VALVES IN INDIAN NUCLEAR POWER PLANTS

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VALVES IN NPPs

A large number of valves of various types, sizes(10mm NB to 900mm NB), material, pressure ratings are used in Indian nuclear power plants.

The total number of valves of different types, sizes and ratings used in one reactor unit of a nuclear power station required is about 16,000.

The percentage break up of various types of valves is as follows:

Gate valves	:19%
Globe valves	:17%
Control valves	:0.7%
Check valves	:5%
B S globe valves	:7%
Butterfly valves	:1%
Diaphragm valves	:13%
Ball valves	: 6.5%
PRVs	: 1.5%
Needle valves	:20%
SRVs	:1.5%
Solenoid valves	:7%
Air release valves	:0.1%
Vacuum relief valves	:0.05%
Excess flow check valves	: 0.3%
Rotary directional valves	: 0.4%
Differential PRVs	:0.3%

- In our NPPs the process fluids in various systems are either heavy water or light water and in few systems gases like helium, CO, nitrogen and oxygen are used.
- Chemistry of system fluids is strictly maintained.
- The systems are basically very clean systems from corrosion point.

TYPES OF VALVES USED IN INDIAN PHWR

SYSTEM	TYPE OF VALVES USED	REMARKS
PRIMARY HEAT TRANSPORT SYSTEM	Gate, globe, check, ball, PRV, SRV, solenoid, needle, diaphragm, B. S. globe, globe control valves	
MODERATOR SYSTEM	Gate, globe, check, butterfly, ball, PRV, SRV, solenoid, needle, diaphragm, B. S. globe, ARV, VRV, globe/butterfly control valves	
REACTOR AUXILIARY SYSTEM	Gate, globe, check, butterfly, ball, PRV, SRV, solenoid, needle, diaphragm	
FUEL HANDLING SYSTEM	Gate, globe, check, butterfly, ball, PRV, SRV, solenoid, needle, diaphragm, B. S. globe, ARV, globe control valves	

SYSTEM	TYPE OF VALVES USED	REMARKS
COMMON SERVICES	Gate, globe, check, ball, PRV, SRV, solenoid, needle, diaphragm, butterfly valves	
HEAVY WATER UPGRADING PLANT	Gate, globe, check, PRV, SRV, solenoid, needle, diaphragm, globe control valves	
RADIOACTIVE WASTE MANAGEMENT PLANT	Gate, globe, check, butterfly, ball, PRV, SRV, solenoid, needle, diaphragm	
STEAM & CONDENSATE (SECONDARY) SYSTEM	Gate, globe, check, butterfly, ball, PRV, SRV, solenoid, needle, globe control valves	

SAFETY FEATURES FOR VALVES FOR NUCLEAR POWER PLANTS

Objective:

The Nuclear valves should have

- High availability and operability-high reliability
- **Easy, less or no maintenance**
- **Long service life**

The valves used inside reactor building are designed as per ASME Sec III Division 1 (Nuclear)

The safety features for nuclear system valves are

- **Special class valves as per ASME B16.34**
- **Structural integrity**
- detailed stress analysis for class1 valves
- 100% volumetric and surface examination and 100% testing
- **Leak tightness**
- External—Through gland, joints
- End connections-BW joints

c) Internal– Through seat

- **Availability**-Operability of valves in all environments

§ **Designed** for easy and quick maintenance so that man-rem consumption is as low as possible

- **Material of construction-**

a) Carbon steel—Low temperature service with impact properties ,

like, SA350 LF2, SA352LCB, SA320 L43, SA540 B23/24

b) Stainless steel—Low carbon variety to avoid HAZ,inter granular corrosion, like, 304L, 316L

c) shall be cobalt free or very low cobalt content, very low halide and sulphur content

- **Water used for testing**—DM water
- **Cleanliness, good packaging for storage**

NUCLEAR VALVES

- Stem Sealing:

a) Double gland packing and lantern ring with leak-off connection for tubing

b) Double gasketted body bonnet joint with inter-gasket leak-off connection for bigger valves

c) Use of bellows sealed globe valves in inaccessible areas and balanced bellows SRVs.

d) Positive locking device for body-bonnet joint fasteners

e) Live loading arrangement for gland packing

- **Stem anti-blow off feature for butterfly valves**
- **Bidirectional sealing of valve seat**

a) Elastomer seat– Zero leakage

b) Metal seat — Leak tightness < Half of MSS-SP-61 leak tightness. For control valves class-V leak tightness as per FCI-70-2.

- Selecting valves with less hold up volume-saving in D2O and less man-rem consumption during maintenance
- Special locking arrangement for safety related valves
- Number of contacts(double, triple) in limit switches for independent wiring to different locations.
- **Power cable glands** for limit switches for air operated valves and LS/TS for electrically operated valves to be LOCA qualified shall be provided with double compression type cable glands.
- **Enclosure** for electrical/electronics items: At least IP65 (IS:2147)
- **Electric actuator:**

a) Additional in-built limit and torque switches for independent wiring for control room, secondary control room and local control panel

b) Additional external limit switches, other than LS provided in actuator

- Actuator rubber diaphragm, seals, O-rings should have good gamma radiation and temperature resistance

FUNCTIONAL QUALIFICATION SPECIFICATION

It is the responsibility of the plant owner or owner's designee to identify the functional requirements of a valve assembly.

QUALIFICATION PROGRAM

A valve assembly that is a candidate for qualification may be qualified by a thorough program of testing and

analysis to become a qualified parent valve assembly, or it may be qualified by a rigorous extension of a qualification program that has been previously performed on a similar qualified parent valve assembly.

QUALIFICATION REQUIREMENTS OF ACTUATORS AND ACTUATOR ASSEMBLY:

- Actuator qualification shall be as per IEEE-382,IEEE-344
- Valve-actuator assembly shall be qualified as per ASME QME-1
- Cycle test for rotary valves (Supplementary Requirement)

Functional Qualification Requirements of valve assemblies :

Active power operated valves:-

- Valve sealing capability
- Cold cyclic operability
- Hot cyclic operability(If fluid temp. >93°C, testing at service temp.)
- Operability under maximum pipe-reaction end loading
- Operability during and after loading representative of the maximum seismic or vibratory incident.

6) Flow interruption and functional capability

7) Adequacy of the materials of construction to survive environmental and ageing effects.

Active Self Operated Check Valves :

1) Valve sealing capability
2) Operability under maximum pipe-reaction end loading
3) Operability during and after loading representative of the maximum seismic or vibratory incident.
4) Flow interruption and functional capability
5) Adequacy of the materials of construction to survive environmental and ageing effects.

Active Pressure Relief Valves :

1) Valve sealing capability
2) Operability under maximum pipe-reaction end loading
3) Operability during and after loading representative of the maximum seismic or vibratory incident.
4) Flow interruption and functional capability
5) Adequacy of the materials of construction to survive environmental and ageing effects.
6) Set point verification
7) Blowdown verification
8) Thermal shock capability(Require to withstand a temperature transients equal to or greater than 260°C in 10 seconds)

TEST SEQUENCE

All testing shall be performed on the same parent valve test assembly in the sequence listed below:

Active Power Operated Valves:

- Pretest inspection—to generate base line data
- Seismic qualification
  a) Fundamental frequency determination
  b) Seismic loading test
- Thermal and radiation aging tests
- Environmental qualification
- Intermediate inspection—to provide data at various test environments.

6) Cycle test
   a) Cold cycle [Part of 2)b)]
   b) Hot cycle
7) Intermediate inspection
8) End-loading test
9) Intermediate inspection

- Flow interruption and functional capability
- Post-test inspection—to determine the effect, if any, of various tests on the valve assembly.

Active Self-Operated Check Valves

- Pretest inspection—to generate base line data

2) Thermal and radiation aging tests

- Environmental qualification

4) Intermediate inspection—to provide data at various test environments
5) End-loading test
6) Intermediate inspection
7) Flow interruption and functional capability
8) Post-test inspection—to determine the effect, if any, of various tests on the valve assembly

Active Pressure Relief Valves

- **Group 1:**
  a) Pretest inspection
  b)Performance and leakage (baseline)
- **Group 2:**
  a) Fundamental frequency determination
  b) Seismic test
  c) Discharge-pipe and reaction-loading qualification
  d) Combined seismic and end-loading test
  e) External environment test
  f) Thermal effect test
- **Group 3:**
  a) Performance and leakage(Final)
  b) Post-test inspection

QUALIFICATION BY SIMILARITY

ANALYSIS:

- Extension of qualification from parent to candidate valves:

Candidate valve assemblies that are identical in construction(i.e., same manufacturer, type, size, rating etc.) to a parent valve assembly may be qualified by similarity analysis.

The procedure is based on a high degree of design similarity between a candidate valve assembly and the parent valve assembly.

Design similarity:

Similarity requirements:

- The valves are of identical type and from the same manufacturer
- The valve actuators are of the same basic product family line
- Similar valve seat configuration
- Valve stem packing is of similar geometric form and style
- A similar method of actuator mounting
- Differences in materials of valve assembly components have been accounted for.

Valve Problems faced in our NPPs:

- Passing through valve seat is the most common problem.
- Failure of actuator rubber diaphragm.
- Failure of bellows and lip seal of B S globe valves.
- Jamming of electric actuator due to degraded stem lubricant.
- Failure of bellows in SRV.

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