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# A Qualitative Risk Assessment of Blast Furnace Gas on Network Pipe Line

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**Abstract:** *Blast furnace gas (BFG) produced from blast furnace (BF) steel-making, cleaned in gas cleaning plant and used as a fuel in captive power plants, boilers etc. Excess BFG is burn using the flaring system. BFG handling in network pipeline is a complex task it has potential hazards like fire and explosion, co poisoning etc. Various risk assessment techniques are applied to improve the BFG safety on network pipeline to prevent the steel plant workers from fatal and death accidents. This paper aims to provide the essential of risk assessment techniques for achieving BFG safety in an integrated steel plant. In this paper Failure mode effect analysis (FMEA), a systematic brainstorming approach is applied to the blast furnace gas network pipeline to find out the hazards and its consequences arise during operation based on Risk priority number. Safety measures suggested in this paper can prevent the occurrence of failures and protect workers from accidents.*

***Key words:*** Blast furnace, fmea, risk assessment, blast furnace gas, network pipeline.

## 1. INTRODUCTION

Blast furnace gas is the byproduct of casting steel production process in the steel industry and usually is composed of 22-25% CO, 16-20% $CO_2$, 4-5% $H_2$ and 51-55% of $N_2$ by volume. Because of CO and $H_2$ are combustible, blast furnace gas is the most significant energy source. In recent years, the use of blast furnace gas is too high [1].Foundries can use the produced gasses, in their own specially adapted captive power plant (CPP) with high-efficiency. Atmospheric Fluidized Bed Combustion Boiler (AFBC), waste heat recovery boiler (WHRB), blast furnace gas boiler (BFGB) work well with low calorific process gasses produced in the iron and steel industry (blast furnace gasses). If the hydrogen content remains low, such low calorific process gasses can be used without problems. However, if the hydrogen contents increases and thus the knocking tendency, the suitability of the fuel gas must first be tested [2]. Excess blast furnace gas is burn using the flaring system. Transferring blast furnace gas through network pipeline to utilizing unit is a complex task, exposes workers to a wide range of hazards that would cause fatal accidents. In past blast furnace gas explosion has shown many tragic and fatal accidents, so transferring the blast furnace gas operation is a complex task for the steel plant workers and safety professionals.

## 2. PROBLEM STATEMENT

BFG source is one of the most important energy sources in steel and iron industry, which consists of the blast furnaces, the transportation pipelines and a series of gas users. Taking a certain steel plant as an example, the structure of the BFG system can be demonstrated as Figure.1, in which blast furnace viewed as the generation units provide the gas into the pipeline network, and the consumption users primarily include stoves, coke oven, sinter plant, blooming mill, hot rolling, cold rolling, boilers, power plant, etc. Also, Excess blast furnace gas is burn using the flaring system.

The BFG system can be monitor by a number of variables, such as the gas flow, the gas temperature and the pipeline pressure of some locations [3].

The aim of this work is to make sure that gas distribution systems in Iron and Steel Works should be as safe. The recommendations which follow take account of the various incidents which may occur in connection with water seals and drain seal pots in the network pipeline gas system. Drain seal pots are designed to perform, the removal of water contained in the gas, and isolation of gas in the mains from the surrounding atmosphere. Drain seal pots also contribute towards reducing dust and other contaminants in the gas as they become entrained in the condensate and are drained out.

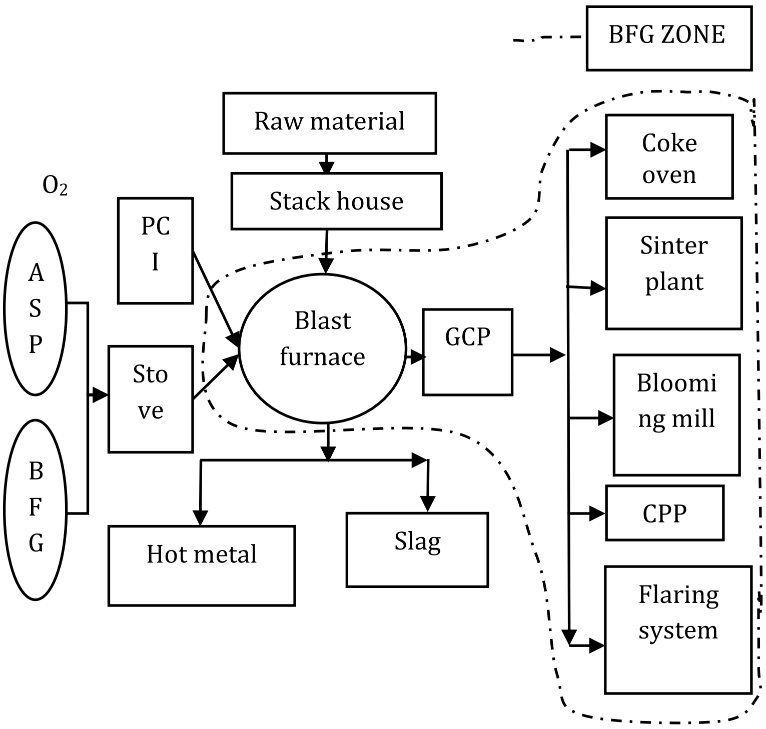


**Figure.1** Blast furnace gas flow chart

The goggle valves or a water seal with spectacle/plate valves are used to isolate a furnace from the GCP and gas distribution system.

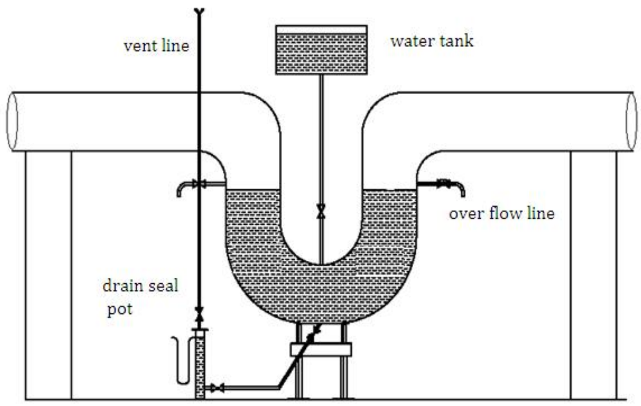


**Figure.2** Network pipeline U-seal

The goggle valves or a water seal with spectacle/plate valves are used to isolate a furnace from the GCP and gas distribution system. In fact under the high gas pressure, if the u-seal (figure.2) was to be used it for their maintenance, the U-seal head should be greater than the maximum furnace gas pressure. Several unsafe conditions lead to an accident in the gas distribution system, FMEA will reduce the unsafe condition in u-seal, drain seal pot.

## 3. FAILURE MODE EFFECT ANALYSIS

Failure Modes and Effects Analysis (FMEA) is a methodology for evaluating the system, product, process, and design of potential failure modes within a system for classification by the severity and likelihood of those failures. Effects analysis refers to studying the consequences of those failures. A crucial step is anticipating what might go wrong with a process or a product. Moreover, the FMEA result in an undesired system state, such as a system, subsystem, component hazard, and thereby also be used for hazard analysis. Failure mode effect analysis was formerly established by NASA to develop and validate the reliability of space program. Even though FMEA has some limitation in prioritizing the failure modes and output may be complex for simple systems, may not easily deal with time sequence, environmental and maintenance aspects.

### 3.1 Risk Priority Number

Risk priority number (RPN) methodology is a technique for prioritizing the risk with potential failures for setting priority. The RPN index is determined by calculating the product of the three factors are severity (S), occurrence (O), and detection (D). The RPN is a valuable tool for setting priority. In the conventional approach, The RPN values range from 1 to 1000; higher RPN values represent higher priority.

$$RPN = S \times O \times D$$

### 3.2 Severity (S)

Severity is ranked based on the seriousness of the effect of potential failure modes. Severity rating with the higher number signifies the higher seriousness or hazard, which lead to damage to system or process. The severity (S) score range between 1 and 10, where the most severe are 10. An example rating for severity is given in table.1.

### 3.3 Occurrence (O)

The occurrence is ranked based on the failure probability, which represents the relative number of failures anticipated during the process. Occurrence values should have data to provide validation. An example rating for occurrence is given in table.1.

### 3.4 Detection (D)

Detection is an assessment of the ability of controls will detect the cause of failure mode. An example for detection rating is as shown in table.1.

| Rank | Severity | Occurrence | Detection |
|---|---|---|---|
| 1 | None | Almost Never | Almost Certain |
| 2 | Very Minor | Remote | Very High |
| 3 | Minor | Very Slight | High |
| 4 | Very Low | Slight | Moderately High |
| 5 | Low | Low | Moderate |
| 6 | Moderate | Medium | Low |
| 7 | High | Moderately high | Very Low |
| 8 | Very High | High | Remote |
| 9 | Serious | Very High | Very Remote |
| 10 | Hazardous | Almost Certain | Almost impossible |

**Table.1** Qualitative Scale for Severity, Occurrence, and Detection [6]

### 3.5 Steps in FMEA

To conduct FMEA there are some necessary steps has to follow. Figure.3 shows step by step process of FMEA procedure. Initially, FMEA team should collect all data with help of plant layout, process flow diagrams, and process instrumentation diagram. With that information, FMEA team finds the potential failure mode and its effects. Next step is to find the failure mode, with the help of severity, occurrence and detection rate, calculate RPN. Recommend the control measures to prevent the occurrence of the failure in process and finally document the FMEA report.

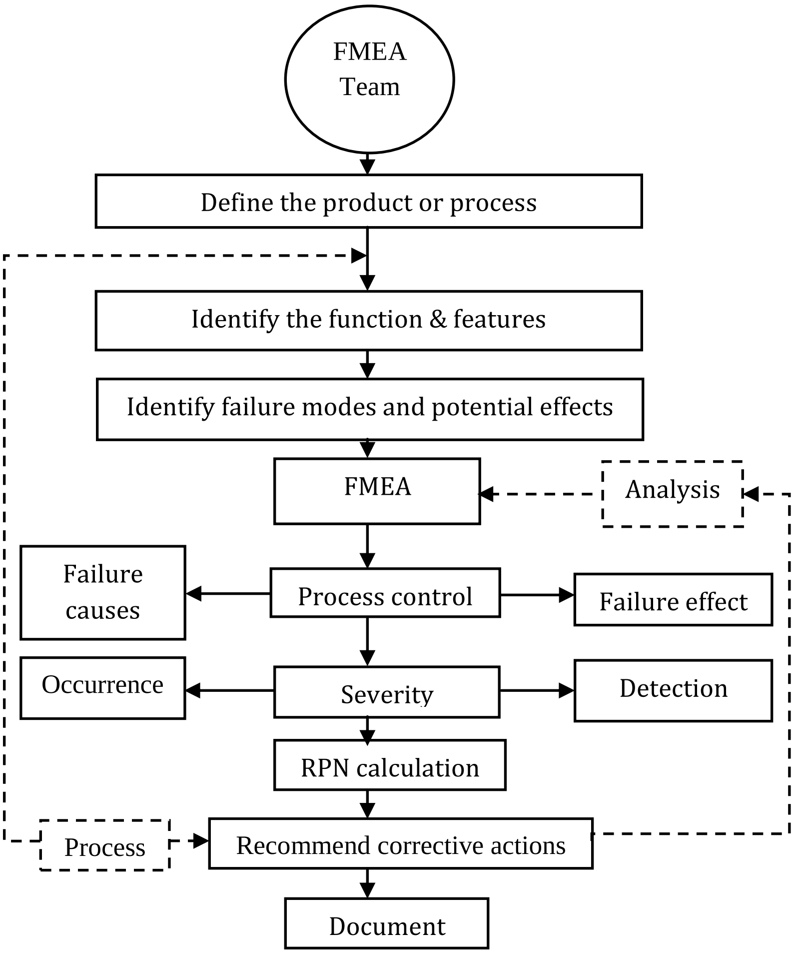


**Figure.3** Step in FMEA

Failure mode effect analysis is achieved by a multidisciplinary team of experts in blast furnace network pipeline operation with the help of process flow chart the analysis team identifies the components and failure modes in the process. The last five years accident reports are taken for the FMEA analysis. The RPN is calculated based on severity, occurrence, and detection.

### 4. FMEA IMPLEMENTATION

The case study is conducted and FMEA technique is applied to the blast furnace gas network pipeline in an integrated steel plant. Blast furnace gas is used as fuel for the production of steam in the boiler, which can utilize other processes. Blast furnace gas is a byproduct of the blast furnace, which is generated 2516901Nm$^3$/Day. Two or more BFG is connected by a common network pipeline, distribute to other consumers and utilization of BFG is around 89%, and gas to the flaring system is around 11%.

### 4.1. Steps to Calculate RPN

**Step.1** The potential failure mode of drip-pot

**Step.2** The potential effect of failure found with severity. Failure not only stops the process it also causes serious accident

**Step.3** From the table.1 values of severity, occurrence, detection values are obtained and calculated and they were obtained as 10, 7 and 5 respectively

**Step.4** RPN value calculated as RPN = S × O × D,

Considering S = 10, O= 7 and D=5

RPN =10 × 7 × 5 = 350

| Component /process | Failure mode | Failure effect | Failure cause | Existing control | S | O | D | RPN | Additional control |
|---|---|---|---|---|---|---|---|---|---|
| Bleeder valves | Failed to operate | Explosion | Corrosion | Reliable supplier | 10 | 4 | 4 | 160 | Regular maintenance for a week |
| Blast furnace gas injection | Pipeline rupture | CO poisoning | Over pressure | Detectors | 10 | 3 | 3 | 90 | Provide detectors with an alarm system |
| oxygen injection | Pipeline rupture | CO poisoning | Over pressure | Detectors | 10 | 2 | 2 | 40 | Provide detectors with alarm |
| Gas cleaning filter bags | Filter bag failure | Improper gas cleaning | Excess temperature | Monitoring system | 10 | 2 | 3 | 60 | Regular inspection for a week |
| Butterfly valve to regulate flow | Valve partially closed | Flow deviation | Dust | Airline respirators | 9 | 2 | 2 | 36 | Periodic maintenance |
| u-seal drip-pot water flow | Valve open | CO poisoning in atmosphere | Valve failure | Detector | 10 | 7 | 5 | 350 | i)Sensor with an alarm system<br>ii)Online gas monitoring system |
| u-seal water tank valve | Valve failure | CO poisoning in atmosphere | Empty tank | Level Sensor & CO detectors | 6 | 2 | 1 | 12 | continual display monitoring system |
| u-seal drip-pot vent | Valve failure | CO leakage | Valve open | Reliable supplier with ISO standard | 7 | 3 | 2 | 42 | Sensor with an alarm system |
| u-seal water overflow line | Valve failure | CO leakage | Valve open | Reliable supplier with ISO standard | 7 | 3 | 2 | 42 | detectors with alarm limit 50ppm |
| Network Pipeline | Pipeline rupture | CO poisoning in atmosphere | Over pressure & temperature | Detectors | 10 | 3 | 2 | 60 | Provide detectors with an alarm system |

**Table.2** FMEA worksheet

### 4.2 Risk Priority Number Relationship

The following graph chart-1 shows the risk priority number values.

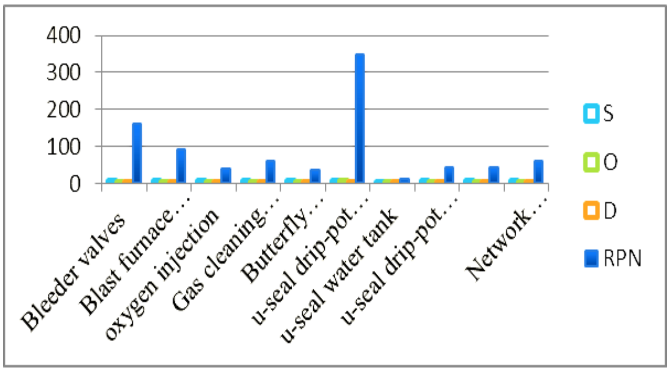


**Chart.1** Risk Priority Number Relationship

## 5. ANALYSIS OF THE RESULT

The higher value of risk priority number was obtained for u-seal drip-pot. Detailed safety audit should be conducted on the u-seal drip-pot to reduce accident rates. Depth knowledge and awareness should be given to the workers involving in network pipeline monitoring activities. Air breathing apparatus, CO monitor should be arranged to prevent in network pipeline workers from CO poisoning. Proper control measures should be implementing on BFG system; this will reduce accident rate and process failure.

## 6. CONCLUSIONS

The present work deals with the basic process of the blast furnace gas network pipeline. With the help of FMEA technique, all possible failure modes are evaluated with their severity and the causes are calculated with occurrence rate. Finally, the RPN for each process was calculated and the preventive control measure was suggested for each and every process, the safety precaution suggested in this paper would help to reduce the down time failure and its effects.

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## BIOGRAPHIES

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