Technical Specification for Design and Construction of Slide Valves and Two Port Diverter Valves for FCC Units

1. Scope

1.1 - This specification sets forth the minimum requirements for the design, fabrication, testing, delivery shipment and performance of slide and diverter valves, to be applied in the following services of FCCU-Fluid Catalyst Cracking Units:

- Regenerated catalyst single disc slide valve;
- Spent catalyst single disc slide valve;
- Cat cooler single disc slide valve;
- Flue gas double disc slide valve;
- Two port diverter valves;

complete with respective linear hydraulic actuator and HPCU-Hydraulic Power and Control Unit.

Note:

The slide valves can be Cold wall and Hot wall types.

1.2 - All deviations and exceptions from this specification, related specifications, standards, requisition sheets, drawings and data sheets shall be clearly identified and submitted for Purchaser's approval before proceeding with manufacture.

1.3- Compliance with this specification does not exempt the bidder from the responsibility of supplying any additional accessory suitable for the intended service.

1.4- Each valve shall be supplied with an electrohydraulic actuator mounted to the valve body. Connections at the support and actuator arm shall be designed to facilitate removal of actuator.
The Manufacturer shall guarantee and assume total responsibility for design, fabrication and delivery of the valve and the respective linear actuator and HPCU-Hydraulic Power Control Unit, in accordance with the specified conditions and applicable standards.

2 – Applicable codes and standards

Slide and diverter valve design shall conform to the ASME B31.3 and Section VIII, Division 1 Codes.
All work shall conform to acceptable practice for refinery and process plant installations as well as to comply with required codes and standards at the last edition.
Any conflict between specifications, recommended practices, and codes or standards shall be brought to the attention of and resolved with Purchaser.
ANSI/FCI 70-2-1991 American National Standard Control Valve Seat Leakage
(formerly known as ASME B16.37)
ASME B16.5 Steel Pipe Flanges, Flanged Valves and Fittings.
ASME B16.20 Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral-Wound, and Jacket.
ASME B16.47 Large Diameter Steel Flanges (NPS 26 Through NPS 60)
ASME B31.3 Chemical Plant and Petroleum Refinery Piping.
AWS D.1.1 Structural Welding Code - Steel.
MSS SP-6 Standard Finishes for Contact Faces of Pipe Flanges and Connecting-End Flanges of Valves and Fittings
Petrobras standards
N-1617 Application of refractory castable
N-1728 Castable Refractory
N-1910 Castable lining design

3 – Client's documents shall be considered by the Vendor for quotation

3.1 – Slide valve assembled drawing;
3.2.– Slide valve data sheet;
3.2 – Technical specification for design and construction of Electrohydraulic Actuating & Control systems for Slide, Plug, Expander Butterfly and Diverter Valves of FCC Units

4 – Slide valves requirements

The following requirements are common to cold and hot wall slide valves.

4.1- General requirements

The slide valve shall be designed to comply, as a minimum requirement, with the following items, as applicable:

a. Valve design shall be such that the flow control orifice plate is located at the inlet of the valve throat, with the discs supported by guides downstream the orifice plate.

b. Valve design shall provide purging system only at the stuffing box.

c. Valve design shall be such that no damage will occur to the body, bonnet, stem, or the actuator in the event that either the stem or disc fasten or bind or otherwise become immovable.

d. Valve body size shall not be smaller than its inlet and outlet pipe diameters.
If necessary to use enlarged body the conical transition pieces shall have cylindrical pieces welded at shop to make the field welds fit up easier.

e. A corrosion allowance of 1/8" (3 mm) minimum shall be added to the metal thickness of the valve Carbon steel components.

f. Stiffening rings shall not be used for any part of the valve.

g. All internal parts shall be easily replaceable through the bonnet opening with the body remaining in the line.

h. All internal bolting shall be through bolts, tightened with a torque wrench according to Manufacturer's recommendations and tack welded after valve clearances are set.
This means that the guides must be bolted to the orifice plate and the orifice plate to the orifice plate support (cone flange) by means a through bolt design.
Threaded holes design is not acceptable.

i. In the case of small diameter valve (nominal diameter less than 20 in) Manufacturer shall propose a boltless system for the internals because of the difficulties to access the internal bolting.

j. Valve could be installed at the vertical or angle position but the stem shall be at the horizontal position anyway.

k. Each disc of the slide valve shall be provided with an electrohydraulic actuator mounted to the valve body. Connections at the support and actuator arm shall be designed to facilitate removal of actuator.

l. Two lifting lugs shall be located symmetrically on the body and one lifting lug on the bonnet flange to sustain the total weight of complete valve and actuator assembly plus 50% of total weight for impact purposes.
The lifting lugs shall be located such that the valve is maintained in its operating position during handling.

m. The tolerance on stub ends from the valve body shall be as follow:
- Circumferential length: ± 0.116" of nominal diameter;
- Out of roundness: ± 0.25%.

4.2- Internal refractory linings

a. All refractory materials shall be supplied and installed according to Petrobras standards and specifications.

b. High density vibrocast refractory lining RESCO RS-17E or sure or free flow refractory RESCO-SUREFLOW-17E shall be applied to the Carbon steel body internal surfaces covering completely the inlet, bonnet and exit areas. Exception is treated for of Hot wall design slide valves**.**

c. Abrasion resistant lining to be applied to internal parts shall be RESCO AA-22S or ACTCHEM 85 All refractory linings shall be furnished and installed according to Petrobras standards and specifications.

4.3- Bonnet requirements

a. Bonnet shall be in rectangular shape with rounded corners in cross section with no more than two longitudinal welds, 180º apart.

b. Bonnet bottom shall be sloped 30º minimum from horizontal for single disc slide valve, for double disc slide valve that it is not required.

c. Bonnet shall accommodate the travel of the disc considering the disc in a position 125% opened.

d. Bonnet shall be at least 16” (400 mm) wide and the bonnet design shall permit the withdrawal and reassembly of the internal parts.

e. Bonnet flange shall be beveled and have four 1/2” (13 mm) diameter dowel pins for flange alignment. These items must be designed so that there is no obstruction to grinding or welding operations on the lip seal gasket between the flanges.

f. Bonnet flange shall have a lip seal metallic gasket designed to allow at least four reuses prior to replacement.

g. The connection between bonnet and valve body shall be auto reinforced using at least a factor of 3 (three) based on the body wall thickness.

4.4- Disc requirements

a. Discs shall be a single flat piece without any stiffening ribs.

b. Disc middle deflection under design load for long term service shall not exceed 0.005 in (0.13 mm). Loading on the disc shall be based on total disc area.
The large disc deflection is caused by lack of contact of the disc with guides and due poor orifice plate adjustment.
When the disc thickness is bigger than 100 mm, due to deflection restriction, Manufacturer shall propose the maximum allowable deflections as a function of a range of chosen disc thicknesses, in order the Client evaluation. The correspondent guide clearances shall also be informed.

c. Disc shall be metallic hard faced on all the running sides on the guides, and the upper and leading edge outside of the abrasion resistant lining.

d. The slot on the disc for the stem T-head shall be closed on the top, with enough clearance relating to the stem. This cover shall be an integral part of the disc. A welded cover plate is not acceptable. Manufacturer must check any possibility of interference disc and stem, due to internal cone thermal expansion during emergency upset temperature excursion conditions.

e. In case of single disc valve, the flow thru the port area shall be aligned with the centerline of the cone during the normal operation.

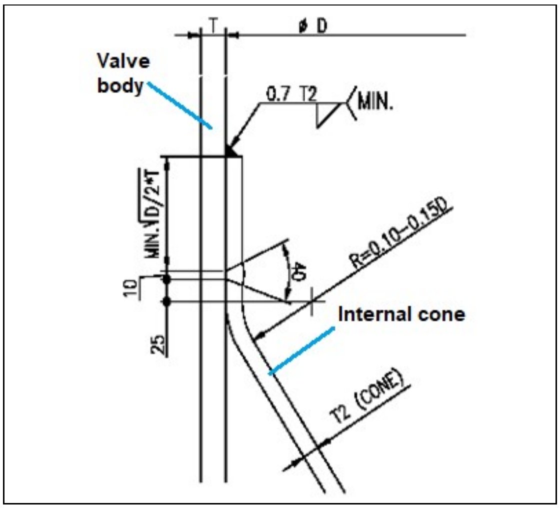
f. The valve discs in double disc slide valve, shall meet at the centerline of the inlet port in the fully closed position.

g. Design shall be such as to prevent vibration, shock or sticking during disc movement.

4.5- Cone and port opening requirements

a. Manufacturer is the responsible to calculate the port opening dimensions based on the minimum, normal and maximum flow. It is recommended that the method considers a flow coefficient depending on Reynolds number.

b. Cone design shall be in compliance with Fig.UW-13.1 of ASME code Sect. VIII Div 1 as per the sketch showed in this specification.
Cone shall have the vent holes for welding gas relief and the holes to be plugged after welding.



Cone weld attachment requirement according to ASME Section VIII Div 1 Fig. UW-13.1

4.6- Guide requirements

a. Guides are the element that supports and directs the movement of the disc inside the valve. Guides shall be supported throughout their entire length by the orifice plate.

b. Guides shall be set back the sides of the inlet port as indicated below.
- For valves with a pressure drop up to 12 psi (0,84 kgf/cm²) minimum of 3” (75 mm) from the edge of the inlet port.
- For valves with a pressure drop greater than 12 psi (0,84 kgf/cm²) minimum 4” (100 mm) from the edge of the inlet port.
- In any case, the set back shall result in a projected angle greater than 15º from the sides of the inlet port to the lower edge of the guide.

c. Guides shall extend into the bonnet to support the disc from the full closed to the back seated position, except the disc shall extend 1 in up to 1½ in (25 mm up to 40 mm) past the end of the guides in both positions.

d. In the past it has been used “U-shaped guides”, but currently guides are made in the “L-shape”, and this new design has greatly increased the reliability of slides valves.

e. Sliding surfaces of disc and guides and surfaces facing the flow shall be hard faced across their full lengths with Stellite No. 1.

f. Guides shall have triangular catalyst drain slots cut vertically in the bottom approximately every 3 in (75 mm). Drain slots are not applied to Flue gas slide valve.

g. Dowel pins shall be used to align the set of guides and disc and withstand the maximum stem thrust force, due to the frictional force in the contact running area between the disc and the guides.

h. Under normal conditions, there are vertical and horizontal displacements to be absorbed by the clearances of the disc in relation to the guides.

4.7- Stem requirements

a. Stem shall be a single forged shaft with an integral “T” head.

b. Stem shall be at least 2” (50 mm) diameter.

c. Stem shall be hard coated across its entire cylindrical portion with a proven metallic overlay of 0.03” (0.75 mm) minimum thickness finished to 16 AARH.
Hardness of the finished overlay shall be a minimum of 50 Rockwell C with an average of 60 Rockwell C at the operating temperature.
As a minimum, hard facing with UCAR-LC 1C or WALLEX 50, detonation gun or spray fused process, shall be respectively provided.

d. Stem bearing shall have a medium deflector and diffuser sleeve at the purge and lubricant port to prevent direct impingement on the stem inside the stuffing box.

e. Stem shall be fully protected from rain, dust and other weather conditions by a shroud or other suitable means.

f. Stem shall be designed to withstand the maximum thrust of the actuator, without buckling, as well as bending due to the self weight.

g. Stem shall be in the horizontal plane whichever the mounting position of the valve is.

h. The maximum allowable tension and compression loads on the stem at design conditions shall be informed.

4.8- Orifice plate requirements

a. The orifice plate is a device formed by a plate with a calibrated opening (orifice), installed downstream to the fluid flow.
This condition causes a sudden change in transverse section of the flow and that implies an acceleration of the main flow (at the center), with the appearance of regions of secondary flow (at the periphery), before and after the plate.
Thus, there is a differential pressure between the entrance and the exit of the orifice plate. That allows the installation of pressure taps upstream and downstream the orifice plate to determine the flow rate at the valve

b. The orifice plate must be long enough to support the guides and disc, avoiding distortions due to the loading of the guides at the operating temperature.
So, vertical distortions shall be reduced to zero and gaps between disc and guides must be preserved.

c. Orifice plate inlet port shape of the single disc valve shall be trapezoidal or half circle on the leading edge with a rectangular base and shall be offset to centralize the flow at the normal operating conditions.
The design shall be such that the short side is at maximum 80% of the long side during normal operating conditions

d. Orifice plate inlet port shape of the double disc valve shall be rectangular or obround. The design shall be such that the short side is around 80% of the long side during normal operating conditions.

4.9- Stuffing box requirements

a. Purgeless stuffing box on the valves is not acceptable

b. Stuffing box design shall be such as to allow replacement of 100% of gland packing during the normal operation, without changing the normal position of the disc. Full details of the stuffing box design including the centering rings and lantern rings shall be submitted for review.

At least are acceptable packing rings from John Crane Style 1625G, 1600N, Grafoil 235 or Slade 330G.

c. Stuffing box shall have a minimum of one purging port complete with a 1 in nominal diameter valve and correspondent drain with a plug, and one sealant injection port complete with a 1 in nominal diameter valve and correspondent drain with a plug.

d. A restriction orifice of 1/16 inch (2 mm) size is recommended for the purge connection at the stuffing box. The size of the restriction orifice shall be confirmed based on the maximum flow allowable across the packing as provided by the valve supplier. The valve supplier shall also provide the maximum allowable purge medium supply pressure for startup and normal operation.

e. Supplier shall provide the piping diagram to purge the stuffing box, informing, as a minimum: materials, piping diameters, valves, bypasses and restriction orifice sizes.
Manufacturer shall also provide the purging procedure and purging conditions: medium quality, flow rate, temperature and pressure into the stuffing box and at the inlet of the system.

f. The bushing of the stuffing box shall be manufacture using Nitronic 60 material, acting as a guide for the stem and also as a deflector and diffuser sleeve at the purging port.

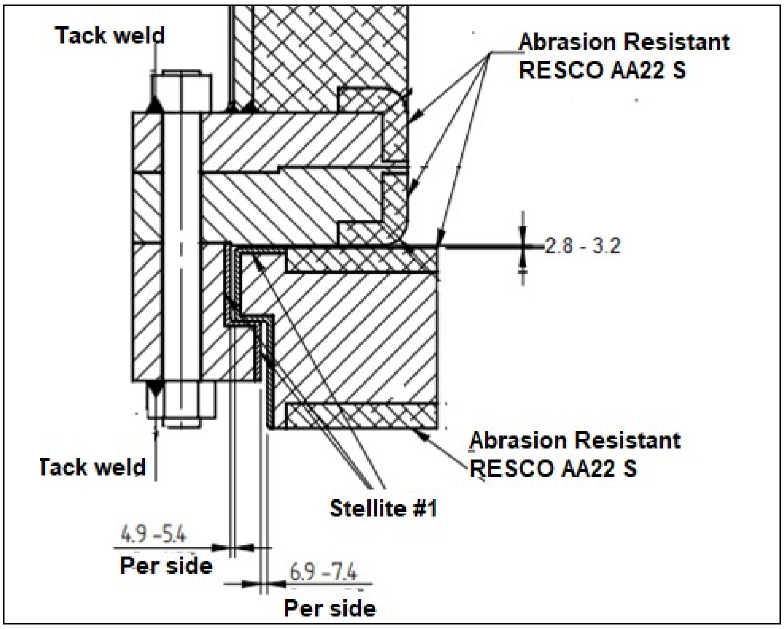
g. The stuffing boxes shall be provided with constant or live loading system type Belleville springs on the bolts.

h. When the stuffing box is working at very high temperature, above 340º.C, there is the risk of sublimation problems with the burning of the PTFE coating in the graphite yarns of the packing, In these cases shall be used packings without PTFE, that can work up to 650ºC, when the steam is used for purging.

i. For purging the stuffing box of the slide valves shall be used air, super-heated steam or Nitrogen.
For Flue Gas slide valve there are no particles that can burn and in this case it may use air.
For Spent and Regenerated and Catalyst cooler slide valves the use of air is forbidden because of the potential burning effect related to the Oxygen that can combine with the Carbon deposited on the catalyst particles.

4.10- Internal clearance check

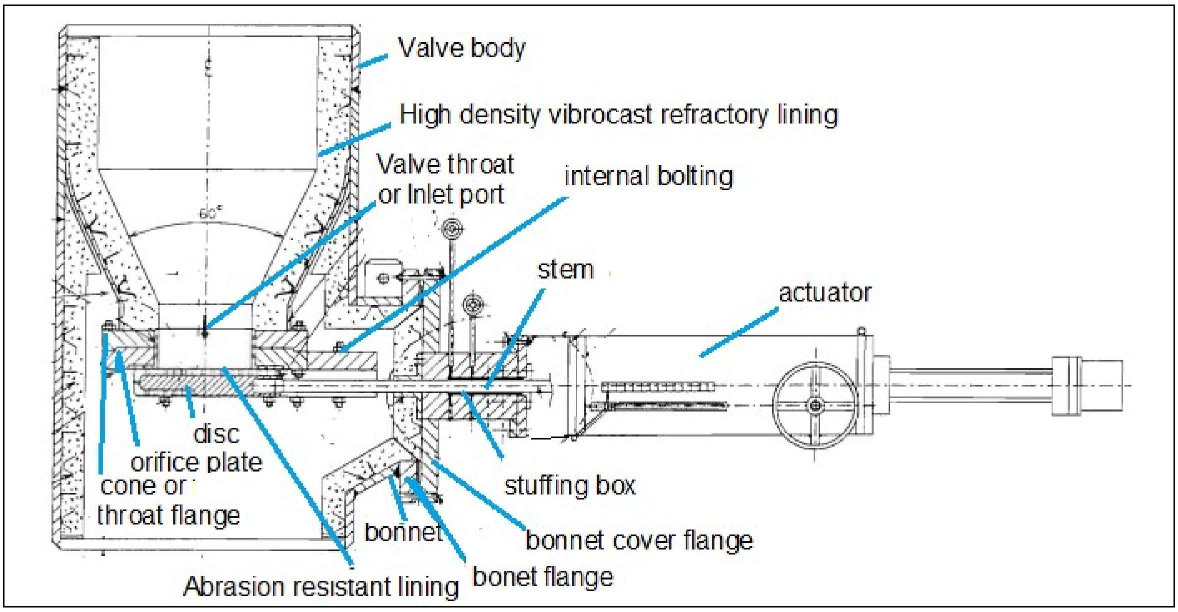
The internal cold clearances between components shall be as per the following figure.



The clearances are very important, because if they are too loose, there will be catalyst flow and the leaks will increase during the operation, causing great erosion on the disc and guides.
The clearances must be enough to also assure no flow at the emergency or upset temperature excursion conditions.
Before the startup of the unit the internal cold clearances shall be checked.

5 – Cold Wall Slide Valves particular design requirements

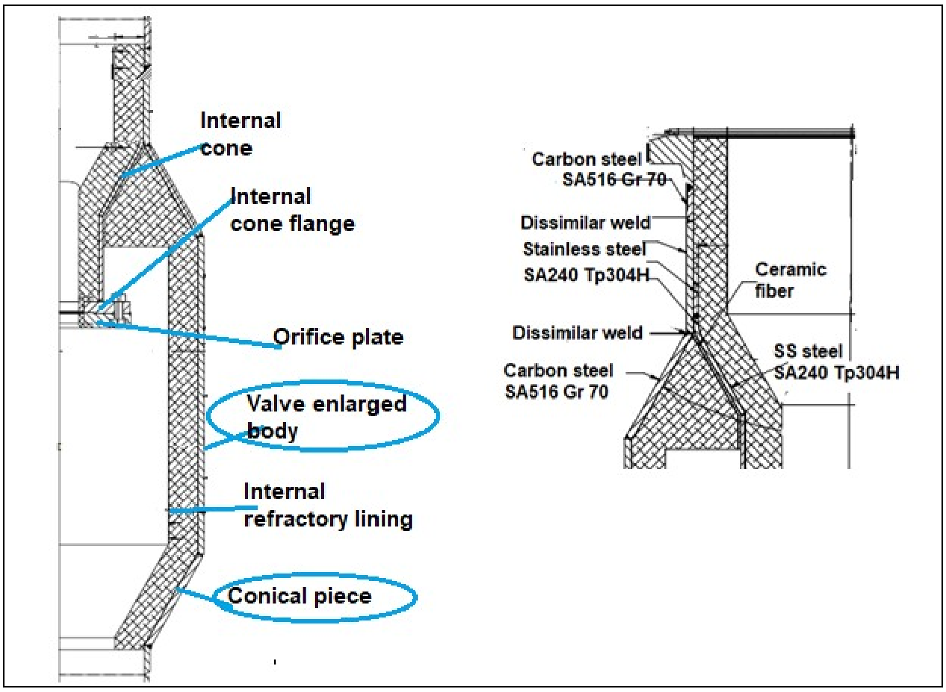
In addition to the items listed in previous item 4 Slide Valves Requirements, the following requirements must also be applied.



Main components of a Cold Wall Slide Valve

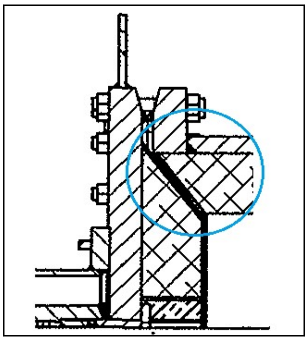
5.1- General

a. Typical enlarged body with the conical transition and cylindrical pieces welded at shop to make the field welds fit up easier.

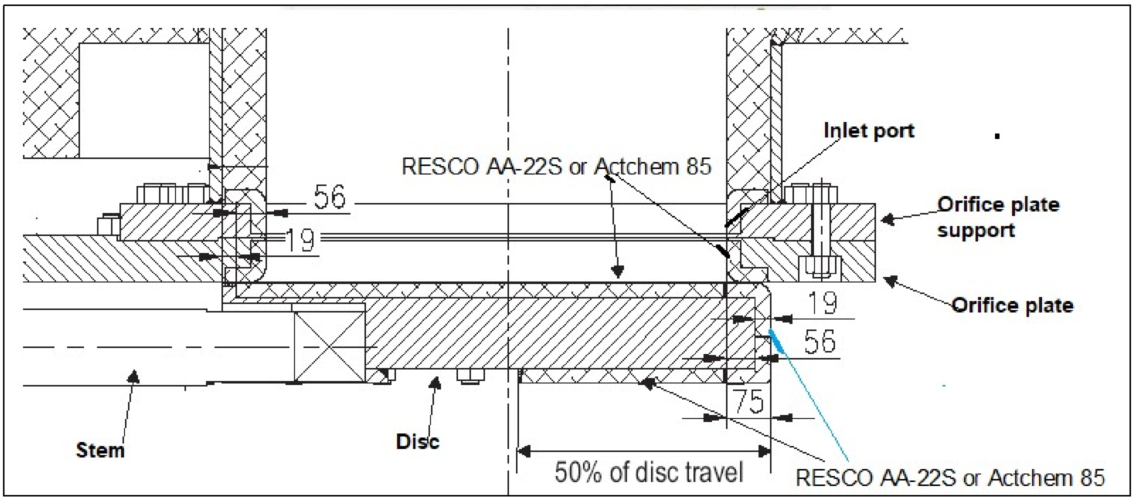


b. The slide valve cold wall design shall be provided with all refractories supplied and installed according to Petrobras standards internal lining specifications.

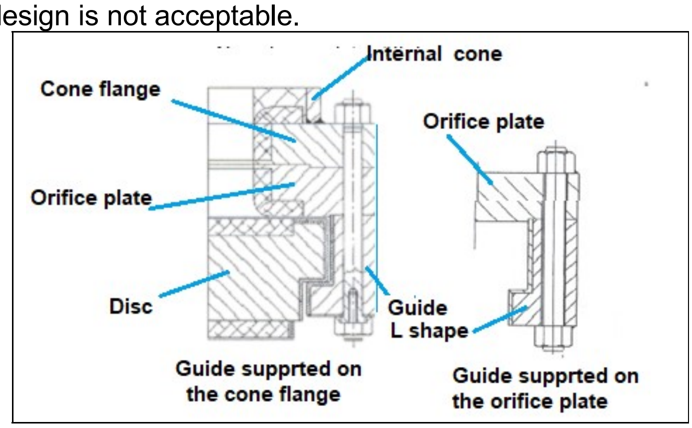
c. High density vibrocast refractory lining RESCO RS-17E or sure or free flow refractory RESCO-SUREFLOW-17E shall be applied to the body internal surfaces covering completely the inlet, bonnet and exit areas.
The refractory lining junction between the valve bonnet and the valve bonnet cover flange shall meet at 45º.



d. Abrasion resistant lining RESCO AA-22S or ACTCHEM 85 shall be applied to the inlet port, upstream face of the disc, around the disc leading edge and the largest of 50% of the disc travel or 6" (150 mm) back under the leading edge.

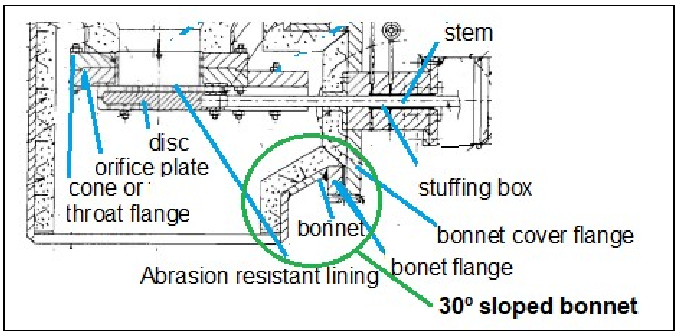


e. All internal bolting shall be through bolts, tightened with a torque wrench according to Manufacturer's recommendations and tack welded after valve clearances are set.
This means that the guides must be bolted to the orifice plate and the orifice plate to the orifice plate support (cone flange) by means a through bolt design.
Threaded holes design is not acceptable.



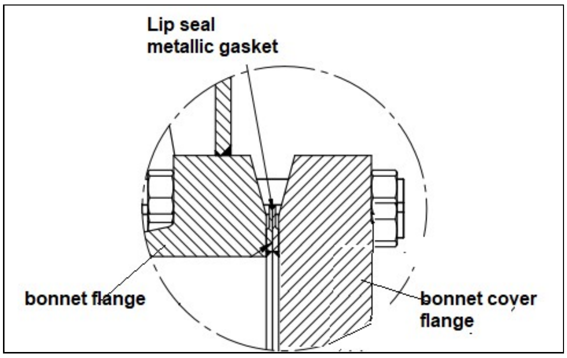
5.2- Bonnet requirements

a. Bonnet bottom shall be sloped 30º minimum from horizontal for single disc slide valve, for double disc slide valve that it is not required.



b. Bonnet flange shall be beveled and have four ½" (13 mm) diameter dowel pins for flange alignment. These items must be designed so that there is no obstruction to grinding or welding operations on the lip seal gasket between the flanges.

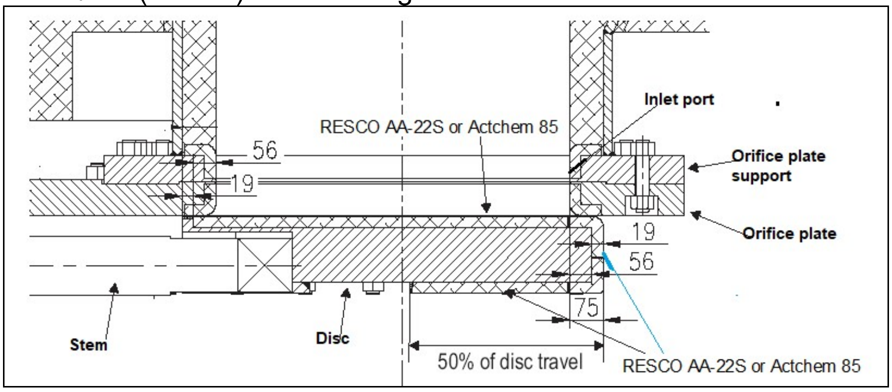
c. Bonnet flange shall have a lip seal metallic gasket designed to allow at least four reuses prior to replacement.

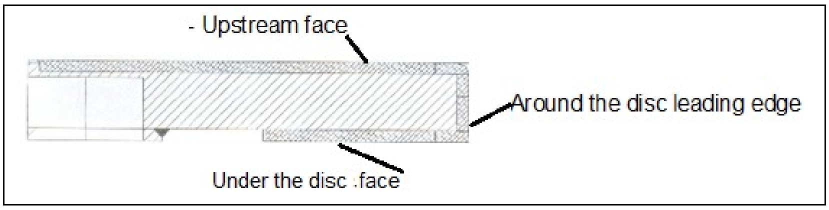


d. All external bolting shall be SA193 Gr. B7 / SA194 Gr. 2H with coating in accordance to ASTM B841 Class 1, Type B/E, Grade 5 to 8, with stress relief and H_2 degassing.

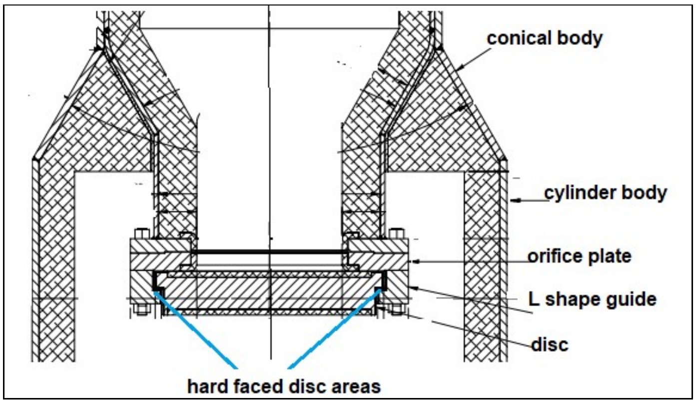
5.3- Disc requirements

a. Abrasion resistant lining RESCO AA-22S or ACTCHEM 85 shall be applied to the discs at the following areas:
- Upstream face;
- Around the disc leading edge for a distance larger of 50% of the normal disc travel or 6 in (150 mm) back under the leading edge;
- On the sides of the disc;
- The lining shall terminate under the orifice plate for a minimum distance of 2 ¼ in (56 mm) from the throat and ¾ in (19 mm) from the edges of the disc or contact surfaces with the guides.

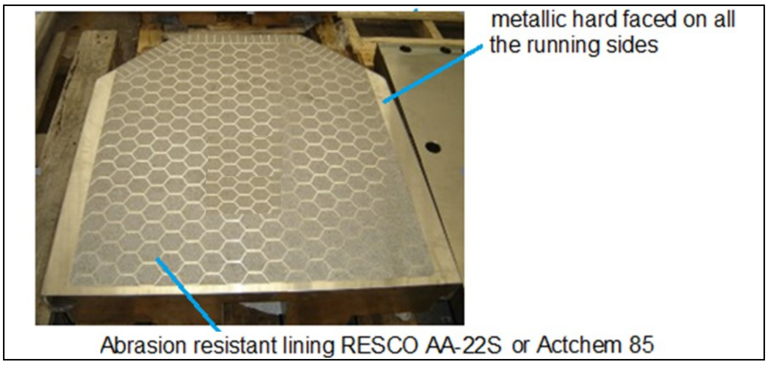




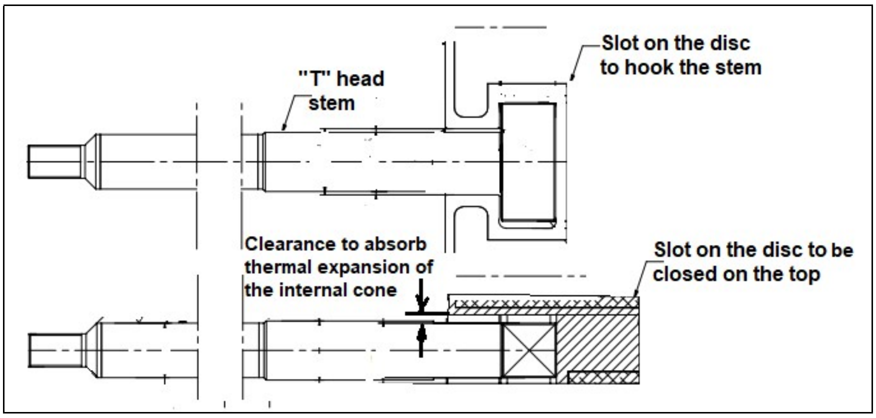
b. Disc shall be metallic hard faced on all the running sides on the guides, and the upper and leading edge outside of the abrasion resistant lining.
In case of the bottom of the disc has contact surfaces with the guides the hard facing on the bottom of the disc shall extend a minimum of ½" (13 mm) beyond the contact surfaces.



c. Hard facing on the top and bottom of the disc shall be inlaid and finished flush with the base metal and the abrasion resistant lining.



d. Manufacturer must check any possibility of interference disc and stem, due to internal cone thermal expansion during emergency upset temperature excursion conditions.

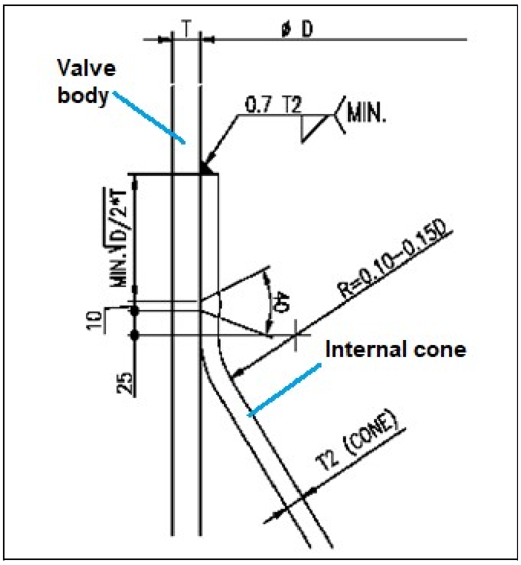


e. In the fully-closed position disc of single disc valve shall extend beyond the edge of the inlet port:
   - 3” (75 mm) minimum for normal differential pressure of 12 psi or small or
   - 4” (100 mm) minimum when the normal differential pressure is higher than 12 psi.

5.4- Cone and inlet port opening requirements

a. Manufacturer is the responsible to calculate the port opening dimensions based on the minimum, normal and maximum flow. It is recommended that the method considers a flow coefficient depending on Reynolds number.

b. Cone design shall be in compliance with Fig.UW-13.1 of ASME code Sect. VIII Div 1 as per the sketch showed in this specification.
   Cone shall have the vent holes for welding gas relief and the holes to be plugged after welding.



Cone weld attachment requirement according to ASME Section VIII Div 1 Fig. UW-13.1

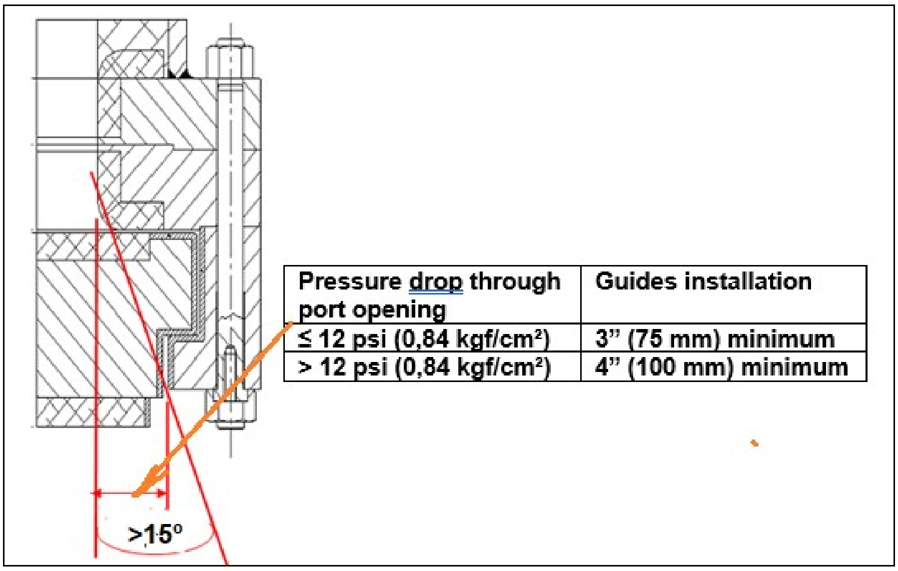
c. The dissimilar welding between Carbon steel x stainless steel parts, must follow the API Recommended Practice 582 "Welding Guide-lines for the chemical oil, and gas industries”, that provides the necessary information on the selection of the filler metal based on the design temperature for dissimilar welding.

d. All corners of inlet port shall be rounded off to a radius of 1½” (40 mm) minimum.

e. Abrasion resistant lining RESCO AA-22S or Atchem 85 shall be applied to the inlet port of slide valves at all surfaces exposed to the flow.

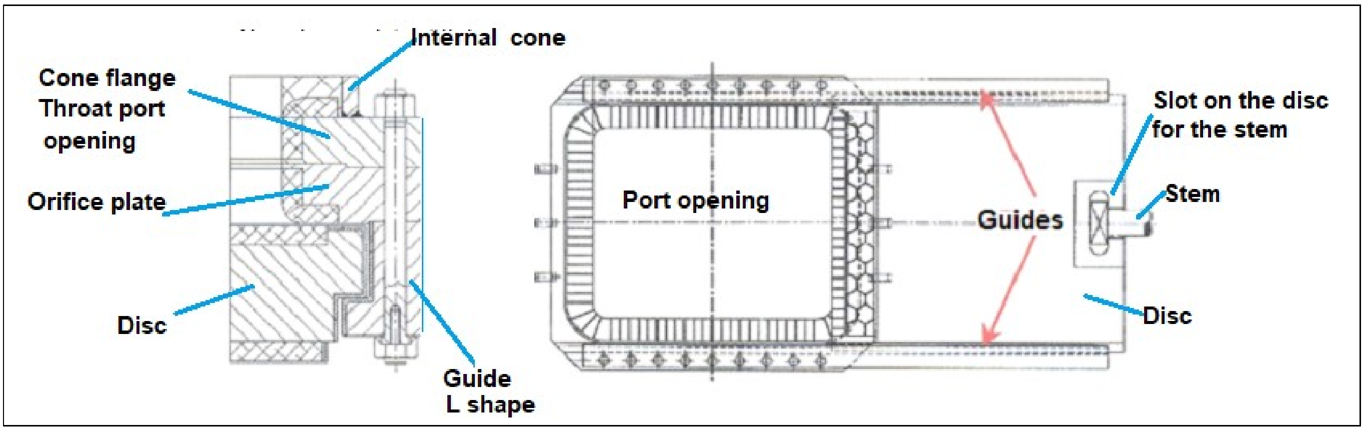
5.5- Guide requirements

a. Guides shall be set back the sides of the inlet port as indicated below.
   - For valves with a pressure drop up to 12 psi (0,84 kgf/cm²) minimum of 3” (75 mm) from the edge of the inlet port.
   - For valves with a pressure drop greater than 12 psi (0,84 kgf/cm²) minimum 4” (100 mm) from the edge of the inlet port.
   - In any case, the set back shall result in a projected angle greater than 15º from the sides of the inlet port to the lower edge of the guide.



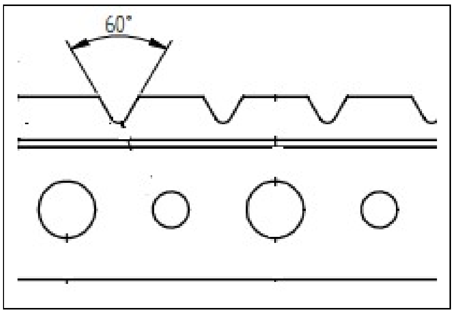
Pressure drop through port opening	Guides installation
≤ 12 psi (0,84 kgf/cm²)	3" (75 mm) minimum
> 12 psi (0,84 kgf/cm²)	4" (100 mm) minimum

b. “L-shape” guides shall be used to support and guide the disc.



c. Sliding surfaces of disc and guides and surfaces facing the flow shall be hard faced across their full lengths with Stellite No. 1.

d. Guides shall have triangular catalyst drain slots cut vertically in the bottom approximately every 3 in (75 mm). Drain slots are not applied to Flue gas slide valve.



5.6- Stem requirements

a. Stem shall be a single forged shaft with an integral “T” head.

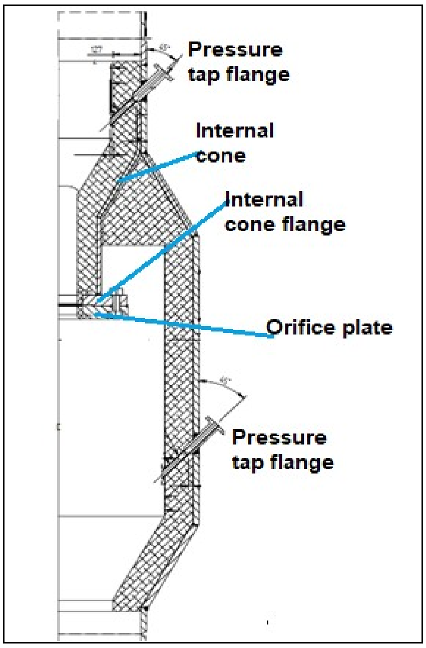
b. Stem shall be at least 2” (50 mm) diameter.

c. Stem shall be hard coated across its entire cylindrical portion with a proven metallic overlay of 0.03” (0.75 mm) minimum thickness finished to 16 AARH.

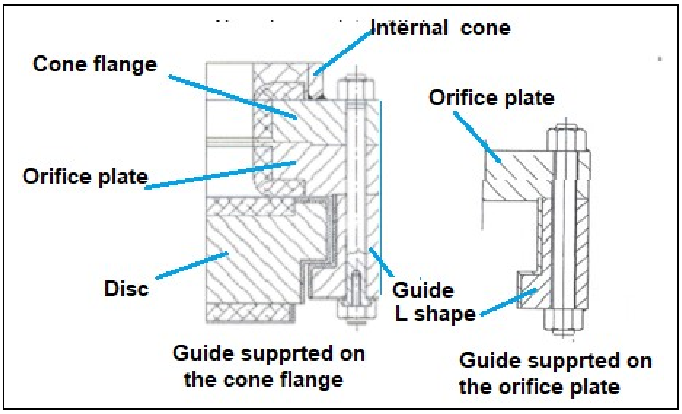
d. Hardness of the finished overlay shall be a minimum of 50 Rockwell C with an average of 60 Rockwell C at the operating temperature.
As a minimum, hard facing with UCAR-LC 1C or WALLEX 50, detonation gun or spray fused process, shall be respectively provided.

5.7- Orifice plate requirements

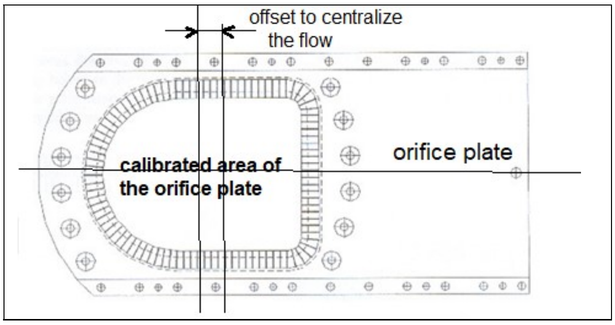
a. Install pressure taps upstream and downstream the orifice plate to determine the flow rate at the valve.



b. The orifice plate must be long enough to support the guides and disc, avoiding distortions due to the loading of the guides at the operating temperature.

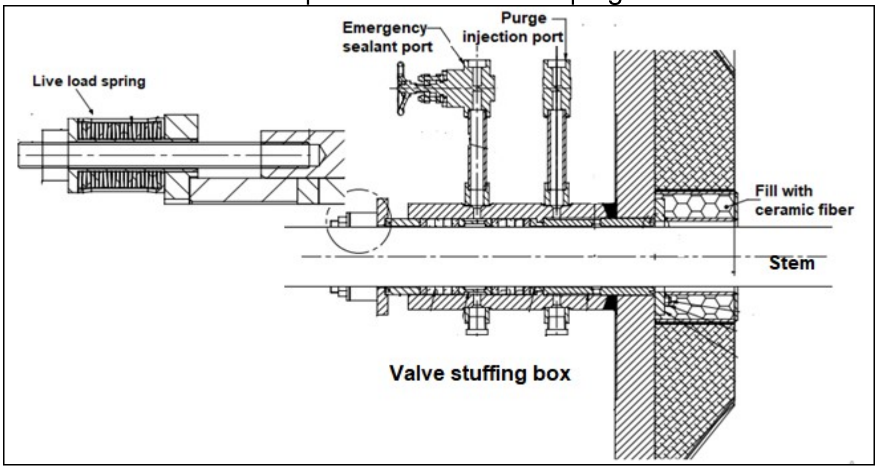


c. In the single disc slide valve there must be an offset to centralize the flow on the orifice plate at the normal operating conditions.



5.8- Stuffing box requirements

a. Stuffing box shall have a minimum of one purging port complete with a 1 in nominal diameter valve and correspondent drain with a plug, and one sealant injection port complete with a 1 in nominal diameter valve and correspondent drain with a plug.



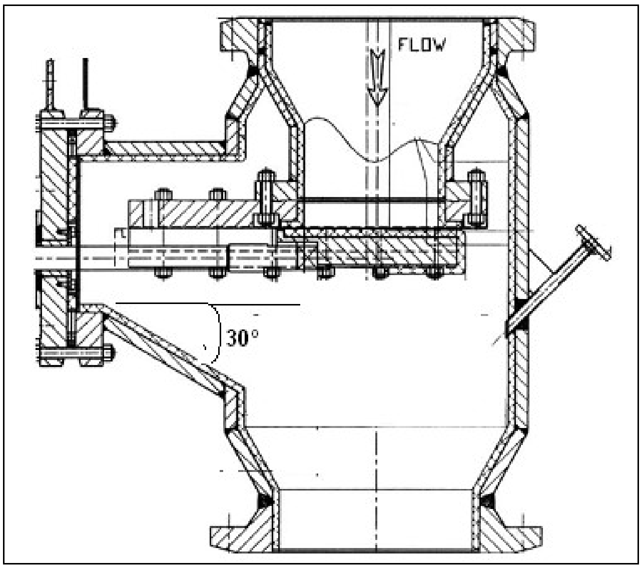
b. Manufacturer shall also provide the purging procedure and purging conditions: medium quality, flow rate, temperature and pressure into the stuffing box and at the inlet of the system.

c. For purging the stuffing box of the slide valves shall be used:

- For the Flue Gas slide valve, can be used air, super-heated steam or Nitrogen;
- For Spent and Regenerated and Catalyst cooler slide valves shall be used just super-heated steam or Nitrogen, because the use of air is forbidden due the potential risk of the Oxygen cause burning effect.

6 – Hot Wall Slide Valve particular design requirements

In addition to the items listed in previous item 4 Slide Valves Requirements, the following particular requirements must also be applied, for the Cr-Mo alloy steel at high temperatures.



Hot wall slide valve with internal abrasion resistant lining all around

For media temperatures up to 540ºC there is the possibility of designing the slide valves without insulating refractory lining, they are the Hot Wall Slide Valves.
It is the case of the spent catalyst valves.

The hot wall slide valve is a valve that it is not internally insulate refractory lined, so Carbon steel materials are not possible, and Cr-Mo alloy steel material is necessary, to support the high temperatures.

In these valves shall be applied just the abrasion resistant refractory lining on the body internal surfaces of valve, covering completely the inlet, bonnet and exit edge.
And the valve must be totally externally thermal insulated except for the flanges.

Special requirements for pressure containing parts (body and welds) of slide valves fabricated with low alloy Cr-Mo steel (1 ¼% Cr ½% Mo)

The following requirements shall be applied to low Chrome (1 ¼% Cr ½% Mo) valves:

a- Base materials according to ASME Sec II:
  - Plates ASME SA-387 Gr 11 Cl2
  - Forgings ASME SA 182 Gr. F11 Cl 2 or SA 336 Gr F11 Cl 2
  - Pipe and /Fittings ASME SA 335 Gr P 11 and SA 234 Gr WP11

b- Base materials shall be furnished in the normalized and tempered conditions (min temperature 710ºC) or 20ºC above PWHT-Post Weld Heat Treatment.

c- The plates shall be ultrasonically tested at the mill in accordance with ASME SA-578.

d- The forgings heavier than 100 kgf or greater than 4 inches thick shall be ultrasonically tested at mill per ASME SA-388.

e- All fabricated parts shall receive a Post Weld Heat Treatment – PWHT in accordance with the ASME Code Section VIII Div 1, with a soak temperature of 690ºC.

e- Charpy V-notch impact testing is required for all pressure containing materials, impact tests shall be conducted in accordance with ASME Code Section VIII Div 1 except there shall be no exemptions from the testing, the test temperature shall not exceed -20ºC and applied average energy of 48J (35 ft.lb), without any individual value below 42J (30ft.lb), in two conditions:
  - Material as furnished, and after all previewed heat treatments (PWHT and hot forming);
  - Aged material: holding at 500 ºC during 24 hr.

  When the tested components or weld will receive heat treatment, the test specimens shall be supplied in a completely heat treated condition.

f- The maximum room temperature tensile strength shall be 100 ksi.

g- Chemical analysis limits for all base materials including consumables for welds:
  J = (Si + Mn) x (P + Sn) x 10,000 <180 max with target=150
  X = (10P + 4Sn + 5Sb + As) / 100 = 23.5 ppm max.
  The following weight percent limits apply to the product analysis of all components, including weld consumables
  P = 0.013% max
  Sn = 0.015% max
  Sb = 0.004% max
  As = 0.025% max
  S = 0.010% max
  V = 0.100% max.
  All elements mentioned here above shall be checked on ladle and on product and clearly recorded at the Certified Material Test Report.

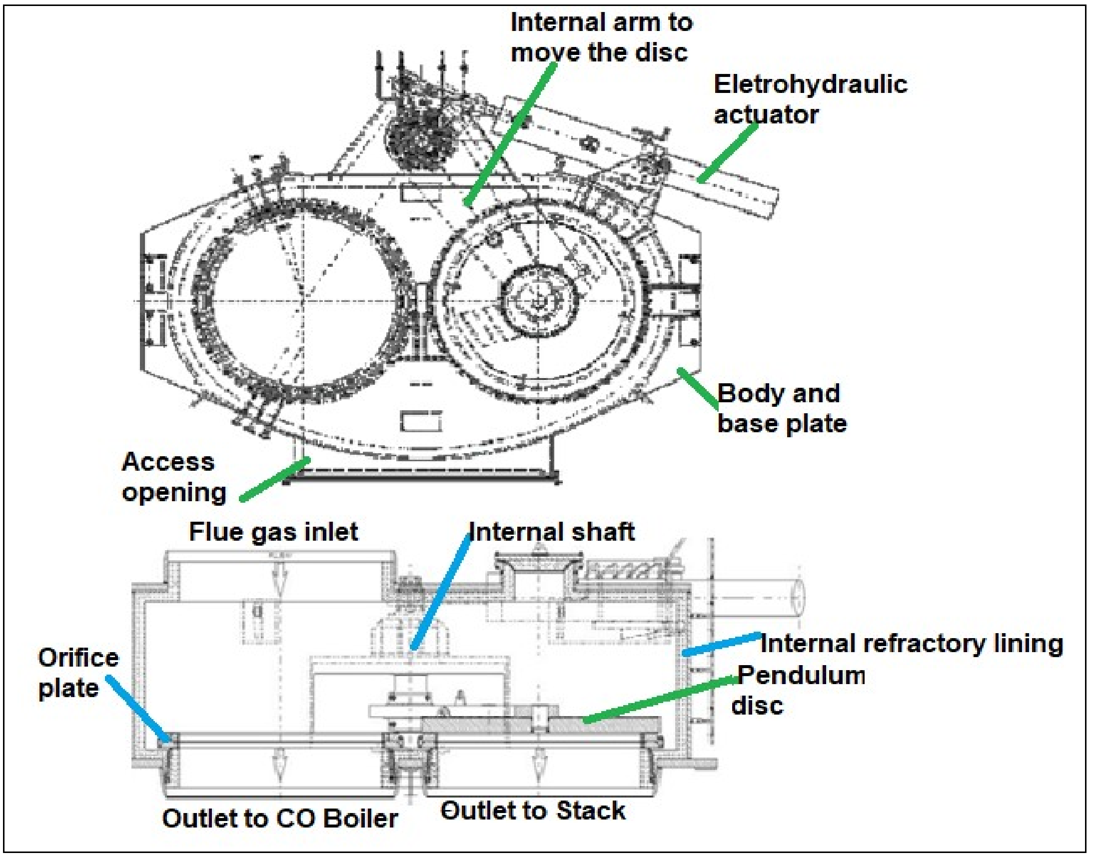
h- Plates shall withstand 5 (five) post weld heat treatments: 695ºC for 2 hours, totalizing 10 hours;
  - After PWHT the hardness of the metal base and heat affected zones shall not exceed 225 Brinell Hardness (BHW).
  - High temperature tension test shall be performed for each bath and the required min yield strength shall be 1,868 kg/cm² at 500ºC for the base plate.

7 – Two Port Diverter valve particular design requirements

Diverter valve design and fabrication shall comply with the following amendments:

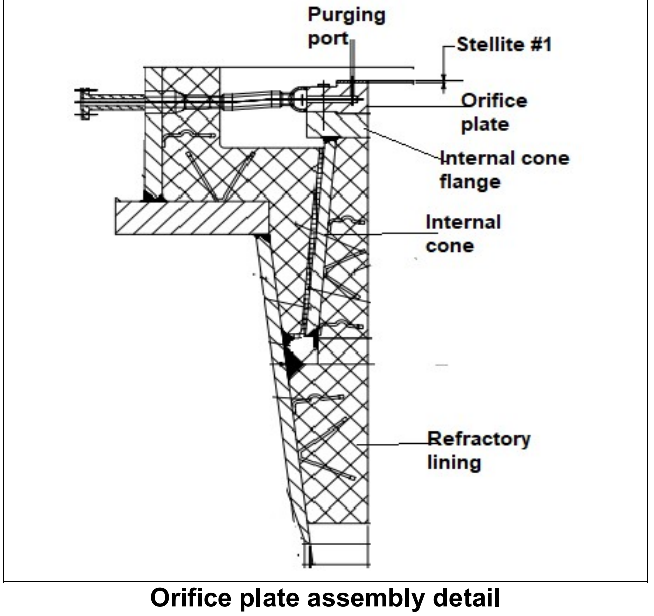
a. The diverter valve design shall conform to the ASME B31.3, Section VIII, Division 1 Codes, and this specification.

b. Diverter valve design shall be “pendulum style” with one inlet on the top side of the assembly and two outlets on the bottom side. The arrangement shall locate the inlet port and normal flow outlet along a common centerline.



Main components of a Two Port Diverter Valve

c. The inlet port shall be circular and sized for the full flow diameter of inlet and outlet pipe connections. The valve shall provide a complete and tight shutoff of either of the two outlets.
d. The outlet orifice plates shall be located upstream at the outlets of the valve. The disc shall be located above the orifice plates and shall be supported by the orifice plates and/or guides.



Orifice plate assembly detail

e. The shaft shall be a one-piece forging and shall be located out of the process flow for all positions of the valve disc.

f. A flanged access opening shall be provided on the valve body to permit removal and maintenance of internal parts.
g. High density vibrocast refractory lining RESCO RS-17E or sure or free flow refractory RESCO SUREFLOW-17E shall be applied to the body internal surfaces covering completely the inlet, bonnet and exit areas. This insulated refractory lining shall be 5 inches (125 mm). thickness and anchor spacing shall be 5 inches (125 mm).
h. Abrasion resistant refractory lining RESCO AA-22S or ACTCHEM 85 shall be installed on the inlet, bonnet, exit areas and on the face of internal disc.
i. The electrohydraulic actuator shall be mounted to the diverter valve body. Connections at the support and actuator arm shall be designed to facilitate removal of actuator.
j. External stiffening rings are not permissible on diverter valves
k. Diverter valves shall be hot-stroked at their operating temperature in the Supplier's shop to ensure correct on-stream performance.

8 – Valves calculation report requirements

8.1- It is required to submit to Client approval the following calculations:
a- Structural thicknesses: cylindrical and conical shells, bonnet to body weldment, bonnet flanges, bonnet flange cover, internal conical piece, throat section, transition piece from cone to throat section, throat flange, disc, guides, stem, shaft, shaft keys, orifice plate, boltings, pins and all internal parts;
b- Stem and shaft thrust required at design and maximum differential pressure;
It shall be considered a safety factor of 200% for designing;
c- Stem and shaft failure load at design conditions;
d- Disc deflection at the design loading;
e- Port opening at maximum flow;
f- Port opening at normal flow;
g- Port opening at minimum flow;
h- Maximum temperatures at body, bonnet and dissimilar welds.

8.2- All structural and mechanical calculations must be in compliance with ASME Section VIII.
The transition from circular section to rectangular at the throat section, and the welding of the internal cone to the valve body must be checked by Finite Element Stress Analysis methods (FEA) plastic solid analysis model and fatigue life. The stress analysis criteria must comply to ASME Section VIII - Division 2, Latest Edition.

8.3- Referring to the fatigue life evaluation, internal cone to body weldment shall be verified for a minimum of:

- 100 cycles considering complete shutdown: normal operating up to ambient temperature; and
- 500 cycles considering partial shutdown: normal operating temperature up to 200ºC.

The loading to be considered shall be

- Mechanical loads: pressure, differential pressure, metal plus refractory linings weights;
- Thermal loads: thermal gradients, different thermal expansions, dissimilar welds
- Vibrations due to the turbulent flow across the port opening area.

It is mandatory to perform a fatigue with a linear FEA evaluation on the dissimilar welding area based on ASME Section VIII Div 2 - Appendix 5.

8.4- All components shall be designed considering the pressure and temperature design conditions. The emergency temperature excursion conditions shall be considered only to establish the allowable tension creep stress, considering the accumulative damage, and to check the operating clearances.

8.5-The effect of the upset excursion conditions shall be considered on internal clearances and on accumulated creep behavior of the material to calculate the allowable stresses. Manufacturer must consider the Larson Miller criteria to take into account the influence of the upset excursions on valve material mechanical strength.

8.6- The criteria to establish the design allowable stress for internals shall consider the accumulated creep damage due to the following upset temperature excursions, considering the specific duration and the design lifetime of the valve, 20 years or approximately 200,000 hrs, as a minimum, for the fixed parts: body, bonnet, suspended internal cone, throat flange and the attachment welds on the body.
The design lifetime of 10 years or approximately 100,000 hrs lifetime shall be applicable to the internal removed parts.
The Larson Miller parameter criteria shall be applicable.

Valve	Design temperature	Upset temperature	Period of upset
Regenerated catalyst single disc slide valve	730ºC to 760ºC	925ºC	10 times 10 hrs/year
Spent catalyst single disc slide valve	550ºC to 590ºC	650ºC	10 times 10 hrs/year
Flue gas double disc slide valve	760ºC	843 °C and 982 ºC .	10 times 1hr/year 1 time 1hr/year
Catalyst cooler slide valve	760ºC	785ºC	10 times 10 hrs/year
Two port diverter valves	760ºC	843 °C and 982ºC	10 times 1hr/year 1 time 1 hr/year

Note: Valve lifetimes: body 20 years and internals 10 years.

Design and upset excursion conditions

8.7- The components of the actuating system and all the internals of the valve shall be designed for 150% safety factor relatively to the required maximum design actuator thrust pull or push force.

8.8- Manufacturer shall provide the valve CV curve according to the port opening area, alternatively is acceptable the flow rate and pressure drop curves as a function of the port opening area.

8.9- The flue gas double disc slide valve without the installation of a turboexpander arrangement shall have each disc cut in an elliptical shape to provide, when at the closed position, the minimum pressure relief safety area, as informed in the data-sheet.

8.10- For flue gas double disc slide valve applied with a turboexpander arrangement, there is a condition when the valve shall operate totally closed, so the relief area shall be provided by a pressure safety valve installed on the duct or pipe at the valve inlet.
At this condition the mechanical calculation shall consider the Regenerator vessel design internal pressure as the design differential pressure on the discs and the pressure at the inlet of the safety valve Manufacturer shall inform the gas flow leakage across the rear plus forward gaps between the discs and orifice plate, with the valve totally closed, during normal operation.
If it is necessary to assure a minimum port area at the closed condition, the Manufacturer shall provide external limit stops in the actuator cylinder.

8.11- When the flue gas double disc slide valve operates totally closed the discs thermal expansion shall be absorbed in the actuating system to avoid distortion of the stems.

8.12- For slide valves the design differential pressure for mechanical design of the disc, guides and guide supports shall be 20 psi (1.41 kgf/cm²) at the valve design temperature, for long term, and 100 psi (7 kgf/cm²) for 1000 hours short term.

Valve	Design or long term differential pressure	Upset or short term pressure	Design or long term temperature	Upset or short term temperature
Regenerated catalyst single disc slide valve	1.41 kgf/cm²	7 kgf/cm² at 1000 hrs	760ºC	925ºC at 10 times 10 hrs/year
Spent catalyst single disc slide valve	1.41 kgf/cm²	7 kgf/cm² at 1000 hrs	590ºC	650ºC at 10 times 10 hrs/year

Flue gas double disc slide valve	1.41 kgf/cm² except as note "a" below	3 kgf/cm² at 1000 hrs	760ºC	843 °C at 10 times 1hr/year 982 ºC at 1 time 1hr/year
Catalyst cooler single disc slide valve	1.41 kgf/cm²	See note "b" below	760ºC	785ºC at 10 times 10 hrs/year

Notes:

a. For **Flue gas double disc slide valve,** working in the Energy Recovery Systems using Turboexpander, the design differential pressure is the same as the value of Regenerator vessel design pressure.

b. For the **Catalyst cooler single disc slide valve** additional requirements are required to the internal differential pressure, for the mechanical design:
- 20 psi design differential pressure;
- 105 psi blasting or up-set condition for a total duration of 1000 hrs;
- 240 psi tube rupture condition for a total duration of 10 hrs.
  The 240 psi condition does not affect actuator thrust because the valve is not required to adjust position in case of tube rupture. This high pressure case only results in the event that a tube rupture occurs while catalyst slumps in the cooler.
  In case of tube rupture the valve is required to hold in position.

c. Valve lifetimes: body 20 years and internals 10 years.

In case of Two Port Diverter Valve, the mechanical design of the body, disc, shaft, keys and pins, arm and all internal parts shall be based on the following conditions:

Design or long term temperature	Body: 345ºC Internals: design 760ºC
Design or long term pressure	1.3 barg (20 psi)
Upset or short term temperature	843°C at 10 times 1hr/year 982ºC at 1 time 1hr/year
Differential pressure:	Long term: 0.2 bar (2.8 psi) at 760ºC Upset: 0.7 bar (10 psi) at 10 times 1 hr/year

Note: Valve lifetimes: body 20 years and internals 10 years.

8.13- Vendor shall consider the friction coefficient of 0.5 minimum between disc and guides at the design temperature in the calculations.

8.14- All mechanical calculations and construction details shall be based upon the rules of ASME Code: Section VIII Div. 1, Section II, Section V and Section IX.
Additionally, Finite Element Analysis (FEA) plastic solid analysis model, shall be done contemplating the valve body; internal cone; transition between internal cone and rectangular throat shape; conical parts of the body and bonnet to body attachment, focusing the stress conditions on the parts involved by dissimilar welding, dissimilar thicknesses, and differential thermal expansion coefficients.
The effects of the actuator thrust force on the internal cone and at the internal cone to body junction shall be considered.
The influence of the upset excursion conditions on accumulated creep behavior of the material shall be considered to establish the tension allowable stresses for the internals of the valve, using the Larson Miller criteria. See in the Annex 1 of this specification a proposed method applying the ASME Code Case N-47-29.
It shall be demonstrated by FEA calculation that the resultant distortion of the body and internals shall not cause binding of the disc, that is, the distortions or deformations are within the limits of the design internal clearances.
The FEA shall be done based on the ASME VIII Div 2 App. 4, using the basic stresses from ASME Sec VIII Div 1 and considering the following internal & external loads acting simultaneously:

Internal loading:
- Design pressure + max differential pressure + maximum actuator thrust pull or push loading at the stuck or stall condition + disc differential pressure + weight of internals + differential thermal expansion between valve body and internals.

External loading:
- Valve and bonnet weight + refractory lining weight + piping loads + actuator self weight.

The calculated differential thermal expansion stresses shall be based on two conditions acting on the valves.:
a- **Winter condition**: the valve internals at design temperature and the valve body at minimum metal temperature. The minimum body metal temperature shall be calculated assuming the minimum ambient temperature and the max wind speed.
b- **Summer condition**: the valve internals at design temperature and the valve body at maximum metal temperature. The maximum body metal temperature shall be calculated assuming the maximum ambient temperature and no wind.

9 – Valves shop fabrication requirements
9.1- All slide and diverter valves shall be fabricated, as a minimum requirement in compliance with this technical specification and the following codes, at the latest Edition and Addenda:
a. - ASME Code Sect VIII Div. 1;
b. - ASME Code Section II;
c. – ASME Code Section V;
d. - ASME Code Section IX;
e - ASME B31.3.

9.2- Supplier shall state in writing that the design and manufacture of the slide valves and diverter valves will be in full compliance with this specification and referenced documents.
Manufacturer should prepare and deliver fabrication drawings, showing complete longitudinal section and cross-section of the valve at 90° to the stream, all dimensions, cold clearances, construction materials, design conditions, and applicable codes, standards and specifications.

9.3 ASME SFA-5.4 E308H or ASME SFA-5.9 ER308H welding electrodes shall be used in the fabrication of 304H stainless steel parts.
The 308H electrodes shall have a preferred range of 3 to 8 Ferrite Number (FN) with maximum value of 10.
Ferrite Number shall be determined by the DeLong Constitution Diagram for stainless steel weld metal.
ASME SFA-5.4 E309/310 or ASME SFA-5.9 ER309/310 welding electrodes shall be used to weld hexmesh to 304 stainless steel parts.

9.4- All pressure-retaining welds shall be full penetration, totally radiographed and substantially smooth with no undercuts or lack of fusion at side walls.

9.5- All pressure-retaining welds shall be subjected to 100% radiographic examination or 100% ultrasonic examination where not accessible for radiography.
Radiographic and ultrasonic examinations shall be done in accordance with ASME Code. Section VIII, Division 1, Paragraphs UW-51 and UW-53 respectively.

9.6- All fillet and nozzle welds shall be subjected to 100% penetrant liquid and ultrasonic examination per ASME Sect VIII Div. 1 App. 8 for stainless steel materials, and 100% magnetic particle examination per ASME Sect VIII Div. 1 App. 6 for carbon and alloy steel parts.

9.7- All fillet welds shall be ground to a smooth concave contour.

9.8- The body valve shall be post weld heat treated, PWHT-Post Welding Heat Treatment, to prevent distortions at operating temperature.

9.9- All internal components shall be thermal stress relieved, PWHT-Post Welding Heat Treatment, to assure dimensional stability and avoid distortions during the operation.

9.10- All hard surfaced parts should be heat treated before any cutting or machining.

9.11- To avoid the risk of sensitization or sigmatization of the austenitic stainless steel parts, during the thermal stress relief, Manufacturer shall carry out the fabrication procedure respecting the following sequence:
a - Do the PWHT in **Carbon steel body** completely welded with exception of the dissimilar welds: 600ºC at 1hr/in greater weld thickness of the bod.
b - Do the thermall relief on the **SS internal parts**, after completion of the internal cone and throat part, and hardness coating deposit on the guides, orifice plate and disc: 900ºC at 1hr/in greater thickness of the internals.
c - Do the body and internal cone **dissimilar welds** without any post welding heat treatment.
When the previewed temperature of the dissimilar weld is below 315°C this weld can be performed with E309 electrode, but if the temperature is above 315°C is required to use Inconel electrodes.

After the heat treatment, all welds shall be examined per magnetic particle-MT or penetrant liquid -PT (when MT is not possible).
Manufacturer shall define which of the NDE-Non Destructive Examinations to be carried out on the weldments before and after post weld heat treatment, and after pressure test.

9.12- Supplier shall specify all surface finishing, fabricating tolerances, maximum misalignment, and out-of-plane of the connected components.

9.13- Hardness test shall be made on all hard surfacing and all fabrication welds.
Test Certificates shall be available whenever is required by Purchaser.

9.14- All surfaces corner weld and “T” weld with full penetration shall be previously 100% ultrasonic examined for lamellar tearing preventing.

9.15- The hard coatings shall be penetrant liquid examined for checking the crack pattern, which shall be in accordance with Client criteria.

9.16- Valve shall be subject to inspection by an authorized inspector or other representative of the Purchaser.

9.17- Valve shall be assembled completely by the Supplier prior to shipment.

10 – High density refractory lining requirements
High density refractory lining shall be in accordance with Petrobras standards with the following additions:
a – Internal insulating with vibrocast refractory material RESCO RS-17EC or alternatively sure or free flow refractory RESCO-SUREFLOW-17E;

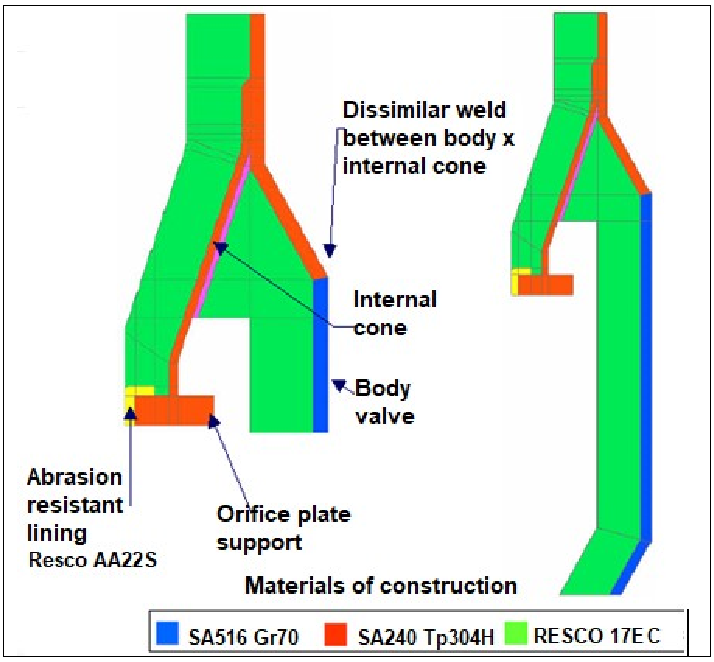
b – Insulated refractory lining with 5 inches (125 mm).thickness and anchor spacing shall be 5 inches (125 mm) maximum on the centers;

c - Lining application cast vibrated method and as an option free flow method may be applied with the alternative material referenced in item (a);

d - Cardboard liners for expansion gap of internal cone sleeve shall be 20 mm thick;

e - Qualify the lining installation procedure;

f - “V” SS Tp304 anchors shall be solution annealed after forming.



11 – Abrasion resistant lining requirements
Abrasion resistant lining shall be in accordance with Petrobras standards with the following additions:
a - Refractory material shall be RESCO Type AA-22S, as an allowable alternative it is possible to use the abrasion resistant lining from Atchem 85 manufacturer.
b - Hexmesh stainless steel 304 material to be 25 mm thick, 14 gage sheet and rolled in hard direction.
c - Hexmesh shall be installed on the front disc with the strips parallel to the leading edge.
d - Each hexmesh on the orifice plate and the disc shall be welded on three sides with a 1/8 in x 1 in (3 mm x 25 mm) long fillet weld.
e - Corner tabs with 1" (25 mm) radius, same material as the hexmesh, shall be used on the throat of the orifice plate and the leading edge of the disc. Corner tabs shall be welded with 1/8 in (3 mm) fillet weld on one side of one leg and the alternate side of the other leg.
f – Before the grinding of the refractory lining on surfaces of the disc and orifice plate it shall be carried out the heat drying at 350ºC.
These surfaces shall be ground flush at the same roughness finishing of the metallic hard coated parts.

12 – Metallic hard surfacing on sliding surfaces of disc and guides
Metallic hard surfacing shall be in accordance with following requirements:
a- The first layer of hard surfacing thickness shall be a minimum of 1/16 in (1.6 mm) and maximum of 3/32 in (2.4 mm) according to AWS A-5.4 Classification E309 or E310, followed by a second layer of Stellite Alloy No. 1.
The Stellite No. 1 is applied on the sliding surfaces of disc and guides.
The orifice plate is not protected with Stellite, just the abrasion resistant lining RESCO AA-22S is used in this case, to protect the port opening edges.

b- The total minimum finished thickness of overlays shall be 7/32 in (5.5 mm). The hardness shall be a minimum of 48 Rockwell C with an average of 50 Rockwell C at the normal operating temperature.
After PWHT the hard running surfaces shall be ground finish to 32 RMS.

c- Deposits shall be applied in such a manner to avoid excessive penetration and produce a satisfactory hairline-cracking pattern.
The crack width shall not exceed 0.01 in (0.25 mm) at the perpendicular direction of the flow.
Cracks parallel to the direction of the flow are not permissible.
In order to control the crack occurrences apply Stellite No. 1 by PTA to avoid excessive dilution and to minimize cracks.
If parallel cracks appear they shall be repaired.

13 – Shop inspection requirements

13.1- Material certificates

Mill material certificates of both pressure containing parts and those attached parts by welding shall be submitted.
Mill material certificates of the throat part, cone sleeve, bonnet, flanges, disc, orifice plate, guides, stem, shaft, bolts/nuts, keys and pins shall also be submitted.
All refractory lining materials shall have quality certificates.
All consumable welding materials shall have quality certificates.
All materials for NDE-Non Destructive Examination shall have quality certificates.

13.2- Radiographic examination

Total radiographic examination shall be applied to all butt-welded joints where accessible to inspect .
Method: ASME Sec. V, Art. 2
Acceptance Criteria: ASME Sec. VIII, Div. 1, UW-51.

13.3- Penetrant Liquid examination

Penetrant Liquid examination shall be applied to all welds in the pressure containing parts (including temporary attachment welds and trace of temporary attachment weld).
Method: ASME Sec. V, Art. 6
Acceptance Criteria: ASME Sec. VIII Div. 1, Appendix 8.

13.4- Magnetic Particle examination

Magnetic particle examination shall be applied to all pressure retaining welds where radiographic examination is not possible.
Method: ASME Sec. V, Art. 7
Acceptance Criteria: ASME Sec. VIII Div. 1, Appendix 6.

13.5- Ultrasonic examination

Ultrasonic examination shall be to all butt welded joints not accessible for radiographic examination
Method: ASME Sec. V, Art. 5.
Acceptance Criteria: ASME Sec. VIII, Div. 1, Appendix 12

The Carbon and Alloy steel plates with thickness of 40 mm and greater shall be ultrasonically tested at mill in accordance with ASME SA-578.
The Carbon and Alloy steel forgings heavier than 100 kgf or greater than 4 inches thick shall be ultrasonically tested at mill per ASME SA-388, and Austenitic Stainless steel forgings per ASME SA-745.

13.6- Hardness Test of hardening overlay

Hardness test shall be performed for stem, disc and guides, where hardening is overlaid and the records of them shall be submitted.

13.7- Visual and Dimensional inspection

Visual inspection of completely assembled unit, including general dimensional inspection, and verification of inventory of all attached accessories will be made with purchasing data sheets, approved specifications and drawings.
The result shall be submitted to the Client.

13.8- Internal clearance check

All internal clearances for running purposes shall be checked during the pre-assembly of the internal set.
The same clearances shall be also checked after the hot stroking test of the valve.

13.9- Refractory lining Inspection

Refractory linings shall be hammered, visually inspected and confirmed that they are free from any harmful defect such as scabs, burrs and unevenness.

14 – Shop test requirements
Upon completion the valve shall be subjected to the following tests at the shop.

a. Hydrostatic Pressure test

Hydrostatic test shall be performed prior to refractory lining and after the post weld heat treatment, under the specified test pressure, according to a procedure to be previously submitted to Purchaser approval. After the pressure test is required MT or PT examinations on the retaining pressure welds.

b. Hot Stroking test

Slide and diverter valves shall be subjected to a hot stroke test at the design temperature to check the operating conditions and the internal clearances of the valve.
Operating conditions shall also be checked during the warmup and cool down periods of the test.
This test could be carried out at the same time of refractory heat curing and dry-out.
At this time the valve shall be operated at least for 10 cycles by the own electrohydraulic actuator from full open to full close position and vice-versa.
The valve must stroke smooth and free (no jerking), without noise and any vibration.
The valve must also meet the required stroke speed.
After hot stroking test, final cold clearances must be checked if meeting the designed cold clearances.
Supplier shall submit to the Purchaser/Client approval the hot stroking test procedure considering the test installation, thermocouple distribution (inside and outside), measuring of the initial and final cold clearances at 0%, 25%, 50%, 75% and 100% stroke opening positions, and all other data to be recorded.
There must be enough thermocouples inside and outside the valve to follow the correspondent metal temperatures.
During the dry-out time the allowable difference between any thermocouples shall be 15ºC maximum,
To solve any possible stagnant area (for instance bonnet inside area) the hot gas flow shall be directed directly to the point using internal vans.

c. Actuator test

The electrohydraulic, mechanical and manual actuators shall be shop tested for operability, stroking time and actuator's characteristics, in accordance with project specifications.
The valve opening indicator setting shall be checked and the valve shall be stroked to ensure that the proper limits are satisfied.

d. Sealing test at ambient temperature

The maximum allowable leakage shall be according to the standard ANSI FCI 70-2 Control Valve Seat Leakage superseding ASME B16.104 Control Valve Seat Leaking

15 – Electrohydraulic actuating system

a. Each valve shall be independently operated by an electrohydraulic actuator and in case of double disc slide valve each disc shall have an own actuator.
b. The mechanical actuator should be electrohydraulic type and complete with a remote and HPCU - Hydraulic Power and Control Unit, according to the Purchaser specification
c. Electrohydraulic actuator shall be mounted to the valve by a flanged connection.
   In the slide valves, the valve mating flange shall be supported from the bonnet flange with an extension adaptor or yoke.
   Dowell pins shall be incorporated into the flange design to easy assembly.
d. The valve body x actuator yoke shall be designed and calculated in order to support the actuator without necessity of any spring hangers or spring supports.
e. Stems of the electrohydraulic actuator and of the valve shall be connected by a flange or split coupler.
f. Design Speed from full stroke time, excluding cushion at end of stroke, based on initial travel:
   - Slide valve and Plug valve: Normal stroking time: 5 sec,
     ESD using the shutdown circuit: 3 sec max;
   - Two Port diverter valve: Normal stroking time 90 sec;
     ESD using the shutdown circuit 60 sec max;

g. The required technical specifications are presented in the technical specification for design and construction of Electrohydraulic Actuating & Control systems for Slide, Plug, Expander Butterfly and Diverter Valves of FCC Units


HPCU photograph - Courtesy of IMI Remosa FCC valves

HPCU - Hydraulic Power and Control Unit components:

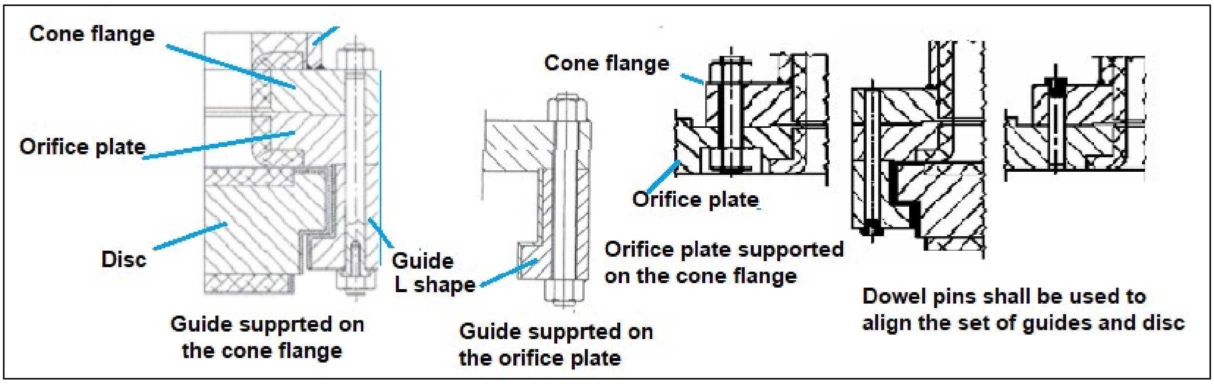
a. Two electrical driven oil pumps: primary and stand-by
b. Two hydraulic filters
c. Hydraulic oil reservoir
d. Main accumulators
e. ESD accumulators
f. Manual hydraulic operator
g. Servo-valve manifold
h. ESD circuit manifold
i. All instrumentation, valves and piping necessary for Unit operation
j. Cylinder isolation manifold
k. Local (or remote) panel with a control system for alarm and monitoring signals data acquisition and position control, and a Human-Machine-Interface (HMI) for alarm and variable indications for all actuator and hydraulic power unit monitoring parameters
l. Back-up control system (jog-control)
m. Air/oil cooling/circulation and filtration system

16 – Recommended construction patterns

The following are recommended construction details for slide valves.

a. Bolted trim details

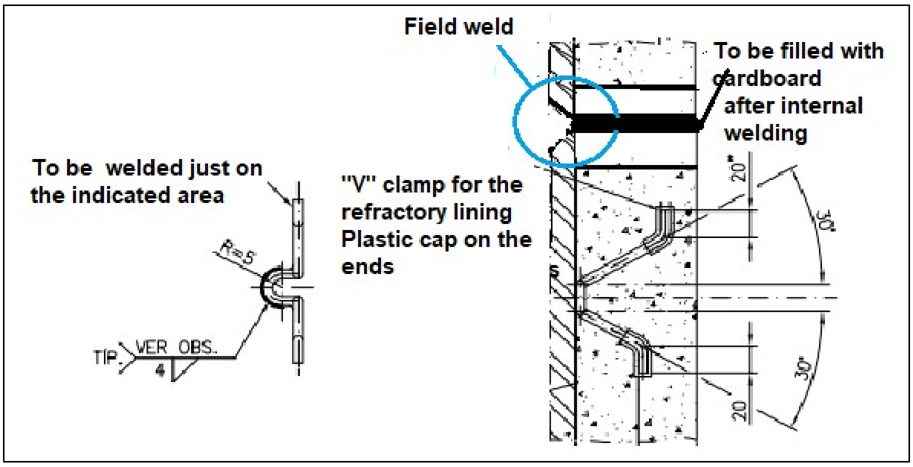
All internal bolting shall be through bolts, tightened with a torque hydraulic torque machine according to manufacturer recommendations and tack welded after valve clearances are set.



Specification of internal bolting (according to ASTM A453 item 3.1.1, bolting is a general definition and includes both bolts, nuts and pins)
a- Material ASTM 453 Gr660 C
b- Rupture test requirement as per ASTM A453 Item 7.2 Table 5 to qualify the material which boltings are made of and it shall be obtained starting from a threaded bar.
c- The nut shall be tested according to ASTM A 194, i.e.: Hardness Test (item 7.1) and Proof Load Test (item 7.2).
d- Heat treatment requirements solution annealing and hardening as per ASTM A 453 Item 5.3 and Table 3 shall be applied to a bar that has already been threaded.
e- Supplementary requirements as per ASTM A453 Item S1.

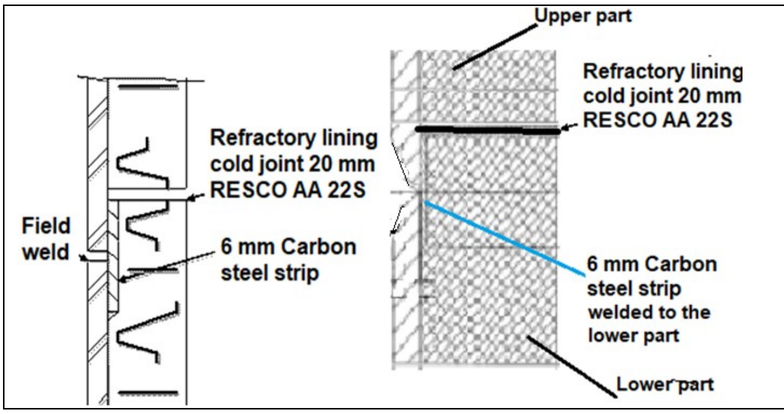
b. Field welds and internal refractory lining finishing

- **When it is possible the internal access for welding**



Field welding and refractory finishing when it is possible the internal access

- **When it is not possible the internal access for welding**



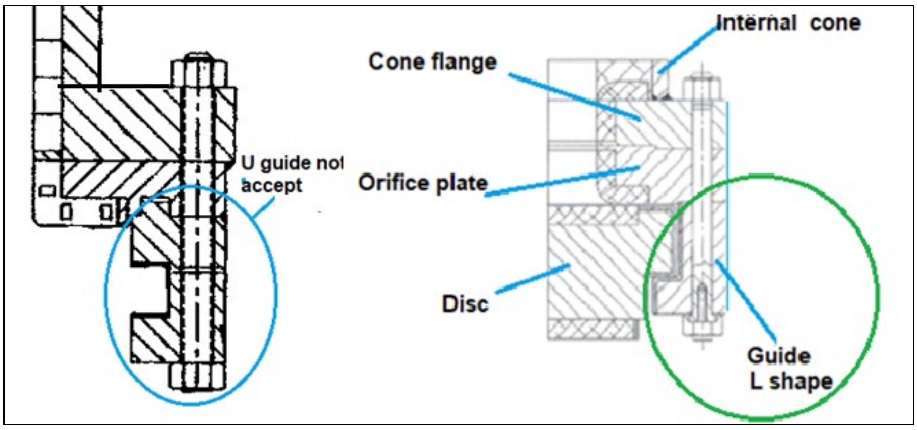
a- Use the backup welding steel strip 50mm wide.
b- Use the cold joint 3mm wide.
c- The 3mm joint shall be coated with the RESCO 22 CAULK immediately before the pipe sections are jointed and welded. The excess will squeeze out of the joint on the inside of the piping.
d- The field joint welds must be RT or UT examined after welding

Field welding and refractory finishing when it is not possible the internal access

c. Guide design

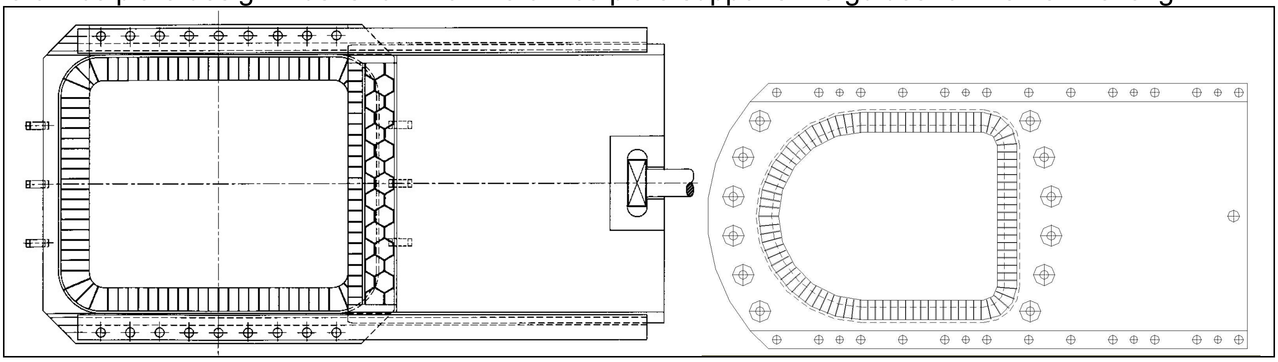
It is forbidden the use of "U" shaped guide.
Use the "L" shaped guide

The "U" shaped guides do not allow a correct performance of the valve, because during the operation with the bending deformation of the disc, there is a tendency of reducing the vertical and lateral clearances, between disc and guides.
The consequence is the valve sticking.
The "L" shaped guides are more reliable and assure a good performance of the valve, because the disc end is more rigid and thicker and the deformation is lower.



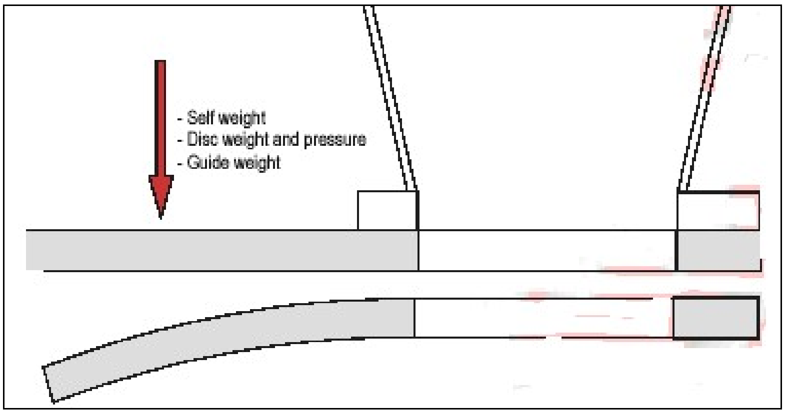
d. Guide supports

Guides shall be supported throughout their entire length by the orifice plate.
The orifice plate design must show that the orifice plate supports the guides for their entire length.



e. Orifice plate thickness calculation

The back of the orifice plate (i.e. the bonnet cover side) shall be designed for bending and taken as a cantilever having self weight and sustaining guides and disc, and the differential pressure action on the disc. The deflection shall not cause the disc sticking between guides and orifice plate.

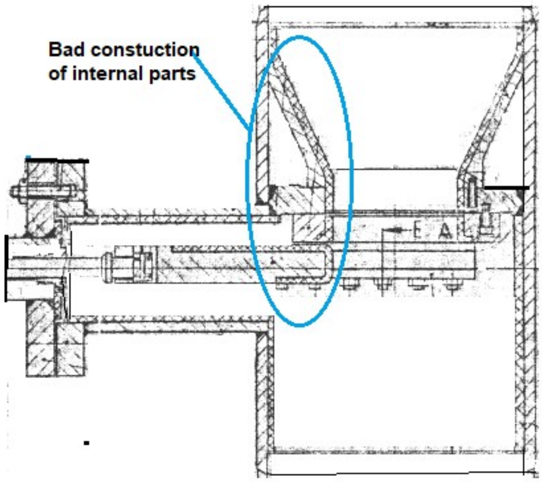


17 – Manufacturing of the internal cone, discs, orifice plate and guides from plate and forgings of stainless steel Gr304H

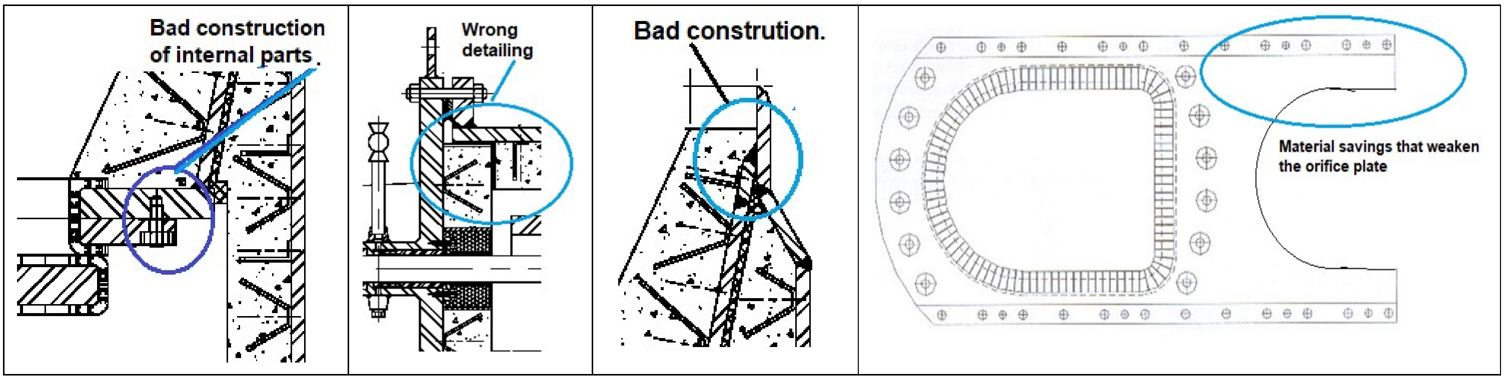
a- Solution annealing heat treatment is requested not only for forgings but also for plates;
b- The lamellar tearing check is only requested on the raw material: "lamellar tearing UT examination".
Note: Any material with risk of lamellar tearing by reason of loads normal to its surface caused by welding stresses or service loads shall be of a quality resistant to such effects.
c- Upper 150 mm thick: forging;
d- Between 100 and 150 mm thick: forging or plate;

e- Up to 100 mm thick: plate.
g- For plate do the UT examination, to check possible double lamination at the steel maker
h- Any machining must do at the same directions of the fibers.
i- After Stellite #1 deposition do the PWHT.

18 – Types of constructions not acceptable
a- Valve straight body construction



b- Valve internals fabrication detailing



ANNEXES

Annex 1
Calculation standard mechanical design allowable stresses for FCC Valves

1.1- Allowable stresses for pressure and weight sustaining internal parts
The mechanical design of parts fabricated with 304H stainless steel, considering the accumulated creep damage at the design temperature and undergoing the short-time over-temperature or up-sets excursions:

For instance, it follows the application of this procedure for the upset temperature conditions of the flue gas double disc slide valve.

Condition	Temperature	Duration
Design	1400ºF	20 years lifetime: 175,200 hrs
Emergency I	1550ºF	10 periods of 1hr per year: 200 hrs
Emergency II	1800ºC	1 period of 1hr per year: 20 hrs

Note: 20 (years) X 365 (days) X 24 (hrs) = 175,200 hrs

Applying the life-fraction rule, as follows:

$$\sum \frac{Ti}{Tri} \leq 1.0$$

Ti = total lifetime at the given temperature (hrs);
Tri = rupture time at the corresponding stress (Si/0.80) and given temperature (hrs).

Using ASME Code Case N-47-29 Figure I -14.6A, and extrapolating the values above 1,500ºF from ASTM Data Series DS 5S2 (former ASTM STP-124) standard we have:

Temperature (ºF)	1,400	1,550	1,800
Adopted Si stress (psi)	1,600	1,600	1,600
Total lifetime Ti (hrs)	175,200	200	20
Rupture time Tri (hrs)	200,000	6,000	200
Ti / Tri	0.876	0.033	0.1

$$\sum \frac{Ti}{Tri} = 1.0 \text{ OK!}$$

So, the allowable tension and bending stresses (Si) is 1,600 psi.
The other allowable stresses are:
Shearing stress: 0.67 (Si);
Bolt shear stress: 0.8 (Si)
Fillet weld shear stress: if with penetration 0.70 (Si);
if no penetration 0.55 (Si);
Bearing stress: 1.6 (Si)

1.2- Allowable Stresses for Structural Components
Stem, shaft, bolts, keys, pins and other parts subjected to the torque effects.

Stress	At design torque	At the emergency or maximum torque (200% design torque)
Tension and bending	0.60 Sy	0.80 Sy
Shear and torsion	0.40 Sy	0.55 Sy
Von Mises local stresses	2.0 Sy	-

Sy: yielding stress of the construction material at the design temperature

1.3- Maximum Allowable Bending Deflection for the Disc
0.005" (0.13 mm)

Annex 2
Allowable high temperature stresses according to ASME B31.3 CODE Appendix V

Appendix V
Allowable variation in elevated temperaure service

V300 APPLICATION

(*a*) This Appendix covers application of the Linear Life Fraction Rule, which provides a method for evaluating variations at elevated temperatures above design conditions where material creep properties [see para. V302(c)] control the allowable stress at the temperature of the variation. This Appendix is a Code requirement only when specified by the owner in accordance with the last sentence of para. 302.2.4(f)(1).

(*b*) Life Fraction analysis addresses only the gross strength of piping components; it does not consider local stress effects. It is the designer's responsibility to provide construction details suitable for elevated temperature design.

V300.1 Definitions

operating condition: any condition of pressure and temperature under which the design conditions are not exceeded.

excursion: any condition under which pressure or temperature, or both, exceed the design conditions.

service condition: any operating condition or excursion.

duration

(*a*) the extent of any service condition, hours

(*b*) the cumulative extent of all repetitions of a given service condition during service life, hours

service life: the life assigned to a piping system for design purposes, hours.

V301 DESIGN BASIS

Life Fraction analysis shall be performed in accordance with one of the following design basis options selected by the owner.

(*a*) All service conditions in the creep range and their durations are included.

(*b*) To simplify the analysis, less severe service conditions need not be individually evaluated if their durations are included with the duration of a more severe service condition.

V302 CRITERIA

(*a*) All of the criteria in para. 302.2.4 shall be met.

(*b*) Only carbon steels, low and intermediate alloy steels, austenitic stainless steels, and high nickel alloys are included.

(*c*) Service conditions are considered only in the calculation of the usage factors in accordance with para. V303 when the allowable stress at the temperature of those conditions in Table A-1 is based on the creep criteria stated in para. 302.3.2.

(*d*) Creep-fatigue interaction effects shall be considered when the number of cycles exceeds 100.

V303 PROCEDURE

The cumulative effect of all service conditions during the service life of the piping is determined by the Linear Life Fraction Rule in accordance with the following procedure.

V303.1 Calculations for Each Service Condition *i*

The following steps shall be repeated for each service condition considered.

V303.1.1 Equivalent Stress for Pressure

(*a*) Using eq. (V1), compute a pressure-based equivalent stress, S_{pi}

$$S_{pi} = S_d P_i / P_{max} \qquad \text{(V1)}$$

where

P_i = gage pressure, kPa (psig), during service condition *i*

P_{max} = maximum allowable gage pressure, kPa (psig), for continuous operation of pipe or component at design temperature, considering allowances, *c*, and mill tolerance, but without considering weld joint strength reduction factor, *W*; weld joint quality factors, E_j; or casting quality factor, E_c

S_d = allowable stress, MPa (ksi), at design temperature, °C (°F)

S_{pi} = pressure-based equivalent stress, MPa (ksi)

(*b*) Compute the maximum longitudinal stress, S_L, during service condition *i*, in accordance with para. 302.3.5(c).

(*c*) The equivalent stress, S_i, for use in para. V303.1.2 is the greater of the values calculated in (a) and (b) above, divided by their respective weld joint strength reduction factor, *W*, in accordance with para. 302.3.5(e).

V303.1.2 Effective Temperature. From Table A-1, find the temperature corresponding to a basic allowable stress equal to the equivalent stress, S_i, using linear interpolation if necessary. This temperature, T_E, is the effective temperature for service condition *i*.

V303.1.3 Larson-Miller Parameter. Compute the *LMP* for the basic design life for service condition *i*, using eq. (V2)

$$\left.\begin{aligned} \text{SI units:} \quad LMP &= (C + 5)(T_E + 273) \\ \text{U.S. Customary units:} \quad LMP &= (C + 5)(T_E + 460) \end{aligned}\right\} \text{(V2)}$$

where

C = 20 (carbon, low, and intermediate alloy steels)
= 15 (austenitic stainless steel and high nickel alloys)

T_E = effective temperature, °C (°F); see para. V303.1.2

V303.1.4 Rupture Life. Compute the rupture life, t_{ri}, h, using eq. (V3)

$$t_{ri} = 10^a \qquad \text{(V3)}$$

where

$$\text{SI units:} \quad a = \frac{LMP}{T_i + 273} - C$$

$$\text{U.S. Customary units:} \quad a = \frac{LMP}{T_i + 460} - C$$

and

T_i = temperature, °C (°F), of the component for the coincident operating pressure–temperature condition *i* under consideration

t_{ri} = allowable rupture life, h, associated with a given service condition *i* and stress, S_i

LMP and *C* are as defined in para. V303.1.3.

V303.2 Determine Creep-Rupture Usage Factor

The usage factor, *u*, is the summation of individual usage factors, t_i/t_{ri}, for all service conditions considered in para. V303.1. See eq. (V4).

$$u = \sum(t_i/t_{ri}) \qquad \text{(V4)}$$

where

i = as a subscript, 1 for the prevalent operating condition; i = 2, 3, etc., for each of the other service conditions considered

t_i = total duration, h, associated with any service condition *i*, at pressure, P_i, and temperature, T_i

t_{ri} = as defined in para. V303.1.4

V303.3 Evaluation

The calculated value of *u* indicates the nominal amount of creep-rupture life expended during the service life of the piping system. If $u \le 1.0$, the usage factor is acceptable including excursions. If $u > 1.0$, the designer shall either increase the design conditions (selecting piping system components of a higher allowable working pressure if necessary) or reduce the number and/or severity of excursions until the usage factor is acceptable.

V304 EXAMPLE

The following example illustrates the application of the procedure in para. V303:

Pipe material: A 335, Gr. P22
Pipe size: NPS 4 (4.50 in. O.D.)
Pipe schedule: S40 (0.237 in.)
Corrosion allowance: 0.0625 in.
Design pressure: 250 psig
Design temperature: 1050°F
Total service life: 200,000 hr

Three service conditions are considered:

(a) Normal operation is 178,000 hr at 250 psig, 1,025°F.

(b) Expect up to 20,000 hr at design conditions of 250 psig, 1,050°F.

(c) Total of 2,000 hr at excursion condition of 330 psig, 1,050°F. (This is a 32% variation above the design pressure and it complies with the criteria of para. 302.2.4.)

Compute pressure-based equivalent stress, S_{pi}, from eq. (V1).

From Table A-1, S_d = 5.1 ksi at 1,050°F.

$$S_{p1} = 5.1\,(250/250) = 5.10 \text{ ksi}$$
$$S_{p2} = 5.1\,(250/250) = 5.10 \text{ ksi}$$
$$S_{p3} = 5.1\,(330/250) = 6.73 \text{ ksi}$$

NOTE: In eq. (V1), design pressure is used in this example for P_{max}, as this will always be conservative. Alternatively, the actual P_{max} of the piping system can be used.

The longitudinal stress, S_L, for each condition *i*, calculated in accordance with para. 302.3.5(c), is

$$S_{L1} = 3.0 \text{ ksi}$$
$$S_{L2} = 3.0 \text{ ksi}$$
$$S_{L3} = 3.7 \text{ ksi}$$

For seamless pipe, *W* is 1.0 for S_{p1}, S_{p2}, and S_{p3}, and for girth weld, *W* is 0.93, 0.91, and 0.91 for S_{L1}, S_{L2}, and S_{L3}, respectively. The equivalent stress, S_i, is the greater of S_{pi}/W and S_{Li}/W. Therefore, S_i is as follows:

$$\begin{aligned} S_1 &= \text{MAX}\,(S_{p1}/W, S_{L1}/W) \\ &= \text{MAX}\,(5.10/1.0, 3.0/0.93) \\ &= \text{MAX}\,(5.10, 3.23) = 5.10 \text{ ksi} \end{aligned}$$

$$\begin{aligned} S_2 &= \text{MAX}\,(S_{p2}/W, S_{L2}/W) \\ &= \text{MAX}\,(5.10/1.0, 3.0/0.91) \\ &= \text{MAX}\,(5.10, 3.30) = 5.10 \text{ ksi} \end{aligned}$$

$$\begin{aligned} S_3 &= \text{MAX}\,(S_{p3}/W, S_{L3}/W) \\ &= \text{MAX}\,(6.73/1.0, 3.7/0.91) \\ &= \text{MAX}\,(6.73, 4.07) = 6.73 \text{ ksi} \end{aligned}$$

T_i = temperature, °C (°F), of the component for the coincident operating pressure–temperature condition i under consideration

t_{ri} = allowable rupture life, h, associated with a given service condition i and stress, S_i

LMP and *C* are as defined in para. V303.1.3.

V303.2 Determine Creep-Rupture Usage Factor

The usage factor, u, is the summation of individual usage factors, t_i/t_{ri}, for all service conditions considered in para. V303.1. See eq. (V4).

$$u = \sum(t_i/t_{ri}) \quad \text{(V4)}$$

where

i = as a subscript, 1 for the prevalent operating condition; i = 2, 3, etc., for each of the other service conditions considered

t_i = total duration, h, associated with any service condition i, at pressure, P_i, and temperature, T_i

t_{ri} = as defined in para. V303.1.4

V303.3 Evaluation

The calculated value of u indicates the nominal amount of creep-rupture life expended during the service life of the piping system. If $u \leq 1.0$, the usage factor

From Table A-1, find the temperature, T_E, corresponding to each S_i:

$$T_{E1} = 1{,}050°F$$
$$T_{E2} = 1{,}050°F$$
$$T_{E3} = 1{,}020°F$$

Compute the *LMP* for each condition i using eq. (V2):

$$LMP = (20 + 5)\ (1{,}050 + 460) = 37{,}750$$
$$LMP = (20 + 5)\ (1{,}050 + 460) = 37{,}750$$
$$LMP = (20 + 5)\ (1{,}020 + 460) = 37{,}000$$

Compute the rupture life, t_{ri}, using eq. (V3):

$$a = 37{,}750/(1{,}025 + 460) - 20 = 5.42$$
$$t_{r1} = 10^{5.42} = 263{,}000 \text{ hr}$$

NOTE: In eq. (V1), design pressure is used in this example for P_{max}, as this will always be conservative. Alternatively, the actual P_{max} of the piping system can be used.

The longitudinal stress, S_L, for each condition i, calculated in accordance with para. 302.3.5(c), is

$$S_{L1} = 3.0 \text{ ksi}$$
$$S_{L2} = 3.0 \text{ ksi}$$
$$S_{L3} = 3.7 \text{ ksi}$$

For seamless pipe, W is 1.0 for S_{p1}, S_{p2}, and S_{p3}, and for girth weld, W is 0.93, 0.91, and 0.91 for S_{L1}, S_{L2}, and S_{L3}, respectively. The equivalent stress, S_i, is the greater of S_{pi}/W and S_{Li}/W. Therefore, S_i is as follows:

$$S_1 = \text{MAX}\ (S_{p1}/W,\ S_{L1}/W)$$
$$= \text{MAX}\ (5.10/1.0,\ 3.0/0.93)$$
$$= \text{MAX}\ (5.10,\ 3.23) = 5.10 \text{ ksi}$$

$$S_2 = \text{MAX}\ (S_{p2}/W,\ S_{L2}/W)$$
$$= \text{MAX}\ (5.10/1.0,\ 3.0/0.91)$$
$$= \text{MAX}\ (5.10,\ 3.30) = 5.10 \text{ ksi}$$

$$S_3 = \text{MAX}\ (S_{p3}/W,\ S_{L3}/W)$$
$$= \text{MAX}\ (6.73/1.0,\ 3.7/0.91)$$
$$= \text{MAX}\ (6.73,\ 4.07) = 6.73 \text{ ksi}$$

$$a = 37{,}750/(1{,}050 + 460) - 20 = 5.00$$
$$t_{r2} = 10^{5.00} = 100{,}000 \text{ hr}$$

$$a = 37{,}000/(1{,}050 + 460) - 20 = 4.50$$
$$t_{r3} = 10^{4.50} = 31{,}600 \text{ hr}$$

Compute the usage factor, u, the summation of t_i/t_{ri}, for all service conditions:

$$t_1/t_{r1} = 178{,}000/263{,}000 = 0.68$$
$$t_2/t_{r2} = 20{,}000/100{,}000 = 0.20$$
$$t_3/t_{r3} = 2{,}000/31{,}600 = 0.06$$

$$u = 0.68 + 0.20 + 0.06 = 0.94 < 1.0$$

Therefore, the excursion is acceptable.

Annex 3
Inlet port area calculation of the valve
(according to UOP specs)

1. **Port area for catalyst slide valves shall be calculated using the following formula**

$$A_{Port} = \frac{1.5 * W}{\% \text{ open} * C_d * \sqrt{\Delta P * \rho}}$$

where:

A_{port} = Total port opening, in^2
W = Flow rate, lb/s
% open = Percent of the port opening left open by the disc in the normal operating position, per slide valve specification (express as a decimal i.e. 0.60 for 60% open)
C_d = Orifice coefficient: 0.83 for catalyst service
ΔP = Pressure drop across valve, psi
ρ = Density of flowing media, lb/ft^3

2. **Port area for flue gas slide valve shall be calculated using the following formula**

$$A_{Port} = \frac{Q * \sqrt{T}}{\% \text{ open} * 355.533 * C_d * P_1 * N * \sqrt{MW}}$$

where:

$$N = \sqrt{\frac{(P_2/P_1)^{2/k} - (P_2/P_1)^{(k+1)/k}}{[(k-1)/2] * [2/(k+1)]^{(k+1)/(k-1)}}}$$

A_{port} = Total port opening, in^2
Q = Flow rate, lb/hr
T = Temperature, °R

% open = Percent of the port opening left open by the disc in the normal operating position, per slide valve specification (express as a decimal i.e. 0.60 for 60% open)
C_d = Orifice coefficient: 0.90 for cold wall and 0.85 for hot wall valve
MW = Gas molecular weight
P_1 = Inlet pressure, psia
P_2 = Outlet pressure, psia
k = Specific heat ratio, C_P/C_V

(Cp/Cv) Ratio of the Heat Capacity at Constant Pressure to the Heat Capacity at Constant Volume for the Flue Gas