**AMP 143 SAFETY-RELATED VALVES (VERSION 2020)**

### Programme Description

This ageing management programme is a component-specific AMP covering the mechanical parts of safety related motor operated valves (MOV), air operated valves (AOV), solenoid operated valves (SOV), manual valves, check valves, and pressure relief valves (PRV). It covers the various ageing-related degradation mechanisms (ARDMs) that valves may be subjected to and the activities necessary to manage the ageing effects. This AMP also refers to other degradation-specific and/or monitoring type of AMPs which deal with particular degradation mechanisms and ageing effects.

Valves are used in all fluid systems of nuclear power plants (NPP). They perform important functions in safety systems such as the containment isolation, reactor shutdown and emergency core cooling, and the residual heat removal under accident conditions.

These components have to ensure opening or closing operations with high degree reliability, e.g. isolate the primary circuit and containment. Valves are required to fulfill two main functions at the same time: a passive function (associated to structural integrity/ pressure boundary) and an active function (associated to the operational function. i.e. open/close, regulate). The safety function of a valve can be related to its passive function or to a combination of both passive and active functions.

Depending on design conditions, valves are welded or mechanically joined (flanged) to the fluid system pipe.

The main types of valves and valve parts covered by this AMP are listed below:

Motor operated valves (MOV):

* Valve body;
* Valve internals: guides, packing, seat, stem/stem nut;
* MOV actuator: transmission gear/linkage (gear box), spring pack.

Air operated valves (AOV):

* Valve body;
* Valve internals: guides, packing, seat, stem;
* AOV actuator: linear – diaphragm or piston, rotary – diaphragm or piston with rotary transmission, elastomers.

Solenoid operated valves (SOV):

* Valve body:
* Valve internals: plunger, seat and trim, spring, elastomers (if presents), diaphragms.

Manual valves:

* Valve body;
* Valve internals: plunger, seat and trim, spring, elastomers (if present), diaphragms;
* Manual actuator: shaft, gear box, handwheel/ lever.

Check valves:

* Valve body:
* Valve internals: discs, hinges, seats, diaphragms, springs, elastomers (if present).

Pressure relief valves (PRV):

* Valve body;
* Valve internals: seat, piston, disc, spring, elastomers (if present), diaphragms.

### Evaluation and Technical Basis

1. ***Scope of the ageing management programme based on understanding ageing:***

In the framework of the ageing management programme for mechanical parts of valves, ageing management review (AMR), and ageing understanding (knowledge), the following basic ageing degradation mechanisms are considered:

* Fatigue;
* Erosion;
* Stress corrosion cracking (SCC);
* Wear;
* General corrosion;
* Flow accelerated corrosion (FAC, see also AMP 114);
* Pitting;
* Microbiologically induced corrosion (MIC) in non-treated water systems;
* Selective leaching (see also AMP 120);
* Thermal embrittlement (see also AMP 112);
* Hardening and loss of strength due to elastomer degradation (radiation, thermal damage).

Main locations for identified degradation mechanisms are as follows:

Valve body:

* Fatigue;
* Erosion;
* SCC;
* General corrosion;
* FAC;
* Pitting;
* MIC in non-treated water systems;
* Selective leaching;
* Thermal embrittlement.

Valve internals:

* Fatigue;
* Erosion;
* SCC;
* Wear;
* General corrosion;
* FAC;
* Pitting;
* MIC in non-treated water systems;
* Selective leaching;
* Thermal embrittlement;
* Hardening and loss of strength due to elastomer degradation (radiation, thermal damage).

Actuators:

* Fatigue;
* Wear;
* Hardening and loss of strength due to elastomer degradation (radiation, thermal damage).

1. ***Preventive actions to minimize and control ageing degradation:***

The preventive actions are carried out during normal operation by monitoring and control of any adverse effects of the water chemistry conditions on the ageing mechanisms (see AMP 103).

Additional preventive actions include preventive maintenance according to component templates (e.g. EPRI preventive maintenance component templates for valves [1]). Examples given include proper lubrication and reduction of transients and maintaining operational conditions within specified limits.

For other preventive actions relevant to valve spare parts carried out during storage, SPP 402 Spare Parts Storage Program can be used.

1. ***Detection of ageing effects:***

The valves are inspected and tested according to requirements of the in-service inspection and testing programmes of each site, as for example [2-4].

Nondestructive testing methods such as a visual test, dimension test, screw joint tightening test, liquid penetrant test for detection of surface cracks, may be used.

Furthermore, ageing effects are monitored by a pressure test and a leak tightness test.

The active safety functions of the valves may be monitored by off-line/on-line performance testing and diagnostics.

Plant walkdowns during plant outages or valve diagnostic techniques may also be performed to check the general condition of valves.

Also, a risk of the fail an active safety functions of the valves may be evaluated by the specific risk assessment calculation programme.

1. ***Monitoring and trending of ageing effects:***

Timely and reliable detection of ageing degradation is provided by implementation of inspection and testing schedules, reliable examination methods, and inspection personnel qualified according to applicable standards, as for example [5-6]. Performance test results are documented and trended. Evidence of corrosion, wall thinning, and cracking in the valves also is evaluated for its potential impact on the integrity of the valves.

Performance indicators are defined to enhance the assessment and improve the implemented programs. For example, statistical indicators such as comparisons between corrective and preventive maintenance efforts (in terms of man-hours), the number of repetitive faults, etc., can be used.

1. ***Mitigating ageing effects:***

Recommendations for mitigation of ageing effects are based on the referred AMPs and results from performed analyses of possible degradation developments. Condition-based maintenance recommendations (from off-line and on-line diagnostics) are also carried out.

Improvements of operational and maintenance procedures can mitigate the effect of stressors/degradation mechanisms. In some cases, component replacement is necessary.

1. ***Acceptance criteria:***

Acceptance criteria are defined in the referred AMPs, and in off-line diagnostic programmes (MOV, AOV diagnostics), on-line diagnostic programmes (for active components) and maintenance procedures. Some indications or relevant conditions of degradation may be evaluated for acceptance in accordance with the governing requirements or guidance documents, for example [2, 7-9].

Examination results and flaws that exceed the acceptance criteria of the pertinent governing requirements or guidance documents may require repair or replacement activities, or further evaluation to demonstrate fitness-for-service of the component, to the satisfaction of the regulatory authority, until the end of the next periodic inspection interval.

1. ***Corrective actions:***

For each acceptance criterion which is not satisfied, the procedure for resolution is defined or elaborated and consequently implemented, according to the referred AMPs. At the end of the process the criterion is fulfilled, and the requested state of the component is restored. Repair and replacement according to requirement of technical documentation of the components and according to governing requirements or guidance documents of the plant are part of possible corrective actions.

When suitable in some cases, changes to operational regimes could be applied.

1. ***Operating experience feedback and feedback of research and development results:***

This AMP addresses the industry-wide generic experience. Relevant plant-specific operating experience is considered in the development of the plant AMP to ensure the AMP is adequate for the plant. The plant implements a feedback process to periodically evaluate plant and industry-wide operating experience and research and development (R&D) results, and, as necessary, either modifies the plant AMP or takes additional actions (e.g. develop a new plant-specific AMP) to ensure the continued effectiveness of the ageing management.

Appropriate sources of external operating experience are EPRI, WANO, INPO, IAEA, Owner’s Groups, and Professions Group.

There are records of failure events in certain valves of the primary circuit blowdown/overpressure protection system in BWRs [10-11]. Visual inspection revealed cracks in the valve pistons and hard chromium cladding failures in the piston stem guide bushings. Based on these observations all similar valves (in total 12) were inspected during the outage. One to four different types of defects were found in the pistons and bushings.

After detection of cracks at valve seal suction pipes in a BWR, non-destructive tests of the inner surface (dye penetrant tests) of the respective austenitic valve housings were performed [10]. These tests revealed indications in the seal areas of the housing heads of three valves made of austenitic steels. The metallographic and fractographic examinations showed a number of cracks and pitting at the inner surfaces of the housings which primarily concentrated in a band over the entire circumference of the housings at the level of the bores of the valve seal suction pipes. The corrosion products analysed contained chloride. The cracks propagated in a transgranular manner and were caused by chloride-induced stress corrosion cracking. The follow up inspections revealed a large number of valve housings and seal plugs with similar indications.

There is a reported event indicating failure in thermostatic actuating devices of valve actuators (the valves were part of the air cooling system of an emergency diesel generator belonging to the plant AC emergency supply system). The reported failure was due to thermal degradation of a rubber diaphragm within the actuator. The most probable cause of the failure is attributed to the greater amount of thermal stress and cycling to which the component was subjected during the annual shelf life tests (as part of the commercial grade dedication process, the Plant had been performing acceptance testing, as well as annual shelf-life testing). Component failure was detected during a functional test (the monthly operability run).

Requirements for ageing management and relationships between equipment reliability and ageing management are included in process description of the equipment reliability [12].

Prevention and condition monitoring programs inspect for the presence and extent of ageing effects. They have been established on the basis of an Ageing Management Review (AMR) for ageing management setup and for long term operation.

Exchange of experiences of valves degradation in WWER 440 and WWER 1000 nuclear power plants has been setup in the Czech and Slovak Republic.

At the time when this AMP was produced, no relevant R&D was identified.

1. ***Quality management:***

The AMP is carried out in agreement with site QA procedures, review and approval processes, and administrative controls, which are implemented in accordance with the different national regulatory requirements, for example [13-14].

### References

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11. JOINT RESEARCH CENTER, Operating Experience with Valves related to Safety at Nuclear Power Plants, JRC Technical Reports, JRC117097, 2019."
12. INSTITUTE OF NUCLEAR POWER OPERATIONS, Equipment Reliability Process Description, AP-913, revision 4, INPO, October 2013.
13. CANADIAN STANDARDS ASSOCIATION, Management System Requirements for Nuclear Power Plants, CSA N286, CSA, Toronto, Canada.
14. UNITED STATES NUCLEAR REGULATORY COMMISSION, 10 CFR Part 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants, Office of the Federal Register, National Archives and Records Administration, USNRC, Latest Edition.