BLACK POWDER SOLUTIONS

MAGNETIC SEPARATOR TECHNOLOGY

September 2019 B

Black Powder Contamination

The abrasive, reactive contamination present in all hydrocarbons and hydrocarbon derivatives. Originates in producing formations and precipitates out during transportation, processing, storage, fractionation, refining, petrochemical production and loading and offloading.

- Consists of iron sulfide and iron oxide, with other compounds including chlorides, sodium, calcium, mill scale, sand, silica and other varying types of contamination labeled “dirt”
- Forms as a sulfur-based corrosion product from microbial and chemical interactions.
- Continues to build as iron sulfide and iron oxide through hydrocarbon pipelines and facilities.

Sources

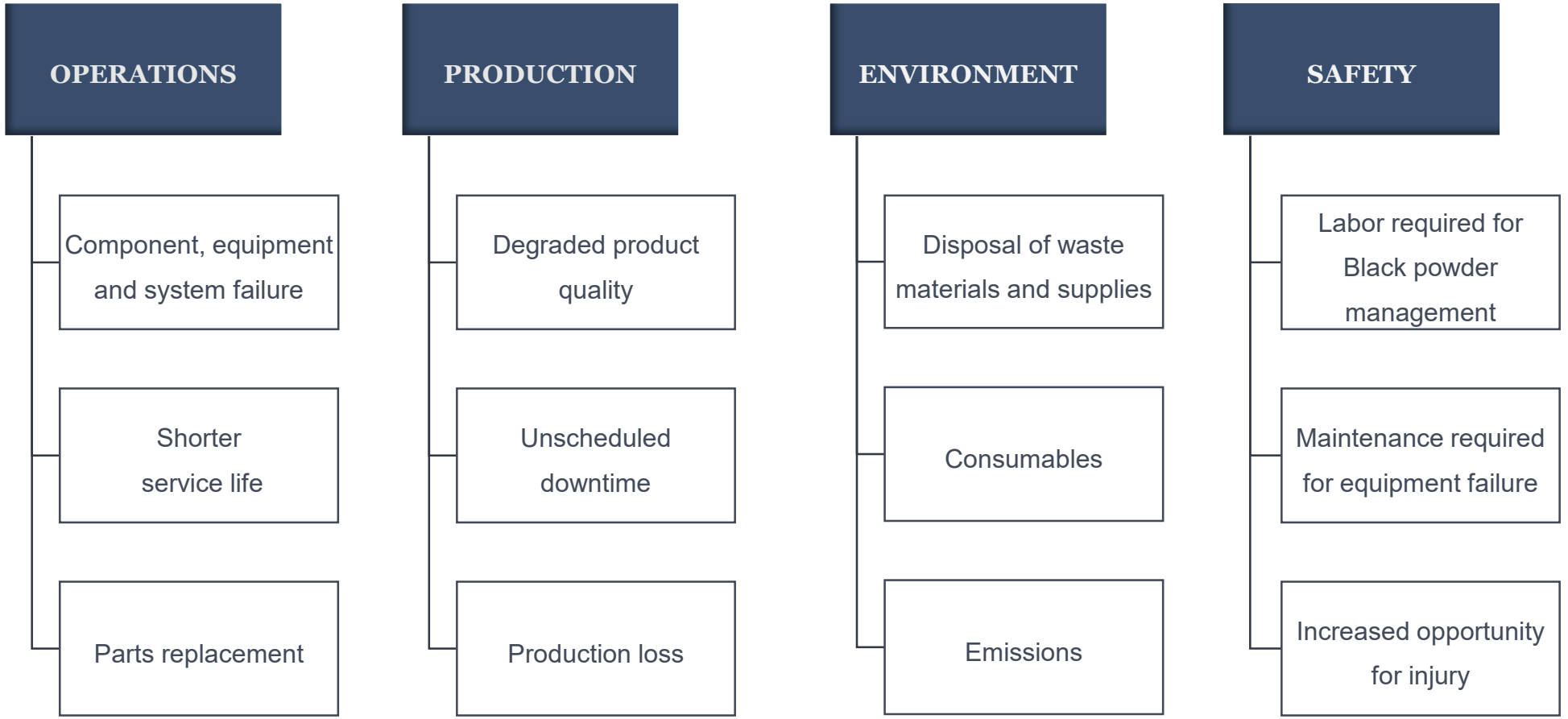
Corrosion

- Bacteria formation: Sulfur and acid producing bacteria, dependent on water and iron reactions
- Chemical formation: Moisture, hydrogen sulfide and temp. or pressure are further catalysts

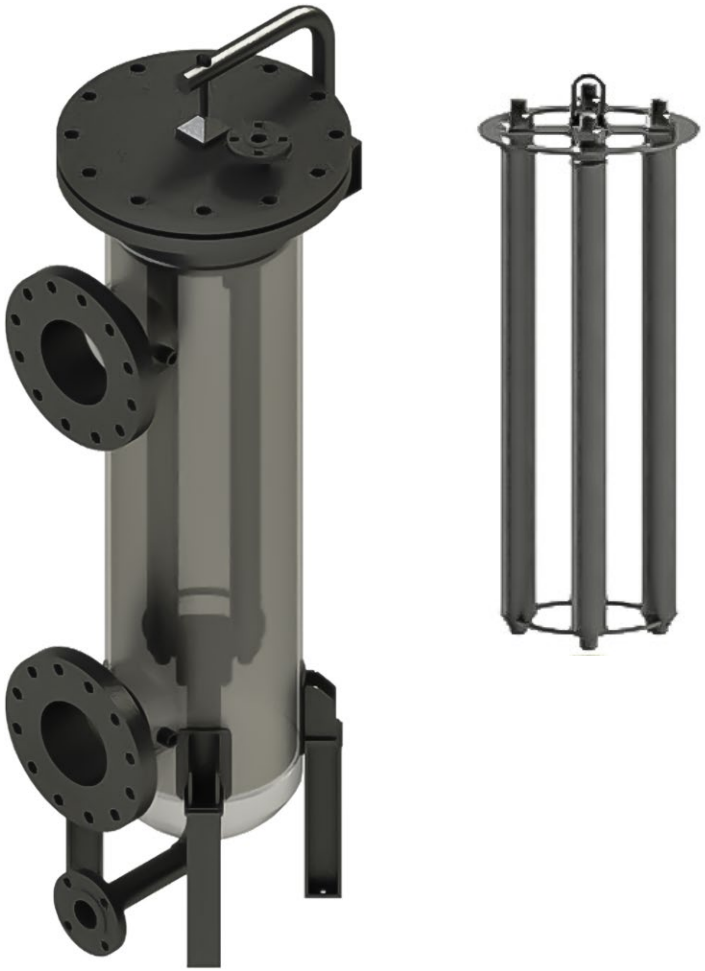
Erosion

- Continues to build due to corrosion, abrasion and erosion as hydrocarbons progress downstream
- If not removed, it will continue to build and eventually plug off pipelines, meters, valves, heat exchanges, reboilers and other equipment, including conventional depth media filters.

Black Powder Business Impact



Magnetic Separator Systems



- 15 + year operating life
- Can be deployed at all points along the value chain
- Remove 95%+of ferrous particulate by accounting for design parameters (pressure, temp, flow, density, viscosity)
- Screenless, minimal restriction allowing for full-flow operation
- Employ a magnetic element array maximizing dwell time
- Capture non-ferrous contamination through static charge

Benefits

- Require cleaning rather than filter disposal – significant savings
- Long life service and utilizes minimal consumables
- High loading capacity allows for extended maintenance intervals of 6 months to 1 year+
- Minimize potential for lost time incidents and reduced footprint

Extended life of critical operating systems

Reduction in downtime and lost production based on extended service intervals

Reduction in waste materials, supplies and disposal fees

Improved product quality

System Mechanical Properties

Mechanical Properties (based on a 2” OD magnetic separator element)	
Efficiency	> 95% +
Clean Pressure Drop	< 0.5 psi
Operating Pressures	All industry standards
Vibration Resistant	Yes
Operating Temperatures	300 °F max (600 °F special order)
Magnetic Separator Element	Patented technology
Black Power Separation Capability Range	< 0.5 µm — > 500 µm

Design	
Design Code	Available on request
Area Classification	Class I, Div I, Div II
Warranty	1 Year
Maintenance Interval	~6-12 months (average)
Magnetic Separator Operating Life	15 + Years
Modular Design	Scaled to flow and contamination requirements
Cleaning Mechanism	Manual Semi-automatic Full-automatic

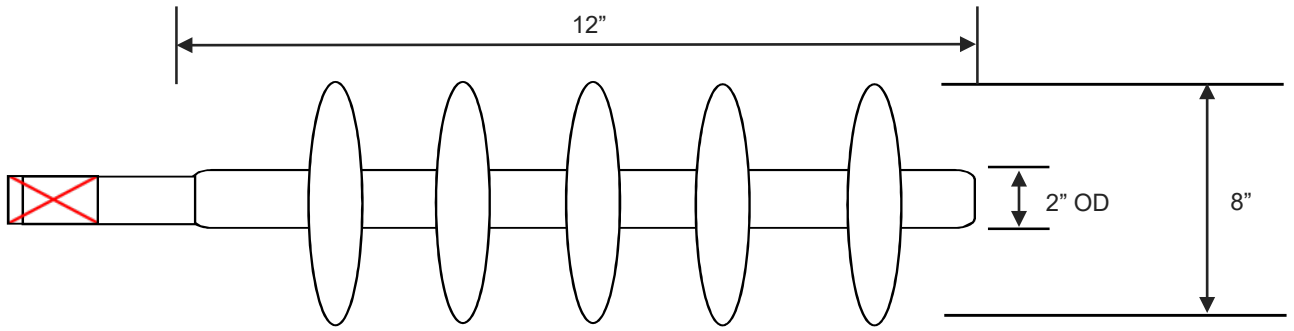
Service
Gaseous Service
Liquid Service
Cryogenic Service

- Standard magnetic separator material is 304/316 stainless steel
- Specialty alloys are available for corrosive applications

Magnetic Elements

Constructed with a patented radial-magnetic-field configuration = high loading capacity of black powder ranging from sub-micron to 100+ microns in size.

Magnetic Filter Element Length	Number of Fields	Diameter of Field	Holding Strength	Magnetic Surface Area
12”	5	8” OD	6.30 lbs/lft	989.6 sq/in



Cleaning Options

Manual Cleaning Station

- The magnetic array is lifted from the separator into a standalone station, the scraper plate is locked in place and the array is lifted upwards to drive the contamination off the magnetic array.

Semi-automatic Cleaning Station

- This system allows for cleaning operations to occur while the magnetic array is contained within the separator vessel.
- The internal scraper plate is mounted on a screw rod assembly, which is actuated from above via a top drive, allowing for the return of the scraper plate to its initial position at the top end of the internal magnetic array.

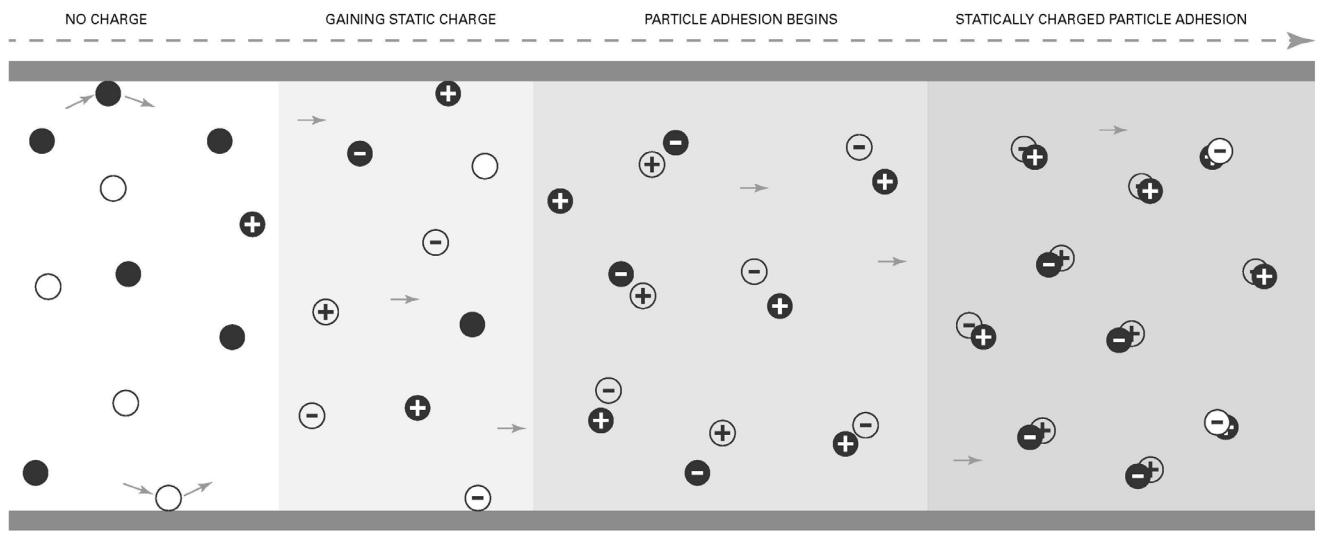
Non-Ferrous Contamination

Non-ferrous particles are magnetically captured due to cross-contamination with ferrous particles. All particulate contamination becomes electrostatically charged due to physical interactions with other particles and surfaces.

Electrostatic charge is generated whenever there is friction between two bodies moving relative to one another. Charge generation occurs on the molecular level at the interface of any two unlike materials, so a static charge will be generated in any moving fluid, with positive or negative charges moving from the fluid onto the bounding surface.

Causes:

- Friction caused by fluids and gasses flowing in pipelines
- High fluid velocities
- Passage of fluids or gasses through filter elements or other microporous structures
- Turbulence created by pumping or compression, particularly centrifugal units
- Fluid discharging on to the free surface of a storage tank

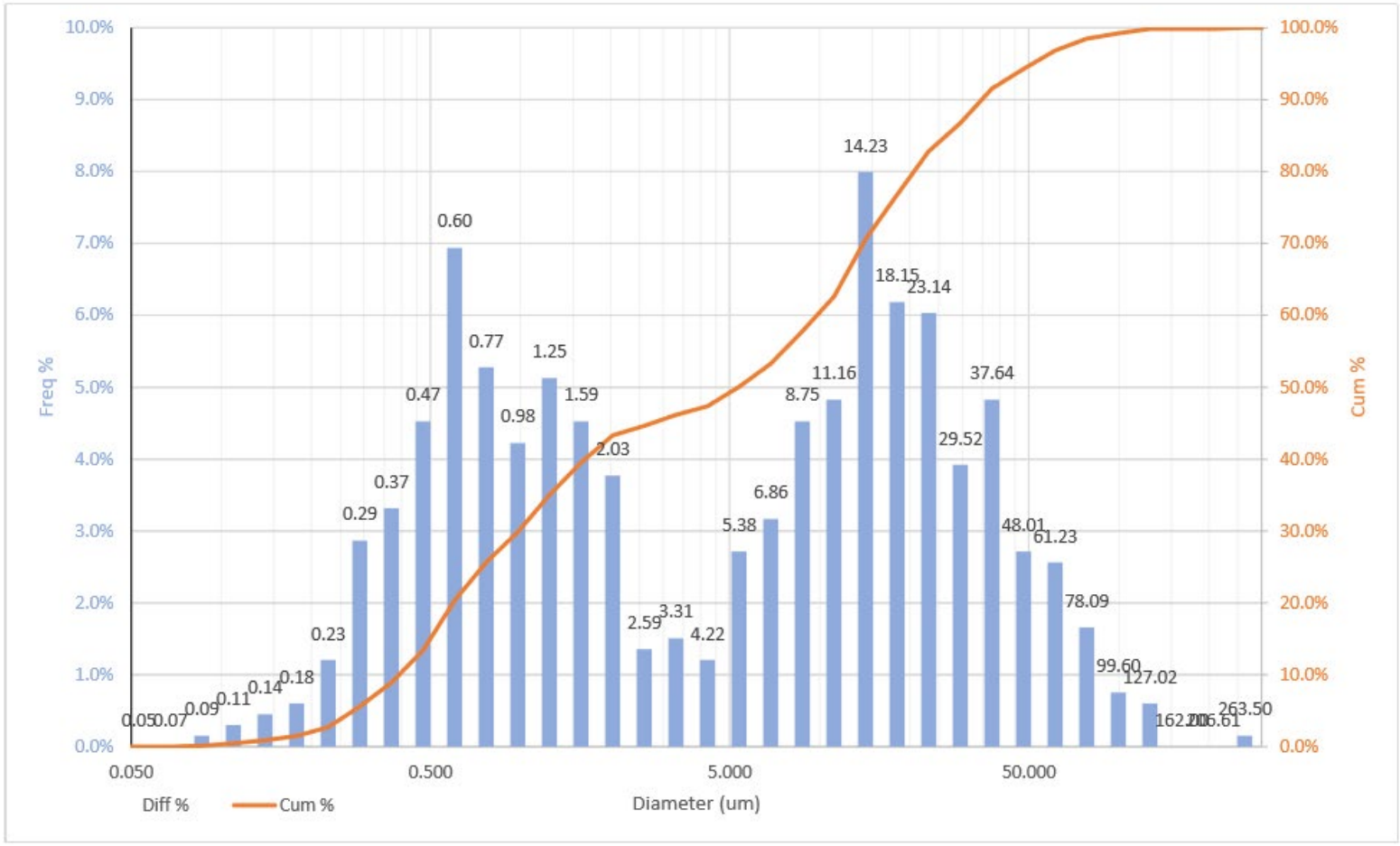


Particle Size

- Sample of contamination taken from a BPS magnetic separator in a gas plant application (Canada) in an amine system.
- This is fairly typical in terms of a particle size histogram (SEM), with ~50% of the particulate contamination being in the 5 micron range and smaller.
- Note that ~45% of it is at or under 3 microns and 30% of the contamination is at or under 1 micron.

Statistics for Particle Size Distribution	
Size (micron)	
Maximum	239.04
Minimum	0.08
Mean	12.76
Median	5.30
Mode	11.2 – 14.2
Range	239.32
Skewness	4.01
Kurtosis	29.44
Standard Deviation	19.96
Quartile1	0.73
Quartile3	16.74

Particle Size continued



Vs. Conventional Filters

- Superior economics: one-time cost for BPS magnetic separators (capex), vs. conventional systems (capex + opex).
- Conventional filter opex increases as filter rating decreases (ie. 10 to 5 microns)
- Contamination disposal only, vs. filters + contamination disposal.
- Conventional filters typically tested in labs in multi-pass closed loops, vs. single-pass real world.
- Conventional filtration: micron ratings are typically achieved closer to plug-off and bypass.

Sample Station

A magnetic separator system for lower volume applications in hydrocarbon liquids and gasses, or as a test station in slipstream applications to confirm the efficiency of magnetic separation in removing black powder contamination.

Can be deployed in process units, such as in amine or glycol systems, or in multiple different applications across a facility.

Deployment

- Crude oil, condensate, NGL, LPG, natural gas, refined product and glycol pipelines
- Fractionation and Stabilization facilities
- Natural gas gathering, compression and processing facilities
- Crude oil and petrochemical refineries
- LPG and LNG loading facilities
- Pipeline pigging operations
- Crude oil transloading
- Water-based deployment in multiple, different applications

Our Customers

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ALLIANCE pipeline

PEMEX

PLAINS ALL AMERICAN PIPELINE, L.P.

PETROMAX REFINERY LIMITED

TRANSMONTAIGNE PARTNERS L.P.

DOW

TARGA

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Eni

CASE STUDY

Total Refinery Protection

Texas, USA

Problem

Crude oil received by barge and pipeline is highly contaminated with black powder contamination. It enters the crude unit and causes (1) increased energy use to heat the crude feedstock, (2) lower product recovery efficiency, (3) trays to fill up, plug off and collapse, (4) more frequent and intensive turnarounds (TARs), which take longer to complete, and (5) contamination to move further into refinery process equipment.

Results

The facility is running much more efficiently with minimal unscheduled downtime with BPS magnetic separators in place. As of June, 2019, there are BPS magnetic separators on the desalter process water, upstream of 8 product pumps (diesel, kerosene, distillate & LPG) and the refiner is looking at deployments on the remaining pumps and in the crude feedstock.

Black powder captured after 6 weeks of operation.

CASE STUDY

Refinery Cracker Column Test (LPG)

Texas, USA

Problem

A refinery in the greater Houston area was experiencing high levels of black powder contamination in its' incoming crude feedstock. Black powder in the LPG product stream on the outlet of the cracker column lowered its quality and product value.

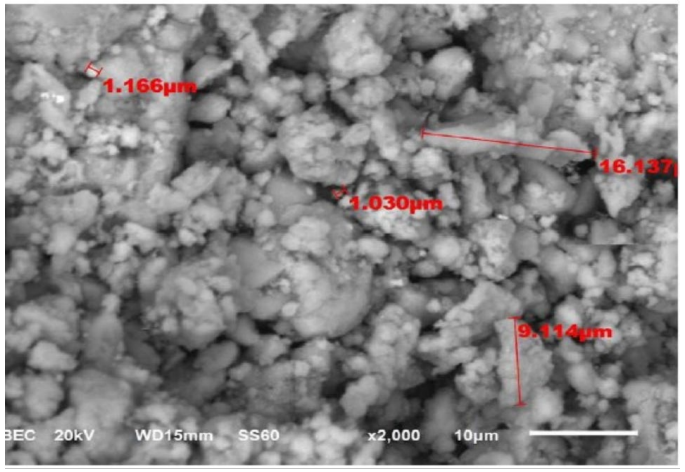
Test

A magnetic Y-strainer was installed on a slip stream downstream of the cracking tower, and downstream of traditional filters to compare filtration efficiencies.

Results

The test was successful; the magnetic separator element captured significant amounts of ferrous and non-ferrous contamination missed by the conventional filters.

Test Data	
BPS Magnetic Separator	1" OD x 3 ½" L
Line Size	½"
Slip Stream Flow Rate	5 gph
Temperature	145° F
Test Duration	14 days
Black Powder Collected	18 g
Sample Size	9.58 g
Particulate Size	1-100 microns
Particulate Composition	50.5% Iron / 23% Iron Sulphate / 21.5 Sulfur / 5% Magnesium, Calcium, Silica, and Aluminum.



CASE STUDY

Refinery Desalter System

Texas, USA

Problem

Black powder contamination in the process water prevented the de-salter filtration from efficiently purifying the water. The Pentair Filter had been increased from 10 to 25 microns in order to get a 5-8 day cleaning schedule at a cost of $13,000 per element change-out (and disposal). As a result, the Pentair unit was unable to protect the MycelX VOC and oil removal system, rendering it out of service. The crude tainted water was sent out for deep well disposal.

Solution

Install 2 BPS Magnetic Separators between the desalter vessel and water tanks.

Results

The Pentair filter change-outs went to 130 days initially, eliminating 65 change-outs annually; the Pentair system has now been removed. The solids loading dropped to expected levels, allowing the MycelX unit to operate and eliminating the need for expensive underground disposal. **Total annual savings of over $2 million.**

Black powder collected on the first magnetic separator element after 18 hours of operation.

CASE STUDY

Diesel Fuel Cracking Column

Texas, USA

Problem

Minimal quantities of black powder would plug the suction screens in front of the product pumps. This was happening constantly, leading to constant swapping of pumps, insulation removal and pipe disassembly to remove the “witch’s hat” strainers for cleaning. Often, the line leading to the strainer was also plugged, the pipe had to be manually cleaned all the way back to the valve.

Solution / Results

An inline magnetic scrubber was installed to replace the cone strainer.

The magnetic separator had sufficient holding strength to capture large quantities of black powder that had been plugging the screens and passing through the pump. The magnetic element is removed from the top of the unit, allowing for a far more highly efficient cleaning process.

The separator also prolonged the change intervals on the coaleser; 15 sets of clay filter element change-outs were eliminated annually. The resultant product cleanliness also allowed for the diesel fuel to be sold at a premium.

CASE STUDY

Kerosene Pump Around Loop

Gulf Coast Refinery, USA / 2018

Application Data	
Operating Fluid	Kerosene
Operating Pressure	450° F
Maximum Flow Rate	1500 gpm

Problem

Crude oil feedstock entering the refinery is loaded with high volumes of black powder contaminants. The entire unit was experiencing issues with black powder building up and plugging the suction screens in front of pumps.

Solution / Results

Deploy a magnetic separator on the kerosene pump around loop to protect the pump. During a recent cleaning, the magnetic separator system protecting Pump 104 had collected not only black powder, but a group of piping knockouts from a recent facility upset. Had they entered the pump impeller and become stuck, the facility would have had to replace the pump resulting in lost product on unplanned maintenance.

LPG Loading Terminal – Ship Loading Arms

Texas, USA

Problem

The plant inlet conventional filters allow black powder contamination to enter the facility and in turn, damage pump and compression equipment. During the loading process, small quantities of black powder plug off the basket screens, extending loading hours, and creating costly downtime and demurrage penalties. Missed loading windows lead to an averaged $50,000/incident, and ~$250,000/annual demurrage.

Results

In one year, there were no unplanned shutdowns during loading. This eliminated demurrage and excess labor costs required for the isolation, venting, purging, cleaning, and venting of the screens. The facility owner/operator has since ordered a number of additional BPS magnetic separator systems for deployment in various NGL applications.

Crude Stabilizer – NGL Product

Texas, USA

Problem

NGL product had high levels of black powder coming out of the stabilizer column. It was causing problems with the downstream pumps, meters and valves and causing problems with off-spec product being rejected by the 3rd party pipeline.

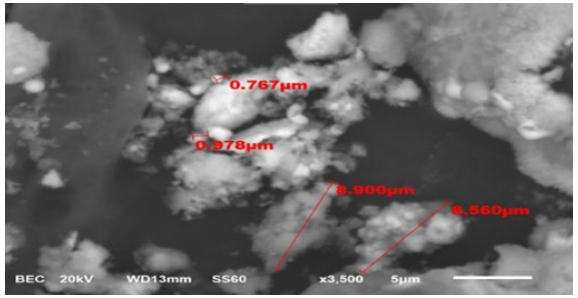
Solution

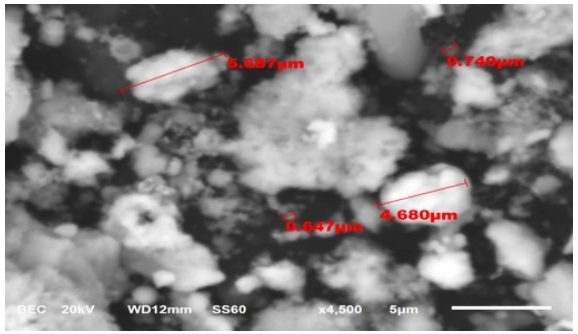
A BPS Separator was installed in the discharge of the NGL going to the pipeline pumps.

Results

Analysis of the contamination determined a composition of 83% iron oxide, 9% carbon, 7% dust as well as dirt, fibers, a grass seed and trace amounts of chrome, manganese and titanium.

Application Data	
Operating Fluid	NGL
Operating Pressure	200 psig
Operating Temperature	90° F
Maximum Flow Rate	200 gpm





Petrochemical Facility

South Korea

Problem

A petrochemical facility in South Korea needs to protect their facility from condensate feedstock loaded with black powder contamination. The contamination was coming from the refinery and tank farm upstream.

Result

The magnetic array was initially cleaned after 48 hours & over 50 pounds of contamination was removed. The magnetic separator system was designed to be oversized for maximum contamination holding capacity. The system continues in operation with focus on the upstream refinery.

Magnetic Separator System	
Vessel	48” OD x 100” L
Magnetic Filter Elements	32
Magnetic Filter Element Size	2” OD x 74” L

Application Data	
Operating Fluid	Condensate
Flow Rate	463.7 m^3/hr

Natural Gas Transmission Line

Portugal

Problem

High volumes of Black Powder contamination were plugging off traditional depth media filtration systems in a natural gas transmission line with a flow rate of 2,500 m3/hr.

Results

The photo shows the contamination removed during the first week after installation. The depth media filter employed after the BPS Magnetic Separator was clean, helping to identify that 95+% of the Black Powder was trapped on the magnetic separator elements.

Chemical Plant Heated Water Line

Texas, USA

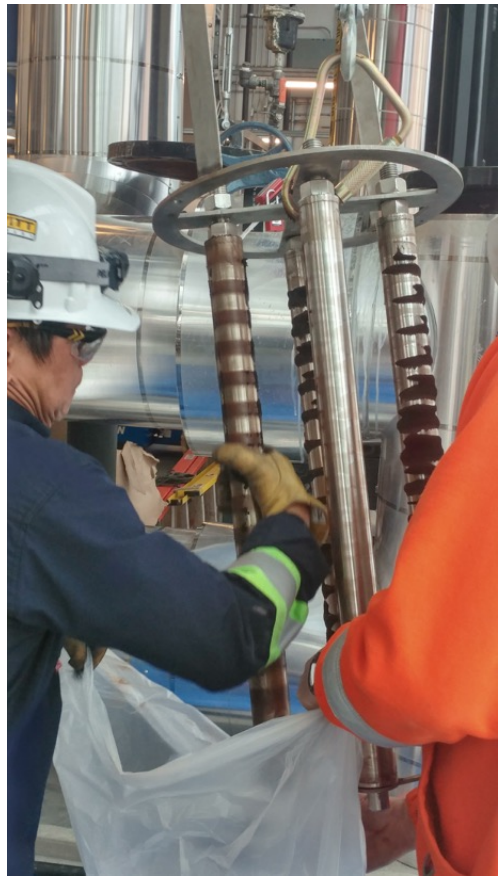
Application

0.5” OD Heated Water Line

Results

Contamination shown in the pictures was collected after 3 months of operation.

The unit has been installed for 1.5 years and the customer is looking to install BPS magnetic separation systems on their glycol systems and heat exchangers.



CASE STUDY

Pipeline Pigging Operations

U.S. Gulf Coast (Onshore)

Problem

A condensate pipeline has significant quantities of black powder in it, requiring frequent scraper pig runs. Large quantities of black powder contamination are liberated from the pipeline during pigging and for up to 7 days post-pigging, overwhelming a duplex conventional filtration system and requiring expensive constant filter change-outs.

Test

Black Powder Solutions designed a transportable magnetic separator system mounted in a support cage with an attached cleaning station that can be temporarily relocated to pipeline pig receiving stations during scraper pig runs. The unit can be tied in as a single-unit or combined with additional magnetic separators for larger amounts of contamination.

Results

During its initial deployment, the transportable magnetic separator was tied-in upstream of the conventional filtration system. No contamination was found in the conventional filters after pigging operations were completed, indicating the magnetic separator captured all contamination during pigging. The unit was subsequently re-deployed to other locations.

Application Data	
Flow Rate (max)	50,000 bpd
Vessel Size	24” OD x 100” H
# of Magnetic Elements	7
100% Holding Capacity (wet)	392 lbs

Pigging — Condensate Pipeline

Saudi Arabia

Problem

Black powder contamination in the condensate stream leaving a fractionator accumulating on the pipeline wall is liberated back into the product during pigging operations.

Solution

Customer installed a 5” OD, 300#, 316 SS BPS Magnetic Separator System skid on a 1” OD slipstream line off of a 14” OD pipeline as a proof of concept in an 8 day test.

Results

- Black powder contamination of 12.5 grams/day was captured prior to the pigging test by the BPS system; 2.9 kilograms of Black Powder was captured after pigging operations by the BPS system registering a 0 psi pressure differential.
- Under a separate test for comparison purposes, conventional filtration plugged off and caused a 25 psi pressure drop after the 8 day test.

Propane Storage, Pipeline & Pump

Texas, USA

Problem

Propane is being piped from underground storage in Port Arthur, TX to Mt. Belvieu, TX from time to time. The propane is usually used as burner fuel, but when there is excess and/or market conditions dictate, it is pipelined, so the pump may be idle for extended periods. It often locks up when it is running and each time, the issue has been black powder contamination getting into the balance bushings and wear rings, causing imbalance and vibration that eventually shuts the pump down.

Results

The plant manufactured a spool piece to hold a temporary BPS magnetic separator element in the pipeline on the suction side of the pump. The pump ran smoothly during the next run period, without interruption.

The customer is now proceeding to order a duplex BPS magnetic separator system to ensure it is always has magnetic separation capability during pump run periods.

Glycol Circulation Pumps

Italy

Problem

There were high levels of black powder in the glycol system and the particles were too small for a Y-Strainer filter screen to remove. This corrosion resulted in fine abrasive particles of iron sulfides and iron oxides reducing the life of glycol and wearing on the circulation pumps and components.

Results

A significant amount of Black Powder was removed from the glycol system that easily passed through the mesh screen. Since installing the magnetic Y-strainers in 2008, the pumps have operated without failure with full efficiency.

Summary

- Black powder is an industry name for the abrasive, reactive contamination particulate present in hydrocarbon fluids, gas and process fluids such as water or amine.
- Pervasive through upstream, midstream and downstream facilities and operations.
- Conventional filtration is not effective in removing contaminants in the < 10 μ range.
- BPS manufactures magnetic separator systems that remove black powder.
- These systems are engineered for all oil and gas facility applications; they are sized and designed for your hydrocarbon product, viscosity, flow rate, pressure, temperature, pipe sizing and amount of contamination.

Black Powder Solutions

MAGNETIC SEPARATION TECHNOLOGY

Effective removal of contamination in upstream, midstream,
and downstream operations.

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