CYCLONE SCRUBBER

APF-CSC

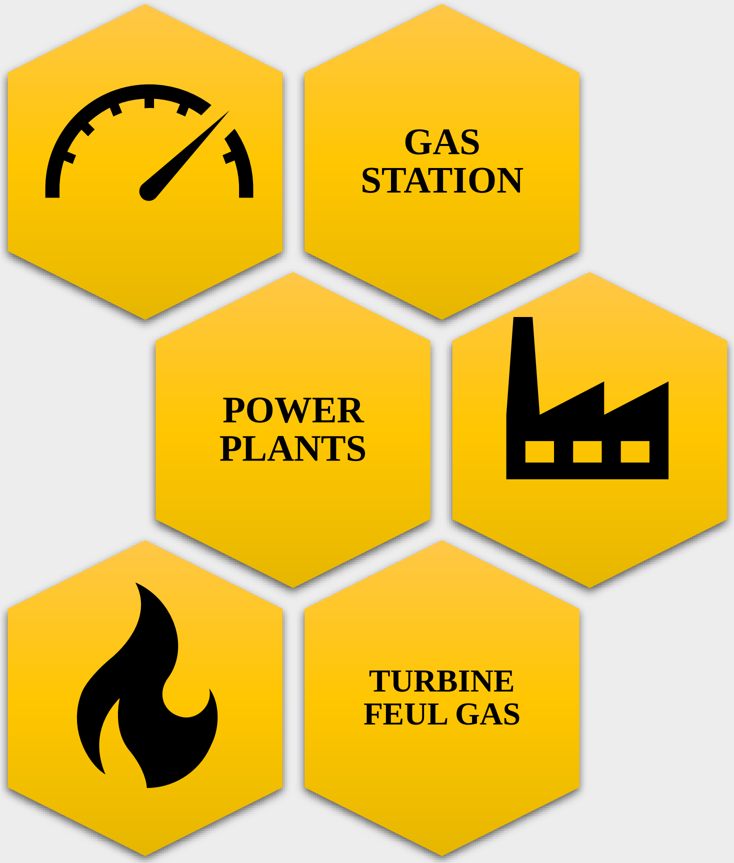
APADANA PETRO FARAYAND

Knowledge is our difference

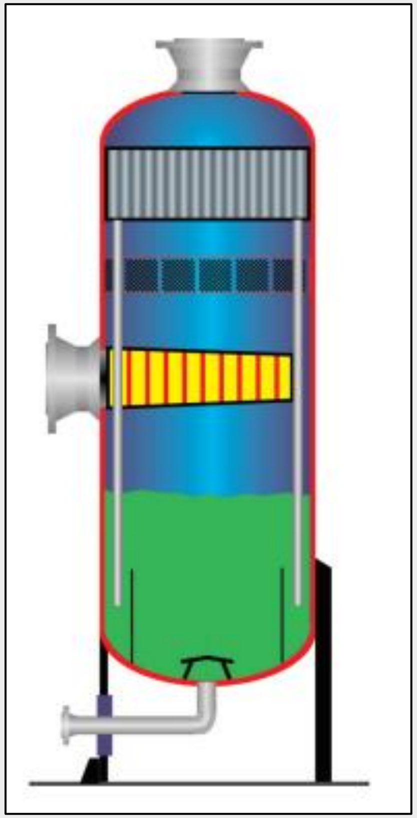
The APADANA PETRO FARAYAND scrubber provide effective, efficient, and economical removal of dust, dirt, scale, rust, and other solid foreign particles from different types of gas streams.

Usage

- ✓ **Gas station**
- ✓ **Gas treatment station for petrochemicals, power plants and industrial factories**
- ✓ **Turbine fuel gas**



Introduction

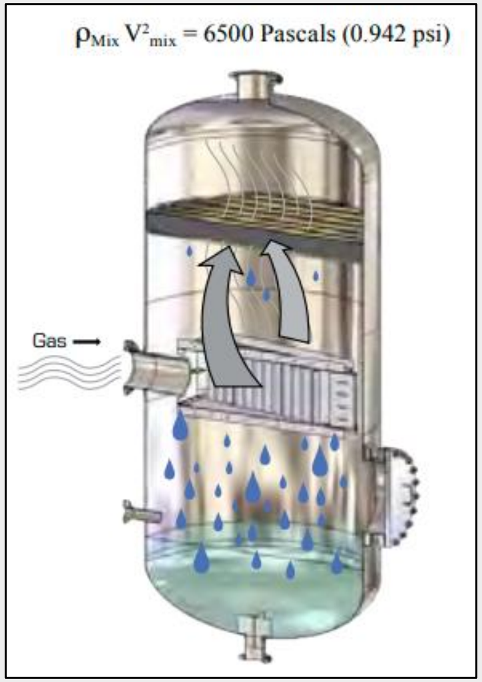


Scrubber or knockout drum is a vessel designed to handle streams with high gas-to-liquid ratios. The liquid is generally entrained as mist in the gas or is free-flowing along the pipe wall. These vessels usually have a small liquid collection section. Vertical separators, are usually selected when the gas-liquid ratio is high or total gas volumes are low. In a vertical separator, the fluids enter the vessel through an inlet device whose primary objectives are to achieve efficient bulk separation of liquid from the gas and to improve flow distribution of both phases through the separator. Liquid removed by the inlet device is directed to the bottom of the vessel. The gas moves upward, usually passing through a mist extractor to remove any small entrained liquid droplets, and then the vapor phase flows out of the vessel. Liquid removed by the mist extractor is coalesced into larger droplets that then fall through the gas to the liquid reservoir in the bottom. The ability to handle liquid slugs is typically obtained by increasing vessel height to accommodate additional surge volume. Level control is normally not highly critical and liquid level can fluctuate several inches without affecting the separation performance or capacity of the vessel. Typical vertical separator L/D ratios are normally in the 2–4 range.

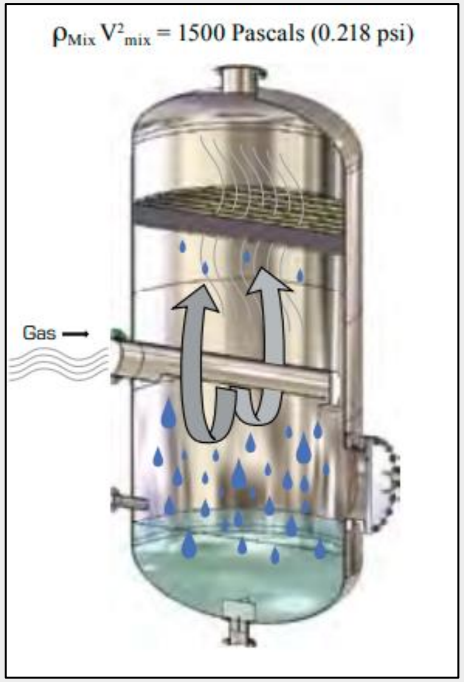
Inlet Devices

The importance of the inlet device with respect to separation performance has been identified only relatively recently, mainly through the use of Computational Fluid Dynamics (CFD) modeling. The main functions of the inlet device are: 1) Reduce the momentum of the inlet stream and enhance flow distribution of the gas and liquid phases. 2) Efficient separation of the bulk liquid phase. 3)Prevent droplet shattering and re-entrainment of bulk liquid phase. There are several different types of separator inlet devices that are commonly use: diverter plat, half-pip, Schoepentoeter

In addition to the inlet device itself, it has been determined that the inlet piping configuration is also important. The Schoepentoeter type inlet devices generally provide improved separation performance compared to the others.



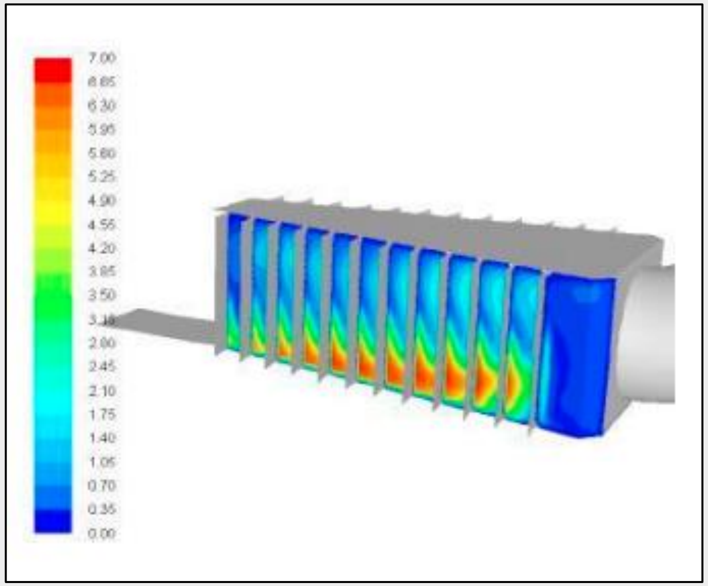
Schoepentoeter

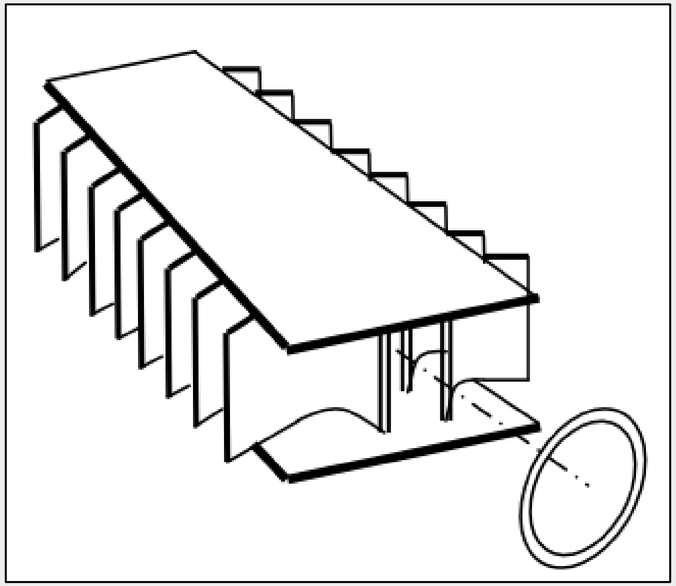


Half-pipe

Schoepentoeter

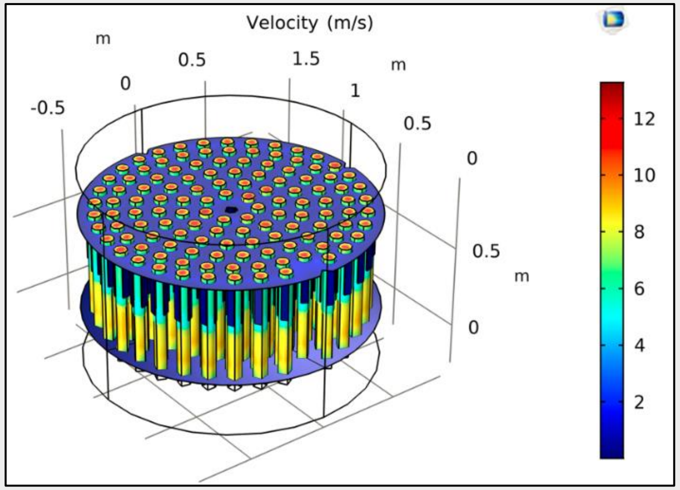
Schoepentoeter was first designed and introduced by Shell company and is a multi-vane inlet device used in horizontal and vertical separators where there is a requirement for good flow distribution with minimum shear and pressure drop. Benefits of this device compared with simpler deflectors include reduced agitation and hence improved 2 and 3 phase operational performance, more stable level control, and reduced foaming. For vertical vessel installations, usually where there is a high gas flow relative to the liquid flow, the Schoepentoeter provides excellent vapor distribution allowing a reduced height to the mass transfer or mist eliminator internals. This device works by smoothly dividing the incoming flow into various segments using an array of curved vanes to suit the overall geometry of the inlet nozzle and distributor length. To achieve this effect the vanes start with a wide spacing and gradually reduce the gap, giving the unit its characteristic tapering shape. The Schoepentoeter is usually constructed from stainless steel and is designed to be installed in sections through a vessel manway and assembled in the vessel.

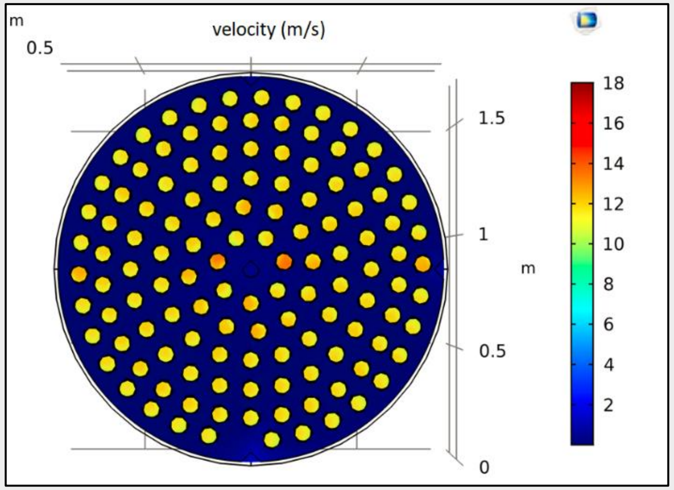




In APF-CSC scrubber designed by APADANA PETRO FARAYAND, cyclones are used as the second part of separation. The cyclone is, in essence, a stainless-steel tube with a swirler at the inlet and longitudinal slits in the tube wall. Liquid is separated by impaction of droplets on the tube wall by the centrifugal forces induced by the swirling gas flow. Re-entrainment of this liquid is prevented by draining the film via the slits to the liquid collection chamber outside the tube. To ensure the proper functioning of the cyclone, it is essential that some gas is also bled through these slits. The main fraction of the gas leaves the cyclone via the primary gas outlet at the top. Drain pipes guide the liquid, collected in the space between the tubes and on the upper cover of the cyclone section, to below the liquid level.

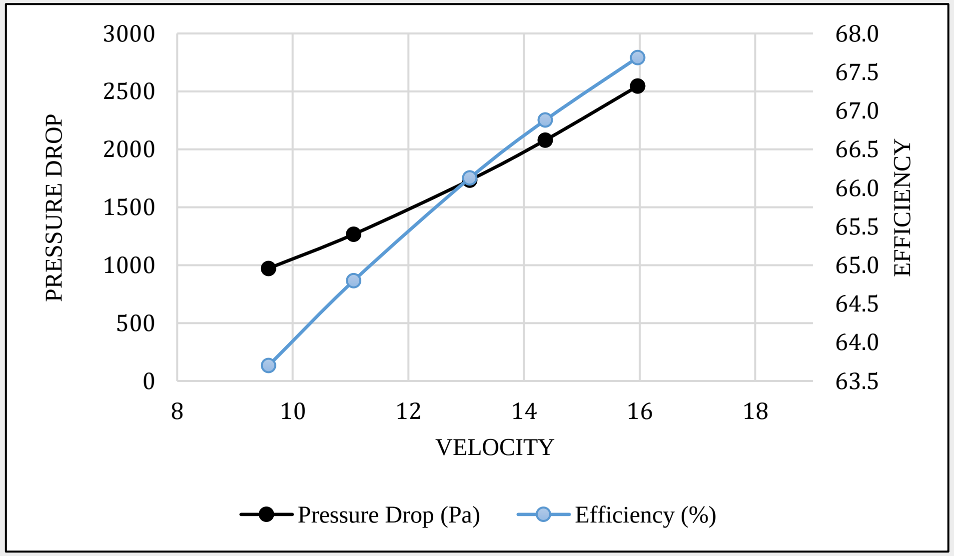
The cyclones used in the APF-CFS scrubber have been optimized after a research period. Computational fluid dynamic is very useful to investigate and optimize various parameters including separation efficiency, pressure drop, velocity Contour and etc. The flow inside the cyclone is a two-phase flow which includes the inlet gas and the solid particles. Therefore, in order to model the flow inside cyclone, it is necessary to use two-phase models. In this method, the momentum equations for the flow are solved and the effect of the liquid on the solid is investigated through the drag force and the slip velocity between the liquid and the solid particles. The picture below shows velocity and pressure contour in cyclone bundle using COMSOL software.



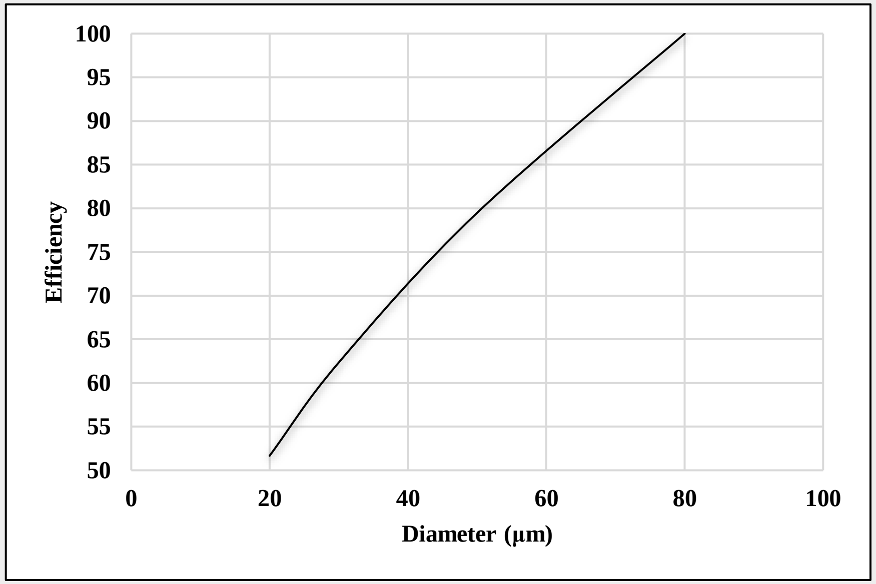


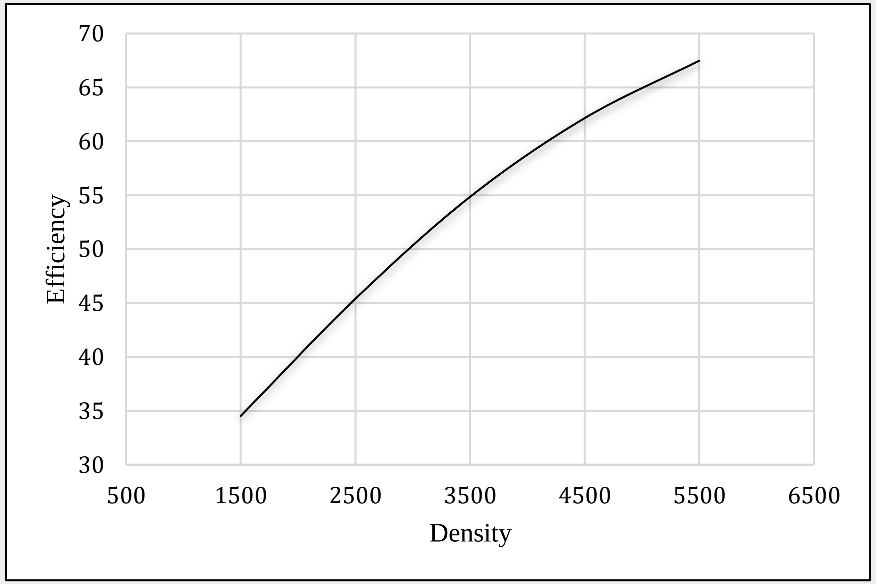
The amount of pressure applied to the cyclone is one of the effective factors in determining their performance and useful life. The following figure shows the pressure distribution at different points in the cyclone. In this figure, the red points are high pressure areas and the blue points are low pressure areas. According to the figure, the pressure in the area close to the cyclone blade is much lower than in other areas, so that the pressure applied to the blade is less than the pressure of the outlet medium. This pressure drop is due to the strong radial flow and the return flow near the blade. Therefore, according to the explanations given, the pressure applied to the blade is very low and this factor reduces corrosion and increases the useful life of this cyclone compared to conventional cyclones. One of the advantages of using the mentioned cyclone is that the efficiency does not depend on the input speed. In conventional cyclones, the efficiency increases with increasing velocity due to the increase of the radial component of velocity and centrifugal force. In this type of cyclone, although the efficiency increases with increasing speed, but the amount of this increase is very small.

Although the efficiency increases with increasing the inlet gas speed, the pressure drop also increases with it. Therefore, in addition to increasing the efficiency, the allowable pressure drop must also be considered. The following figure shows the change in efficiency and pressure drop versus change in inlet gas speed. As mentioned before, in cyclones designed by Apadana Petro Farayand, inlet gas speed changes have little effect on efficiency changes, as the figure below confirms. This diagram is drawn for particles with a diameter of 30 microns.



The diameter and density of the pollutants entering the cyclone have a great impact on the performance and separation efficiency. As the diameter and density increase, separation becomes easier and efficiency increases. As the density increases, the force on the particles, including the weight force and the centrifugal force, increases and more particles are separated from the gas stream. It should be noted that the density of solid particles has no effect on pressure drop. The following diagrams show the effect of diameter and density of particles entering the cyclones on separation efficiency.





BENEFITS

INCREASE EQUIPMENT UPTIME

REDUCE MAINTANANCE COST

EXTENDS EQUIPMENT CHANGEOUTS

Mechanical features

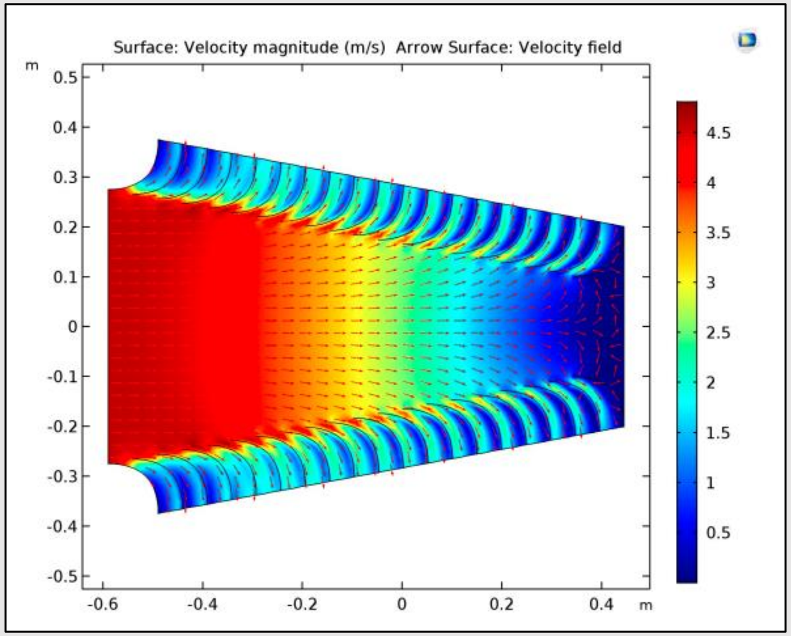
- ✓ **Safety opening system**
- ✓ **Level, pressure and differential pressure gage included**
- ✓ **Inspection openings**
- ✓ **Vent and drain valve included**
- ✓ **Low pressure drops**
- ✓ **Self-supported and lifting lug included**
- ✓ **Long life 'O' ring sealing design**
- ✓ **Standard class rating ASME 150,300,600**

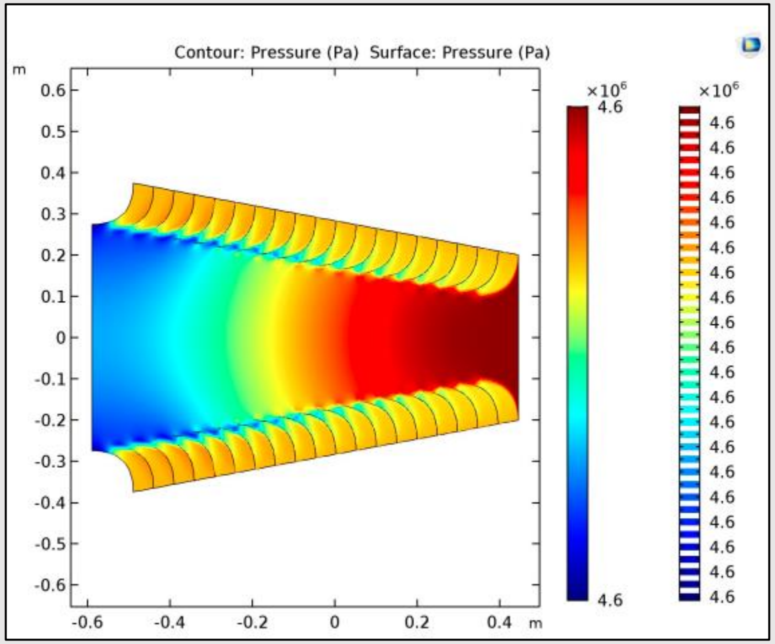
Optional features

- ✓ **Design for specific capacity, pressure and temperature**
- ✓ **Design class rating ASME 900,1500,2500**
- ✓ **Design for sour gas and corrosive fluid**
- ✓ **Use of level switch, level alarm, differential**

Knowledge is our difference…

We believe that investment in research and development is an essential component for long term success. Computational Fluid Dynamics is a reliable tool for design optimization, troubleshooting, and product development. Flow distribution is critical in all gas-liquid and liquid-liquid separation vessels. As vessel sizes are reduced or more capacity is expected from existing equipment, traditional design rules for vessel geometry and flow distribution must be reviewed for all elements that can affect separation performance such as flow velocity through inlet and outlet nozzles, spacing between nozzles, internals and liquid levels. CFD modeling is used by engineers at APADANA PETRO FARAYAND to simulate flow conditions and vessel geometry. The modeling provides a close approximation of the fluid flow profile inside the vessel.





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