Pall Corporation

Technical Bulletin

Bulk Diesel Fuel Filtration for Mining

Sizing for annual fuel volumes and contamination mass

Introduction

It's a well known fact within the mining industry that contamination within diesel fuel is costly and is something that should be avoided. However, preventative measures come at a cost too and therefore it is critical to understand the many possibilities that can cause contamination and address each one prior to choosing a suitable solution.

When selecting a bulk filtration system there are several things to consider – capital cost, system size, filtration efficiency, installation and location of the system. All of these important aspects should be discussed with a filtration solutions partner to ensure that the correct system is selected and installed. This document takes a look at the topic of sizing bulk diesel fuel filtration systems and the important role it plays in the bulk fuel filtration selection process for the mining industry.

Contamination

Many types of contaminants exist in diesel fuel – hard abrasive particles, waxes and other soft resinous materials, including fuel break down products, asphaltenes in some fuels, microbial growth, air and water. The hard abrasive particles are the predominant cause of wear of injector surfaces and nozzles. The predominant wear mechanisms are abrasive and erosive wear. Abrasive wear is caused by the entrapment of particles in between moving surfaces that are in sliding contact. These particles damage the surfaces, altering clearances, which affects the delivery of the fuel to the combustion chamber (see Figure 1).

Figure 1: Injector plunger showing abrasive wear.

Erosive wear is caused by high velocity particles impinging on surfaces. In fuel injectors, erosive wear erodes the spray nozzle surface, altering its geometry, which affects the spray pattern, combustion efficiency, and overall fuel economy (see Figure 2).

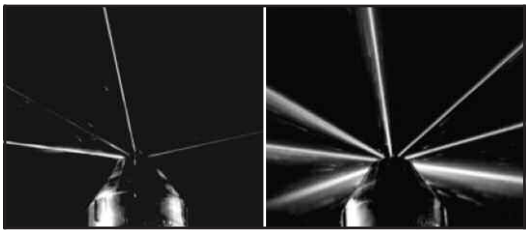

Figure 2: Injector spray patterns showing both worn and new injectors.

The risk of fuel system wear is increased with the use of low sulfur diesel fuels. Low sulfur diesel fuels are produced during the hydro-treatment phase in the refinery. The procedure involves the removal of nitrogen and sulfur compounds, polar materials, bicyclic aromatics, polycyclic aromatics, and oxygenated compounds. While it has been reported that the removal of sulfur has shown no detrimental effects to engine performance, the removal of other compounds can lower the lubricity of fuel, resulting in potential injector system component wear, especially in modern fuel systems such as MEUI, HEUI and Common Rail Injection systems, which are far more sensitive to inadequate lubrication that may be provided by low lubricity fuels. In locations where winter blends of fuel are required to prevent components of the fuel from solidifying and precipitating at low temperature, the fuel is blended with pour point depressants to prevent the above. However, there are instances of pour point depressant additives precipitating out of the fuel due to improper blending, resulting in very short filter element service life.

Sizing Bulk Fuel Filtration Systems for Mining

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When dealing with these huge volumes of fuel, it is important to understand the mass of the contamination that the filtration system is expected to remove . . .

Prior to purchasing any fuel filtration system for your mining operation, it is critical to consider not only the technological aspects of the product being evaluated, but also the inevitable annual filter element change-outs that follow the initial equipment purchase and the budget put in place to cover the costs.

In the increasingly competitive world of mining, finance for capital projects such as fuel system upgrades has become more and more difficult to justify. Even when an upgrade has proven to be a necessity or a viable proposition, cost is one of the main defining attributes that a mine site looks at when making a purchasing decision. The size of a filtration system is one of the main contributors to this cost.

Diesel filtration systems are typically sized using a formula that takes into account the pump flow rate (or rate of delivery required), fuel viscosity, fuel density, and system pressures. Once these factors are known, a system can be sized. However, experience over recent years has shown that in most cases, fuel filtration solutions that are being presented to mine sites are drastically undersized for their intended purposes. On the surface this may seem strange, considering the formula noted above, however, upon deeper analysis, systems are typically found to be sized missing one key aspect in the sizing formula. The missing aspect is the annual fuel volumes being used at the mine site and the annual mass of contamination that this fuel carries. Why is this important?

Mine sites are one of the largest single consumers of diesel fuel anywhere in the world. Many mine sites can consume over 200 million liters of diesel fuel per year with some larger mines consuming over 400 million liters per year. These volumes can be greater than some countries use in five years.

When dealing with these huge volumes of fuel, it is important to understand the mass of the contamination that the filtration system is expected to remove over this time period. An example is shown in Table 1.

Table 1: Fuel Contamination Table

Annual Fuel Consumption (ltrs)	Delivered Fuel ISO Cleanliness Level		Annual Solid Contamination Mass (kg)*		Delivered Fuel Water Contamination (ppm)		Annual Water Volume (ltrs)**	
300,000,000	23/21/18	21/19/16	9,600	2,400	1000	800	300,000	240,000
	19/17/14	16/14/11	600	75	500	250	150,000	75,000
200,000,000	23/21/18	21/19/16	6,400	1,600	1000	800	200,000	160,000
	19/17/14	16/14/11	400	50	500	250	100,000	50,000
100,000,000	23/21/18	21/19/16	3,200	800	1000	800	100,000	80,000
	19/17/14	16/14/11	200	25	500	250	50,000	25,000
75,000,000	23/21/18	21/19/16	2,400	600	1000	800	75,000	60,000
	19/17/14	16/14/11	150	19	500	250	37,500	18,750
25,000,000	23/21/18	21/19/16	800	200	1000	800	25,000	20,000
	19/17/14	16/14/11	50	6	500	250	12,500	6,250

* *The above table serves to illustrate sizing concepts for mining bulk diesel fuel filtration solutions. Noted contamination masses are taken from known weights of ISOFTD as this closely matches the Total Suspended Solids (TSS) of mine site diesel fuels. Since actual contamination in diesel fuel may be different from application to application, so too may actual filter element service life.*

** *Noted water volumes are based on 1000 ppmv being equal to 0.1% of water by volume.*

From the example above, for a mine site with an annual diesel fuel consumption of 200,000,000 liters a year, with a delivered fuel cleanliness of ISO 21/19/16, the mass of contamination expected to be removed by a filtration system each year can be as high as ~1,600 kg (1.6 tonnes). Additionally, with a water contamination level of 500 ppm, a coalescer system would be expected to remove some 100,000 liters of water each year.

The mass of contamination noted in the example is typical of that delivered in bulk to a mining operation. This is certainly the case for remote mining operations where the transportation of fuel utilizing a combination of methods such as barges, bulk tanker trucks, and pipelines increases the risk of contamination ingression.

Having understood the mass of contamination that mine sites can face, we need to consider the mass of contamination that the filtration system is able to remove. As previously discussed, most bulk diesel filtration systems for mine sites are sized using actual pump flow rates as one of the main attributes that determines the size and number of vessels and elements required.

. . . it becomes clear that the sizing formula used is inadequate.

. . . the cost of filtration would be extreme and perhaps outweigh any benefits from the installation at all.

At mine sites, it is common to observe filter installations (see Figure 3), that are sized to filter 1,200 liters/min (317 GPM) of diesel fuel. However, when the annual contamination masses involved in mining operations are considered it becomes clear that the sizing formula used is inadequate.

Figure 3: Typical filter and coalescer system utilized in mining operations capable of 300 GPM.

In the Table 1 example of 1,600 kg of contamination per year, it is important to understand the actual capacity of the filter elements installed in mining bulk diesel systems. Systems such as the type pictured in Figure 3 can have reported dirt-holding capacities as low at 900 grams for the three elements in the housing at the given flow rates. Taking into account the 1,600 kg of annual contamination, this equates to an annual consumption of 1,388 elements.

One may assume that with a usage rate of this quantity, the cost of filtration would be extreme and perhaps outweigh any benefits from the installation at all. Such vast numbers of filter elements not only increase filtration costs, but also consume time and energy in filter element replacement, which further adds cost and contributes to increasing the overall carbon footprint on a mining operation.

Evidence of contamination masses within mining operations can be seen in the thermographic photo of a bulk diesel fuel tank in Figure 4. Shown in green color, the mountain of contamination that can accumulate within mining bulk diesel fuel tanks is clear.

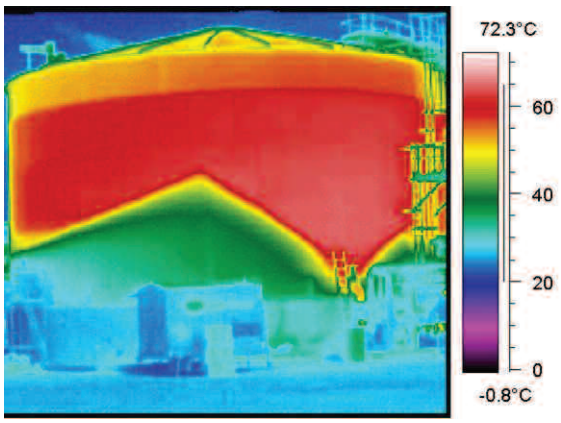

Figure 4: Contamination masses with bulk fuel tanks.

Factors such as pump flow rates, viscosity, density, temperature, and pressure must be utilized in the sizing formula. It is clear that a deeper understanding of the solid and water contamination levels in the fuel, as well as performance characteristics of the filtration system (specifically the filtration efficiencies as a function of particle size and contaminant capacity, as it relates to actual field service life, of the filter elements employed), must be known by the supplier in order to estimate a cost-effective solution.

Capital costs play a part in a final determination; however, they should not be the final factor in selecting the product. A more appropriate solution is provided when all aspects (such as those discussed in this paper) are taken into consideration.

Pall Corporation has developed specific tools and sizing models to assist Pall sales teams and distributors in correctly sizing bulk diesel filtration systems for the mining industry. For more information on how Pall can assist with your mining filtration solutions, visit us on the web at www.pall.com/mining or call your nearest Pall office or distributor.

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