Restriction Orifice

Single or Multi Stage Orifice to

Reduce Pressure or

Limit the Flow Rate

Restriction Orifice Plates

Series ROPS

✓ Principle

Restriction Orifice Plates and Critical Flow Devices and their calculation, construction and application is going to described in this section; for pressure control and flow limitation which are known usually as RO and FO devices. Please consider there are differences between them, although all are known as Restrictions.

Flow measurement of liquid, gas and steam according to the differential pressure principle has been recognised principle for very many years using orifice plates, venturi tubes and flow nozzles. A restriction in the pipe line creates a pressure drop if the fluid flows. The pressure drop is determined by the velocity of the fluid.

The method is thoroughly described in many standards, practices and handbooks.

This special use is not covered by international standards and is only *indirectly* mentioned in literature.

However we have to separate the description in to two parts:

- Restriction Orifice Plates
- Critical Flow Devices

- **Part 1:Restriction Orifice Plates**

As the headline implies two main types of flow limitation exist. One type is the restriction orifice plate, which in construction and calculation follows the orifice plate, i.e. the restriction orifice plate normally has a thickness of 3- 6 mm depending on the size of the tube.

The discharge coefficient of the restriction orifice plate is, as for the orifice plate, approximately 0.6 according to ISO 5167 standard.

For this type of restriction orifice plates the flow value through the orifice plate will vary with the pressure before and after the orifice plate.

The restriction orifice plate is mostly applied in *Non-critical flow* limitation. This could for instance be after a control valve in order to divide the required pressure loss into two elements. This is done to reduce the noise in liquids and to avoid cavitation. It is advisable to avoid cavitation in order to protect the process elements before the restriction orifice plate in blow-down systems, and as flow limiter.

The use of the expression "non-critical" must not be compared to the word "critical" in critical flow devices. Non-critical is here to be understood as non-complicated with less requirements for the accuracy.

- **Part 2: Critical Flow Devices**

A safe flow limitation is obtained through the application of a critical flow device.

- Gas flow

When a gas flow is passing through a restriction the density is reduced and the velocity of the gas flow is increased. If the downstream pressure is reduced at the same time as the upstream pressure is kept constant, then the flow quantity or Value will increase. A further reduction in the pressure will furthermore, increase the flow quantity, until the so called *"Choked Flow"* is reached. After this a further reduction of the pressure will not increase the flow quantity.

- Liquid flow

If the pressure in *"Vena Contracta"* (because of high velocity) decreases to the vaporisation pressure of the liquid, a cavitation zone is created. This cavitation zone will act as a flow limitation.

What is Cavitation?

Cavitation occurs frequently in liquid flow restrictions where a large pressure drop exists. When the downstream pressure is below the vaporisation pressure vapour bubbles are created. When the liquid has passed through the restriction orifice plate the area is increased, the velocity decreases, and the pressure increases. This leads to the collapse of the vapour bubbles.

This collapse of the bubbles generates noise, and the plate as well as the tube will erode. It is, therefore, important to avoid a full cavitation through a liquid flow restriction.

A differential pressure of DP as indicated below should be used:

$$F_l = \Delta P / (P_1 - P_v) < 0.7$$

F_l= Critical flow factor

P_1= Upstream pressure

P_v= Vaporisation pressure (or Vapour Pressure)

At particularly large drops in pressure more restriction orifice plates in series are used to avoid full cavitation.

It means sometimes we have to use a "Restriction Orifice Spool" or as it is famous in piping and instrumentation: *"MULTI STAGE RESTRICTION ORIFICE"*

What is Discharge Coefficient (Cd)?

The discharge coefficient *Cd* is dependent on the Reynolds No. It has been shown by Cunningham that a standard plate constructed according to ISO 5167 cannot create a critical flow.

Ward-Smith has shown theoretically that critical velocity can be obtained, when the discharge coefficient is approaching 1.

The discharge coefficient is 0.839 if:

$$1 < t/d < 7$$

Where t = thickness of the plate and d = bore of the plate.

The ratio t/d can be reduced to 0.3, if the upstream side of the plate is very sharp. Furthermore, t/d can be increased to 10 or more, if the bore is very smooth.

Below t/d = 0.3 a critical flow cannot be obtained.

Calculation of the thickness of the plate

Apart from the determination of the thickness of the plate, with respect to the discharge coefficient, the determination must also include a calculation with regard to the strength of the plate; we call it Mechanical Calculation.

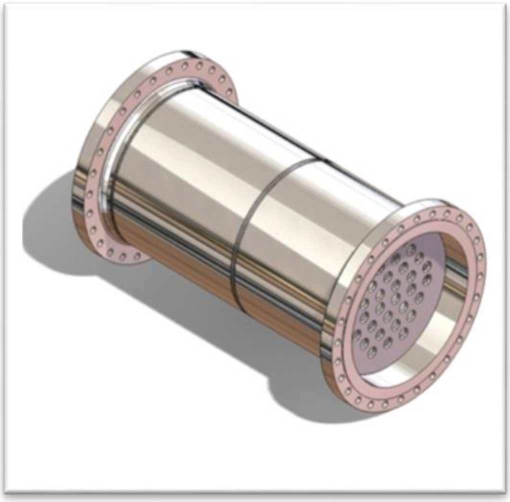
Different standards can be used for the calculation, but the common standard is the ASME.

According to ASME Boiler and Pressure Vessel Code section VIII div. 1 chap. UG 34 the thickness of the plate is calculated as a flat blank.

Since the plate has a bore a complete calculation can be made with regard to reinforcement of the bore according to chap. UG 39 (b) of same reference.

Single Stage or Multi Stage?

When the required pressure drop is more than critical pressure of the fluid, we have to use two or more orifice plates queue after each other. It means we need a SPOOL instead of a simple PLATE. The calculation for each step and the layout of steps vary case by case.



Single Hole or Multi Hole?

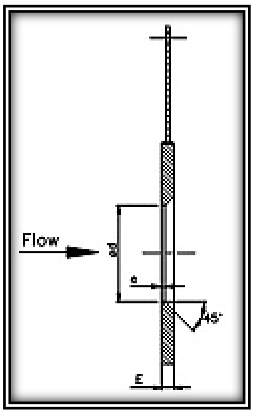
When flow goes through the bore, according to the Vena diameter and velocity, a sound appears. To avoid increasing this sound, sometimes, we can use several small bores instead of one single bore. This solution not only reduces the sound level, but also avoid dangerous vibration.

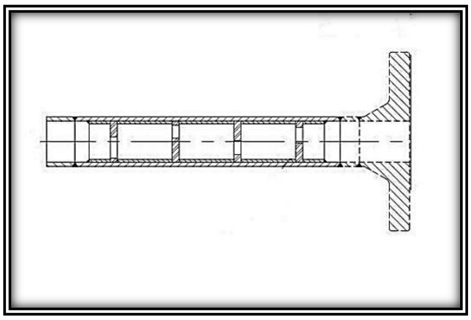
Construction

Restriction orifice plates must be sharp edged and with a cylindrical bore, i.e. without bevelling on the backside. Of course the Iranian Petroleum Standard (IPS) allows the bevelled bore with no mention to the calculation methods.

Apart from this the construction details are as for standard orifice plates for insertion between RF and RTJ flanges. However, it should be considered for thick RTJ plates to have a RTJ groove in the plate instead of having the plate as a part of a seal ring. This will give a better sealing, since a standard soft seal ring can be applied.

Typical Draft





Single Stage Restriction Orifice Plate *Multi Stage Restriction Assembly*

Mounting style : *Single Stage*: As same as Normal Orifice Plate; Between raised face flanges according To ANSI B16.36 or DIN 19214, Or other standards on request.

Multi Stage: Normally between flanges as a Spool, also BUT WELD type is available to be welded through a pipe line.

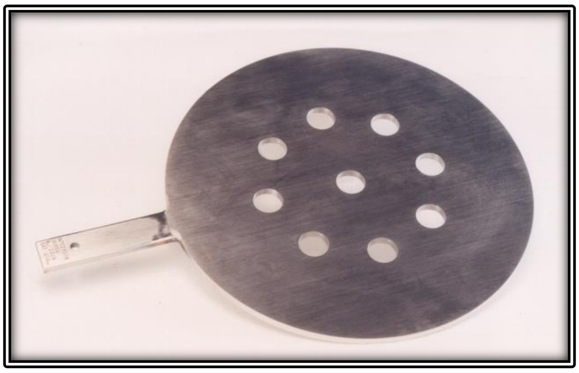
Marking : With name plate in AISI 316 with the following inscription: TAG no., serial no., Flange Size, type, Facing and pressure rating, Inlet and Outlet Pressure, inner pipe diameter, material of construction and UPSTREAM mark.

NOTE : Sound Level and Mechanical Calculation is mandatory as well as Flow or Process Calculations.

Multi Stage Restriction Orifice Assembly

(To avoid Vibration, Cavitation and high Sound Level in operation)

Some Samples of Restriction orifice, Single or Multi Stages:



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