

GUIDE TO VALVE SELECTION**JGS 210-120-1-75E**

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1. SCOPE

This manual provides the guidelines for the selection of valve type for P&ID preparation. The detailed material selection are specified in "Piping Material Specification" of the individual project.

This manual covers only normal type valves, not special type valves.

It should be recognized that valve selection is a very extensive and complex subject and it is not possible to select only one type based on this manual.

The valve selected to work under the same conditions will differ client by client.

It is necessary to compare the cost, and come to an agreement with client.

This manual is the supporting document to achieve this purpose.

2. SELECTION PROCEDURE

The selection of valve type requires an understanding of the following.

- (a) Valve Function
- (b) Service Characteristics
- (c) Cost of Valve

2.1 Valve Function

There are two basic principles on which valves are constructed.

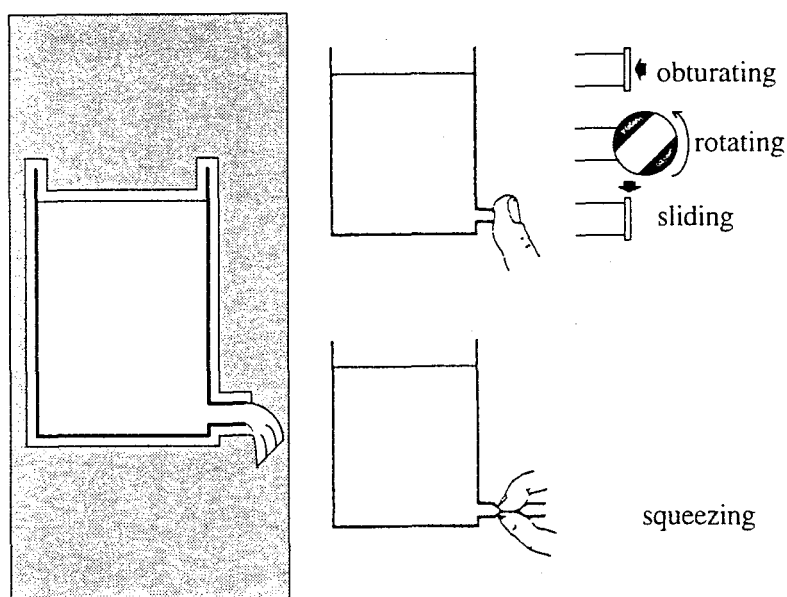
(1) The first principle is developed in three ways:

- Moving the stopper by direct thrust on to the orifice seating.
This obturating movement is the basis of globe type valves.
- Rotating the stopper. This is the basis for plug or ball type valves.
- Sliding the stopper across the face of the orifice seating.

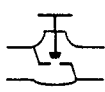
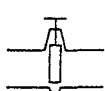
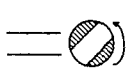
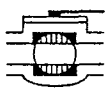
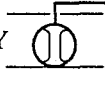
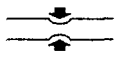
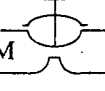
This is the basis of gate type valves.

(2) The second principle, squeezing action, is the basis of all diaphragm type valves.

These are shown in the following Figure.



(3) Each of the four valve motivations has its own advantages and disadvantages, as listed in the following Table.

			ADVANTAGES	DISADVANTAGES
PUSHING				
1 	GLOBE		Best shut-off and regulating characteristics	High head loss
SLIDING				
2 	GATE		Straight through flow	Slow acting. Bulky
ROTATING				
	PLUG		Quick acting. Straight through flow	Temperature limitations on PTFE sleeved valves and need for attention to lubricant in lubricated valves
3 	BALL		Quick acting. Straight through flow. Easy operation	Temperature limited by seating material
	BUTTERFLY		Quick acting. Good regulating characteristics Compact	Metal to metal seated type does not give tight shut-off. Temperature limited by seating material on resilient seated type
SQUEEZING				
4 	DIAPHRAGM		Glandless. Positive shut-off on dirty fluids	Pressure and temperature limited by diaphragm material

To summarize, there are four basic valve types, each type having its own individual characteristics and offering its own particular advantages or disadvantages. For this reason, many modifications and variations of the basic type are made by valve manufacturers. An appraisal of the chief characteristics of the four basic valve types is given in the following.

(a) Globe valve

The globe valve is used for flow regulation or as a block valve where resistance to flow is not critical and a positive closing action is required. They have a tortuous configuration which is typical of the closing method and results in a higher resistance to flow compared with other valves.

(b) Gate valve

Gate valves are used for on/off operation on hydrocarbon, general process and utilities services for all temperature ranges.

They have straight through configurations which are typical of the sliding method, therefore, minimum resistance to flow.

Disadvantages are that they have the slowest action of all valves because the gate has to be moved a distance greater than the bore of the valve, which also means that the valve is of necessity bulky in height.

(c) Plug valve

Plug valves have quarter turn operation, plugs are tapered or parallel plugs, and are suitable for most on-off clean process and utility services, including non-abrasive slurries.

They have straight through configurations typical of the sliding method.

The disadvantages of the basic plug cock are two fold.

Firstly, its quick action can lead to water hammer on hydraulic installation when it is closed too rapidly, and secondly, it is difficult to combine tight shut-off with ease of operation.

(d) Ball valve

A low torque quarter turn valve, with low resistance to flow, suitable for many on-off utility and process services.

It has a straight through configuration typical of the sliding method of closure.

(e) Butterfly valve

A low torque, quarter turn, rotary action valve with a straight through flow configuration in which the disc is turned through 90 degrees, close to open position, in axial turning bearings and is used as a control or block valve. It is of compact design and may be obtained with or without flanges and linings. Seating arrangement may be soft (use of body lining, trapped 'O' ring etc.) or metal to metal.

(f) Diaphragm valve

Diaphragm valves have straight through flow or weir configurations employing the flexing method and may be used for low pressure chemical plant process on-off or regulating operation of most gases and liquids, e.g. slurries, viscous fluids and fluids which are chemically aggressive.

The inherent disadvantage is that the diaphragm has to be made from an elastomeric material, usually either a natural or synthetic rubber, and this limits the application of the valve in respect to both temperature and pressure. Also, because of the stresses induced in the diaphragm, the valve has a shorter working life than other valve types.

2.2 Typical Valve Type

Typical valve types for various operating functions are given in the following table.

Valve Function	Typical Valve Type
Isolation	Gate Valve Ball Valve Butterfly Valve Diaphragm Valve
Control (Flow/Pressure)	Globe Valve Ball Valve Butterfly Valve Diaphragm Valve
Prevention of Flow Reversal	Check Valve (Swing, Lift, Nonslam, etc)
Flow Diversion	Ball Valve, Plug Valve, Angle Valve (Three Way, Four Way, etc.)

2.3 Service Characteristics

Valve selection is dependent on characteristics of the services as follows.

- (1) Fluid type
- (2) Fluid characteristics
- (3) Pressure and temperature limitations
- (4) Operation and maintenance requirements

2.3.1 Fluid Type

The fluid being handled should be classified as follows,

- (1) Liquid (including Two Phase)
- (2) Gas
- (3) Steam
- (4) Slurry
- (5) Solids

2.3.2 Fluid Characteristics

The characteristics and condition of fluids and slurries require careful identification since these are often the most significant factors in selecting the correct type of valve.

Clean fluids generally permit a wide choice of valve types, for dirty fluids the choice is often restricted and may require a specific type of valve.

The fluid is divided into the following characteristics.

(1) Clean Service**(2) Dirty Service**

- (a) Dirty service involves fluids with suspended solids that may seriously impair the performance of the valve unless the correct type design is selected. This type of service is often of major significance since many valves are very sensitive to the presence of solids.

Dirty service is further classified as abrasive or sandy.

- (b) Abrasive Service is a term used to identify the presence of abrasive particulate found in piping systems and includes the presence of pipe rust, scale, welding slag, sand and grit which are damaging to many valves. These materials can damage seating surfaces and clog working clearances in valves often resulting in excessive force required to operate valves, sticking, jamming, and leakage through the valves.

- (c) Sandy service is a term identifying severe abrasive and erosive conditions and is used in oilfield production to identify the production of formation sand with reservoir crude oil or gas.

(3) Slurry Service

Slurry service involves liquids with substantial solids in suspension.

Slurries vary widely in nature and concentration of solids, and hard abrasive solids of high concentration can cause severe abrasion, erosion and clogging of components.

Soft, non-abrasive solids can cause clogging of components.

In certain chemical processes polymerization may block the cavities, preventing valve operation.

(4) Solids

There are many other conditions where solids may be present in the form of hard granules, crystals, soft fibres or powders.

The transporting media may be liquid or gas. Air or fluidised bed systems may be used for some particulate.

Specialized valves are available for many of these services but development work may sometimes be necessary.

(5) Hazardous & Flammable Service

- (a) Hazardous and flammable material is specified in Japanese Fire Service Law and/or Client's specifications.

- (b) Toxic substances such as chlorine, hydrofluoric acid, hydrogen sulfide, CO, phenol etc..

- (c) Highly corrosive fluids such as acids and caustic alkalis.

(6) Corrosive Service

- (a) Corrosive service is a term generally used to identify clean or dirty fluids containing corrosive constituents that, depending on concentration, pressure and temperature, may cause corrosion of metallic components.

Corrosive fluids include sulfuric acid, acetic acid, hydrofluoric acid (HFA), wet acid gas (wet CO₂), sour gas (wet H₂S) and chlorides.

Many chemicals are highly corrosive.

- (b) The choice of suitable corrosion resistant materials for valve pressure retaining components (body bonnet) and trim is necessary to avoid corrosion that can impair the integrity or performance of the valve.

(7) Viscous Service

- (a) Viscous service is a term that generally identifies a wide range of dirty or clean fluids with pronounced thickness and adhesive properties that, for the range of operating conditions (pressure, temperature and flow) may require high operating torques and cause a sluggish response affecting seating. Fluids include high viscosity oils (lube and heavy fuel oil) and non-newtonian fluids e.g. wax crude, gels and pastes.

- (b) The choice of valves for viscous service can vary depending on fluid properties. Special attention should be given to check valves where sluggish response may cause operating difficulties and even hazardous conditions.

(8) Fouling Service

(a) Fouling or scaling service involve liquids that form a deposit on surfaces. Such deposits may vary widely in nature, with varying hardness, strength of adhesion and rates of build up.

Valves for these services require careful selection particularly where thick, hard, strongly adhesive coatings occur. The temperature of the fluid may be a vital factor and in some cases valves may need tracing or be steam jacketed or of purged design.

(9) Solidifying Service

Solidifying service is a general term used to identify fluids that will change from liquid to solid unless maintained at the correct conditions of temperature, pressure and flow.

It is a term generally associated with fluids such as liquid sulfur and phthalic anhydride where valves of steam jacketed design may be required or heavy fuel oil where valves often require tracing to maintain temperature and operability.

2.3.3 Pressure and Temperature Limitation

Valves are normally allocated a rating according to the maximum operating pressure and temperature or the ratings of the piping system and flanges.

The temperature also limits the materials used in the valve construction, particularly the internals, trims, seals, rings or lubricants.

These are defined in the "Piping Material Specification".

2.3.4 Operation and Maintenance Requirements

Operation and maintenance requirements can influence selection and design.

Consideration should be given to:

- Fire Resistance : There may be a requirement for valves having non-metallic (soft) seating to include 'fire safe' features so that in the event of the soft seat and/or seals being damaged or destroyed by fire the valve will still be operational and any leakage will be within the acceptable limits laid down by a particular standard or specification.
- Operability
- Leak tightness (internal and external)
- Maintainability
- Storage and commissioning
- Pipeline requirements (e.g. ability to pass cleaning pigs)

2.3.5 Valve Type Selection Guide

To assist in the rapid selection of probable valve types for the majority of general services the following tables may be used;

Table-1 : Selection of Isolation and Check Valves (Service Conditions)

Table-2 : Selection of Isolation and Check Valves (Service, Size, Lining Material)

**TABLE 1 SELECTION OF ISOLATION (BLOCK) AND CHECK VALVE
(SERVICE CONDITIONS)**

VALVE TYPE CONDITIONS		G A T E	G L O B E	C H E C K	N E E D L E	B A L L S O F T S E A T	B A L L M E T A L S E A T	B U T T E R F L Y S O F T S E A T	B U T T E R F L Y M E T A L S E A T	D I A P H R A G M W E I R	D I A P H R A G M S T R A I G H T
F L U I D	LIQUID (AND TWO PHASE)	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
	GAS	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
	STEAM	⊙	⊙	⊙	⊙	×	○	×	○	×	×
	SLURRY	×	×	△	×	⊙	○	⊙	○	×	⊙
	SOLIDS (POWDER ETC.)	○	×	△	×	○	○	○	○	×	○
F L U I D C O N D I T I O N S	CLEAN	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙
	DIRTY (ABRASIVE)	△	△	△	△	○	○	○	○	○	○
	VISCOUS	○	△	○	△	⊙	⊙	⊙	⊙	⊙	⊙
	CORROSIVE	M	M	M	M	M	M	M	M	M	M
	FLAMMABLE	⊙	⊙	⊙	⊙	F	⊙	△	○	×	×

⊙ : SUITABLE

○ : MAY BE SUITABLE.
CONSULT
MANUFACTURER.

△ : NOT RECOMMENDED.

× : NOT SUITABLE.

F : FIRE SAFE TYPE
REQUIRED.M : SATISFACTORY SUBJECT
TO APPROPRIATE CHOICE
OF MATERIALS.

**TABLE 2 SELECTION OF ISOLATION (BLOCK) AND CHECK VALVE
(SERVICE, SIZE, LINING)**

VALVE TYPE CONDITIONS		G A T E	G L O B E	C H E C K	N E E D L E	B A L L S O F T S E A T	B A L L M E T A L S E A T	B U T T E R F L Y S O F T S E A T	B U T T E R F L Y M E T A L S E A T	D I A P H R A G M W E I R	D I A P H R A G M S T R A I G H T
P R E S S .	VACUUM	△	○	○	○	○	×	○	×	×	×
	LOW ≤ CL.150	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
	MID. CL.300 / 600	◎	◎	◎	◎	◎	◎	◎	◎	×	×
	HIGH CL.900 ~ 2500	◎	◎	◎	◎	○	○	△	○	×	×
T E M P .	CRYOGENIC : < -50°C	◎	◎	◎	◎	◎	◎	○	○	×	×
	MED ~ LOW. : -50°C ~ 200°C	◎	◎	◎	◎	○	◎	○	◎	○	○
	HIGH : 200°C ~ 450°C	◎	◎	◎	◎	×	○	×	○	×	×
L E A K A G E	TIGHT SHUT : (GAS)	○	○	○	×	○	×	○	×	×	×
	TIGHT SHUT : (LIQUID)	○	○	○	×	◎	×	◎	×	◎	○
	LOW LEAKAGE PERMITTED	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
S I Z E	≤ 1-1/2	●	●	●	●	●	●	▲	▲	●	●
	2" TO 8"	●	●	●	○	●	●	○	○	●	●
	10" TO 16"	●	△	●	▲	○	○	●	●	○	▲
	> 16"	●	△	●	▲	○	○	●	●	▲	▲
L I N I N G	RUBBER	▲	▲	●	▲	▲	▲	●	▲	●	●
	PTFE	▲	▲	●	▲	●	▲	●	▲	●	○
	OTHER POLYMERS	▲	▲	●	▲	●	▲	●	▲	●	○
	GLASS	▲	▲	●	▲	○	▲	▲	▲	●	●

◎ : SUITABLE

○ : MAY BE SUITABLE.
CONSULT
MANUFACTURER.

△ : NOT RECOMMENDED.

× : NOT SUITABLE.

F : FIRE SAFE TYPE
REQUIRED.

● : AVAILABLE.

▲ : NOT AVAILABLE.

2.4 Typical Usage of Individual Valve

Typical examples of valve use for P&ID preparation are as follows, It's necessary to check the unit cost before determination of valve type.

(1) Gate Valve

Gate valve is generally used for Isolation Service except some cases.

Typical usage of Gate Valve are as follows:

- Block valve for control valve
- Pump suction valve
- Pump discharge valve
- (This is limited to use in piping where it is not required to control flow rate. Check the valve cost.)
- Block valve for level controller & level gauge
- Drain valve of equipment
- Drain valve of process & utility line
- First block valve of sampling nozzle
- Block valve for safety valve
- Block valve for equipment
- Inlet valve for utility supply line to heat exchanger
(Compare with the cost of butterfly valve)
- Block valve for steam trap
- Block and by-pass valve for oval and turbine type flow meter
- By-pass valve for emergency shut-down valve
- Block (outlet) and by-pass valve for rotameter
- Flow control valve for large size gas & city water line

(2) Globe Valve

Globe valve is generally used in Manual Control Service.

Typical usage of Globe Valve are as follows:

- Manual-flow control valve
 - By-pass valve for control valve
 - Hose connection
 - Vent valve of equipment & piping
 - Pump discharge valve
 - (For large size line, it's necessary to check the cost.
Large size globe valve is more expensive than gate valve.)
 - Minimum flow line for pump
(In case the restriction orifice is installed, gate valve is used.)
 - Outlet valve of cooling water line from heat exchanger
(2" & large size line, compare with the cost of Butterfly Valve)
 - Pressure gage outlet
(Gate valve is also used as pressure gauge outlet)
 - Valve for down-stream of sight glass
 - Low point drain valve for high pressure steam line
(For low pressure steam line, gate valve is used.)
 - By-pass line valve of reciprocating compressor
 - In the Y-type valve the orifice in the body is arranged at an incline to the normal flow line. This results in less distribution of the flow pattern than in a conventional globe valve and a correspondingly smaller loss of pressure across the valve.
- These are used for the following services.
- * Slurry service
 - * Solid handling
 - * Viscous fluid
 - * Boiler blow down

- Usage of Needle Valve
 - * In the < 1-1/2 line which requires accurate flow control
 - * Sampling connection for higher than 3k/G pressure
- Usage of Bellows Valve
 - * Lines which should avoid the leakage of toxic/radioactive material.
 - * Vacuum service line in which leaked air could possibly cause explosion.

(3) Check Valve

Check valve is used for prevention of flow reversal.

(4) Butterfly Valve

Butterfly valve is used for isolation & manual control service.

- (a) Inlet & outlet valve of cooling water line to heat exchanger (Compare with the cost of gate valve)
- (b) Flow resistance valve for large size line (Inlet line to thermosyphon reboiler)
- (c) Block valve of large size effluent gas line

(5) Ball Valve

A low torque quarter turn valve, with low resistance to flow, suitable for many on-off utility and process services.

Usage of ball valve

- (a) Generally, ball valve is normally used for many process services in chemical plant.
- (b) For slurry service
- (c) For pipelines for oil and gas transportation
- (d) For pipelines of LNG, oil and gas which are high pressure and large size, 20" ~ 48"
- (e) In high pressure lines, ball valve is more compact and reliable against leakage than gate valve.
- (f) In the likelihood of the soft seat/seals being damaged or destroyed by fire, 'fire safe' features should be selected.
- (g) Flow divider as three or four way valves.

(6) Diaphragm Valve

No separate stem gland is necessary, as the diaphragm both shuts off the flow and acts as a gland. Also, the flexibility of the diaphragm provides shut-off even for dirty fluids.

Usage of diaphragm valve

- (a) Flow control and isolation service by applying the suitable lining material for corrosion, abrasion and temperature.
 - (b) Slurry Service
 - (c) In case of using the diaphragm valve, it's necessary to pay attention to pressure, temperature and material of diaphragm.
- Especially, pressure factor is important, large size diaphragm valves become low in pressure resistance.

(7) Plug Valve

Usage of plug valve

- (a) For slurry service
- (b) For high viscous service
- (c) For vacuum service