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Guideline for Selection of ON –OFF Valve on Severe Service Application

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Abstract— Guideline of selection of On off valve on high temperature severe service application for hydrocarbon industries for vapour and gas.Table 1 to 22 and Figure 1 to 10.

Index Terms—Definition of On-Off Valve, Feature of On-off valves , Limitations, Leakage rate, Piece Design, Severe service application, Selection of trim and coating, Selection of guiding , seat material of on off valve in severe service application.

1 Introduction

The modern processing plant contains hundreds, and often thousands, of isolating or block valves in a wide range of sizes, pressure ratings, materials, and types. If they are to perform acceptably during a long life, careful attention needs to be given to their selection and specification since the universal valve, suitable for all applications, does not yet exist.
The selection of valves requires the consideration of many factors in addition to the guidelines given here, and past experience of particular applications should always be taken into consideration. It is fact that, "experience is the best teacher". This is an important quest for the most effective process for the sizing and selection of Valves in industrial application.

Many of the factors involved can be simplified by an early evaluation of valve requirements and preparation of procurement specifications that adequately define them. This approach can be of benefit in modifying existing plant, is of considerable importance on new projects, and may be of overriding importance where valve development is required for special applications.

The focus is to optimize the selection of types of valve in ON –Off (Tight Shut Off) application with special service requirement in Hydrocarbon Industries.

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Applicable codes and standards for high temperature and severe service ball valve
TABLE 1

Description	Testing Standard
Construction	API 6D
Face to Face Dimension	API 6D & ASME B16.10
End to End Dimension	API 6D & ASME B16.10
Flange End Dimension	≤24" ASME B16.5
	>24" ASME B16.47 series A or B or API 605 or MSS-SP-44
Fugitive emission (gland Emission)	ISO-15848 part 2
	ASME Sec V Article 10 helium mass spectrometers Tracer probe Technique for qualitative test . ASME Sec V Article 10 helium mass spectrometers Tracer Hood Technique for quantitative test .
Fire safe Design	API 607/ API 6FA/ BS 6755 part2
Testing	API 6D
Inspection and testing	API 598/ ISO 5208/MSS-SP-61

2.0 Definition of On-Off Valve:

The On –Off valve shall be defined broadly as follows.
An on/off valve designed for and capable of positive closure to prevent flow within a piping System.
An on/off valve is the fluid equivalent of an electrical switch: a device that either allows unimpeded flow or acts to prevent flow altogether. These valves are often used for routing process fluid to different locations, starting and stopping batch processes, and engaging automated safety (shutdown) functions.
The On- off valve function will 100% stop the flow of media when completely in the closed position. On-Off valves will also close around any product to make sure there is a 100%

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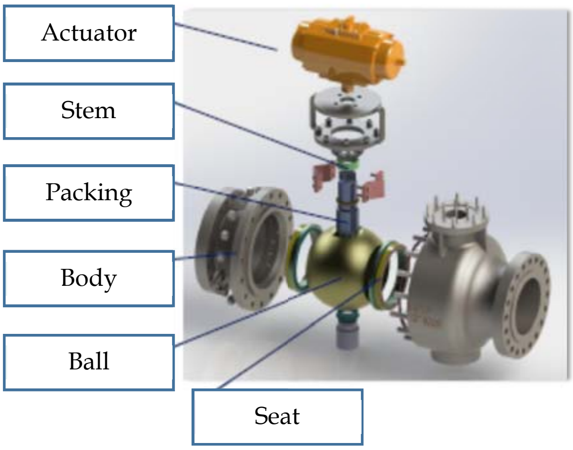
seal.

3.0 Features of ball valve:



Actuator:
Self and powered actuation. This part works in conjunction with some internal parts located in the valve trim. This part is responsible for running the stem and disk. There are many types of actuator that are available in the market today. Some are hand wheels, levers, motors, solenoids, pneumatic operators or hydraulic arms. Most valve manufacturers' provide a design where the actuator is mounted with the bonnet through a yoke.Options are available and can be designed per customer specific specifications

Packing:
This part commonly prevents leaks from the space between the valve stem and bonnet. The valve packing can be made from fibrous materials like flax or some other materials like Teflon. Regardless of the valve packing composition, it should be able to form a seal between the internal parts and the outer valve environment where the stem extends from the valve body. The packing must be properly placed to prevent leaks that can cause further damages to the entirevalve system. The packing must neither be too loose nor too tight. and can be designed per customer specific specifications

This part is regarded as the principal part of a valve, regardless of its shape and type. It is the part that gives framework to the whole valve because it holds all the other parts intact. It also serves as the pressure boundary of the valve because it is the first line of resistance against the volume and pressure of the liquid flowing through all the pipes connected to it.. Options are available and can be designed per customer specific specifications.

Trim:
This part is a collection of different internal valve parts such as disk, seat, stem and sleeves. Because of these internal parts, the valve can perform basic motions to provide flow control. The disk together with the seat is important in determining the performance of the valve system. In most designs, the disk serves as the third layer of pressure boundary. It can permit and prohibit fluid flow due to its pressure-retaining capacity. The seat, also called as seals ring provides an interface to where the disk is seated. The seal rings can either be forged within the body by welding or by machine. The stem is responsible for positioning the disk. It connects the actuator and the disk usually though welded joints. and can be designed per customer specific specifications.

2.1 Different types of On-Off Valve:

Valve styles commonly used for on/off service include ball, plug, butterfly (or disk), gate, and globe. This document shall describe about Ball valves which are one of the most free flowing valve types for On-Off application.

2.2 Ball valves definition:

A ball valve is a form of quarter-turn valve which uses a hollow, perforated and pivoting ball to control flow through it. It is open when the ball's hole is in line with the flow and closed when it is pivoted 90-degrees by the valve handle. Ball valves are durable, performing well after many cycles, and reliable, closing securely even after long periods of disuse. These qualities make them an excellent choice for shutoff and control applications, where they are often preferred to gates and globe valves, but they lack their fine control in throttling applications.

4.0 General Type of Ball valves and it Body Design.

There are four general types of ball valves: full port, standard port, reduced port, and v port.

4.1 Full Port Ball Valve:

A full port or more commonly known full bore ball valve has an over-sized ball so that the hole in the ball is the same size as the pipeline resulting in lower friction loss. Flow is unrestricted but the valve is larger and more expensive so this is only used where free flow is required

4.3 Reduced port ball valves

In reduced port ball valves, flow through the valve is one pipe sizes smaller than the valve's pipe size resulting in restricted flow.

4.4 V port ball valve.

A V- port ball valve has either a 'v' shaped ball or a 'v' shaped seat. This allows the orifice to be opened and closed in a more controlled manner with a closer to linear flow characteristic. When the valve is in the closed position and opening is commenced the small end of the 'v' is opened first allowing stable flow control during this stage. This type of design requires a generally more robust construction due to higher velocities of the fluids, which would quickly damage a standard valve.

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4.5 There are four general body styles of ball valves: single body, split body, top entry, and welded.

4.5.1Single piece design

In the single piece design valve, the body will be cast/forged as one piece. The insertion of the ball will be through the end of the body and is held in position by body insert. This design restricts the valve to be of regular port only

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4.5.2 Two piece design

In two piece design, the body is constructed in two pieces and the ball is held in position by body stud. There can be full port or regular port design possible in this construction. In case of three as two end pieces and one centr studs.

4.5.3Three Piece Design & Guiding Design

The three piece construction permits in line servicing without disturbing the existing pipe work. If the valves have socket weld, screwed or butt welding ends, this design totally dispenses with the necessity of companion flanges.

5.1What's the big difference between 2 and 3 piece ball valves?

5.1.1 Two Piece ball:

- Two piece ball valves were also designed with maintenance in mind.
- Ball cannot be taken out without disturbing the two wnd caps.
- Low cost compared to three piece design.
- Simple design w.r.t three piece.
- Parts such as seat, ball etc are not easily replaceable

5.1.2 Three Piece ball:

- Low maintenance in long run.
- Ball can be taken out without disturbing the two wnd caps.
- High cost compared to two piece design.
- Complexity in design.
- Parts such as seat, ball etc are easily replaceable

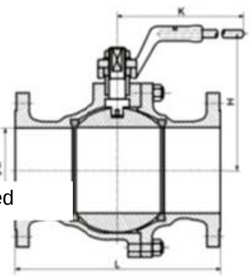
5.2 Trunnion Guided design

The Trunnion ball valve has an additional anchoring on the bottom of the ball which project's out to form an axis on which it is pivoted as shown in the diagram. This type of guiding is suitable for higher size and higher pressure application.

5.3 Floating Guided design

The Floating ball valve has a free floating ball that moves in the response to the fluid. In closed position of the valve will be pushed by the pressure of the fluid against the seal, so the seal is taking advantage of the pressure of the fluid. Suitable for high temp and tight shut off requirement for bi directional flow.

Guided



6.0 Advantages and Disadvantages of Ball Valves:

6.1 Advantages

- Provides bubble-tight service.
- Quick to open and close.
- Smaller in size than a gate valve.
- Lighter in weight than a gate valve.
- Multi-port design offers versatility not available with gate or globe valves. It reduces the number of valves required.
- Several designs of ball valves offer flexibility of selection.Canbe used in clean and slurry applications.
- High-quality ball valves provide reliable service in high-pressure and high-temperature applications.
- Force required to actuate the valve is smaller than that required for a gate or a globe valve.

6.2 Disadvantages of Ball Valves.

- They are not suitable for sustained throttling applications.
- In slurry or other applications, the suspended particles can settle and become trapped in body cavities causing wear, leakage, or valve failure.

7 Typical Critical process Application:

In refinery and petrochemical, OIL and Gas processing , several type of processes are involved. Some process is regular and some process is critical. The critically of the process may be defined in terms of operating conditions , such as high Temperature and High Pressure, High Temperature slurry, Cracking process, Sequencing operation, Thermal cyclic operation with a wide range of variation of Temperature and pressure, Different type of fluid involvement during different cycle of the process etc. Some of the critical process in refinery and petrochemical application are mentioned below.

- FCC Catalytic cracking process.
- Coking and Decoking Cycle.
- Molesievedryer&Propylene Dryer, PSA Swing in H2 Plant.
- C2 Plus Dryer.
- Adsorptionand Regeneration cycle of Desulphurization process.
- Process required positive isolation on both side of the valve with different fluid different temperature.

8.0 Major issues affecting the valve design:

The following issues affect due to catalyst and coke build up which results in valves will fail to operate.

- Clogging of the valves due to catalyst and coke build up which results in valves that will fail to operate.
- Seizure / Struck up problem at high temperature due to uneven thermal expansion between seat ball, and body.

- Erosion of the ball , seat and bore resulting due to uneven thermal expansion which can result the failure of the seat.
- Loss of sealing capacity due to surface damage of ball and seat provoked by very high temperature and thermal shock.
- Leakage problem between seat and ball which will cause the unsafe operation of the process.
- Requirement of positive isolation on both sides also results the leakage issue due to selection of unidirectional valve.

8.1 Special valve design envisaged for critical process.

It is observed from past experience that the selection of normal valve like Ball, Butterfly etc. resulted the failure of the operation due to failure of valve for the above mentioned reason as stated above in major cases.
To obtain the solution of the problem, special valve design is envisaged for safe and optimum operation of the plant. Also after analysis of failure, and after doing research and development, proven special valve design was given by several vendor specific to application type and criticality.
As an example, it is observed that, some of unit such as Delayed coker Unit has special valve. Also in sequence operation, Licensor's are recommending special valve for the safe operation.

8.2 Delayed Coker Unit special valve:

In delayed Coker unit, the valve shall be capable of handling coke particle. Also during decoking cycle the valve has to provide the positive isolation between Hydrocarbon and steam and water. In-fact, due to this severity of complexity of the process Delayed Coker unit isolation valve design are special and speciality designed valve is termed as Speciality Valve.

8.3 Propylene Dryer and Mole sieve Dryer:

In propylene Dyer and Mole sieve dryer, the vale has to operation frequently and switching between two reactor. This will cause the frequent operation of the valve. Normally shut down valve are applied in the process industries for shutdown application i.e. it will operate under abnormal situation. So the operation is not frequent.

However, for application like sequencing, switching, thermal cyclic operation the no of operation of the valve quite high.

As a result of frequent operation, more wear and tear will occur between ball and seat. This will more in case sequence operation with thermal cyclic effect because of thermal expansion. The issue shall result the failure of valve.

Hence to have a solution some special design is required wherein, the friction loss can be minimized to obtained the effective and safe operation of the plant. Rising stem ball valve is one of the best solution for such application. It is also observed that process licensors such as Technip, UOP are giving the recommendation of rising stem ball valve for critical switching and sequence operation as on date.

9.0 Limitations of type of valve in Critical Application:

9.1 Advantages of Ball valve with Floating Guided Design

a) Floating ball spheres is floating in medium pressure function, ball of displacement and physical produce certain tightly compressed the seal surface in exports, ensure outlet seal.
b) Floating ball valve small volume, light weight, simple structure, good sealing, but ball work under medium load all passed to export sealing ring.
c) The floating ball valve utilizes natural line pressure to press and seal the ball against the downstream seat. The line pressure is exposed to a greater surface area - the entire upstream face of the ball, which is an area equal to the actual pipe size. With freely floating ball can better guarantee seal.
d) Small volume, light weight, simple in structure and function,; Ball valve with circular hole sphere as on-off pieces, in stem drive next ball around stem centre for 0 ~ 90 degree rotated, complete opening and closing functions; With compact structure, turning the characteristics of quick opening 90 degrees, can close the valve, cut pipeline medium
e) Cavity between ball and seat is minimum. Hence chances of deposition of particle is less.
f) Can provide excellent positive isolation on both side equally due to flow assisted shut off.
g) Ideal for high temperature, Thermal cyclic, differential shut off, sequence operation. Slurry.

9.2 Dis-Advantages of Ball valve with Floating Guided Design.

Since it is flow assisted shut off, hence the friction between ball and seat is more.

a) The largest size available is 10″ @ ANSI #150; as per standard manufacturing range.
b) Shut off at lower pressure is less than the higher pressure.
c) Actuator sizing is more and also require large open/close initial torque.
d) Double block and bleed arrangement is not a standard features.
e) Higher pressure it is not suitable due to floating design.
f) Service life is less than trunnion guided design.

9.3 Advantages of Ball valve with Trunnion Guided Design

a) Design is the lower open- rating torque, ease of operation, minimized seat wear.
b) Trunnion ball valve suitable for various in high pressure piping, used in the medium truncated or connect piping.
c) Trunnion ball valve sphere is fixed, do not produce mobile after pressurized.
d) Trunnion mounted ball design is also capable of bi-directional sealing.
e) Trunion mounted ball valves are uses a spring mechanism so can provide better shut off at lower pressure.
f) Trunnion ball design over floating ball is the lower operating torque of the ball.
g) The trunnion ball valve can be used in high pressure conditions and the size can be up to 60 inches.

9.4 Dis-Advantages of Ball valve with Trunnion Guided Design

a) Body Cavity Relief (Pressure Equalisation).
b) Ball valves are double seated valvestrunnion guided design which incorporates a cavity between the seats.
c) Body cavity will get pressurized only when the seats are damaged.
d) Cavity relief provision required only for trunnion mounted ball valves. Not required for floating ball valves as the seats are fixed & the ball is floating.
e) Where possible, cavity relief shall be to the upstream side of the valve.
f) In slurry or other applications, the suspended particles can settle and become trapped in body cavities causing wear, leakage, or valve failure.
g) Cannot provide excellent sealing like floating guided design at high pressure and at differential shut off.
h) Not suitable for severe service applications requiring the highest reliability in terms of seat leakage.

9.5 Advantages of Ball valve Rising stem (RSBV) Design:

a) It is suitable severe service applications, sequence application, requiring the highest reliability.
b) Friction-free movement between seat and ball that significantly reduces valve wear and keeps routine maintenance to a bare minimum. Benefit of long life without maintenance.

c) Sealing surfaces do not contact during stroking of the valve
d) The RSBV uses a unique helix system that opens and closes the valve without rotation.
e) The stem also has a backseat to prevent possible blowout and repacking stem seals under pressure when the valve is fully open.
f) Helix coil stem ensures absolutely no stem rotation.
g) Bellow seal construction is possible for critical and lethal services.
h) Top entry design Allows easy in-line inspection and maintenance.

9.6Dis -Advantages of Ball valve Rising stem (RSBV) Design:

a) Proven size available up to 8", and beyond 8" the sizes are not industrially proven.
b) Limitation of design temperature up to 427 Deg C.
c) For very high temperature and high temperature thermal cyclic operation no proven design is available.
d) Do not have bi directional seal hence not suitable for the application which has differential shut off or sealing required in both direction.

9.7 Advantages of Tripple offset Butterfly Design:

a) Can provide bubble-tight shut off.
b) Allows a lower torque-actuator to be fitted.
c) There are no cavities between sealing components, resulting in no clogging, low maintenance and extended valve life.
d) Metal-to-Metal sealing ensures bubble tight shut-off, resulting in zero-leakage performance
e) Suitability to harsh media because the construction of the valve features no elastomers or materials typically affected by corrosion.
f) Geometric design of sealing components provides friction-free stroking throughout the valve. This extends the valve life and allows a lower torque-actuator to be fitted.
g) Cam-action' and 'right angled' conical sealing design ensures the metal
h) Sealing components are never in contact until its final degree of closing.

9.8 Dis-Advantages of Tripple offset Butterfly Design:

a) Throttling is limited to low differential pressure services and that too with a 30- to 80-degree disc opening.
b) There is a chance for cavitation and choke as the disk is always in the flow Turbulence flow can affect the disc movement.

9.9 Analysis of process condition of severe service and sequence application, High temperature thermal cyclic application:

9.9.1 It is observed that selection of normal ball valve with conventional design leads to operation problem in terms of leakage for most of the process condition of severe service and sequence application, High temperature thermal cyclic application.

9.9.2 Critical service of Adsorption and Regeneration shall undergo the following conditions like desulphurization technology Prime G /IN Adept G:

- Thermal cyclic effect along with variation of temperature and pressure for each valve which shall undergo sequence operation for temperature > 400˚C.
- Number of cycle of the valve per year.
- Composition of fluid of each valve.
- Range of Particle size which may present in the fluid faced by valve.
- Requirement of positive isolation on both sides for different fluid with stringent leakage requirement for safe operation of the plant.

9.9.3 Critical service of Adsorption and Regeneration shall undergo the following conditions.

- Thermal cyclic effect along with variation of temperature and pressure for each valve which shall undergo sequence operation for temperature < 400˚C. Like PP dryer, Mole sieve dryer.
- Number of cycle of the valve per year.
- Composition of fluid of each valve.
- Range of Particle size which may present in the fluid faced by valve.
- Requirement of positive isolation on both sides with stringent leakage requirement for safe operation of the plant.

9.9.4 Critical service of High Temperature application with process contains slurry shall undergo the following conditions >400 ˚C like FCC, delayed Coker etc.

- Range of Particle size which may present in the fluid faced by valve.
- Thermal cyclic effect along with variation of temperature.
- Requirement of positive isolation on both sides for different fluid with stringent leakage requirement for safe operation of the plant

9.10 Selection of Valve for temperature ≤ 400 ˚C for sequence application:

9.10.1 From detailed verification it is observed that normal ball valve with conventional design is not suitable option. The process requirement envisaged for special type deign. Some of the process licensor also recommends some special designed valve like rising stem ball valve for sequence application. However the limitation of the design is

- ➢ Availability of proven size beyond 8″ and temperature beyond 400 ˚C.
- ➢ Also this valve is having unidirectional seat and not suitable for positive isolation required with differential shut off.
- ➢ This design is having cavity between ball and seat which is not suitable for fluid containing particle.

9.10.2 The alternate option of the above is double seated spring energized ball vale with trunnion guided design with double block and bleed facilities. However this design also having some limitations.

- This is not suitable for temperature beyond 400 ˚C.As in the higher temperature venting of double block and bleed is not feasible.
- Also, the stringent leakage condition is very difficult to achieve because of spring energized design.
- This design is having cavity between ball and seat which is not suitable for fluid containing particle.
- Wide variation of temperature and pressure shall affect the spring resulting the leakage of seat.
- Not suitable for process contains slurry at high temperature.

9.10.3 The alternate option of the above is double seated floating guided design for size above 4″ 300#.

- This is suitable for temperature beyond 400 ˚C with moderate pressure but at high temperature.
- Cavity between ball and seat is very minimum and is suitable for high temperature slurry application.
- Also, the stringent leakage condition is possible to achieve because of flow and pressure assisted shutoff.
- However, in floating guided design with double block and bleed facilities is not standard feature.
- High pressure and higher size >12″ the design is not standard one.
- Actuator required very high opening and closing torque leading to bigger size actuator.

9.11 On verification and case study the following are the recommendations for selection of ball valve in severe service, high temperature, and sequence application.

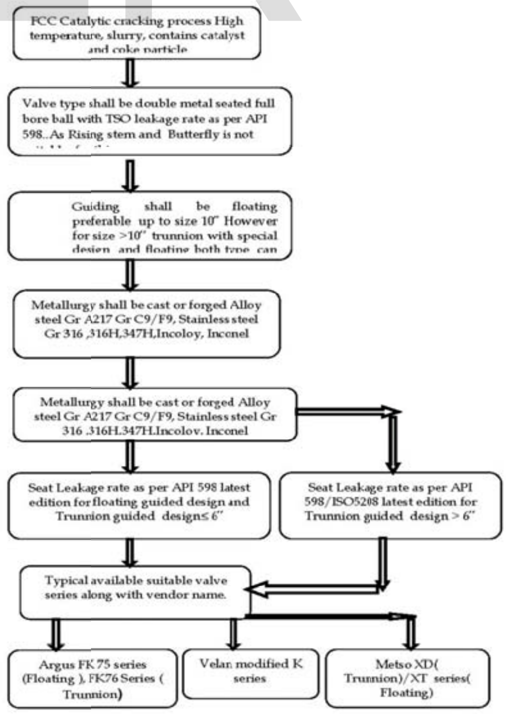
TABLE-2
Selection of ball valve

Application	Temperature Range	Rising Stem Ball	Floating Guided Ball	Trunnion guided ball
High temperature slurry FCC/ Delayed coker etc	≥ 400 ˚C	X	YES	X
High temperature sequence application with clean fluid	≥ 40 ˚C ≤ 400 ˚C	YES	X	X
High temperature sequence application with fluid contains particle	≥ 40 ˚C ≤ 400 ˚C	X	Yes	Yes with special design of bearing and ball.
High temperature sequence application with clean fluid	≥ 400 ˚C	X	Yes preferred	Yes with special design of bearing and ball.
High temperature sequence application with fluid contains particle	≥ 400 ˚C	X	Yes	X
High temperature slurry application	≥ 400 ˚C	X	Yes	X

10.0 Selection of Valve in FCC Catalytic cracking process

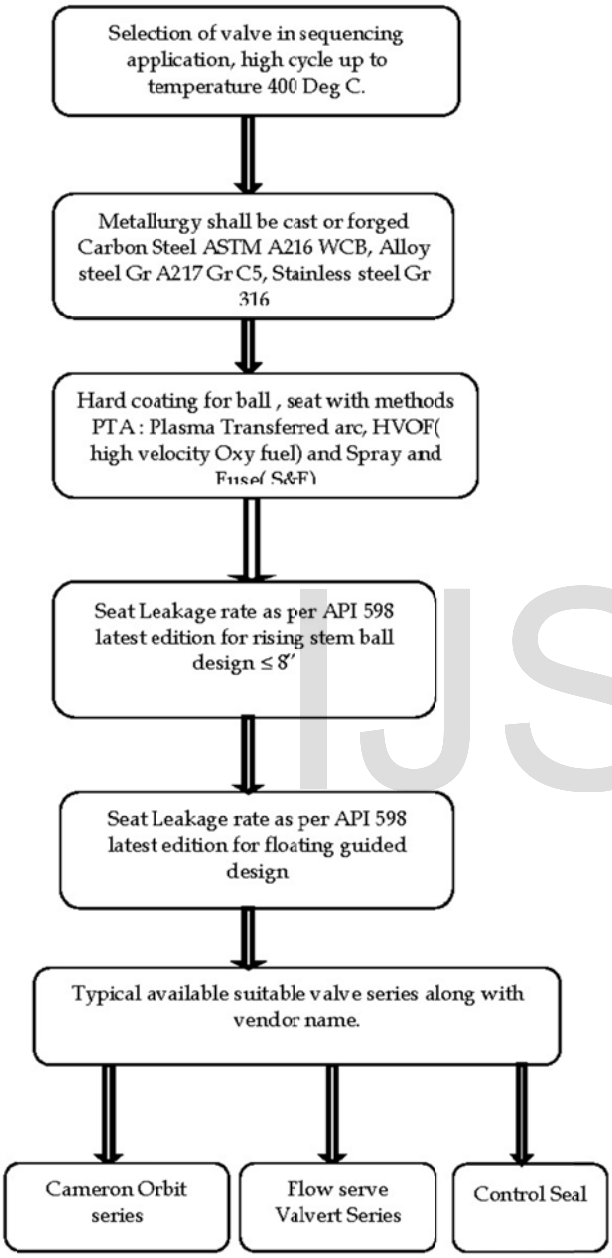
10.1 Type of valve Selection:

FCC Catalytic cracking process having High temperature, presence of catalyst and coke particle and thermal shock due to variation of temperature. The selection guide of the proper type of valve shall be as shown in Fig.8.



10.2 Recommended Selection of Valve in Sequencing application up to temperature 400˚C.

10.3 Type of valve



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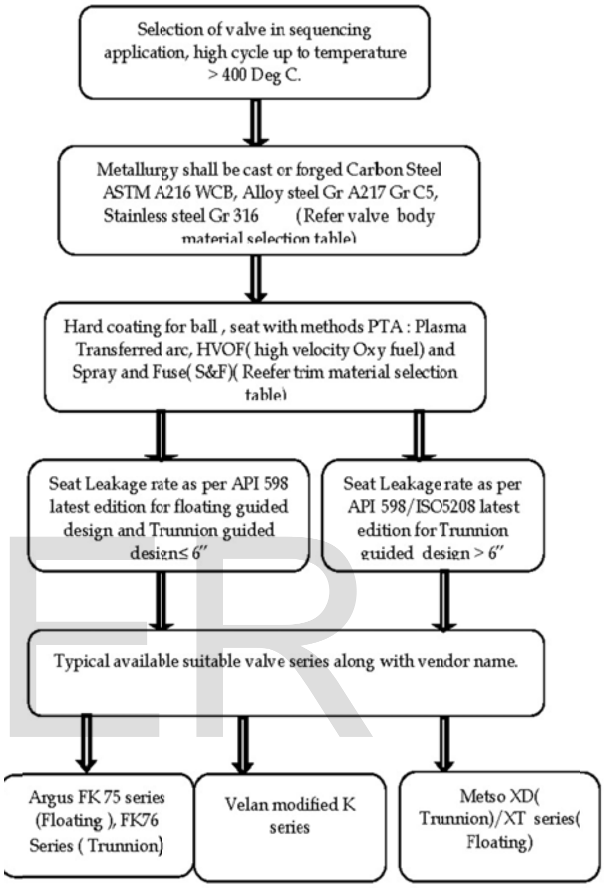
10.4 Recommended Selection of Valve in Sequencing application up to temperature >400˚C.



11.0 Valve Body material selections chart for floating and trunnion guided ball valve.

TABLE-3

VALVE BODY MATERIAL FULL BORE BALL VALVE								
Sr No	Material Group	Body Material Type	Material Type	Forging specification	Casting Specification	Sizes and rating	Temp Range	Application
1	CARBON STEEL	Carbon Steel (CS).	C-Mn-Fe	ASTM A105	ASTM A216 WCB/WCC	• From DN25 to DN 100. • From size DN100 to DN250 for sequence and high temp • Rating from 150# to 1500#.	-29°C to 427 °C	Hydrocarbon Liquid, Gas and vapour, H2, Sequencing, non
		Low Temperature Carbon Steel (LTCS)	C-Mn-Fe	ASTM A350 LF2.	ASTM A352 LCB/LCC		-45 °C to 340°C	Hydrocarbon Liquid on Low temperature non corrosive services.
2	LOW TEMPERATURE ALLOY STEEL	Nickel Steel	31/2 Ni	ASTM A350 LF3.	ASTM A352 LC3	• From DN25 to DN 100. • From size DN100 to DN250 for sequence and high temp • Rating from 150# to 1500#.	-101 °C to 340°C	Non corrosive/ cryogenic HC services.
3	LOW ALLOY STEEL	Moly steel	C-1/2 Mo	ASTM A182F1	ASTM A217F1	• From size DN100 to DN1200 for sequence and high temp • Rating from 150# to 1500# • ≥ 600# for DN 100	≤ 468 °C	Hydrocarbon Liquid, Gas and vapour non corrosive services, .
		Chrome Moly	11/4Cr-1/2 Mo	ASTM A182F11cl2	ASTM A217WC6	• From size DN100 to DN1200 for sequence and high temp • Rating from 150# to 1500# • ≥ 600# for DN 100	≤ 593 °C	Hydrocarbon Liquid, Gas and vapour ,H2non corrosive services,
			21/4Cr-1/2 Mo	ASTM A182F22cl3	ASTM A217WC6		≤ 593 °C	HP Steam non corrosive services,
			5Cr-1/2 Mo	ASTM A182F5a	ASTM A217C5		> 500 °C & < 650 °C	Hydrocarbon Liquid, Gas and vapour ,H2non corrosive services in high temperature refinery application,
			9Cr-1 Mo	ASTM A182F9	ASTM A217C12		> 500 °C & < 650 °C	Hydrocarbon Liquid, Gas and vapour,, in high temperature refinery slurry application.
			9Cr-1 Mo-V	ASTM A182F91	ASTM A217C12A		≤600 °C	High pressure steam
4	STAINLESS STEEL MATENSITIC	ALLOY 20	20Ni-19Cr-Cu-Mo	ASTM A182 F 20	ASTM A351CF7M	• From DN25 to DN 100. • From size DN100 to DN250 for sequence and high temp Rating from 150# to 1500#.	UP TO 316°C	Hydrocarbon Liquid, Gas and vapour, non corrosice services
		Duplex 2205	22Cr-5Ni-3Mo-N	ASTM A182 F 51	ASTM A351CD3MN			
		Super Duplex 2507	25Cr-7Ni-4Mo-N	ASTM A182 F 53	ASTM A351CD4MCu			
		Super Duplex	25Cr-7Ni-	ASTM A182 F 55				
		Super Austenetic 6Mo	20Cr-18Ni-6Mo	ASTM A182 F 44				

VALVE BODY MATERIAL FULL BORE BALL VALVE								
Sr NO	Material Group	Body Material Type	Material Type	Forging specification	Casting Specification	Sizes and rating	Temp Range	Application
5	AUSTENETIC STAINLESS STEEL 300 SERIES STAINLESS STEEL	SS304	18Cr-8Ni	ASTM A182 F 304	ASTM A351CF8	•From DN25 to DN 100. •From size DN100 to DN250 for sequence and high temp •Rating from 150# to 1500#.	0.04% min carbon for up to 450 °C	Hydrocarbon Liquid, Gas and vapour, non corrosive services.
		SS304L	18Cr-8Ni	ASTM A182 F 304L.	ASTM A351CF8		-105 °C to 427°C	Hydrocarbon Liquid cryogenic service.
		SS304 H	18Cr-8Ni	ASTM A182 F 304LH	ASTM A351CF10		UP TO 427°C	Liquid service CW, DM WATER SOUR WATER.
		SS316	16Cr-12Ni-2Mo	ASTM A182 F 316	ASTM A351CF8M	•From DN25 to DN 100. •From size DN100 to DN250 for sequence and high temp •Rating from 150# to 1500#.	0.04% min carbon for UP TO 538 °C	Hydrocarbon Liquid, Gas and vapour, non corrosive services.
		SS316L	16Cr-12Ni-2Mo	ASTM A182 F 316L	ASTM A351CF3M		UP TO 427°C	Hydrocarbon Liquid, Gas and vapour, non corrosive services.
		SS316 H	16Cr-12Ni-2Mo	ASTM A182 F 316H	ASTM A351CF10M		UP TO 316°C	Hydrocarbon Liquid, Gas and vapour, non corrosive services.
		SS321	18Cr-10Ni-Ti	ASTM A182 F 321			0.04% min carbon for >538 °C	Hydrocarbon Liquid, Gas and vapour, non corrosive services
		SS321H	18Cr-10Ni-Ti	ASTM A182 F 321H				
		SS347	18Cr-10Ni-Cb	ASTM A182 F 347	ASTM A351CF8C		0.04% min carbon for >538 °C	Hydrocarbon Liquid, Gas and vapour, non corrosive services
		SS347H	18Cr-10Ni-Cb	ASTM A182 F 347H	ASTM A351CF8C			
		SS317L	18Cr-16Ni-4Mo	ASTM A182 F 317L	ASTM A351CG3M		UP TO 427°C	Hydrocarbon Liquid, Gas and vapour, non corrosive services

VALVE BODY MATERIAL FULL BORE BALL VALVE								
Sr NO	Material Group	Body Material Type	Material Type	Forging specification	Casting Specification	Sizes and rating	Temp Range	Application
6	NICKEL IRON ALLOY	Incoloy 800	33Ni-42Fe-21 Cr	B564-N08800			≤538 °C	Hi temp Hydrocarbon Gas and vapour, non corrosive services
		Incoloy 825	42Ni-21.5Cr-3Mo-2.5Cu	B564-N08825*			≥316 to ≤648 °C	Hi temp Hydrocarbon Gas and vapour, non corrosive services
7	NICKEL SUPER ALLOY	Incoloy 600	72 Ni-15Cr-8Fe	B564-N06600			-150 °C TO 925 °C	Variety of applications involving temperatures from cryogenic to above 2000°F (1095°C).
		Incoloy 625	60 Ni-22Cr-9Mo-	B564-N06625			UP TO 925 °C	Hi temp Hydrocarbon Gas and vapour, non corrosive services
		Hastelloy C-276	54Ni-15Cr-16Mo-	B564-N10276			-150 °C TO 1100 °C	Variety of applications involving temperatures from cryogenic to above 1100°C corrosive service.
8	NICKEL COPPER	Monel 400	67Ni-30 Cu	B564-N04400			-200 °C TO 1000 °C	Many corrosive environments marine and chemical processing. and oxygen service
		Monel 500		B564-N0500			-200 °C TO 900 °C	HC industries , chemical processing. and oxygen service

12.0 Selections and Trim Material chart for floating guided ball and trunnion valve

TABLE-4

API Trim	Nominal trim	Trim code	Stem	ball	seat	Coating	Hardness (Brinell)	Application
1	ASTM A182 Gr F6a/ ASTM A276 410	F 6	SS 410 (13 Cr)	ASTM A182 Gr F6a/ ASTM A276 410	SS 410 (13 Cr)		Ball:250 Seat: 200– 250 Stem: 250-275	Hydrocarbon Liquid, Gas and vapour, H2, Sequencing, non corrosive services. -100°C to 320 °C.
2	ASTM A182 Gr F304/ ASTM A351 CF3	SS304	ASTM A182 Gr F304/ ASTM A351 CF8	ASTM A182 Gr F304/ ASTM A351 CF3	ASTM A182 Gr F304/ ASTM A351 CF8		-	Moderate pressure corrosive service of temperature - 265°C to 450°C
3	SS 310	310	SS310 (25 Cr- 20 Ni)	SS310 (25 Cr- 20 Ni)	SS310 (25 Cr- 20 Ni)		-	Moderate pressure corrosive or non corrosive service of temperature - 265°C to 450°C.
4	Hard SS410	F 6-H	Hard SS410(13 Cr)	F 6 (13 Cr)	F 6 (13 Cr)	HVOF /PST	Ball:275 Seat: 250-275 Stem:275	Moderate pressure corrosive service of temperature - 265°C to 450°C.
5	SS410+ Full hard faced	F 6-HF	SS410(13 Cr)	F6+ST6 (Co-Cr Alloy)	SS410+ ST6 (Co-Cr Alloy)	HVOF /PST	Ball:350 Seat: 300-350 Stem:350	High pressure slightly erosive and corrosive service of temperature - 265°C to 650 °C. Good for Hp steam.
5A	SS410+ Full hard faced	F 6-HF	SS410(13 Cr)	F6+Hard Faced (Ni-Cr Alloy)	SS410+ Hard Faced (Ni-Cr Alloy)	HVOF /PST	Ball:350 Seat: 300-350 Stem:350	High pressure slightly erosive and corrosive service of temperature - 265°C to 650 °C. Good for Hp steam.
6	SS410+ Ni-Cu	F 6-HFS	SS410(13 Cr)	F 6 (13 Cr)	Monel 400 Faced (Ni-Cu Alloy)	HVOF /PST	Ball: 175-250 Seat: 175-250 Stem: 175-250	More corrosive service marine and chemical processing, and oxygen up to 450 °C.
7	SS410+ full hard	410	SS410(13 Cr)	F 6 (13 Cr)	F 6 (13 Cr)	HVOF /PST	Ball: 250-750 Seat: 250-750 Stem: 250-750	High pressure slightly erosive and corrosive service of temperature up to 650 °C..
8	SS410+ hard faced	F 6-HFS	SS410(13 Cr)	F 6 (13 Cr)	SS410+ ST6 (Co-Cr Alloy)	HVOF /PST	Ball:250-350 Seat: 250-350 Stem:250	High pressure slightly erosive and corrosive service of temperature - 265°C to 650 °C. Good for Hp steam.
8A	SS410+ hard faced	F 6-HFS	SS410(13 Cr)	F 6 (13 Cr)	SS410+ hardf (Ni-Cr Alloy)	HVOF /PST	Ball:250-350 Seat: 250-350 Stem:250	High pressure slightly erosive and corrosive service of temperature - 265°C to 650 °C. Good for Hp steam.
9	Monel	Monel	Monel (Ni-Cu Alloy)	Monel (Ni-Cu Alloy)	Monel 400 (Ni-Cu Alloy)	HVOF /PST	-	Corrosive service of temperature up to 480 °C.
10	SS316	SS316	SS316 (18 Cr-Ni-Mo)	SS316 (18 Cr-Ni-Mo)	SS316 (18 Cr-Ni-Mo)	HVOF /PST	-	Super resistance to corrosion of liquid up to450 °C.
11	Monel and hard faced	Monel -HFS	Monel (Ni-Cu Alloy)	Monel (Ni-Cu Alloy)	Monel 400 +ST6	HVOF /PST	Ball:350 Seat: 350 Stem:350	Moderate pressure more corrosive of temperature up to 480 °C.
11A	Monel and hard faced	Monel -HFS	Monel (Ni-Cu Alloy)	Monel (Ni-Cu Alloy)	Monel 400 + hardf (Ni-Cr Alloy)	HVOF /PST	Ball:350 Seat: 350 Stem:350	Moderate pressure more corrosive of temperature up to 480 °C.
12	SS316 and hard faced	SS316-HFS	SS316 (18 Cr-Ni-Mo)	SS316 (18 Cr-Ni-Mo)	SS316+ST6	HVOF /PST		Super resistance to corrosion of liquid up to 538 °C.
12A	SS316 and hard faced	SS316-HFS	SS316 (18 Cr-Ni-Mo)	SS316 (18 Cr-Ni-Mo)	SS316+ hardf (Ni-Cr Alloy)	HVOF /PST	Ball:350 Seat: 350 Stem:350	Super resistance to corrosion of liquid up to 538 °C.
13	Alloy 20	Alloy 20	Alloy 20 (19 Cr 29Ni)	Alloy 20 (19 Cr 29Ni)	Alloy 20 (19 Cr 29Ni)		-	Moderate pressure more corrosive of temperature up to -45°C to 320 °C.
14	Alloy 20 and hard faced	Alloy 20 - HFS	Alloy 20 (19 Cr 29Ni)	Alloy 20 (19 Cr 29Ni)	Alloy 20 +ST6		Ball:350 Seat: 350 Stem:350	Moderate pressure more corrosive of temperature up to 320 °C.
14A	Alloy 20 and hard faced	Alloy 20 - HFS	Alloy 20 (19 Cr 29Ni)	Alloy 20 (19 Cr 29Ni)	Alloy 20 + hardf (Ni-Cr Alloy)		Ball:350 Seat: 350 Stem:350	Moderate pressure more corrosive of temperature up to 320 °C.
15	SS304 full hard faced	SS304-HF	SS304 (18 Cr-8Ni-Mo)	SS304 +ST6	SS304 +ST6	HVOF /PST	Ball:350 Seat: 350 Stem:350	Erosive service at higher pressure, temperature to 538 °C.
16	SS316 full hard faced	SS316-HF	SS316 (18 Cr-8Ni-Mo)	SS316 +ST6	SS316 +ST6	HVOF /PST	Ball:350 Seat: 350 Stem:350	Erosive service at higher pressure, temperature to 538 °C
17	SS347 full hard faced	SS347-HF	SS347 (18 Cr-10Ni-Cb)	SS347 +ST6	SS347 +ST6	HVOF /PST	Ball:350 Seat: 350 Stem:350	corrosive service at higher pressure, temperature to 800 °C
18	Alloy 20 full hard faced	Alloy 20 -HF	Alloy 20 (19 Cr 29Ni)	Alloy 20 +ST6	Alloy 20 +ST6		Ball:350 Seat: 350 Stem:350	higher pressure water, gas, lower pressure steam temperature to 230 °C
na	SS316 and hard faced	SS316 - HFS	SS410+ hard faced	SS316 and hard faced	SS316 and hard faced	HVOF /PST	Ball:350 Seat: 350 Stem:350	Super resistance to corrosion of liquid up to 538 °C.
na	SS316 and hard faced	SS316 - HFS	Inconel 718	SS316 and hard faced	SS316 and hard faced	HVOF /PST	Ball:350 Seat: 350 Stem:350	Super resistance to corrosion of liquid up to 538 °C.
na	SS321	SS321	SS321 (18Cr-10Ni-Ti)	SS321 (18Cr-10Ni-Ti)	SS321 (18Cr-10Ni-Ti)		-	Super resistance to corrosion of liquid up to >538 °C.
na	SS316	SS316	17-4-PH	SS316	SS316		-	Super resistance to corrosion of liquid up to 320 °C.
na	SS316	SS316	SS316+St Gr 6	SS316+ St6	SS316 + St6		-	Super resistance to corrosion of liquid up to 380 °C.
na	Duplex 2205	Duplex 2205	ASTM A182 F 51 (22Cr-5Ni-	ASTM A182 F 51 (22Cr-5Ni-3Mo-N	ASTM A182 F 51 (22Cr-5Ni-		-	HC gas vapour up to 316 °C.
na	Super Duplex 2507	Super Duplex 2507	ASTM A182 F 53 (25Cr-7Ni-4Mo-N)	ASTM A182 F 53 (25Cr-7Ni-4Mo-N)	ASTM A182 F 53 (25Cr-7Ni-4Mo-N)		-	HC gas vapour up to 316 °C.
na	Super Duplex F55	Super Duplex F55	ASTM A182 F 55 (25Cr-7Ni-3.5Mo-N-Cu-W)	ASTM A182 F 55 (25Cr-7Ni-3.5Mo-N-Cu-W)	ASTM A182 F 55 (25Cr-7Ni-3.5Mo-N-Cu-W)		-	HC gas vapour up to 316 °C.

13.0 Advanced HVOF Technology for Superior Coating Characteristics .

a) **High density:** Typical coatings have less than 2 % porosity and some coatings as low as 0.5 % porosity.

b) **High bond strength:** For example, typical car bide coatings sprayed with HVOF exhibit bond strengths in excess of 69 MPA (10,000 psi). Other coating materials sprayed with HVOF have significantly higher bondstrengths than the same materials applied using other atmosphere ic thermal spray processes such as air plasma spray.

c) **Improved Toughness:** Depending on chemistry and other factors, the short dwell time and lower temperatures of HVOF can produce wear resistant coatings with excellent impact resistance.

d) **Beneficial Residual Stress:** Compressive residual stresses and, in some cases, very low tensile stresses enhance the fatigue life of a coated component, reduce the susceptibility of cracking and permit greater coating thickness limits.

e) **Higher Coating Thickness:** Coatings exhibit greater coating thickness limits than plasma, combustion or wire coatings of the same coating material. These high thickness limits are at tribute to a stress-relieving 'shot-peening' effect produced by the high velocity particles im pact ing upon the previous layers of coating. Some tungsten carbide coatings can have a thickness greater than 6.4 mm (0.250 inches).

f) **Excellent Wear Resistance:** HVOF coatings can exhibit superior resistance to sliding / adhesive wear, fret-ting, erosion or cavitation de pending on the material and process parameters chosen.

g) **Superb Corrosion Resistance:** The high den sity and exceptional metallurgical properties of HVOF coatings provide enhanced resistance to the effects of corrosion, including hot corrosion, oxidation and the effects of corrosive media such as acidic and alkaline atmospheres and liquids

h) **Optimum Hardness:** A 12 % tungsten carbide / cobalt coating will have a typical micro hard ness of 1100 to 1350 DPH300

i) **Fine Surface Finishes:** Smooth surfaces finishes allow HVOF-produced coatings to be used in the as-sprayed condition for many applications. Coatings can be machined, ground, lapped, honed or super-finished to produce very high surface finishes to precise tolerances.

14.0 Seat Leakage rate & selection guideline for TSOvalve in on-off Application

14.1 In engineering point of view, the vales are said to bubble tight. The seat leakage rate is measured as per the following international standard for valves in on-off application.

1. ANSI FCI 70.2-2013.
2. ISO -5208-8th Edition
3. MSS SP-61 -2009.
4. API598 10Th edition.

Among all the above standard ISO -5208-8th Edition, API598 10Th edition and MSS SP-61 -2009 is used for seat leakage rate testing for metal and soft seated valves in On-Off application. ANSI FCI 70.2-2013 is used to test the seat leakage rate for control valve . If line isolation and/or absolute tight shut-off is a normal expectation of the valve application, the FCI Control Valve and Regulator Sections recommend specifying another standard, such as API 598, "Valve Test and Inspection.

14.2 Introduction to ANSI FCI70.2-2013:

The standard was revised in 2003 to add the option to permit low pressure gas testing to determine Class V leakage. During the canvass of the 2003 version, one respondent asked for the standard to be modified to specifically exclude on/off valves used for tight shut-off. The FCI Control Valve and Regulator Section notes that FCI 70-2 has been intended to apply to control valve seat leakage. If line isolation and/or absolute tight shut-off is a normal expectation of the valve application, the FCI

Control Valve and Regulator Sections recommend specifying another standard, such as API 598, "Valve Test and Inspection.

14.3 Leakage specifications & classes.

a) CLASS I. A modification of any Class II,III or IV valve where design intent is the same as the basic class, but by agreement between user and supplier, no test is required.

b) CLASS II. This class establishes the maximum permissible leakage generally associated with commercial double-seat control valves or balanced single-seat control valves with a piston ring seal and metal-to-metal seats. Use test procedure Type A.

c) CLASS III. This class establishes the maximum permissible leakage generally associated with Class II (4.2.2), but with a higher degree of seat and seal tightness. Use test procedure Type A.

d) CLASS IV. This class establishes the maximum permissible leakage generally associated with commercial unbalanced single-seat control valves and balanced single -seat control valves with extra tight piston rings or other sealing means and metal-to-metal seats. Use test procedure Type A.

e) CLASS V. This class is usually specified for critical applications where the control valve may be required to be closed, without a blocking valve. This class is generally associated with metal seat, unbalanced single -seat control valves or balanced single-seat designs with exceptional seat and seal tightness. Use test procedure Type B using water at the maximum operating differential pressure or Type BI by using air at the specified conditions.

f) CLASS VI. This class establishes the maximum permissible seat leakage generally associated with resilient seating control valves either unbalanced or balanced single-seat with "0" rings or similar gapless seals. Use test procedure Type C.

14.4 Test Procedures as per ANSI FCI70.2.

Table-5

Test Procedure	Test Medium	Testing Temp	Test Pressure condition		Applicable to Leakage class
Type-A	Clean air/ water	10-51°C (50-125°F).	1. Pressure of test medium shall be 3-4 barg (45-60 psig) or 2. within +l- 5 percent of the maximum operating differential pressure, whichever is less.		Class II,II and IV
Test Procedure Type B	clean water	10-52°C (50-125°F).	1. The water test differential pressure shall be within +1- 5 percent of the maximum service pressure drop across the valve plug, not exceeding the maximum pressure at room temperature as determined by ANSI B16.1, B16.5, or B16.34, 2. Some lesser pressure by individual agreement.	Water test: 5x 10-4 ml per minute of water per inch of seat diameter per psi differential	Class-V
Type B1	clean air or nitrogen	10-52°C (50-125°F).	➢ Inlet pressure of test medium shall be 3.5 barg, (50 psig).	Air test: 4.7 standard ml per minute of air per inch of orifice diameter	Class-V
Type C -	air or nitrogen gas	10-52°C (50-125°F).	➢ Pressure of the test medium shall be the maximum rated differential pressure across the valve plug or 3.5 bar (50 psig) whichever is the least		Class-VI

Notes for all leakage classes:

1. Leakage rate shall be measured once the flow is stabilized..
2. Seat Diameter is measured at the point of seating contact to the nearest (1/16”) 2mm.
3. 1 bubble is equivalent to approximately 0.015 ml.

14.5 Leakage rate table as per

14.5.1 ANSI FCI 70.2-2013.(Refer Table-6)

- **High Pressure water test:**
  Body size : 4” ,150# Body material CF
  Test Pressure: 275 Psig. As per body material.
  Leakage in per inch valve in per psig pressure deferential= 0.0005 ml/min
  Leakage for 4” valve = 0.0005x4x275= 0.55 ml/min.
- **Air test calculation for 4” valve:**
  Test Pressure: 50 Psig.
  Seat Dia: 4”
  Leakage limit per inch of valve per psig pressure differential: 4.7 ml/min.
  Allowable leakage is =4.7ml/min x4=18.8 ml/min.
- **Air test calculation for 8” valve:**
  Test Pressure: 50 Psig.
  Seat Dia: 8”
  Leakage limit per inch of valve per psig pressure differential: 4.7 ml/min.
  Allowable leakage is =4.7ml/min x8=37.6 ml/min.

14.6 Leakage rate table as per ANSI FCI70.2

Table-6

Test pressure	Tpype	Size	ANSI FCI 70.2 -2013		
			CLASS V in ml/min	CLASS VI in ml/min	
50 psig	Type B1	1”	4.7	0.15	Air test 4.7 standard ml per minute of air per inch of orifice diameter at 50 psig and 10 °C to 50 °C.
		1.5”	7.05	0.30	
		2”	9.4	0.45	
		3”	14.1	0.90	
		4”	18.8	1.70	
		6”	28.2	4.00	
		8”	37.6	6.75	
		10”	47	11.1	
		12”	56.4	16.0	
		14”	65.8	21.6	
		16”	75.2	28.4	

14.7 Leakage rate table as per iso-5208-2008..

- High Pressure water test:
  Test pressure 302 psig BASED ON 1.1 times of CF8F body as per ASME B 16.34 clas 150#DN number of the valve =4” (100mm).

Rate B :
0.01mm3/secx100x1ml/1000mm3x60 sec/min
=0.06ml/min

Rate C :
0.03mm3/secx300x1ml/1000mm3x60 sec/min
=0.18ml/min

Rate D :
0.1mm3/secx300x1ml/1000mm3x60 sec/min
=0.6ml/min

Low pressure air test for ml/min
Test pressure 87 psig
DN number of the valve =4” (100mm)

Rate B :
0.3mm3/secx100x1ml/1000mm3x60 sec/min
=5.4ml/min

Rate C :
3.0mm3/secx300x1ml/1000mm3x60 sec/min
=54ml/min

RateD : 30mm3/secx300x1ml/1000mm3x60 sec/min =540ml/min

Low pressure air test for bubble/min
Test pressure 87 psig
DN number of the valve =12” (300mm)
Rate B : 0.0046bubble/secx300x60 sec/min=82.8bubble/min

Rate C
: 0.046bubble/secx300x60 sec/min
=824.4 bubble/min

- **RateD** : 0.456bubble/secx300x60 sec/min =8208 bubble/min

14.8 Leakage rate table as per ISO 5208 -2008 Table -V

Table-7

DN No of the valve	Sizes in Inch	SEAT LEAKAGE RATE API 6D/ISO 5208 Gas/Vapour												
		All resilient (soft) seated valve for Liquid / Vapour and Gas												
		Rate A	Rate AA		Rate B		Rate C		Rate CC		Rate D		Rate E	
			0.003X DN	0.18X DN	0.0046x DN	0.3X DN	0.0458x DN	3.0X DN	0.3407X DN	22.3X DN	0.4584 XDN	30XD N	4.5837XD N	300X DN
		Bubble /min	bubble / min	ml/ min	Bubble / min	ml/ min	Bubble / min	ml/ min	Bubble /min	ml/ min	Bubble /min	ml/ min	Bubble/ min	ml/ min
≤ 50	≤ 2"	0	9	0.54	13.8	0.9	1374	9	1022.1	66.9	1375.2	90	13751.1	900
75	3"	0	13.5	0.81	20.7	1.35	2061	13.5	1533.15	100.35	2062.8	135	20626.65	1350
100	4"	0	18	1.08	27.6	1.8	2748	18	2044.2	133.8	2750.4	180	27502.2	1800
150	6"	0	27	1.62	41.4	2.7	4122	27	3066.3	200.7	4125.6	270	41253.3	2700
200	8"	0	36	2.16	55.2	3.6	5496	36	4088.4	267.6	5500.8	360	55004.4	3600
250	10"	0	45	2.7	69	4.5	687	45	5110.5	334.5	6876	450	68755.5	4500
300	12"	0	54	3.24	82.8	5.4	8244	54	6132.6	401.4	8251.2	540	82506.6	5400
350	14"	0	63	3.78	96.6	6.3	9618	63	7154.7	468.3	9626.4	630	96257.7	6300
400	16"	0	72	4.32	110.4	7.2	10992	72	8176.8	535.2	11001.6	720	110008.8	7200
450	18"	0	81	4.86	124.2	8.1	12366	81	9198.9	602.1	12376.8	810	123759.9	8100
500	20"	0	90	5.4	138	9	1374	90	10221	669	13752	900	137511	9000
600	24"	0	108	6.48	165.6	10.8	16488	108	12265.2	802.8	16502.4	1080	165013.2	10800
650	26"	0	117	7.02	179.4	11.7	17862	117	13287.3	869.7	17877.6	1170	178764.3	11700
700	28"	0	126	7.56	193.2	12.6	19236	126	14309.4	936.6	19252.8	1260	192515.4	12600
750	30"	0	135	8.1	207	13.5	2061	135	15331.5	1003.5	20628	1350	206266.5	13500
800	32"	0	144	8.64	220.8	14.4	21984	144	16353.6	1070.4	22003.2	1440	220017.6	14400
900	36"	0	162	9.72	248.4	16.2	24732	162	18397.8	1204.2	24753.6	1620	247519.8	16200
1000	40"	0	180	10.8	276	18	2748	180	20442	1338	27504	1800	275022	18000
1050	42"	0	189	11.34	289.8	18.9	28854	189	21464.1	1404.9	28879.2	1890	288773.1	18900
1200	48"	0	216	12.96	331.2	21.6	32976	216	24530.4	1605.6	33004.8	2160	330026.4	21600

14.9 Leakage rate table as per ISO 5208 -2008 Table –VI

(Table-8)

DN No of the valve	Sizes in Inch	SEAT LEAKAGE RATE API 6D/ISO 5208 Liquid												
		All resilient (soft) seated valve for Liquid /Vapour and Gas												
		Rate A	Rate AA		Rate B		Rate C		Rate CC		Rate D		Rate E	
			0.0001 XDN	0.006 XDN	0.00016 xDN	0.01X DN	0.0005x DN	0.03X DN	0.0013 XDN	0.08X DN	0.0016 XDN	0.1X DN	0.0048 XDN	0.3X DN
		Bubble/ min	bubble / min	ml/ min	Bubble / min	ml/ min	Bubble / min	ml/ min	Bubble /min	ml/ min	Bubble /min	ml/ min	Bubble /min	ml/ min
≤ 50	≤ 2"	0	0.3	0.018	0.48	0.03	1.5	0.09	3.9	0.24	4.8	3	14.4	0.9
75	3"	0	0.45	0.027	0.72	0.045	2.25	0.135	5.85	0.36	7.2	4.5	21.6	1.35
100	4"	0	0.6	0.036	0.96	0.06	3	0.18	7.8	0.48	9.6	6	28.8	1.8
150	6"	0	0.9	0.054	1.44	0.09	4.5	0.27	11.7	0.72	14.4	9	43.2	2.7
200	8"	0	1.2	0.072	1.92	0.12	6	0.36	15.6	0.96	19.2	12	57.6	3.6
250	10"	0	1.5	0.09	2.4	0.15	7.5	0.45	19.5	1.2	24	15	72	4.5
300	12"	0	1.8	0.108	2.88	0.18	9	0.54	23.4	1.44	28.8	18	86.4	5.4
350	14"	0	2.1	0.126	3.36	0.21	10.5	0.63	27.3	1.68	33.6	21	100.8	6.3
400	16"	0	2.4	0.144	3.84	0.24	12	0.72	31.2	1.92	38.4	24	115.2	7.2
450	18"	0	2.7	0.162	4.32	0.27	13.5	0.81	35.1	2.16	43.2	27	129.6	8.1
500	20"	0	3	0.18	4.8	0.3	15	0.9	39	2.4	48	30	144	9
600	24"	0	3.6	0.216	5.76	0.36	18	1.08	46.8	2.88	57.6	36	172.8	10.8
650	26"	0	3.9	0.234	6.24	0.39	19.5	1.17	50.7	3.12	62.4	39	187.2	11.7
700	28"	0	4.2	0.252	6.72	0.42	21	1.26	54.6	3.36	67.2	42	201.6	12.6
750	30"	0	4.5	0.27	7.2	0.45	22.5	1.35	58.5	3.6	72	45	216	13.5
800	32"	0	4.8	0.288	7.68	0.48	24	1.44	62.4	3.84	76.8	48	230.4	14.4
900	36"	0	5.4	0.324	8.64	0.54	27	1.62	70.2	4.32	86.4	54	259.2	16.2
1000	40"	0	6	0.36	9.6	0.6	30	1.8	78	4.8	96	60	288	18
1050	42"	0	6.3	0.378	10.08	0.63	31.5	1.89	81.9	5.04	100.8	63	302.4	18.9
1200	48"	0	7.2	0.432	11.52	0.72	36	2.16	93.6	5.76	115.2	72	345.6	21.6

14.10 Seat Leakage Test duration as per ISO 5208 (Table9)

Testing Standard	Test pressure & Temperature	Valve Size DN	NPS	Test duration seat closure rest in sec
ISO 5208 EN12226-1	80 to 100PSIG@ 38°C	≤ 50	≤ 2"	15
	XMAWP @38°C	≤ 50	≤ 2"	60
	80 to 100PSIG@ 38°C	>50 , ≤ 150	>2" ,≤ 6"	60
	XMAWP @38°C	>50 , ≤ 150	>2" ,≤ 6"	60
	80 to 100PSIG@ 38°C	>150, ≤ 300	>6" ,≤ 10"	120
	XMAWP @38°C	>150, ≤ 300	>6" ,≤ 10"	120
	80 to 100PSIG@ 38°C	≥ 350	≥ 12"	120
	XMAWP @38°C	≥ 350	≥ 12"	120

14.11Seat Leakage rate Pressure testing requirement Table as per ISO 5208 (Table-10)

TEST DESCRIPTION	size	ASME Class	VALVE TYPE Floating Ball	Trunnion guided Ball	Butterfly
Shell test liquid	All	All	Required	Required	Required
Shell test Gas	All	All	Optional	Optional	Optional
Back seat	All	All	Not Required	Not Required	Not Required
Low pressure closure	DN(NPS) ≤ 100	Class ≤1500 and ≤ 250	Required	Required	Required
		Class >1500 and > 250		Optional	Optional
	DN(NPS) >100	Class ≤ 600 and PN ≤100		Required	Required
		Class >600 and >100		Optional	Optional
High pressure closure	DN(NPS) ≤ 100	Class ≤1500 and ≤ 250	Optional	Optional	Optional
		Class >1500 and > 250		Required	Required
	DN(NPS) >100	Class ≤ 600 and PN ≤100		Optional (b,e)	Optional (b,e)
		Class >600 and >100		Required	Required

Plug valves that rely on a sealing compound to effect a closure seal may be closure tested with the compound installed.
Successful completion of a backseat test should not be interpreted as a recommendation by the valve manufacturer that, while and installed valve is pressurized, the stem seal may be altered, repaired or replaced when back seated.
In the case of bellows stem sealed valves, a backseat test is not required. .

14.12API 598 Pressure seat closure test requirement.

Table-11

TEST DESCRIPTION	size	ASME Class	VALVE TYPE Floating Ball	Trunnion guided Ball	Butterfly
Shell	All	All	Required	Required	Required
Back seat	All	All	NA	NA	NA
Low pressure closure	DN(NPS) ≤ 100	Class ≤1500	Required	Required	Required
		Class >1500		Optional (b)	Optional (b)
	DN(NPS) >100	Class ≤600		Required	Required
		Class >600		Optional (b)	Optional (b)
High pressure closure	DN(NPS) ≤ 100	Class ≤1500	Optional (b,e)	Optional (b,e)	Optional (b,e)
		Class >1500		Required	Required
	DN(NPS) >100	Class ≤600		Optional (b,e)	Optional (b,e)
		Class >600		Required	Required

a. The backseat test is required for all valves that have the backseat feature, except for bellows seal valves.
b. When an "optional" test is specified by the purchaser, the test shall be performed in addition to the required tests.
c. The high-pressure closure test of resilient-seated valves may degrade subsequent sealing performance in low-pressure service.
d. For power-operated and manually operated gear actuated globe valves, including nonreturn type globe valves, the high-pressure closure test shall beperformed at 110 % of the design differential pressure used for sizing of the operator.
e. A high-pressure closure test is required for all valves specified to be double block and bleed (DBB) valves, unless specified otherwise by thepurchaser.
f. For lubricated plug valves, the high-pressure closure test is mandatory and the low-pressure closure test is optional.

14.13 Allowable Leakage rate table as per API 598

Table-12

14.9 Leakage rate table as per API 598					
DN No of the valve	Sizes in Inch	SEAT LEAKAGE RATE API 598 at 80 psi pressure and ambient temperature			
		All resilient (soft) seated valve for Liquid /Vapour and Gas	Metal seated valve		
			Gas/Vapour in		liquid
			Bubble /min	ml/min	ml/ min
≤ 50	≤ 2″	0	0	0	0
75	3″	0	12	0.12	6
100	4″	16	16	0.16	8
150	6″	0	24	0.24	12
200	8″	0	32	0.32	16
250	10″	0	40	0.40	20
300	12″	0	48	0.48	24
350	14″	0	56	0.56	28
400	16″	0	64	0.64	32
450	18″	0	72	0.72	36
500	20″	0	80	0.80	40
600	24″	0	96	0.96	48
650	26″	0	104	1.04	52
700	28″	0	112	1.12	56
750	30″	0	120	1.20	60
800	32″	0	128	1.28	64
900	36″	0	144	1.44	72
1000	40″	0	160	1.60	80
1050	42″	0	168	1.68	84
1200	48″	0	192	1.92	96

a. For the liquid test, 1 mL is considered equivalent to 16 drops. For the gas test 1 mL is considered equivalent to 100 bubbles.
b. There shall be no leakage for the minimum specified test duration (see Table 4). For liquid test, 0 drops means no visible leakage per minimum specified test duration. For standard gas test, 0 bubbles means less than 1 bubble per minimum specified test duration. For high-pressure pneumatic closure test refer to paragraph 5.4.
c. Leakage rates for sizes above DN 1200 (NPS 48) shall be calculated by the following formulas:

Liquid Test for Metal Seated Valves except Check: 2 x NPS (drops/min).
Gas Test for Metal Seated Valves except Check: 4 x NPS (bubbles/min)

14.14 API 598 Pressure Test Duration for seat closure

Table-13

Testing Standard	Test pressure & Temperature	Valve Size		Test duration seat closure rest in sec
		DN	NPS	
API598	80 to 100PSIG @ 38°C	≤ 50	≤ 2″	60
	1.1 XMAWP @38°C	≤ 50	≤ 2″	60
	80 to 100PSIG @ 38°C	>50 , ≤ 150	>2″,≤ 6″	60
	1.1 XMAWP @38°C	>50 , ≤ 150	>2″,≤ 6″	60
	80 to 100PSIG @ 38°C	>150, ≤ 300	>6″,≤ 10″	120
	1.1 XMAWP @38°C	>150, ≤ 300	>6″,≤ 10″	120
	80 to 100PSIG @ 38°C	≥ 350	≥ 12″	120
	1.1 XMAWP @38°C	≥ 350	≥ 12″	120
ISO 5208 EN12226-1	80 to 100PSIG @ 38°C			

14.15Leakage rate table as per MSS-SP-61:

- The seat closure test shall be performed at a fluid (liquid or gas) pressure no less than 1.1 times the valve's 100°F (38°C) design pressure rating rounded to the next higher 5 psi (0.5 bar). At the manufacturer's option, a gas pressure of no less than 80 psi (5.6 bar) may be substituted for the valve sizes and pressure classes listed in the table.

Table-14

Liquid		Gas		Test Medium	Pressure and Temperature
Per NPS	Per DN	Per NPS	Per DN		
10 cc/hr	0.4 cc/hr	0.1 SCFH 2.88 SCIM	120 cc/hr	Clean water/ Air./N2/ helium	80 psi@ 38 °C
0.167 cc/min	6.6x10-3 cc/min	47.2 CC/min	2 cc/min		
2.66 drops/min	.011 drops/min	1180 bubbles/min	50 bubbles/min		

1. 1 ml = 1 cc
2. SCFH = Standard cubic feet per hour. (14.7 psia @ 60°F)(1.01 bar @ 16°C)
3. SCIM = Standard cubic inch per minute, (14.7 psia @ 60°F)(1.01 bar @ 16°C)

Table-15

Valve size in Inch	As per API 598 gas service (Metal seat) Test Pressure 80psig @ 50 °C		As per ISO 5208for gas Test Pressure 80psig @ 50 °C								As Per ANSi FCI 70.2-2013 for gas Test Pressure 80psig @ 50 °C		
	Bubble /min	Ml/ min	Rate A(soft seat)		Rate B		Rate C Rate		Rate D Rate		Size	Class V (Metal)	Class VI(soft seat)
			Bubble /min	Ml/ min	Bubble /min	Ml/ min	Bubble /min	Ml/ min	Bubble /min	Ml/ min		Ml/min	Ml/min
≤ 2″	0	0	0	0.9	0.48	0.03	1.5	0.09	1375.2	90	1″	4.7	0.15
3″	12	0.12	0	1.35	0.72	0.045	2.25	0.135	2062.8	135	1.5″	7.05	0.30
4″	16	0.16	0	1.8	0.96	0.06	3	0.18	2750.4	180	2″	9.4	0.45
6″	24	0.24	0	2.7	1.44	0.09	4.5	0.27	4125.6	270	3″	14.1	0.90
8″	32	0.32	0	3.6	1.92	0.12	6	0.36	5500.8	360	4″	18.8	1.70
10″	40	0.40	0	4.5	2.4	0.15	7.5	0.45	6876	450	6″	28.2	4.00
12″	48	0.48	0	5.4	2.88	0.18	9	0.54	8251.2	540	8″	37.6	6.75
14″	56	0.56	0	6.3	3.36	0.21	10.5	0.63	9626.4	630	10″	47	11.1
16″	64	0.64	0	7.2	3.84	0.24	12	0.72	11001.6	720	12″	56.4	16.0
18″	72	0.72	0	8.1	4.32	0.27	13.5	0.81	12376.8	810	14″	65.8	21.6
20″	80	0.80	0	9	4.8	0.3	15	0.9	13752	900	16″	75.2	28.4
24″	96	0.96	0	10.8	5.76	0.36	18	1.08	16502.4	1080			
26″	104	1.04	0	11.7	6.24	0.39	19.5	1.17	17877.6	1170			
28″	112	1.12	0	12.6	6.72	0.42	21	1.26	19252.8	1260			
30″	120	1.20	0	13.5	7.2	0.45	22.5	1.35	20628	1350			
32″	128	1.28	0	14.4	7.68	0.48	24	1.44	22003.2	1440			
36″	144	1.44	0	16.2	8.64	0.54	27	1.62	24753.6	1620			
40″	160	1.60	0	18	9.6	0.6	30	1.8	27504	1800			
42″	168	1.68	0	18.9	10.08	0.63	31.5	1.89	28879.2	1890			
48″	192	1.92	0	21.6	11.52	0.72	36	2.16	33004.8	2160			

15.0 Guideline for Selection of Guiding and Leakage rate

Table-16

DN no	Size	Rating	Guiding Type	Seat Leakage Rate API 598	Seat Leakage Rate API 6D/ISO 5208
≤ 50	≤ 2″	≤ 1500#	Floating	API 598	-
		> 1500#			
75	3″	≤ 1500#			
		> 1500#			
100	4″	≤ 300#			
		≥ 600#	Trunnion	API 598	-
		≤ 1500#	Floating	API 598	-
150	6″	≤ 300#	Floating	API 598	-
		≤ 300#	Trunnion	Optional	API 6D/ISO 5208
		≥ 600#	Trunnion	Optional	API 6D/ISO 5208
		≤ 1500#	Floating	API 598	-
		>1500#	Trunnion	Optional	API 6D/ISO 5208
200	8″	≤ 300#	Floating	API 598	
		≤ 300#	Trunnion	Optional	API 6D/ISO 5208
		≥ 600#	Trunnion	Optional	API 6D/ISO 5208
		≤ 1500#	Floating	API 598	
		>1500#	Trunnion	Optional	API 6D/ISO 5208
250	10″	≤ 300#	Floating	API 598	
		≤ 300#	Trunnion	Optional	API 6D/ISO 5208
		≥ 600#	Trunnion	Optional	API 6D/ISO 5208
		≤ 1500#	Floating	API 598	
		>1500#	Trunnion	Optional	API 6D/ISO 5208
300	12″	≤ 300#	Floating	API 598	
		≤ 300#	Trunnion	Optional	API 6D/ISO 5208
		≥ 600#	Trunnion	Optional	API 6D/ISO 5208
		≤ 1500#	Floating	API 598	
		>1500#	Trunnion	Optional	API 6D/ISO 5208
350	14″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
400	16″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
450	18″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
500	20″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
600	24″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
650	26″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
700	28″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
750	30″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
800	32″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
900	36″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
1000	40″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
1050	42″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208
1200	48″	≤ 2500#	Trunnion	Optional	API 6D/ISO 5208

16.0 Guideline for Selection of Gland Emission Testing Standard.

Table-17

DN no	Size	Service	Guiding Type	Emission standard ISO 15848-2:2015	Emission standard ASME Sec V Article 10
All	All	HC Liquid	Floating	√	X
		HC Gas /Vapour	Floating	√	X
		HC + H2	Floating	X	√
		H2	Floating	X	√
		Steam HP	Floating	√	X
		Steam MP	Floating	√	X
		Non HC Gas/Vapour	Floating	√	X
		HC Liquid	Trunnion	√	X
		HC Gas /Vapour	Trunnion	√	X
		HC + H2	Trunnion	X	√
		H2	Trunnion	X	√
		Steam HP	Trunnion	√	X
		Steam MP	Trunnion	√	X
		Non HC Gas/Vapour	Trunnion	√	X

16.1 Gland Emission Allowable Leakage , Test medium, Pressure(Table-18)

SIzes	Testing Standard	Leakage rate	Test Pressure and Medium
All	ISO 15848-2:2015	≤ 50 ppmv	Medium: Helium 97% Pressure : 6 bar
	ASME Sec V Article 10 helium mass spectrometers Tracer Probe Technique	≤1 × 10−5 std cm3 /sec	Medium: Helium 97% Pressure : 6 bar
	ASME Sec V Article 10 helium mass spectrometers Hood Technique	≤1 × 10−6 std cm3 /sec	

17.0 Soft seat material selection guideline(Table-18)

Table-19

Soft Seat Material	Type and Application	Constraints	Temperature and Pressure Range.
PTFE (100% Virgin Poly tetra fluoro ethylene)	Consists of Carbon and Fluorine. Non-reactive to many chemicals and applied to severe chemical environments, PTFE is ideal for low cycle life applications	Do not use in molten alkali metal and molten Fluorine applications.	Temperature Range: -10°C to 204°C. Max Pressure at Room Temperature: 1000 psi. Color: White.
RPTFE (Reinforced Teflon®: 85% PTFE, 15% Glass Fiber).	RTFE has improved wear and abrasion resistance over PTFE while maintaining its chemical compatibility. Its versatile temperature characteristics allow RTFE to be used in saturated steam applications. Better life cycle than PTFE.	This seat should not be used in caustic (sodium hydroxide, potassium hydroxide, etc.) service.	Temperature Range: -45°C to 232°C. Max Pressure at Room Temperature: 2000 psi. Color: OffWhite.
CTFE (25% Carbon Graphite, 75% PTFE)	CTFE is used for low pressure steam applications, abrasive, and slurry services. It offers comparable chemical resistance to PTFE		Temperature Range: -45°C to 248°C. Max Pressure at Room Temperature: 2000 psi. Color: Black
PCTFE (Polychlorotrifluoroethene)	PCTFE is ideal in applications with low and cryogenic temperatures. It offers comparable chemical compatibility to PTFE	should not be used for Ethylene Oxide applications,	Temperature Range: -195°C to 100°C. Max Pressure at Room Temperature: 1000 psi. Color: Transparent White
PEEK (Polyether Ether Ketone)	PEEK has good chemical resistance, and also high temperature tolerance. Ideal for high pressure applications. Other thermoplastics should be used for low pressure applications. Use of PEEK seats require the use of a 17-4 PH® stem.	Do not use in applications prone to thermal shock, or in Chlorine and Sulfuric Acid applications..	Temperature Range: -10°C to 288°C. Can withstand up to 316°C Max Pressure at Room Temperature: 6000 psi. Color: Beige .
Delrin® (DuPont™ Polyoxymethylene)	It has decent chemical resistance, and is ideal for high pressure characteristics	Do not use in Oxygen service	Temperature Range: -40°C to 82°C. Max Pressure at Room Temperature: 6000 psi. Color: White.
Devlon® V-API Devlon	Devlon® V-API is a polyamide that has mechanical properties that are comparable to PEEK, but does not share its high temperature characteristics. It is able to withstand high pressures, and is standard on our Class 150/300 (larger than 12") and Class 600 trunnion ball valves	Avoid using with alcohols, amines, and acids	Temperature Range: -50°C to 190°C. Max Pressure at Room Temperature: 6000 psi. Color: yellow
TFM	Offers the properties of reinforced TFE with greater strength, toughness and improved thermo mechanical properties.		Temperature Range: -45°C to 260°C. Max Pressure at Room Temperature: 2000 psi. Color: Off White

18.0 Seat and seal material selection guideline(Table-20)

Service pressure	Corresponding saturated steam Temperature	Seat	Stem seal	Body Seal
Pressure Steam up to 150 psi	Maximum 186℃	PTFE/TFM	TFM	Graphite
Pressure Steam up to 170 psi	Maximum 191℃	RPTFE	Graphite	Graphite
Pressure Steam up to 250 psi	Maximum 208℃	Carbon PTFE /Metal PTFE	Graphite	Graphite
Pressure Steam up to 300 psi	Maximum 288℃	Peek	Graphite	Graphite
Pressure Steam above 300 psi	Above 288 ℃	Metal	Graphite	Graphite
Pressure Steam above 300 psi	Above 400 ℃ up to 538 ℃	Metal	Graphoil	Graphoil

19.0 Method To achieve Shut off.(Table21)

Valve type	Shut off by	
	Torque/Force	Position
Gate (wedge , expanding)	√	
Gate (slab , parallel side)		√
Globe	√	
Ball floating and trunnion mounted		√
Butterfly	√	
Plug (sleeved, lubricated balanced)		√
Plug (wedge lift type , expanding)	√	

20.0 Available proven model for severe service application(Table-22)

Application	Manufacturer	guiding	Model	Proven size available	Advantage / limitations
High Temp Gas Vapour , sequence and thermal cyclic operation of temp amb to 540 °C.	Flowserve	Rising Stem	Valvert	Available proven size is 6", of rating up to 600#.,	Unidirectional Seat. Recommended up to ≤ 400° C. Excellent choice for sequence and high cycle application with unidirectional sealing requirement. Not recommended for process required both side sealing.
	Flowserve Argus	Trunnion	FK76M	From 4", 600# to 24" and higher of all rating.	Spring energized Bi directional doubled Seated design.. ≤ 400° C. Excellent choice for sequence and high cycle application with Bidirectional sealing requirement.
		Floating	FK75M	From 1",to 6" and higher of I rating up to 1500#..	It is having Bidirectional seat design. Excellent choice for Tight shut off at higher pressure. Recommended ≥ 400 ℃.
		Floating	FK75F1	Sizes available for more than 6" to 12" of rating up to 1500#.	It is having unidirectional seat design. Excellent choice for Tight shut off at higher pressure. Recommended ≥ 400 ℃.
		Floating	FK75F2		It is having Bidirectional seat design. It is having Bidirectional seat design. Excellent choice for Tight shut off at higher pressure. . Recommended ≥ 400 ℃.
	Velan	Tunnion/Floating	Modified K	From 4", 600# to 24" and higher of all rating.	It is having Bidirectional seat design. Excellent choice for Tight shut off at higher pressure. Recommended ≥ 400 ℃.
	Metso	Floating	XT	From 1",to 8" and rating up to 600#	It is having Bidirectional seat design. Excellent choice for Tight shut off at higher pressure. Recommended up to ≤ 400° C
		Trunnion	XG	From 4", 600# to 24" and higher of all rating	It is having Bidirectional seat design. Excellent choice for Tight shut off at higher pressure. Recommended up to ≤ 400° C.
			XD		It is having Bidirectional seat design. Excellent choice for Tight shut off at higher pressure. Recommended ≥ 400 ℃.

21.0 Typical selection flow chart for normal application.

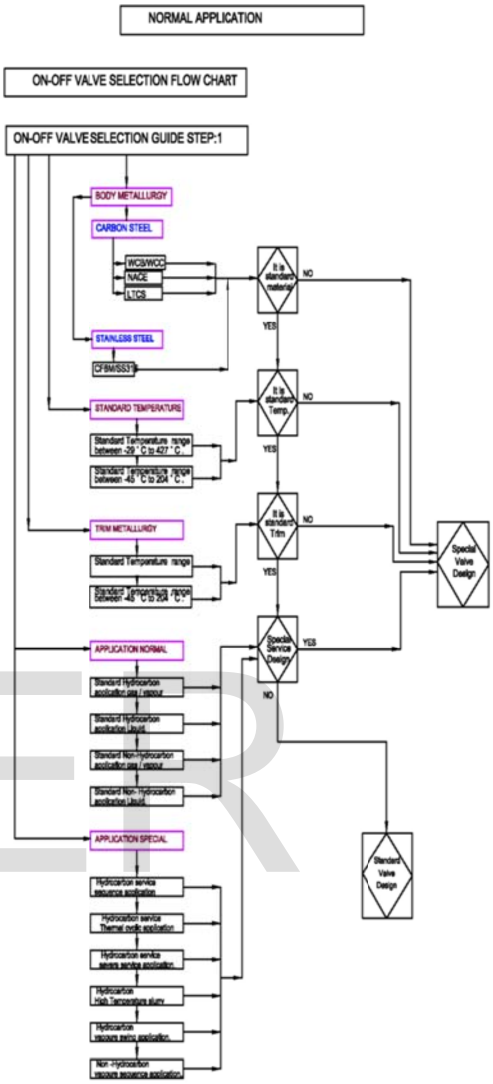


Chart 1

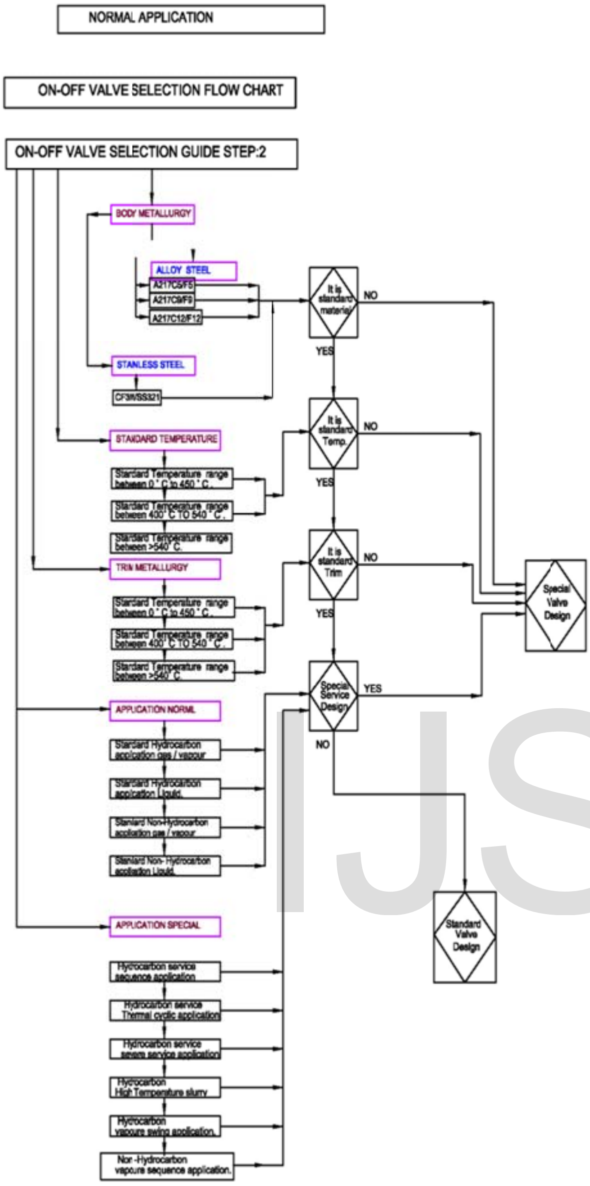


Chart-2

21.1 In Carbon steel/Alloy steel and stainless steel.

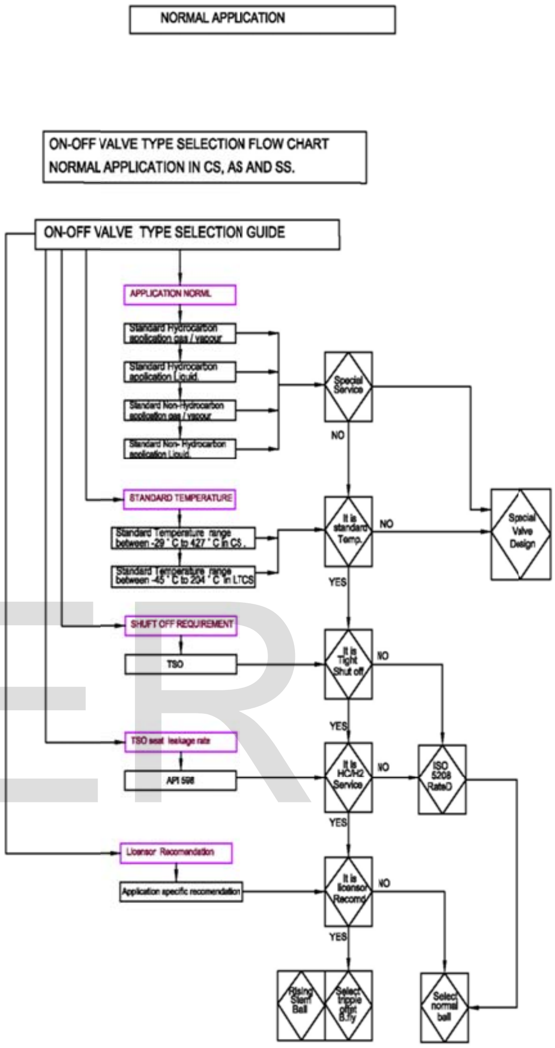


Chart-3

21.2 In special application in Carbon steel and Alloy steel.

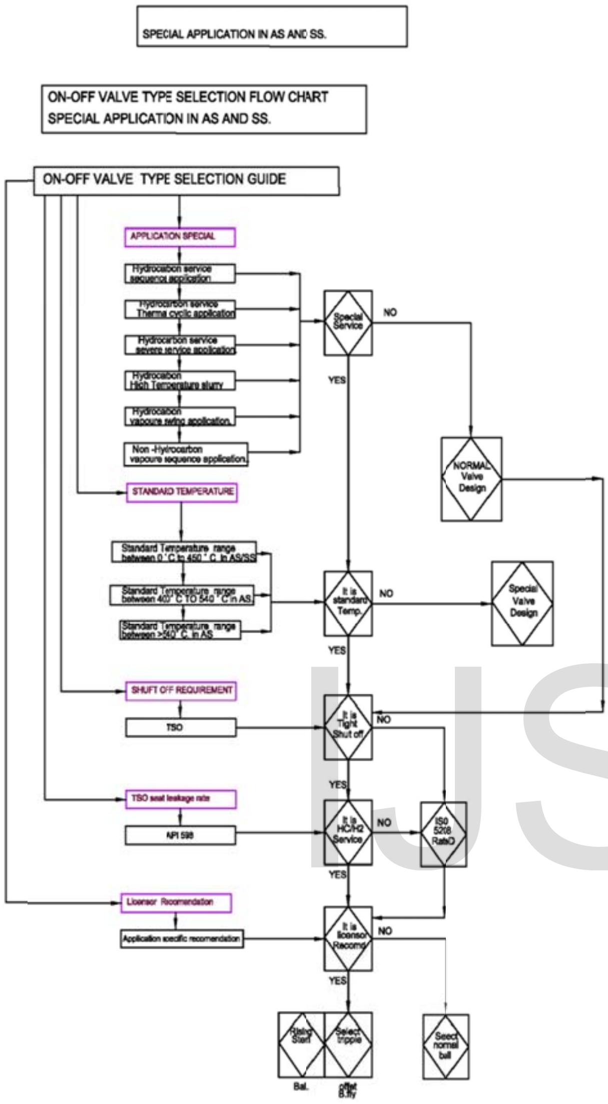


Chart-4

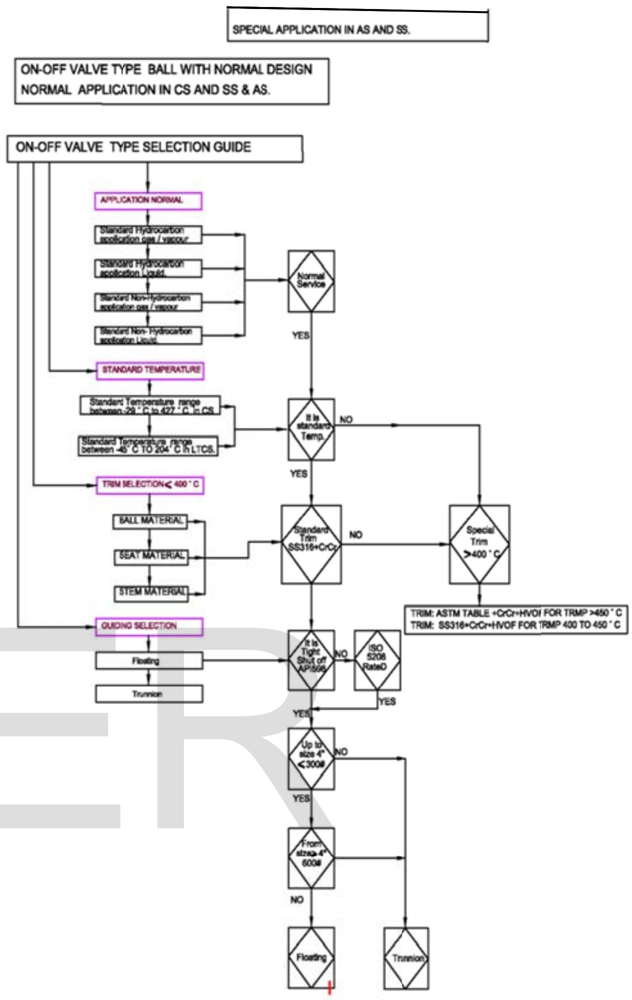


Chart5

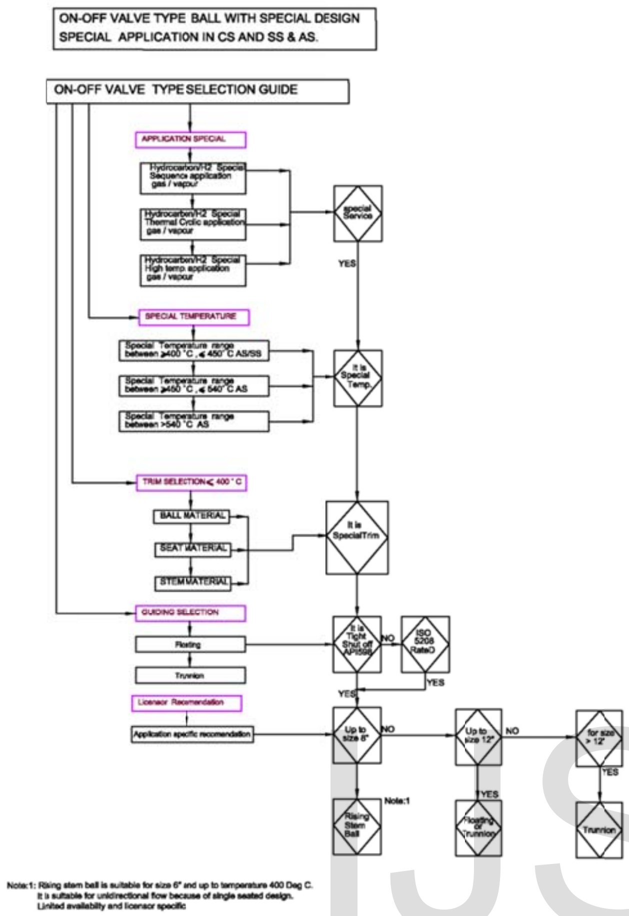


Chart-6

22.0 Acknowledgment

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I wish to express sincere thanks to **Sh Rajiv Gupta (Head of the department, Instrumentation) of M/s Engineers India Limited** for the spontaneous support and guidance provided. Also a I am equally thankful to M/s Velan, M/S Flowserve India Pvt Ltd and M/s Mestso for their knowledge sharing to prepare this guideline.

23.0 References

[1] Manufacturing standard design and catalogues of On –off valve from M/s Velan, M/S Flowserve India Pvt Ltd and M/s Mestso Automation.

[2] Reference standard API 598 10th edition, ISO 5208 2015 , ANSI FCI 70.2 latest edition , MSS-SP-61 latest edition for seat leakage rate.

[3] Reference standard ISO-148482-2015 and ASME Sec V Article 10 for gland emission.

[4] API 6D for valve construction .

[5] API 6D & ASME B16.10 for valve face to face dimension.

[6] ASME B16.5, ASME B16.47 series A or B or API 605 , or MSS-SP-44.