

2014

Black Powder Solutions-
Roger Simonson



[THE EFFECTS OF BLACK POWDER]

The effects of black powder contamination on traditional filtration, as well as pipeline components, are demonstrated commencing with the composition and cause of this contaminant and moving toward the solutions for removing it from gas and hydrocarbon fluid pipelines. The current trends and future trends in removal efficiencies will be discussed. Case studies on black powder in both traditional and new fuels will be presented. These new fuels include LNG, CNG and LPG and their emergence into North America and around the world. And finally, the negative effects this contamination can have on operating companies and end users will be explained.

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1.0 Black Powder Contamination

Black Powder (BP) is an abrasive contaminant (primarily iron oxides and sulfides) present in all gas and hydrocarbon fluid transmission lines. BP is largely the result of moisture which causes bacterial and chemical corrosion of the carbon steel walls within pipelines and storage reservoirs. Suspended in the gas and or fluid BP acts like sandpaper, wearing the pipe wall and creating more contamination particles ranging from 100+microns to sub-micron in size. Combined, the corrosion and erosion causes premature wear of the pipeline wall, damaging meters, turbines, compressors, pumps, and their components. This process does not stop at the gas plant and/or refinery but continues as it is transported down the transmission line through to the end user.

2.0 Gas

2.1 Solutions

The solution to mitigate the damage is to remove the BP in as many locations as possible along the transmission lines such as before metering and compression stations. This will protect meters, valves, and compression equipment components and supply a cleaner product.



Old Technology

Traditionally the solution has been to employ separators, cyclones and depth media filter systems. The cyclones are only efficient down to 8 microns. Depth media filtration causes serious flow restriction, requiring increased horsepower to flow the gas and are only efficient down to 3 microns. BP in most applications is under 3 microns with the majority under 1 micron in size. Maintenance and consumable costs are very high to operate a large depth media filter system. To date traditional filtration has not proven to be effective in removing BP from a gas stream.

Traditional depth media filtration for gas applications advertises an efficiency rating of 99.99% down to 3 microns, but this is not realised in actual application. Black powder is generally 3 microns and smaller allowing an efficiency of less than 60%. These depth media filters become clogged when exposed to large volumes of BP. When saturated and removed from service they become a hazardous waste, with a high cost of disposal.

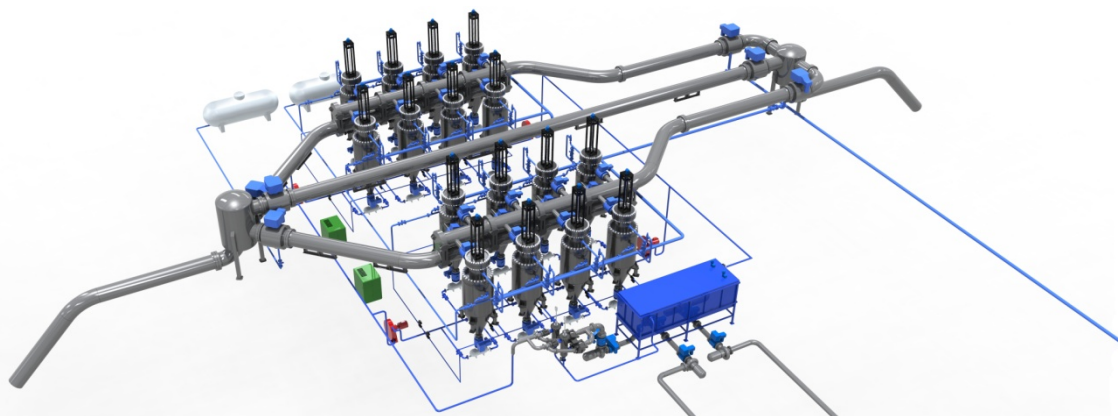
For wet gas traditional practice is to employ a cyclone and a tank separator followed by depth media filtration, which creates flow restriction. New designs for wet gas systems employ a cyclone below the depth media filters. This causes the cyclone to lose efficiency, reducing the efficiency of removing



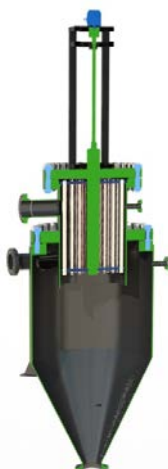
the entrained liquids from the gas, increasing the amount of liquid trapped in the depth media element, and causing entrained liquids to continue down the line.

New Technology

Black Powder Solutions has designed a new technology that is capable of removing BP (both ferrous and non-ferrous) to sub-micron levels without flow restriction. This is achieved by employing patented, powerful radial magnetic field technology. These separators have a long operational life, have very little consumables and have three levels of service from manual cleaning to fully automated systems designed for employment on all sizes of gas pipelines.



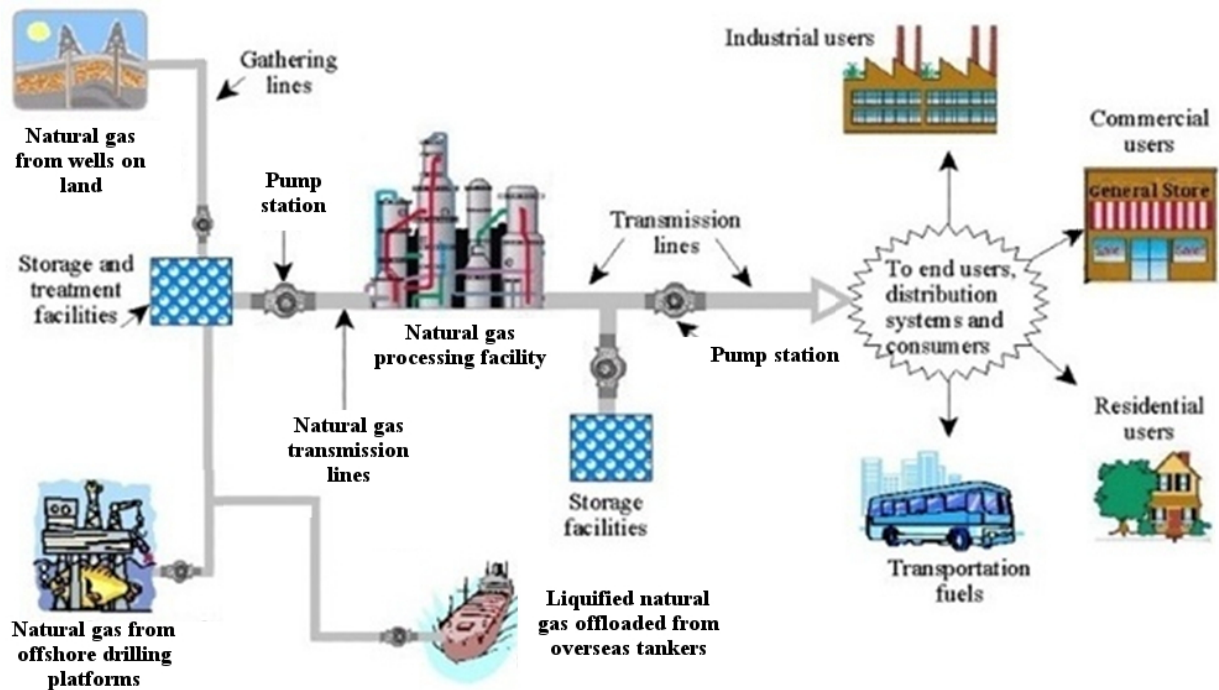
For wet gas, Black Powder Solutions has combined cyclone technology prior to the magnetic separators to remove entrained liquids and BP (efficient to 8 microns). The magnetic separators then remove the remaining black powder to sub-micron levels without flow restriction, eliminating the need for increased horsepower. The cyclone includes an enclosed automated cleaning system to clean the Black Powder and other contaminants from the magnetic separators and cyclone system without human contact. Once the entrained liquids and contamination are removed from the system they are then put through a 2 stage separator, separating the solids and liquids, the solids are then sent for recycling. For increased contents of iron sulfides a permanganate solution is added to the flush system to reduce pyrophoric opportunities. This unit requires minimal consumables and offers years of service with negligible operational costs.



BPS magnetic separators are able to remove contamination to sub-micron levels at an efficiency rating of 95+%. Analysis of BP has identified a varying percentage of non-ferrous contamination such as silica and calcium which black powder magnetic separators are able to remove using two methods. The first is static adhesion, as the particles flow through the pipe they gain an electromagnetic charge and these charged



particles are trapped by the magnetic separator. The second is through entrainment, where a sub-micron particle of ferrous contamination embeds and gets married up with a non-ferrous particle and they are then both trapped by the magnetic separator. With minimal flow restriction, the cyclones used for wet gas are able to work as they are designed and remove the entrained liquids from the gas efficiently.



2.2 Case Studies Gases

In March 2014 EDP Gás in Porto Portugal was experiencing high volumes of Black Powder plugging off their traditional depth media filter systems. Due to these inefficiencies EDP decided to install a magnetic separator prior to these filters on its 6" gas transmission line flowing 2500-3616 m³/hr. The photo shown here is the contamination removed during the first week after installation. The ROI is quickly realized by reduced maintenance and replacement parts costs and delivery of a clean product. Mr. Santos, EDP's Technical Director, is "pleased with the overall performance of the solution".



In 2008 a large EPC supplying compression skids for the pipeline industry employed BPS separators on the seals for buffer gas. These seals are designed with no contacting faces, and the normal operating gas between the faces is approximately 2 microns.

Therefore, any accumulation of particulate larger than 2 microns will cause the faces to contact each other, resulting in seal failure. By incorporating Black Powder Magnetic Separators with filtration capabilities down to sub-micron levels the results

show an increase in productivity and reduced maintenance costs of \$80,000/seal plus downtime.

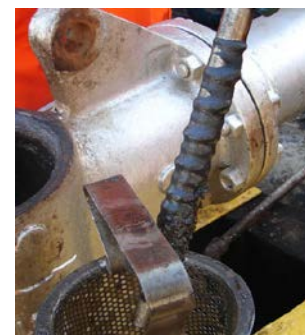


In June 2010 Petrobras Guamaré Refinery in Rio Grande Brazil had a Black Powder contamination issue in its New Diesel Fuel Line. It was using the traditional basket strainer with



large pore mesh and found that the contamination was not being removed but was continuing down the line, prematurely wearing flow meters, pumps, seals, seizing valves, and degrading the fuel quality. Black Powder Solutions suggested the installation of a magnetic separator rod inside the basket


screen to improve the filtration efficiencies and was able to remove the contamination to submicron levels as seen in this photo.





In April 2012 Snam Rete Gas in Ravenna Italy had a Natural Gas dispenser feed line for transit buses that contained BP contamination which was damaging the meter, valves and the compressor seals. Costly maintenance was required to repair and clean the pipe system and compressor components every three months and the company was receiving many complaints from customers of dirty gas. Alex Priori of Renox S.r.l. suggested installing a Magnetic Separator prior to the compressor to remove the BP.

Mecoil's analysis of the Black Powder captured by the magnetic separator showed high quantities of ferrous and NON ferrous contamination that was removed from the flow. The Return on Investment (ROI) is realised as the cost of sending two technicians to conduct maintenance every three months over the past 24 months has been eliminated as well as complaints of dirty gas have ceased. The contaminant holding capacity of this magnetic separator requires cleaning every three to five years depending on BP levels.



MECOIL

DIAGNOSI MECCANICHE


SPECTRO INC. Laboratorio con Sistema Qualità
Agente per l'Italia certificato ISO 9001
Cert. RINA N°656/97

RENOX Srl

Unit ID: **SNAM - MATERIALE PER ANALISI**

Model: _____

Machine Type: **Single sample**



UNRATED
NESSUN GIUDIZIO

The atomic emission analysis detects a high presence of iron and silicon.
Analysis on the vacuum membrane filtration residue (microscopy, see enclosed images) detects the presence of coarse particulate, predominantly metal (with magnetic properties, steel), and rust.

Ing. Matteo Campatelli, 22 Mar 2013

Oil	NON SPECIFICATO UNKNOWN	Sample ID	4C7F90 (M2005)	
Note:		Sampled on	n.a.	
		Received on	19 Mar 2013	
		h Total		
		h Oil		
		Top up (l.)		
			Warning Limits	
	Iron	ppm	>2000	
	Chromium	ppm	3	
	Nickel	ppm	11	
	Molybdenum	ppm	<1	
ASTM D6595-00 WEAR METALS	Aluminium	ppm	58	
	Lead	ppm	20	
	Copper	ppm	13	
	Tin	ppm	<1	
	Silver	ppm	<1	
	Titanium	ppm	5	
ASTM D6595-00 CONTAMINANTS	Silicon	ppm	417	
	Sodium	ppm	46	
	Vanadium	ppm	<1	
	Potassium	ppm	41	
	Calcium	ppm	196	
ASTM D6595-00 ADDITIVES	Magnesium	ppm	60	
	Phosphorus	ppm	154	
	Zinc	ppm	93	
	Barium	ppm	<5	
	Boron	ppm	10	

Date 22 Mar 2013

3.0 Hydrocarbon Fluids

3.1 Solutions

Old Technology

Like gas transmission lines, Black Powder formed from corrosion and erosion is present in hydrocarbon fluid lines. Traditionally large pore mesh screens in basket and cone strainers are used in removing contamination from hydrocarbon fluids as flow cannot be restricted. This allows Black Powder particles to contaminate the crude and refined oil. This also causes damage to pump seals and meters and increases the cost of the refining processes.

Another source of Black Powder, in large pieces, (referred to as slag) is the result of corrosion of the storage reservoirs. As the oil levels fluctuate in the reservoir, condensation forms on the carbon steel walls resulting in corrosion, this creates large pieces of slag which drop into the reservoir and are transferred down the line. Traditional screens are meant to trap these large particles which can be more than 10 inches in size. These large particles are broken into smaller pieces as they make contact with the screen mesh, allowing them to eventually flow through the mesh.

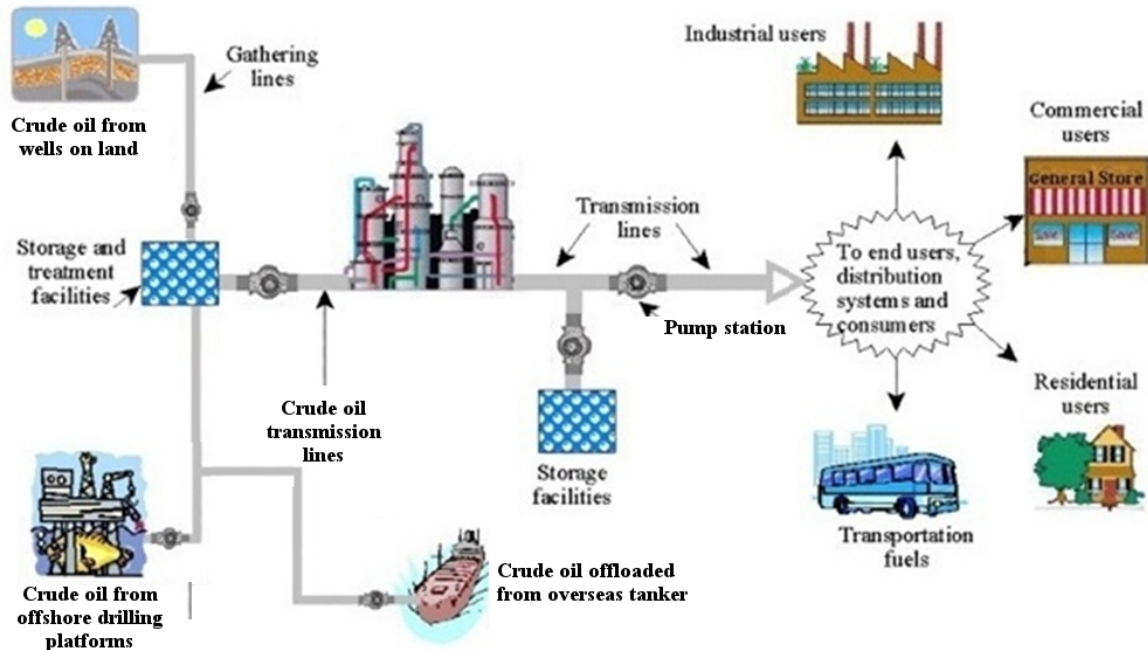


New Technology

The same magnetic separation technology designed for gas applications is employed on hydrocarbon fluid transmission lines. The Black Powder is removed to sub-micron levels without flow restriction. These magnetic separators are capable of holding large quantities of BP, have a long operational life, have very little consumables, and have three levels of service from manual cleaning to fully automated systems designed for employment on hydrocarbon fluid transmission lines.

New magnetic separator technology can be employed in traditional carbon steel basket strainers but this is not recommended as the efficiency is low due to the minimal opportunity to employ magnetic filtration. BPS has designed its Black Powder Separators with stainless steel housing to allow maximum magnetic separator deployment and retention time resulting in 95+% removal efficiency.





3.2 Case Studies Hydrocarbon Fluids

In August 2011 Ecopetrol in Colombia was having pump component failures due to Black Powder contamination in their oil pipeline transfer station. The oil was being moved from tanker trucks to the pipeline for transmission to refineries. Black Powder Solutions recommended the installation of a BPS magnetic separator in the existing basket strainer, prior to the pump, in order to remove the contamination to sub-micron levels. ECP Plant Chief Engineer Jessica Sanchez, and ODL Maintenance Technical Support Engineer Fabio Soto, are very pleased with the results as the removal of a large amount of BP has had a positive impact on product quality and reduced wear of the system components.

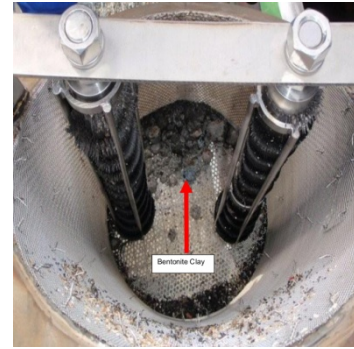


In June 2013 Robert Garcia, Staff Engineer for Transmontaigne in Houston Texas was finding a high level of Black Powder (BP) in their 6" propane line. The BP was damaging their valves, meters and pump components, and degrading the liquid propane quality.



A Black Powder Magnetic Separator was installed as a test project to see what the volume of BP was in the flow of 100 BPD. After 30 days of operation a large amount of BP contamination was trapped on the magnetic separators. This reduction in contamination resulted in cleaner propane as well as reduced wear on the pipeline wall and the pump components. The ROI is quickly realized by reduced maintenance and replacement parts costs and delivery of a clean product. Robert Garcia is pleased with the results and is looking at other areas where this magnetic technology can be employed throughout the line.

January to May 2010, Kinder Morgan conducted a test installation in its Kamloops tank farm of two BPS 24" L x 2" D magnetic separators on their 12" pipeline running from Vancouver to Edmonton. A significant amount of Black Powder contamination was trapped on the magnetic separators. The removal of this contamination will reduce premature wear of the pipe wall, pump components and meter. Kinder Morgan was happy with the results, but had these magnetic separators been installed in BPS stainless steel housing with 4x1 ratio for flow to allow for increased dwell time, the results would have been dramatically better.



4.0 Changing Trends with New Fuels

Industry needs newer, cleaner fuels. "Many fleets are moving from diesel or gasoline to compressed natural gas (CNG), liquefied propane gas (LPG) or liquefied natural gas (LNG) in order to reduce the emissions from burning these fuels". The U.S. Environmental Protection Agency calculated the potential benefits of LNG versus diesel based on the inherently cleaner-burning characteristics of natural gas, summarized in *Clean Alternative Fuels: Liquefied Natural Gas* published by the United States Environmental Protection Agency. Fleets using LNG:

- Produce half the particulate matter of average diesel vehicles
- Significantly reduce carbon monoxide emissions
- Reduce nitrogen oxide and volatile organic hydrocarbon emissions by 50% or more
- Potentially reduce carbon dioxide emissions 25% depending on the source of the natural gas
- Drastically reduce toxic and carcinogenic pollutants
- Increase methane emissions (not a benefit)

When comparing LNG to CNG gases there are many advantages and disadvantages of both which are summarised in the table below drawn from *Agility Fuel Systems* comparison.

CNG Advantages	CNG Disadvantages
<ul style="list-style-type: none"> • Unlimited hold times with no fuel loss • More mature technology • Gas/vapor instead of cryogenic • Simple fuel tanks and pressure management • System design can be customized for application 	<ul style="list-style-type: none"> • Cost of compression - energy and maintenance with a compression station • Size of storage tanks • Possible weight disadvantage
LNG Advantages	LNG Disadvantages
<ul style="list-style-type: none"> • Fewer tanks/less space requirements • Greater fuel density • Lower weight storage 	<ul style="list-style-type: none"> • The complexity of tanks • Pressure and temperature management of fuel to engine is more complex • High maintenance cost of cryogenic parts • Use the fuel or lose it • Reliability is challenging • The life cycle fuel cost over CNG may be higher

All of these benefits add up to one conclusion, the use of these fuels will continue to increase and the safe transmission of these will be our priority. By installing new Black Powder Separation technology and removing the contamination still present even in the new fuels, these emissions will continue to drop further as a cleaner burning fuel allows for fewer particulate and methane emissions.

5.0 Effects of Contamination

5.1 Effects in Gas

Black Powder causes a variety of effects on both operating companies and their end users. BP, as it flows down gas pipelines, damages compressors, orifice meters, instrumentation, control valves, turbines, and other essential components. Black Powder seriously impacts the production values in power generation, in some cases causes plant shut downs.

Employing Black Powder Separators to remove this contamination before compressor and metering stations, LNG plants, and gas plants, throughout the entire process, will benefit significantly both suppliers and end users.

5.2 Effects in Hydrocarbon Fluid

BP, as it flows through hydrocarbon fluid pipelines, damages burner jets, seals, pumps, and other pipeline components. In some cases the amount has been so immense that it has stopped the flow of fluid completely. The effects of this black powder at the end user level results in damage as this contamination wears the engine components such as valves, compressor seals and pistons.

80% of all maintenance expenditures results from contamination problems. By removing Black Powder contamination before pumping stations, chemical plants and refineries using Black Powder separation systems this will result in increased operational time, reduced maintenance costs and clean product for your customers.

