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Design Facilities to Prevent Deflagration

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Introduction

This paper describes three distinct steps for the assessment and management of deflagration hazards associated with combustible solids, flammable and combustible liquids, and flammable gases in chemical processes. This includes rapid combustion in the form of explosion or flash-fire.

Step I: Identifying Hazardous Locations/Areas

Gases, vapors, and dusts can all form flammable atmospheres under certain process operating conditions; both normal and abnormal. For many years, hazardous area classification procedures have been used to select and install suitable electrical equipment in flammable atmospheres to ensure that the electrical equipment does not become a source of ignition to the identified flammable atmosphere. The same hazardous area classification approach may be used to identify areas where ignitable atmospheres could be present under both normal and abnormal processing conditions. However, the broader objective for risk management of deflagration hazards is to expand the hazardous area classification to include all ignition sources that would be capable of igniting the atmosphere of concern and not just electrical equipment and devices.

Per NFPA 70; NFPA 497; and NFPA 499 (the National Electrical Code) hazardous locations are identified by Classes and Groups that distinguish between different types of flammable atmospheres (Class I for gases and vapors, Class II for dusts, and Class III for fibers and flyings) and the fuel properties (Group A, B, C, D, E, F, or G designation). The hazardous locations are further divided into Divisions (or Zones in international classification approach), based on the likelihood of the fuel being present. Continuous exposure within a given area to a flammable substance would require a Division 1 classification, for example, and areas where the flammable atmosphere could occur due to an abnormal condition or component failure are classified as Division 2.

A hazardous area classification establishes the dimensional extent of the "classified" area and involves due consideration and documentation of the following:

- The flammable materials that may be present;
- The physical properties and characteristics of each of the flammable materials;
- The sources of potential releases, including spills and releases from equipment;

- Maximum ambient temperatures (and pressures);
- Pressures and temperatures within equipment containing the flammable materials;
- How explosible atmospheres could result from equipment failures;
- Availability, reliability, and rates of ventilation (forced and natural);
- Range of dispersion of released vapors and dusts, within the flammable limits;
- Housekeeping practices;
- The probability of each spillage and release scenario.

Step II: Identifying Ignition Sources

The second step is to identify all the potential sources of ignition. Sources of ignition would include open flames, cutting and welding operations, sparks (static, electrical, and mechanical), hot surfaces, radiant heat, frictional heating, smoking, spontaneous combustion, chemical reactions, lightning, etc.

The assessment of ignition hazards arising from mechanical equipment may be performed by using the following four-step approach:

1. Equipment and/or component description;
2. Identification of ignition hazards, including internal fire or explosion;
3. Ignition hazard estimation, including energy, power, and/or temperature;
4. Ignition risk evaluation (what is the likelihood that the ignition source is incendive to the atmosphere of interest).

Information required for the ignition/explosion hazard assessment includes:

- The intended process operations and operating conditions;
- The Ignition Sensitivity, Thermal Instability, Explosion Severity, and perhaps the Electrostatic-chargeability/resistivity properties of the materials to be processed;
- Equipment maintenance programs and practices;
- Accident history of similar devices (if available);
- Design drawings and specifications (speeds of motion; energies of impact); and
- Results of tests and examinations performed on the equipment.

An assessment of the probability of ignition of a deflagration is then based on considering three different operating situations:

- Normal operation;
- Frequently occurring disturbances or equipment malfunctions (expected or predictable malfunctions), including emergency shutdowns and equipment startups;
- Rare malfunctions, such as acts of nature.

Multiple-jeopardy Initiating situations of interest also include:

a. Simultaneous occurrences of up to three independent but expected malfunctions; or
b. Occurrence of a rare malfunction during occurrence of an expected malfunction.

Step III: Evaluating Equipment and Processes, with the Objective of Mitigating the Consequences of Deflagrations

During the third step, existing processes and work practices are evaluated, and measures to control the evolution and spread of hazardous atmospheres are identified. If the prevention of flammable atmospheres within or around the process equipment or device is not possible, preventive or protective measures should be considered, in the following order:

- Ensure that ignition sources are not present (by design);
- Ensure that ignition sources that can occur are controlled (administrative, including permits);
- Additional measures to contain the potential fuel within the equipment (increased preventative maintenance);
- Reduce the effects of deflagration (venting; sprinklers; PPE; exits).

Electrical equipment and installation methods are evaluated against the requirements of the National Electrical Code (NEC), as presented in NFPA 70; NFPA 497; NFPA 499. Mechanical equipment and processes are assessed using relevant Codes, Standards, and best industry practices, such as international standards EN13463, Part 6, and EN 15198.

Examples of technical measures for ensuring safety include:

- Proper selection of electrical equipment;
- Control of static electricity that can be introduced by persons, product, moveable or fixed plant and equipment, or electrically insulating items;
- Improvements in general and local exhaust ventilation to prevent accumulations of flammable gas and vapor;
- Improvements in local exhaust ventilation to prevent accumulations of combustible dust;
- Explosion relief or suppression and isolation systems for equipment and dust collectors;
- Installing physical protective barriers and containment;
- Basic Process Control and Safety Instrumented Systems;

Examples of Organizational Measures for ensuring safety include

- Permit-to-work procedures and permits for potentially hazardous activities;
- Operator and staff training with regard to recognition and control of deflagration hazards;
- Written operating procedures for operators and maintenance personnel in potentially hazardous areas;
- Mechanical integrity policies and preventive maintenance procedures and inspections;
- Providing adequate exits and exit pathways;
- Emergency evacuation and response procedures and drills;

Routine performance of the above measures for ensuring safety should become part of every design effort and also be included in a site's periodic audits of safety performance.

References

Directive 1999/92/EC, Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres, commonly known as ATEX 137 Directive (formerly 118A).

NFPA 68, Guide for Venting of Deflagrations

NFPA 69, Standard on Explosion Prevention Systems

NFPA 70, National Electrical Code

NFPA 77, Recommended Practice on Static Electricity

NFPA 497: Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

NFPA 499, Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

NFPA 654, Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids

EN 60079-10-2, Explosive atmospheres. Classification of areas. Combustible dust atmospheres.

EN 60079-17, Explosive atmospheres. Electrical installations inspection and maintenance.

EN 60079-14, Explosive atmospheres. Electrical installations design, selection and Erection

EN 13463-1, Non-electrical equipment for use in potentially explosive atmospheres. Basic method and requirements.

EN 13463 Part 6, Non-electrical equipment for use in potentially explosive atmospheres.

EN1127-1, Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology.

CLC/TR 50404, Electrostatics - Code of practice for the avoidance of hazards due to static electricity, CENELEC.