CYCLONE FILTER SEPARATOR

APF-CFS

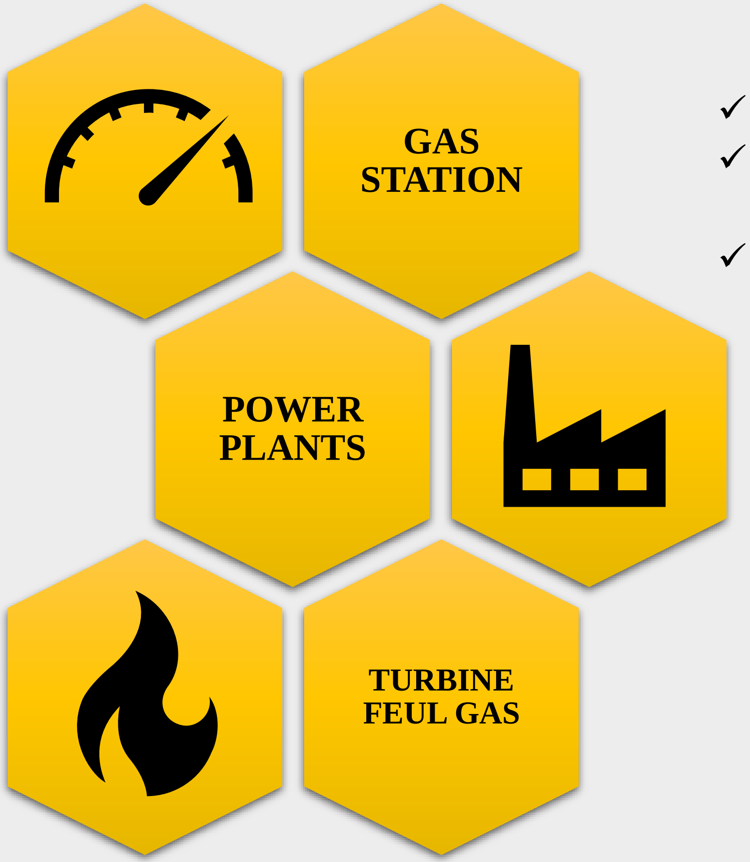
APADANA PETRO FARAYAND

Knowledge is our difference

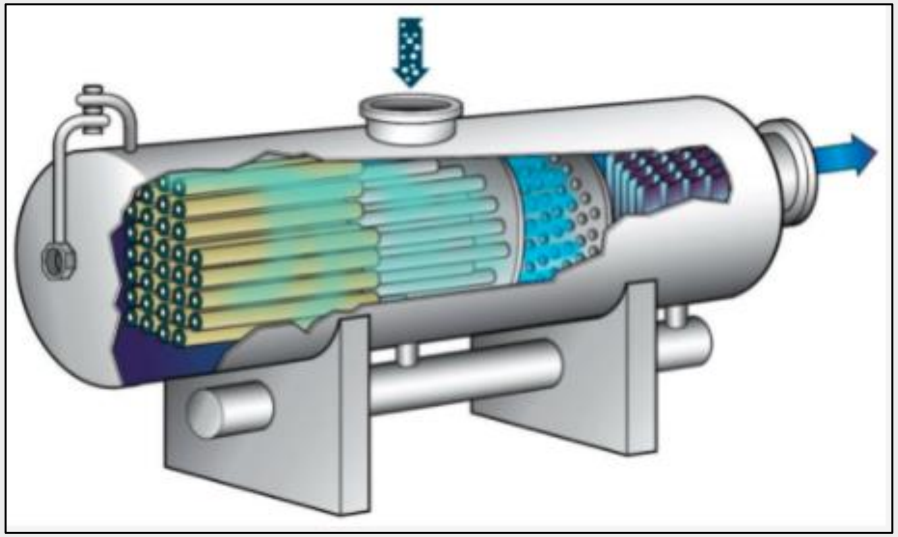
The APADANA PETRO FARAYAND filter separator provide effective, efficient, and economical removal of dust, dirt, scale, rust, and other solid foreign particles from different types of gas streams.

Usage

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

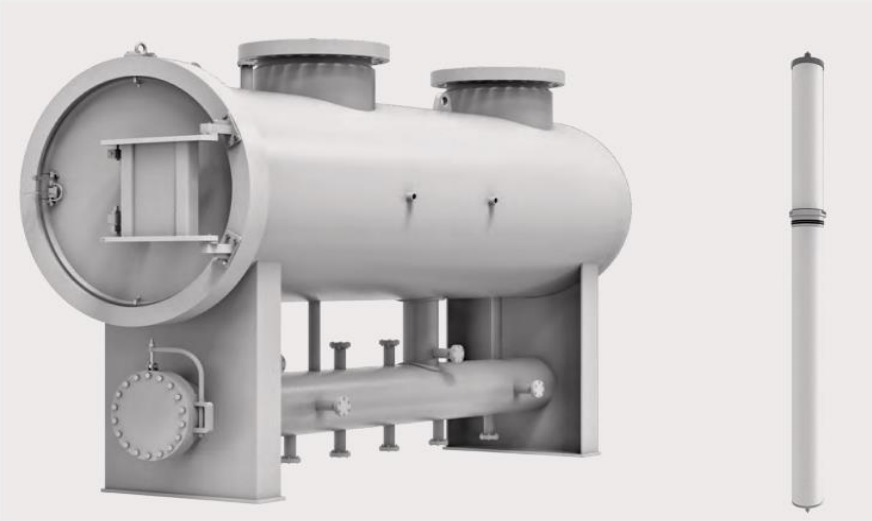


Introduction



A filter separator usually has two parts. The first part contains filter elements while the second usually contains a vane type, swirl tube or wire mesh mist extractor. As the gas flow through filter elements, the liquid droplets coalesce into larger particle and fall to the center core. While gas moves toward second part, remaining particles removed. The second part usually contain wire mesh or vane type separator. Filter separator also contains a lower barrel for liquid storage. Separation of oil, water, hydrocarbons and solid particles in the gas stream is critical to protecting downstream equipment and can prevent major damage to equipment such as compressors and valves in downstream units. Due to the very small pores in the filter elements, this equipment also acts as a filter for solid particles.

A cartridge filter consists fiberglass as a filter material. A perforated support body ensures optimum strength and perfect protection for the filter fleece. The filter element can filter out very fine dirt particles of 3 to 50 microns. Due to the large surface, the filter elements are capable to eliminate contaminate with a low-pressure loss, high-volume flow and long service life. Flow of the gas is from the outside to the inside of the filter cartridge. Thus, the contained dirt particles remain adhered to the surface of the filter medium. The cleaned gas is discharged from the filter cartridge and returned to the system.



The pressure drop in the filters is due to two phenomena. Pressure drop due to fluid passing through the filter and pressure drop due to solid remaining on the filter. The following equation illustrates this point.

$$\Delta P = \Delta P_r + \Delta P_s$$

To estimate each of these two parameters, there are many equations. One of them has shown below.

$$\Delta P_r = K_r \eta \upsilon$$

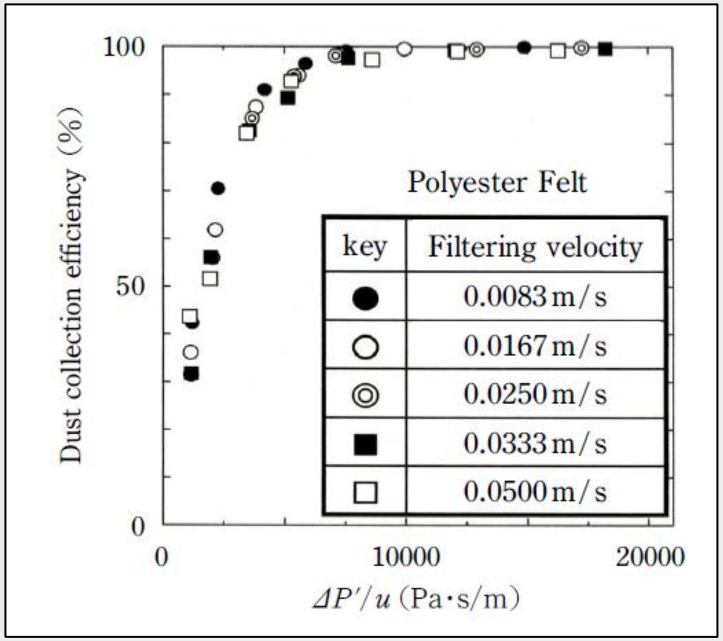
$$\Delta P_s = K_s \eta h(t) \upsilon$$

In the above equations, K_r and K_s are the coefficient of resistance of the filter and the solid respectively, η is the dynamic viscosity of the gas, υ is the velocity of the gas inside the filter and h(t) is the solid thickness left on the filter. The K_r and K_s coefficients are available in handbooks and articles. Very few studies have been performed on changing the efficiency of the filter by increasing the residual solid on the filter. In one of these studies, the change in efficiency of polyester filters in terms of pressure drop is expressed as the following equation.

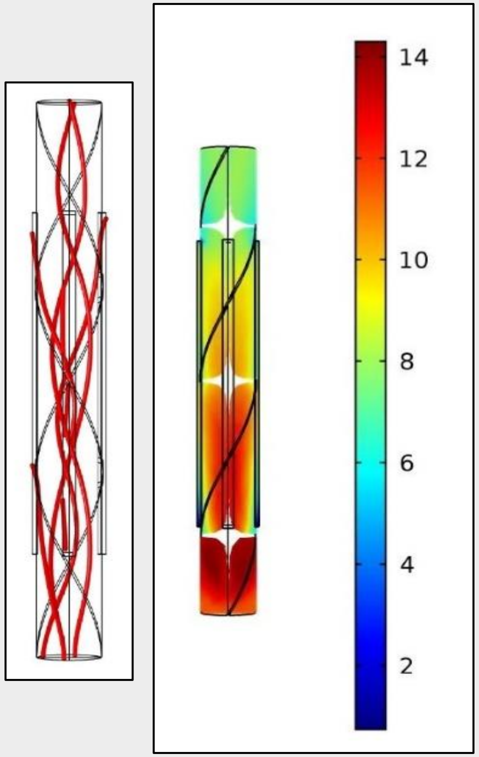
$$\eta = 1 - \exp\left(-1.36 D_p^{\frac{2}{3}} \left(\frac{\Delta P}{u}\right)^{\frac{6}{5}}\right)$$

In the above equation, D_p is the particle diameter in meters, ΔP is the filter pressure drop in Pa and u is the filtration rate in m/s .

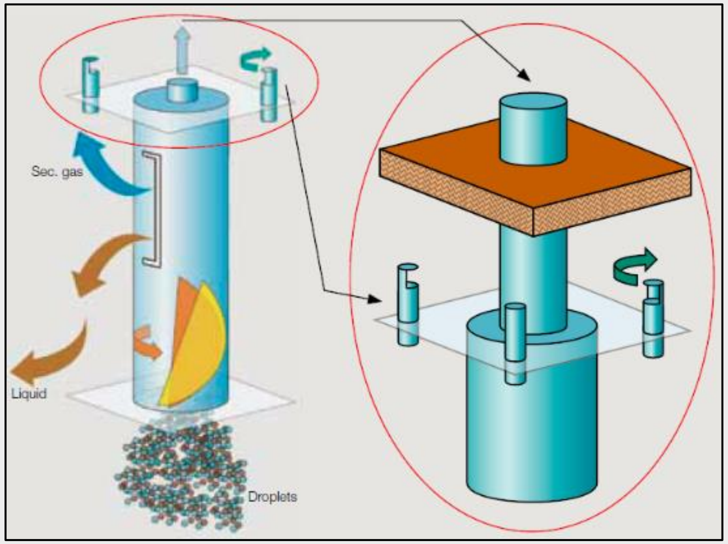
As an example, for a particle size with a diameter of 0.4 microns, the efficiency change diagram with respect to the change in the ΔP/u parameter is shown in the figure below. As can be seen, the efficiency value for ΔP/u greater than about 10,000 is equivalent to 1. Typically, filtration speeds in industrial units are 0.1 meters per second and the minimum pressure drop is equivalent to 2 psi. Thus, the minimum ΔP / u in industrial units is 137895 Pa.s/m. Thus, in industrial units, the efficiency for all values of pressure drop depending on the particle size is about 1. After using the filter for a while, a layer of solid covers the surface of the filter, and this solid layer helps to improve the efficiency of the filtration.



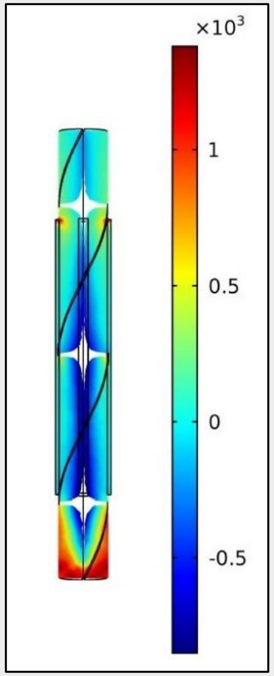
In APF-CFS filter separator designed by APADANA PETRO FARAYAND, cyclone is used as the second part of separation. The cyclone is, in essence, a stainless-steel tube with a swirler at the inlet and longitudinal slits in the tube wall. Liquid is separated by impaction of droplets on the tube wall by the 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.



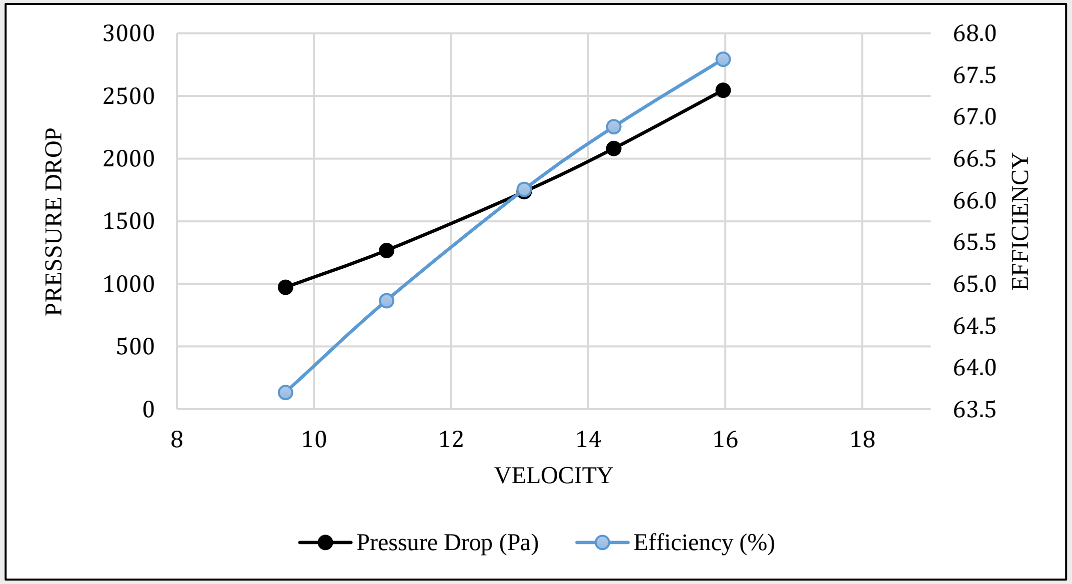
The cyclones used in the APF-CFS filter separator have been optimized after a research period. Computational fluid dynamic is very useful to investigate and optimize various parameters including separation efficiency, pressure drop, velocity contour and etc. The flow inside the cyclone is a two-phase 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 shows velocity and stream lines at different point inside cyclone.



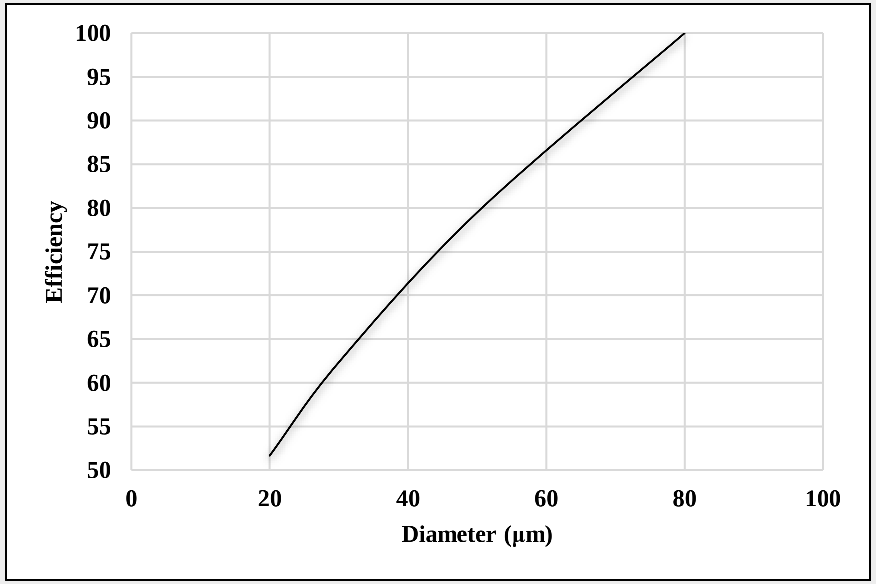
The amount of pressure applied to the cyclone is one of the effective factors in determining their performance and useful life. The following figure shows the pressure distribution at different points in the cyclone. In this figure, the red points are high pressure areas and the blue points are low pressure 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.

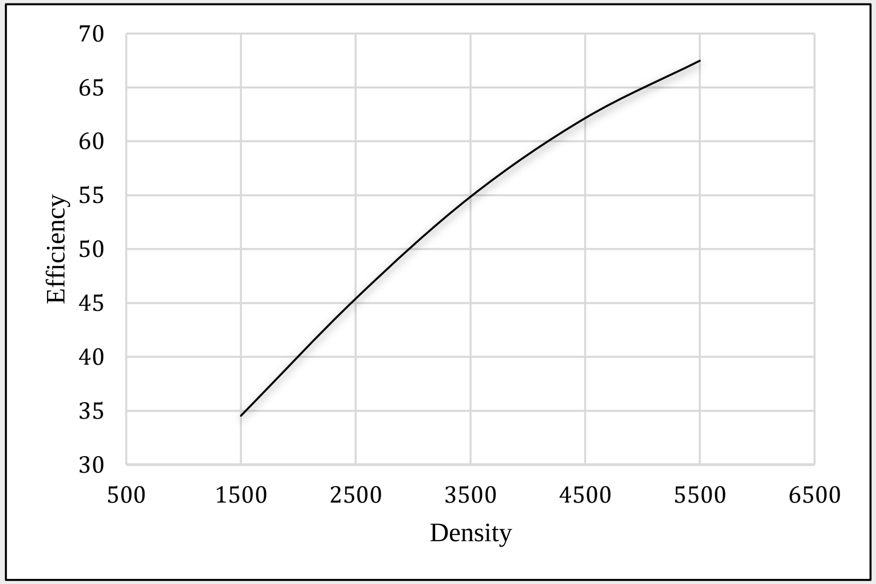


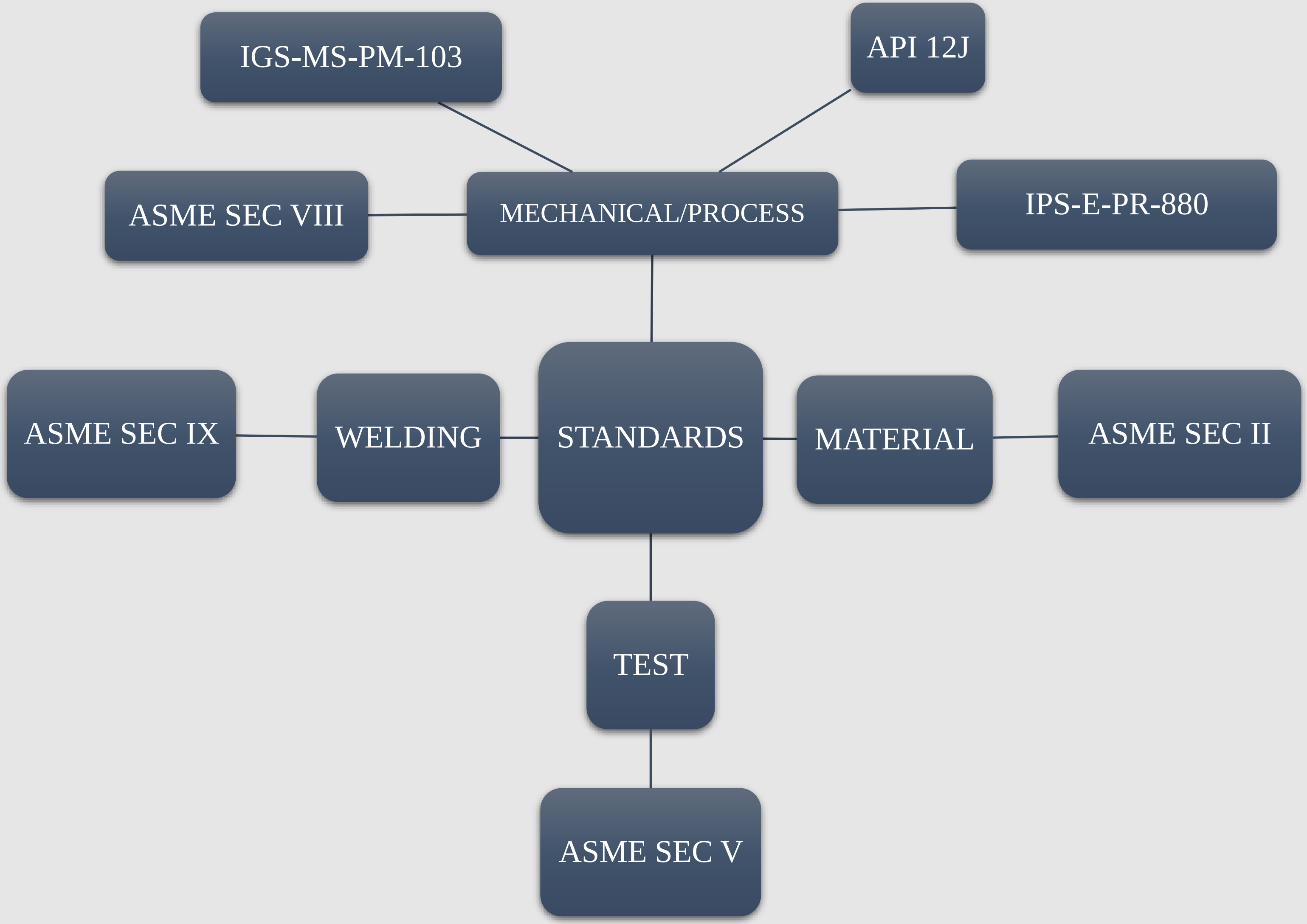
Although the efficiency increases with increasing the inlet gas speed, the pressure drop also increases with it. Therefore, in addition to increasing the efficiency, the allowable pressure drop must also be considered. The following figure shows the change in efficiency and pressure drop versus change 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 rise up. 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.

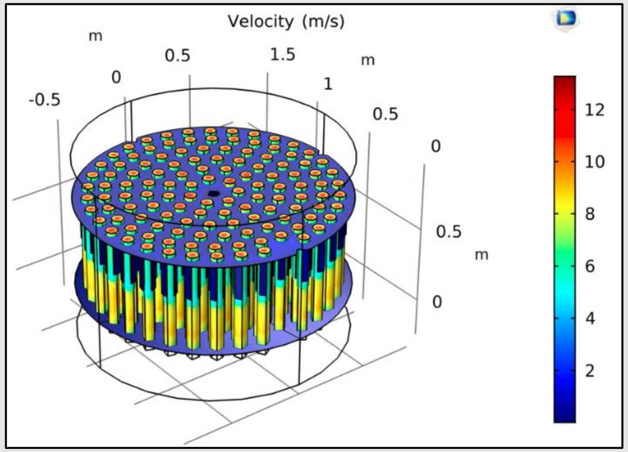


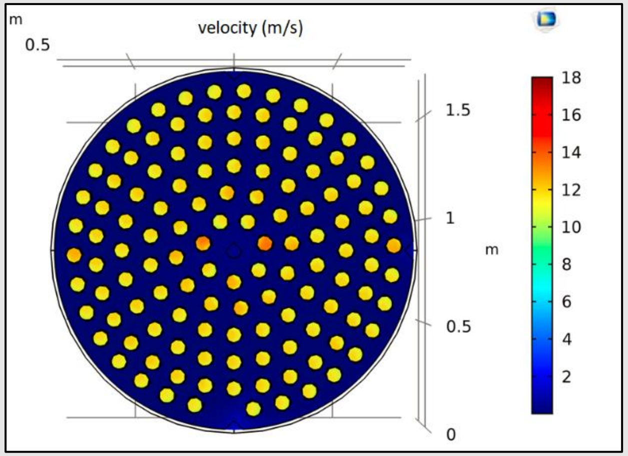



IGS-MS-PM-103
API 12J
ASME SEC VIII
MECHANICAL/PROCESS
IPS-E-PR-880
ASME SEC IX
WELDING
STANDARDS
MATERIAL
ASME SEC II
TEST
ASME SEC V

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





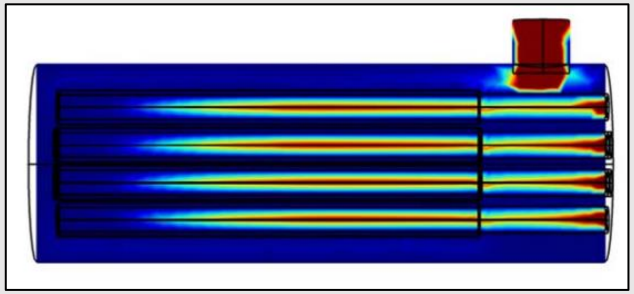
Mechanical features

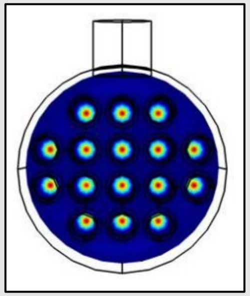
- ✓ ASME type quick opening closure
- ✓ Safety opening system
- ✓ Level, pressure and differential pressure gage included
- ✓ Inspection openings
- ✓ Vent and drain valve included
- ✓ Low pressure drops
- ✓ Self-supported and lifting lug included
- ✓ Long life 'O' ring sealing design
- ✓ Standard class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

Knowledge is our difference…

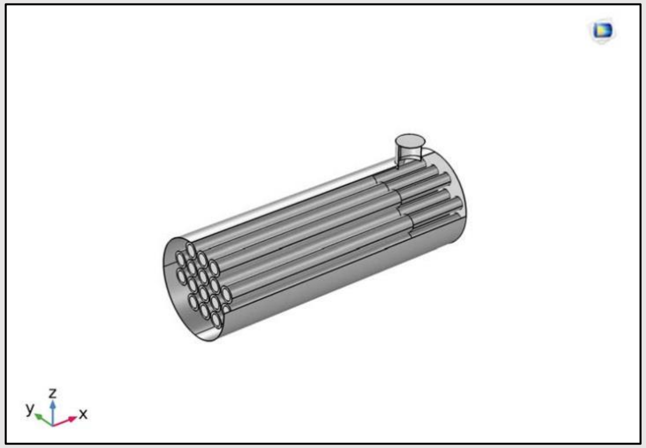
We believe that investment on research and development is an essential component for long term success. Computational Fluid Dynamics is a reliable tool for design optimization, troubleshooting, and product development. Flow distribution is critical in all gas-liquid and liquid-liquid separation vessels. 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.

In the pictures below, using COMSOL software, velocity contours are shown along the length and cross section of the filter elements.

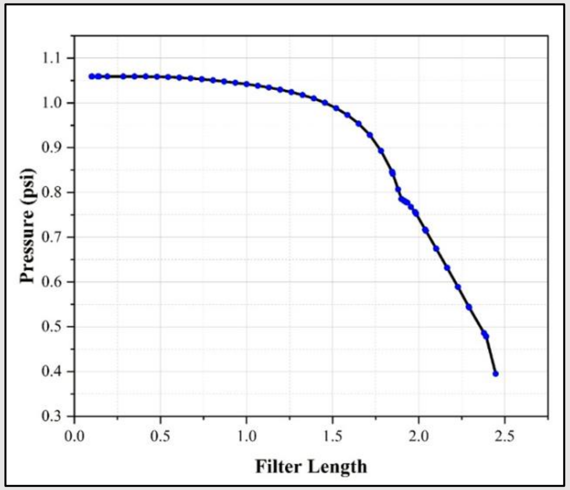




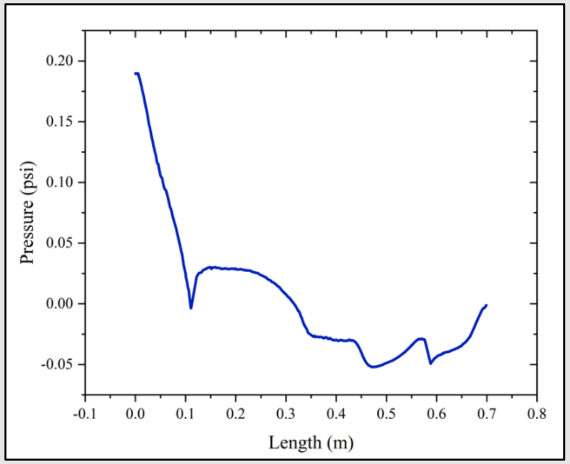
The following picture shows geometry of filter element part, made by COMSOL software.



The following picture shows the pressure change diagram in terms of element filter length using COMSOL software.



The following picture shows the pressure change diagram along cyclone length, using COMSOL software.



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