FOCUS ARTICLE

Beyond Hazardous Area Classification

Mechanical Equipment Ignition Risk Assessment (MEIRA)

In explosion and flash fire incidents, electrical arcs and electrostatic sparks are often considered primary ignition sources because they are "everywhere" and because they have enough energy to ignite most flammable gases, vapors and dense clouds of combustible dust.

However, there is a wide variety of other ignition sources. They include the following,[1,2,3] presented in the descending order of the likelihood and risk of ignition hazard in a chemical plant:

Table 1: Relative Risks of Non-Electrical [and Electrical] Ignition Sources

IGNITION TYPES	IGNITION EXAMPLES	ENERGY	LIKELIHOOD	RISK
Open Flames	Heaters; Boilers; Flares	Very High	High	Very High
Hot Work	Welding; Cutting; Power Tools	Very High	High	Very High
[Electrical]	[Unclassified Equipment]	[Very High]	[Very High]	[Very High]
Frictional Hot Spots	Conveyors; Bearings; Calendar	High	High	High
Flash Fires; Explosions	Reactors; Process Equipment	Very High	Low	Moderate
Malicious	Arson; Sabotage	Very High	Very Low	Moderate
Hot Surfaces	Ovens; Driers; Piping; Motors	Moderate	Moderate	Moderate
Spontaneous	Self-heating Dryers/Pyrophoric Materials; Oils	Moderate	Moderate	Moderate
[Electrostatic]	[Ungrounded Equipment]	[Low]	[High]	[Moderate]

Table 1 continued

Adiabatic Compression	Compressors; Blowers	Moderate	Moderate	Moderate
Self-Ignition	Dusts on Hot Surfaces	Moderate	Low	Low
Stray Currents	Ground Loops; Corrosion Protection	Moderate	Low	Low
Hot Particles/Sparks	Grinding; Air Heaters; Impact	Low	Moderate	Low
Smoking Materials	Matches; Lighters	Moderate	Low	Low
Vehicles	Exhaust; Ignition System	Low	Moderate	Low
Electromagnetic Energy	Radio Transmitters; Cell Phones	Moderate	Low	Low
Lightning	Storms	Very High	Very Low	Low
Ionizing Radiation	Level Instruments	Very Low	Moderate	Very Low
Ultrasonic Vibration	Level Sensors; Cleaning Equipment	Very Low	Low	Very Low

Mechanical equipment is commonly found in manufacturing sites and can present a significant non-electrical ignition hazard. Hazardous Area Classification, to manage selection and installation methods of electrical devices, traditionally only addresses the ignition hazard of electrical equipment. Mechanical equipment such as bucket elevators, mixers and blenders, and rotary air-locks can cause frictional heat or frictional sparks during routine operation or during equipment-upset conditions.

A "Mechanical Equipment Ignition Risk Assessment" (MEIRA) can be used to identify, eliminate, or control these types of ignition sources.

A MEIRA generally follows procedures presented in the standard EN 15198 "Methodology For The Ignition Hazard Assessment Of Non-Electrical Equipment And Components For Intended Use In Potentially Explosive Atmospheres" [Reference 4]. While this standard applies to the European Union, its methodology and approach are very effective and can be applied in the U.S.

It is important to limit the scope of a MEIRA to equipment or locations where a flammable gas, vapor or a combustible dust cloud of sufficient concentration could occur, since the above equipment could also be present at many non-hazardous locations in a chemical plant. However, if electrical or electrostatic ignition sources are identified during the MEIRA, they should also be reported, perhaps separately.

When evaluating the probability of occurrence of a fire or explosion, there are two likelihoods that should be determined:

- The likelihood of an explosible fuel/air mixture occurring.
- The likelihood of a sufficiently-energetic ignition source occurring within the explosible mixture.

As in other hazard evaluations, a spreadsheet is generally used to document the analysis.

For the purpose of a MEIRA, all equipment is divided into categories. Category definitions used for equipment in hazardous areas are as follows:

Category 1

Equipment designed to keep within its operational parameters, as stated by the manufacturer, and ensured a very high level of protection for its intended use in areas where explosive atmospheres caused by mixtures of air and gases, vapors, mists, or suspended dusts are either highly likely to occur or are present, either continuously or just frequently.

Category 1 equipment is equipment intended to be used in Class I / Class II Division 1 hazardous locations inside the process equipment.

Equipment in this category is characterized by integrated explosion protection measures functioning in such a way that:

- In the event of a failure of one integrated measure, at least a second independent means of protection provides for a sufficient level of safety.
- In the event of two faults occurring independently of each other, a sufficient level of safety is ensured.

Examples are:
- Hermetically-enclosed/encapsulated equipment
- Inherently safe devices that even in the worst-case scenario would not generate sparks or hot surfaces capable of igniting a surrounding flammable atmosphere
- Type X and Y [Reference 6] air-purged equipment.

Equipment must have provisions to control electrostatic ignition sources as required by NFPA 77.

Category 2

Equipment designed to be capable of keeping within its operational parameters, as stated by the manufacturer, and based on a high level of protection for their intended use, in areas in which explosive atmospheres caused by mixtures of air and gases, vapors, mists, or suspended dust are likely to occur. Category 2 equipment is equipment intended to be used in Class I/Class II Division 1 hazardous locations external to the process equipment.

The explosion protection relating to this category must function to provide a sufficient level of safety, even in the event of frequently occurring disturbances or equipment faults that normally have to be taken into account.

Examples are:

- Dust-ignition-proof equipment in enclosures similar to NEMA Type 9.
- Explosion-proof equipment [NEMA Types 7, 8, and 10] with appropriate surface temperature limitations.
- Type X or Y [Reference 6] air-purged equipment also could be used.

Equipment must have provisions to control electrostatic ignition sources as required by NFPA 77.

Category 3

Equipment designed to keep within its operational parameters, as stated by the manufacturer, and based upon a normal level of protection for its intended use, in areas where explosive atmospheres caused by mixtures of air and gases, vapors, mists, or suspended dust are unlikely to occur or if they do occur, do so infrequently and for a short period of time.

Category 3 equipment is equipment that is intended to be used in Class I / Class II Division 2 hazardous locations.

Equipment in this category must provide a sufficient level of safety during normal operation. Examples are:

- Equipment in dust-tight or vapor-tight enclosures [NEMA Types 4, 6, 12, and 13] with appropriate surface temperature limitations.
- Type X, Y, or Z air-purged equipment also could be used with appropriate surface temperature limitations [Reference 6].

Equipment must have provisions to control electrostatic ignition sources as required by NFPA 77.

As indicated by the above categories for the design and operation of non-electrical equipment, there is a strong similarity to the requirements for the design and operation of electrical equipment in hazardous areas.

The following failure modes should be considered during a MEIRA study:

Table 2: Equipment failure modes to be considered during a MEIRA, to determine the appropriate Category

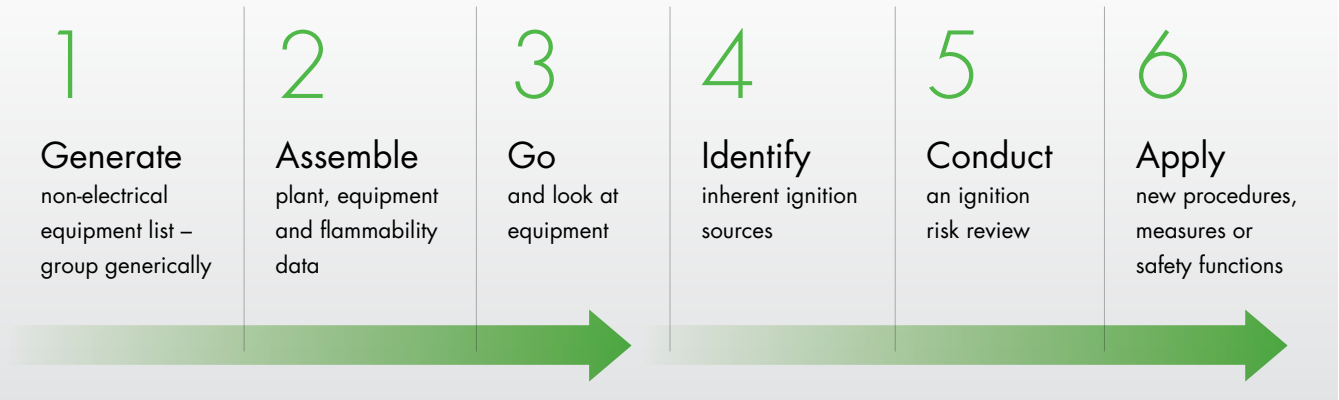
LOCATION	LIKELIHOOD OF FLAMMABLE ATMOSPHERE PRESENCE	CATEGORY 1	CATEGORY 2	CATEGORY 3
Inside the Equipment	Class I, Division 1 Class II, Division1 Zone 0/ Zone 20	Should consider expected and rare failure modes		
External to Equipment	Class I, Division 1 Class II, Division1 Zone 1/ Zone 21	Should consider expected failure modes	Should consider expected failure modes	
Internal/External to Equipment	Class I, Division 2 Class II, Division 2 Zone 2,/Zone 22	Should consider normal operation	Should consider normal operation	Should consider normal operation

Before performing a MEIRA, it is important to determine:

- What are the process safety properties of the flammable atmosphere? As a minimum, the Flash Point, Autoignition Temperature, Lower and Upper Flammable Limits, and the Minimum Ignition Energy for liquids, vapors, and gases, and the Minimum Ignition Energy, Minimum Ignition Temperature, and Minimum Explosible Concentration for powders and dusts, and electrostatic properties, such as conductivity and dielectric constant.
- What are the Hazardous Area Classifications inside and around the equipment?
- Design information and limitations of the equipment being assessed:
    - o Drawings
    - o Manufacturer instructions for operation and maintenance
    - o Speed and power of moving parts
    - o Materials of construction
    - o Lubricated vs. sealed bearings / gearboxes
    - o Types of seals, and seal-face materials
    - o Expected temperature rise
    - o Electrostatic properties and grounding systems
    - o Operating environment
    - o Mitigation systems – e.g., instrumented trips, flammable-vapor concentration sensors, tramp-metal detection, belt-alignment sensors, vibration sensors, explosion protection
    - o Equipment mode of operation (continuous, intermittent, etc.)
- Has equipment been serviced and maintained to the manufacturer's instructions?
- Are there records of this work?
- Has the equipment been modified since the original installation?
- Are there records of the changes?
- Are the manufacturer's original operating and maintenance instructions still valid?
- Was the equipment originally designed for the length of duty, such as continuous or hours per day?
- Is the equipment material of construction compatible with the process materials?
- Is there an opportunity for the operator to achieve over-speed of the pump/compressor/belt?
- Are standard operating procedures available for the equipment and have operators received the appropriate training?

Once this information is obtained, the MEIRA study can be conducted by performing following steps:

MEIRA STUDY STEPS



The MEIRA results can be summarized in the format shown in the following table.

Table 3 An Example of a MEIRA Documentation Table for a Gearbox with Motor in an external Class II, Division 2, Group G environment:

POTENTIAL IGNITION SOURCE	NORMAL OPERATION (CATEGORY 3)	EXPECTED MALFUNCTION (CATEGORY 2)	RARE MALFUNCTION (CATEGORY 1)	MEASURES APPLIED TO PREVENT THE SOURCE BECOMING EFFECTIVE	RECOMMENDATIONS
Hot surfaces	Motor surface	Motor Surface		Motor is rated as T3B (165oC) and hence is suitable for the hazardous environment with a decomposition temp of 179oC for the material.	None
Hot surfaces continued	Gearbox surface temperature. Wear and tear of mechanical components			Gearbox internals cooled by oil below 25oC - completed temperature study determined that normally these gearboxes are operating at 24oC to 25oC. Mechanical friction due to wear and tear of moving components will be detected as excessive noise picked up during operator's tours of areas before an ignition source is generated.	None
Hot surfaces continued		Running with no oil in Gearbox		Currently no protection other than process operators' good practice. Currently only breakdown maintenance is performed on these gearboxes.	Follow OEM maintenance instruction and change oil after every 2000 hrs of Gearbox operation. Check oil level at least once a year
Hot surfaces continued		Misalignment of Gearbox and drive		Direct drive connection. Misalignment conditions are not applicable.	None
Hot surfaces continued		Gearbox running at over-speed		Fixed speed drives are installed. Replacement motors are purchased and installed in line with the manufacturers' instructions.	None
Hot surfaces continued	Electrical sparks occurring in normal operation	Failure of drive shaft bearing		External temperature unlikely to rise to 165oC due to intermittent gearbox operation (20 seconds On, 120 seconds Off), and type of the installation – bearings are internal, lubricated by the gearbox oil, and are not exposed to the processed powder.	Follow OEM maintenance instructions
Hot surfaces continued		Excess ambient temperature		Gearmotor is designed to operate at temperatures < 40oC. Ambient temperatures do not exceed this (104oF).	None
Electrical apparatus		Electrical sparks occurring in expected malfunctions.		Motor is rated as Class II, Div 1, Group G, T3B and hence is suitable. for the hazardous area where it is located.	None
Static electricity		Discharge from isolated conductors		Grounding and bonding on equipment assured by design and construction.	Routine continuity check: resistance <10 Ohms to ground) should be performed on all equipment at least once a year.

Summary

Whenever a manufacturing site handles and/or processes combustible powders or dusts or flammable liquids, vapors, or gases, a minimum standard of safety must include the appropriate control of ignition sources. In addition to completing an electrical Hazardous Area Classification, sites must also consider ignition hazards associated with "mechanical equipment" sources that could ignite these materials. The MEIRA method provides sites with an analysis of non-electrical ignition sources that can pose a danger to personnel, equipment, and the business.

About DEKRA Process Safety

DEKRA Process Safety (DPS) is an industry leader in process safety management, fire, and explosion prevention and protection measures, and safety engineering related to flammable liquids and gases, and combustible dusts. We have consulting offices in North America, Europe, and Asia Pacific as well as laboratories in Princeton (NJ), Chicago (IL), Southampton (UK), and Shanghai (PRC). DPS has international consulting and state of the art ISO 17025 and GLP accredited dust explosion, gas and vapor, flammability, and electrostatic testing laboratories as well as specialist facilities for the evaluation of thermal runaway reactions and energetic materials (pyrotechnics, propellants, explosives). We have been providing process safety consulting, training, and testing services to almost all of the largest chemical, pharmaceutical, and food processing companies around the world.

References

1. Mannan, S. [editor], "Lees' Loss Prevention in the Process Industries", 3rd Ed., Pages 2/17, 16/57, and 17/31 (2005).
2. Babrauskas, V., "Ignition Handbook", Pages 234, 389, and 499 (1992).
3. British Standard BS EN 1127-1:2019 "Explosive atmospheres – Explosion prevention and protection. Part 1: Basic concepts and methodology" (2019).
4. EU Standard EN 15198:2007 "Methodology for the ignition hazard assessment of non-electrical equipment and components for intended use in potentially explosive atmospheres", (2007).
5. Directive (2014/34/EU) "Equipment for explosive atmospheres (ATEX)".
6. National Fire Protection Association, "Standard for Purged and Pressurized Enclosures forElectrical Equipment", NFPA 496, Paragraphs 3.3.8, 4.9, 4.10, 4.11, 5.4, 5.5, A.4.9, A.4.10, and A.4.11 (2017).

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