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# Challenges of Black Powder in Gas Lines

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**Abstract**

The contamination due to black powder in gas stream has been a matter of great annoyance. At one of its oilfields, Kuwait Oil Company (KOC) experienced the occurrence of black powder in gas stream. Black powder occurrence causes operational, maintenance, HSE as well as integrity and reliability issues. It leads to various unwanted consequences like product contamination, production loss, economic loss, and sustainability concerns (e.g. due to flaring), for both the operators and the downstream customers. Various measures, that continue to evolve, are being adopted by the industry to handle the black powder challenge.

**Keywords:** Black Powder; Black Powder Solution; Corrosion; Gas Pipelines; Black Powder Measures

## Introduction

Black Powder is often used in the Oil & Gas Industry to refer to the material found in pipelines that consists of corrosion products and several other contaminants.

The physical form of the black powder has been different on different occasions. It can be wet or dried, black, tarnished, or grey.

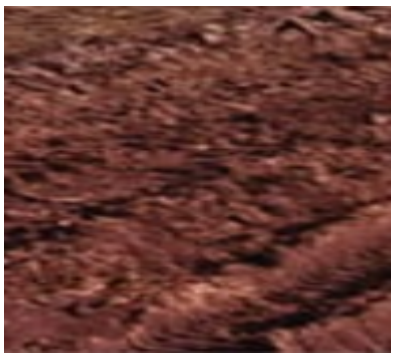

**Figure 1:** Image showing Black Powder.

### Constituents of black powder:

Iron Sulphides is the prevalent constituent, whereas in some cases no traces of Iron Sulphides have been seen, combination of iron Sulphides, Iron Carbonates and Iron Oxides have been mentioned in general.

### Black Powder Formation:

Great deal of literature is available on the formation mechanisms of black powder over the years.

It is documented that the black powder is formed because of chemical / microbial actions triggering internal corrosion of the pipeline.

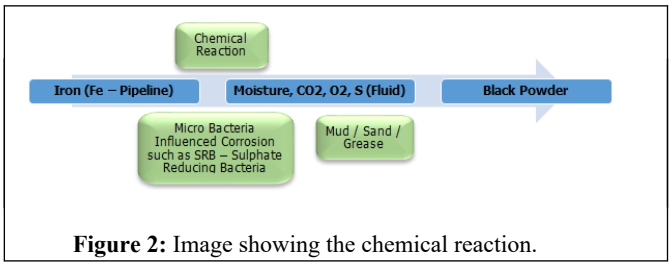


**Figure 2:** Image showing the chemical reaction.

Black powder forms throughout the process; through well bores, into gathering lines, in separation facilities, and along the transmission pipelines. The black powder continues to build in the gas plants and refineries and reaches to the end user storages.

## Materials and methods

Chemical reactions of iron present in the pipelines with various corrodents leads to form black powder. Corrodents such as S, O2, CO2, H2S etc. in presence of moisture, whereas, CO2 and H2S are the normal constituents of the gas. Moreover, Sulphate reducing bacteria (SRB) also contributes to produce H2S.

Microbiologically induced corrosion (MIC) or microbial corrosion can take place due to acid producing bacteria (APB) or iron oxidizing bacteria (IOB) or simply promoted by microorganisms. Presence of condensed water leads to the growth of these bacteria.

These corrosion products combine with variety of other contaminants physically or chemically present in the pipeline as well as the fluid / gas. Black Powder is found traveling with the gas / condensate streams and has been discovered that it attaches to the internal surface of pipelines / equipments.

## Problems associated with black powder

**KOC's encounter with Black Powder:**

At the oilfield areas of KOC, black powder has been observed in gas streams.

It causes operational, maintenance as well as HSE issues leading to financial loss, environmental impact etc.

- Contamination of feed
- Choking of instrument impulse lines
- Damage to equipments

**In general, following issues can be considered:**

Black Powder deposition inside the pipelines create flow restrictions, this requires additional energy leading to increased operational cost to transmit the given quantity of the gas / fluid.

It could block orifice meter that causes inaccuracy in measuring flowrates thus disturbing the downstream processes where dependency upon the accurate measurement of flow is important.It possibly reduces the performance of rotating machines such as compressor, turbines etc.

The issue of choking of impulse lines of instruments due to black powder may lead to foul control valves, PSVs, isolation valves etc., threatening the process control as well as process safety. Example, it is worth to be mentioned here that the Middle East Regions' O&G fields are facing a critical issue over the maintenance of the 'Isolation Valve' of safety relief valve. Safety relief valves are the critical equipments to any plant. Safety relief valves are usually installed with an upstream block valve to facilitate O&M of the safety relief valve. The adverse impact of Black Powder on the operation of isolation valve is affecting the very maintenance of the Safety Relief Valve.

Frequent plugging of filters due to black powder requires extra maintenance and may leads to production loss as well as flaring.

Black powder may contain pyrophoric materials, this requires extra precautions during operations, maintenance. In this case its disposal from pipelines / equipments require extra safeguards.

The black powder presence in the gas streams will contaminate the export gas, thereby leads to cut the feed supply to downstream customers.

It affects inline inspection (ILI), and pigging operations, involving extra cost and time.

## Results and discussion

Presence of black powder not only leads to product contamination but also decreases effectiveness of the whole system by accelerating corrosion & erosion rates, as well as choking and flaring, safety & various hazards, and finally it culminates into financial losses to the industry.

Black powder occurrence is considered as a complex phenomenon, as its occurrence, physical and chemical characteristics vary broadly. It has been testified that even in parallel lines, one line may show evidence of the problem while the other does not. Summing up, it involved problematic features, complexity, and unpredictability, and thereby finding lasting solution becomes a tedious and difficult task.

Since the pipelines and associated system is designed taking into consideration the solid and liquid portions in the gas. Such considerations prove wrong when the black powder occurs during operation stage. This happens because the design aspects usually, do not consider the occurrence of black powder due to its difficult predictability.

Therefore, when the occurrence of black powder is observed during operation, e.g. a specific filter may frequently get clogged or 'passed through' by some constituent of the black powder leading to the damage to various equipments such as Exchangers, Compressors etc.

## Strategies for managing the challenge of black powder

Managing the problem of black powder, several strategies are applied, which can be categorised as follows: (1) prevention, (2) mitigation and (3) removal.

### Prevention

It is learnt that fully eliminating the black powder problem, once it starts, is yet not known. Therefore, it is better to prevent it from occurring. The usual plan would be to carry out some preventive program over a defined period that could address the root cause of black powder formation. This would involve several measures as follows:

The quality of the gas to be transported should be removed with various constituents such as Water, Sulphur, Hydrogen Sulphide, Oxygen, Carbon Dioxide, etc. that contribute to black powder formation through chemical and microbial actions.

Gas dew point should be considered while operating the pipeline as water moisture along with acid gas components trigger severe corrosion. This is to ensure avoiding chemical / biological reactions. Providing internal anti-corrosion coating reduces the occurrence of black powder to certain extent. NACE Standard's compliance should be ensured, while, selecting the material of construction to prevent chemical and microbial action.

Special care shall be taken during construction, commissioning & entire service life to prevent contamination, presence of water (e.g. after hydrotesting), microbial growth, corrosion. Precautions shall be taken to ensure that the contaminations are eliminated from the pipelines such as dirt, debris, construction wastes. Flushing, draining and drying operations of the pipelines system to be done appropriately to prevent corrosion. Moreover, quality of water for testing / flushing should be appropriate.

### Mitigation

Internal corrosion control is key to mitigating the black powder problem. Moreover, it is also important to recognize that improper selection of mitigation measures may unintentionally worsen the corrosion viz the black powder problem.

### Removal

As described earlier, whether, black powder material is attached to the internal wall or deposited in the pipeline or being carried away with the gas, various methods are utilized, either individually or in combination for its removal.

Mechanical Cleaning: Mechanical pigs are utilized to take out the black powder material which is attached to the wall and clean any deposits inside the pipeline system.

Chemical Cleaning: Pipeline cleaning by various chemicals.

**Gas-Filters:** Such as cartridge type filters are used to remove solid particles from the stream of gas.

**Cyclonic Separators:** Where two phases are separated through centrifugal forces of separation.

The objective of this paper is to demonstrate the success of immediate / Short-Term measures taken to minimize the occurrence of black powder and its subsequent removal from gas pipelines.

The paper is expected to create awareness and enrich knowledge base regarding the occurrence of Black Powder in the middle east region and its immediate / short-term handling solutions.

This shall benefit the Oil & Gas industry in addressing issues of gas contamination and its associated issues by attaining satisfactory immediate / Short-Term solutions.

Numerous technical reports as well as research works are found in the literature relating to black powder.

Contribution towards such cause, the paper attempts to review the problem of occurrence of black powder and various strategies that are adopted to handle the associated issues, in general.

Further it shares the experience of minimizing the occurrence of black powder by revisiting the chemical injection dosages, frequent pigging operations and other methods at one of the oilfield areas in Kuwait, classified as Short-Term / immediate measures.

## Conclusion

Involved complexity, problematic feature & worries, companies' general response is to implement a black powder management system combining prevention, mitigation, and removal strategies.

Accordingly, when occurrence of black powder, along with liquid carry-over, in sour gas streams at one of the Kuwait's oilfield was observed, various short-term strategies in hand were reviewed such as adjusting chemical injection dosages, frequent pigging operations. Affected lines in the network were identified, as described in the below sketch, various pipelines were classified as 'High', 'Medium' and 'Low' producing Black Powder lines.

Results were carefully monitored in select time intervals after employing frequent pigging operation as well as adjusting chemical doses. Special attention being given to the stagnant lines and pigging were scheduled for these lines and the lines which were not in operation were mothballed.

Rigorous / strict frequent corrosion monitoring was undertaken.

This results in remarkable reduction in the occurrence of black powder and accelerating its removal from the gas lines.

Based on the results it is observed / concluded that the immediate Short-Term methods were effective in minimizing the occurrence of black powder in gas lines and its removal.

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