AOVs except for AOVs that meet the requirements of para. IV-3410 (e).

(c) Inservice Testing shall be performed in accordance with para. IV-3400 (b), (c), (d) and (e), as applicable.
(d) Requirements of para. IV-3520 shall be utilized for AOV replacement, repair, modification or maintenance.

**IV-3822 LSSC AOVs**

LSSC AOVs shall be tested as follows:

(a) An initial Performance Assessment Test shall be performed to assess functional margin. The Preservice Performance Assessment Test may be used to meet this requirement.

(b) Periodic Performance Assessment Testing, in accordance with para. IV-3410, is not required for LSSC AOVs.

(c) Inservice Testing shall be performed in accordance with para. IV-3400 (b), (c), (d) and (e), as applicable.

(d) Requirements of para. IV-3520 shall be utilized for AOV replacement, repair, modification or maintenance.

**IV-4000 RESERVED**

**IV-5000 PERFORMANCE ASSESSMENT TEST METHODS**

**IV-5100 PERFORMANCE ASSESSMENT TEST PREREQUISITES**

All testing shall be conducted in accordance with plant-specific technical specifications, installation details, acceptance criteria, and maintenance, surveillance, operation or other applicable procedures.

**IV-5200 PERFORMANCE ASSESSMENT TEST CONDITIONS**

Performance Assessment Test conditions shall be sufficient to determine the AOV's functional margin per para. IV-6400. Test conditions shall be recorded for each test per para. IV-9000.

**IV-5300 PERFORMANCE ASSESSMENT TESTING LIMITS AND PRECAUTIONS**

Performance Assessment Testing limits and precautions include:
(a) Manufacturer or vendor limits and precautions associated with the AOV and with the test equipment shall be considered.
(b) Plant-specific operational precautions, design precautions, operational limits and design limits shall be followed. Items to be considered shall include, but are not limited to, water hammer and intersystem relationships.
(c) The benefits of performing a particular test should be balanced against the potential increase in risk for damage caused to the AOV by the particular testing performed.

IV-5400 PERFORMANCE ASSESSMENT TEST DOCUMENTS

Approved plant documents shall be established for all Performance Assessment Tests specified in this Mandatory Appendix and shall provide for:

(a) Methodical, repeatable, and consistent performance testing; and

(b) Collection of performance assessment data required to analyze and evaluate the AOV functional margin in accordance with para. IV-6400, where applicable.

IV-5500 PERFORMANCE ASSESSMENT TEST PARAMETERS

Sufficient Performance Assessment Test parameters shall be selected for measurement to meet the requirements of para. IV-6000.

IV-6000 PERFORMANCE ASSESSMENT TEST ANALYSIS AND EVALUATION

IV-6100 PERFORMANCE ASSESSMENT TEST ACCEPTANCE CRITERIA

Acceptance criteria shall be established for each AOV within the scope of this Mandatory Appendix. Applicable test parameters (as defined in para. IV-2000) shall be used.

Instrumentation and Test Equipment accuracy shall be considered in accordance with para. ISTA-4000 when establishing the test acceptance criteria.

Acceptance criteria shall be reviewed and updated, as required, if an AOV application is changed, the AOV is physically modified, or the system is modified in a manner that invalidates the acceptance criteria.
IV-6200 PERFORMANCE ASSESSMENT TEST DATA ANALYSIS

Data obtained from a test required by this Mandatory Appendix shall be analyzed to determine if the AOV performance is acceptable. The Owner shall determine which methods are suitable for analyzing tested parameters for each AOV and provide the necessary instructions for performance of the analyses.

Whenever data are analyzed, all relevant operating and test conditions shall be considered.

The Owner shall compare performance test data to the acceptance criteria.

Performance Assessment Test data analysis shall include a qualitative review to identify anomalous behavior. If indications of anomalous behavior are identified, the cause of the behavior shall be analyzed and corrective actions completed, if required, in accordance with para. IV-6500.

IV-6300 PERFORMANCE ASSESSMENT TEST DATA EVALUATION

The Owner shall determine which methods are suitable for evaluating Performance Assessment Test data for each AOV and application.

The Owner shall develop procedural guidelines to establish the methods and timing for evaluating AOV Performance Assessment Test data.

Where periodic Performance Assessment Testing is being performed, evaluations shall determine the loss of functional margin that occurred over time and shall consider the influence of past maintenance and test activities to establish appropriate frequencies for future Performance Assessment Test activities.

IV-6400 PERFORMANCE ASSESSMENT TEST DETERMINATION OF AOV FUNCTIONAL MARGIN

Where periodic Performance Assessment Testing is being performed, the Owner shall demonstrate that adequate functional margin exists between valve operating requirements and the available actuator output capability to satisfy the acceptance criteria (para. IV-6100). In addition to meeting the acceptance criteria, the Performance Assessment Test interval, as required by para. IV-3410, shall be set such that adequate functional margin shall exist to provide reasonable assurance that changes in AOV operating characteristics over time do not result in reaching a point at which the acceptance criteria are not satisfied before the next scheduled test activity.
IV-6500 PERFORMANCE ASSESSMENT TEST CORRECTIVE ACTION

If the AOV performance is unacceptable, as established in para. IV-6200, corrective action shall be taken in accordance with Owner's corrective action requirements.

IV-7000 STROKE TEST AND FAIL SAFE DATA ANALYSIS AND EVALUATION

IV-7100 STROKE TEST ACCEPTANCE CRITERIA

Test results shall be compared to the reference values established in accordance with paras. IV-3510, IV-3520 and IV-3530.

(a) Valves with reference stroke times of greater than 10 seconds shall exhibit no more than ±25% change in stroke time when compared to the reference value.

(b) Valves with reference stroke times of less than or equal to 10 seconds shall exhibit no more than ±50% change in stroke time when compared to the reference value.

(c) Valves that stroke in less than 2 seconds may be exempted from para. IV-7100(b). In such cases the maximum limiting stroke time shall be 2 seconds.

Instrumentation and Test Equipment accuracy shall be considered in accordance with para. ISTA-4000.

IV-7200 STROKE TEST AND FAIL SAFE CORRECTIVE ACTION

If a valve fails to exhibit the required change of obturator position or exceeds the limiting values of full stroke time [see para. IV-3420(b)(1)], the valve shall be immediately declared inoperable.

Valves with measured stroke times that do not meet the acceptance criteria of para. IV-7100 shall be immediately retested or declared inoperable. If the valve is retested and the second set of data also does not meet the acceptance criteria, the data shall be analyzed within 96 hours to verify that the new stroke time represents acceptable valve operation, or the valve shall be declared inoperable.

If the second set of data meets the acceptance criteria, the cause of the initial deviation shall be analyzed and the results documented in the record of tests (see para. IV-9000).
Valves declared inoperable may be repaired, replaced, or the data may be analyzed to determine the cause of the deviation and the valve shown to be operating acceptably.

Valve operability based upon analysis shall have the results of the analysis recorded in the record of tests (see para. IV-9000).

See para. IV-3520 for guidance on returning a repaired or replacement valve to service.

IV-8000 RESERVED

IV-9000 RECORDS AND REPORTS

IV-9100 RECORDS

The Owner shall maintain a record that shall include the following:

(a) Records as required by paras. ISTA-9000 and ISTC-9000;

(b) Documentation showing that legacy AOV Program activities met requirements within this appendix, if used to satisfy para. IV-3410(a);

(c) Documentation of engineering evaluation per para. IV-3410 (e);

(d) Any abnormal or erratic action in accordance with paras. IV-3410 and IV-3420;

(e) Documentation of engineering evaluation as applicable per para. IV-3520;

(f) Risk ranking methodology and finalized risk category from a Plant Expert Panel as documented in an engineering evaluation per para. IV-3810 and IV-3820;

(g) Documentation of Performance Assessment Test acceptance criteria per para. IV-6100;

(h) Summary of analysis, evaluation, and functional margin required per paras. IV-6200, IV-6300, IV-6400, and IV-7000.

IV-9200 TEST PLANS

The Owner shall maintain a record of test plans that shall include the following:

(a) Test Plans as required by paras. ISTA-9000 and ISTC-9000;
(b) Values of test data, test parameters, and test information established by para. IV-5000;

(c) Performance Assessment Test methods and conditions, described in para. IV-5000, including description of valve lineups, process equipment, and type of test;

(d) Test plans when grouping AOVs in accordance with para. IV-3600.