AN OVERVIEW OF INTERNATIONAL ELECTRICAL AND SAFETY CODES AND STANDARDS GOVERNING THE APPLICATION OF TURBOMACHINERY IN HAZARDOUS AREAS

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ABSTRACT
A plethora of codes, standards, and guidelines exist throughout the world offering a significant amount of input for the design engineer as he attempts to safely apply hydrocarbon processing equipment to hazardous areas. Fire suppression standards generated in and applicable to use in North America are also used throughout Europe. Off shore techniques are more stringent and must be carefully followed to protect the owner's investment and for the safety of the equipment operators.

This paper is a digest of all internationally recognized codes issued through commonly employed authorities extracting the peculiarities from each and building upon some basic premises to form a design specification that can be modified to suit the specific application or individual company policies.

The discussion will be limited to enclosed and unenclosed gas turbine drivers and hydrocarbon gas processing compressors. Indoor and outdoor installations of this type equipment will also be considered.

INTRODUCTION
The application of turbo-compression equipment can cover many different processes including gas transmission, gas gathering, gas re-injection, liquification of natural gas, chemical processing and air separation. When these processes employ gas turbine drivers, operation takes place in an environment that has flammable or explosive hydrocarbon compounds. Hydrocarbon compounds are considered hazardous (explosive or flammable) and therefore require special consideration for machinery monitoring control and protection.

The type of gas being handled or processed and the possibility of it being released into the machinery environment will determine the area classification that must be utilized in equipment design.

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Each gas is categorized by its properties and classified by degree of hazard. These properties include flammability, auto ignition temperature, maximum explosion pressure and explosive mixture range.

The application of safety codes to turbomachinery depends on many factors. These include:
1. Gas/Fuel being processed or used
2. Area Classification
3. Owner or Project Specifications
4. Location indoor or outdoor
5. Onshore/offshore
6. Governing local codes
7. Type of equipment used (approved or not)
8. Approval Techniques
   a. explosion proof or flameproof
   b. Intrinsic safety
   c. Purge/Pressurization

AREA CLASSIFICATION
The area classification defines the degree of hazard by type of gas present and it's occurrence either periodically or constantly. Area classification is usually defined by the equipment owner and his insurance carrier. The classification of the equipment area will follow guidelines from API or one of the national safety codes such as CSA (Canada) or National Electric Code (USA).

The CSA and NEC codes are almost identical in their classification of hazardous areas. In the majority of applications in North America, turbomachinery is located in an

Presented at the International Gas Turbine and Aeroengine Congress and Exposition
The Hague, Netherlands — June 13–16, 1994
environment that is classified as a Class I, Group B, C or D, Division 1 or 2 location. As defined by the above referenced codes, a Class I location is an environment where flammable gases or vapors can be present in the air in quantities that are sufficient to produce explosive or ignitable mixtures. A Class I, Division 1 Location is defined as an area where ignitable concentrations of gases or vapors exist under one or more of the following conditions:

1. Under normal operating conditions
2. Frequently during repair or maintenance procedures or leaking equipment
3. During breakdown or faulty operation of equipment or processes which might also cause simultaneous failure of electrical equipment that could become an ignition source.

A Class I, Division 2 location is defined by the CSA and NEC codes as an environment in which volatile flammable liquids or flammable gases are handled, processed or used but in which the liquid vapors or gases will:

1. Normally be confined within closed containers or systems from which they can escape only in case of accidental rupture or breakdown of these containers or systems or in case of abnormal operation of equipment
2. Be prevented from reaching ignitable concentrations by the use of positive pressure ventilation equipment but could become ignitable through failure or abnormal operation of the ventilation equipment or
3. Be in an area adjacent to a Class I, Division 1 location.

If turbomachinery is located within a Class I, Division 2 location and has an equipment enclosure around it for cooling, noise reduction or any other reason, it is treated as a Class I, Division 1 area. This is based on the following:

1. There is a source of fuel from high pressure hydrocarbon gas
   a. the compressor or process
   b. fuel gas for a gas turbine prime mover
   c. starting gas for gas turbine prime mover
2. There is a source of ignition or elevated temperature due to:
   a. Physical contact between rotating and stationary parts
   b. Elevated surface temperatures of machinery, i.e., equipment above auto ignition temperature.
3. An enclosure is inadequately ventilated when forced ventilation fans are inoperable.

Area classification definitions provided by IEC and CENELEC and defined by IEC 79-10 are similar to the North American codes. The European codes classify hazardous areas by zones instead of by Class and Division:

- In a Zone 0 area an explosive air-gas mixture is continuously present or present for long periods. This is equivalent to a Class I, Division 1 location.
- In a Zone 1 an explosive air-gas mixture is likely to occur in normal operation. This is equivalent to a Class I, Division 1 location.
- In a Zone 2 area an area where an explosive air-gas mixture is not likely to occur, and if it does occur, it will only exist for a short period of time. This is equivalent to a Class I Division 2 location.
- A non-hazardous area is one that has not been classified as a Zone 0, 1, or 2.

Equipment selected for compliance with IEC standards requires further analysis of the protection category that will be employed to comply with the area classification. There are several methods of protection, but we will list here only those that are applied in practice with gas turbine drives.

"d" Flameproof Enclosure

Parts that are capable of igniting the hazardous gas are contained within an enclosure that, by design, can contain the potential explosion and prevent the transmission of the explosion to the surrounding atmosphere. This method of protection is applicable to Zones 1 and 2.

"e" Increased Safety

Protection by taking measures to increase security against the possibility of arcing or sparking and excessive temperatures (i.e., prevents ignition) by the components within the enclosure. This method of protection is applicable to Zones 1 and 2.

"i" Intrinsic Safety

Energy is limited to below the allowed level so that it is not possible for the hazardous gas to be ignited. Components in the "ia" category must not allow ignition in the event of two failures and "ib" category must not allow ignition in the event of one failure. This method of protection is applicable to Zones 0, 1, and 2.

"p" Pressurized

Hazardous gas is prevented from entering an enclosure by maintaining a positive pressure with air or an inert gas inside the enclosure. This method of protection is applicable to Zone 1 and 2.

APPLICATION OF AREA CLASSIFICATION RULES

Of all the documents published the most useful for evaluating specific issues associated with the definition of area classifications for gas turbines, gas compressors and enclosures is API RP 550. This RP addresses heavier and lighter than air gas considerations, adequate and inadequate ventilation, and multiple hazardous gas sources in buildings. Figures 1 thru 6 summarize the pertinent issues associated with the subject covered by this paper.

PURGED AND VENTILATED EQUIPMENT ENCLOSURES

When the area classification is defined, such as Class I Group C and D Division 1 inside equipment enclosures, the process of selecting components and methods required to meet the area classification begins. First, all equipment selections must be either explosion proof design or intrinsically safe to meet the Class I requirements. In some cases this is not possible. Normal engine mounted instrumentation supplied by the gas turbine manufacturer may not be available in explosion proof construction or may not be capable of being made intrinsically safe with the use of zener barriers. Some devices require more power to operate than allowed by intrinsic safety analysis. In this case, the hazardous area classification must be reduced by purging or ventilating the equipment enclosure. The guide lines for utilizing this technique are defined by NFPA 496 for equipment built in compliance with the National Electric Code (USA), T.I.L. E-13A for equipment built in compliance with the
Purging is a technique employed to install or mount unproved electrical equipment inside an enclosure that is maintained at a positive pressure above the surrounding atmospheric pressure with an inert gas or clean air. The enclosure may be located within a hazardous area with the unproved electrical equipment energized as long as the requirements for purging are maintained (i.e. positive pressure and absence of flammable gas or vapor). According to NFPA 496, there are three types of purge that may be employed depending on the degree of hazard reduction required:

1. Type "X" purge - Technique that allows mounting and use of general purpose equipment in a Division 1 area.
2. Type "Y" purge - Technique that allows the mounting and use of equipment suitable for Division 2 in a Division 1 area.
3. Type "Z" purge - Technique that allows the mounting and use of general purpose equipment in a Division 2 area.

The use of the pressurization technique requires that non-approved equipment be de-energized when the pressurization system is not operating. It is also a requirement that prior to the energization of non-approved equipment, the enclosure experience a certain number of air changes and the gas detection system confirms that a combustible mixture is not present. If after operation has begun, a combustible mixture is sensed within the equipment enclosure, the turbomachinery must be shutdown and the non-approved equipment must be de-energized. If immediate de-energization of non-approved equipment could cause potential damage to operating equipment or make the situation more hazardous (reference NFPA 496-4.2.6.1 & 4.2.7), then a short delay of up to 30 minutes is permissible to enable the equipment to be stopped safely. When a type Y or Z purge is being employed and the equipment enclosure purge is lost and the gas detection system does not detect the presence of a combustible mixture, the non-approved enclosure may remain energized for a limited time while the purge is restored.

NFPA 496 and DN RP C102 require that with the use of an equipment enclosure, gas detection equipment and proof of enclosure pressurization equipment (switch or transmitter) be employed to monitor the integrity of the enclosure area.

FIRE AND GAS DETECTION

Turbo Machinery equipment installations can represent a multi-million dollar investment. If an equipment enclosure is provided, a fire detection and suppression system for the enclosure should also be provided. Considering equipment replacement costs, lost revenue due to fire or gas related equipment damage, remote operation of the equipment and insurance premiums, it is prudent to include a fire detection and suppression system as part of the installation.

Gas detection equipment is used to monitor the enclosure interior and the ventilation air inlet for possible presence of hydrocarbon vapors. The gas detectors should be strategically located to pick up gas leakage from potential sources by being elevated for lighter than air gas applications, lowered for heavier than air gas applications, should not be located in a dead air space and should not be located in a high velocity air path. If any single detector detects a lower explosive limit (LEL) greater than 20% an alarm should be annunciated. If any single detector detects a LEL greater than 40%, a machinery shutdown should be processed, the compressor train should be blocked and vented of all hydrocarbon gas, and gas turbine fuel should be isolated from the equipment enclosure. The enclosure ventilation system needs to remain energized to purge the equipment enclosure of any accumulated hydrocarbon vapors. Some installations, such as offshore platforms may require that the fire suppression agent be discharged on detection of gas. Also, some installations may require voting to initiate a trip.

All components in the fire and gas system are supervised for fault detection and loop integrity which will result in an alarm annunciation should a fault be detected. If the equipment is not operating the start permissive is removed. A fire detection system is designed to detect a fire by one of several methods including rate compensated thermal detectors, absolute temperature detectors and ultraviolet/infrared flame detectors. A fire can be detected by any one of the devices. A smoke detector may also be employed but experience indicates that this is not necessary unless the fuel is a liquid. The placement of these detectors within an equipment enclosure is very important. The UV/IR detectors must be located so that they have an unobstructed view of all anticipated fire zones. The rate compensated thermal detectors should be located such that potential sources of fire are in close proximity to the detector to enable timely activation and the rapid thermal increase experienced during normal operation of the gas turbine does not initiate a false alarm. When an enclosure is employed, care should be taken to locate the absolute temperature sensor so that it is in the direct path of the ventilation air exit(s) and not in a dead space.

FIRE SUPPRESSION

An integral part of the overall installation is the fire suppression system. The two most common types of fire agent employed with turbomachinery are carbon dioxide (CO2) and Halon. Halon has proven to be both an effective fire agent and explosion suppressant but has lost favor due to its negative environmental impact. With the current demand for CO2 systems being strong, it is necessary to increase personnel awareness of the safety precautions that must be implemented because of the possibility of suffocating in a confined area where CO2 has been released. Automatic CO2 release systems designed in accordance with NFPA 12 require that an audible and visible warning device be used to warn personnel of pending discharge of the suppression agent. In practice the fire protection system will have a built in time delay from the time a fire is detected until the suppression agent is released to allow for personnel evacuation. The turbomachinery will be immediately shutdown and isolated (blocked and vented) from fuels and process gas to eliminate the possibility of external fuel sources feeding the fire.

The enclosure fire protection system should be provided with local manual lockout devices that allow operator access into the equipment enclosure, limit switches on the equipment enclosure access doors that inhibit agent release when an
The fire detection system logic presented in figure 8 only addresses the area inside the gas turbine enclosure. The total system is comprised of two rate compensated temperature sensors (TSHH 5,6) located above potential fire sources, one temperature switch or RTD (TSHH 7) located near the ventilation exhaust, two flame sensors (AE 8,9) viewing likely fire zones, a manual release station (HS 10), an inhibit switch (HS 11) located at each enclosure entrance, and a pressure switch (PSS 12) to confirm that the fire agent has been released. Each component and loop are supervised for continuous functionality. Local alarm horns and beacons will alert personnel of impending fire agent release.

After the enclosure fans are energized, the enclosure pressurization switch (PDSLL 14) confirms that a positive pressure has been established, then the required number of air changes takes place (varies from 10 to 90) and the equipment not suitable for the non-ventilated enclosure classification may be energized. The logic interfaces with maintenance bypasses, the fire system, and the gas detection system.

DISCUSSION OF APPENDICES
Appendix A is a summary of commonly employed codes that impact the subject of this paper. The appendix is not intended to replace the codes or standards themselves nor is it intended to function as a short cut to applying the appropriate techniques discussed in this paper. By reviewing the noted paragraphs from each code or standard listed, it will be possible to evaluate the impact of that document on the proposed installation. The summary will also help in determining the impact of referenced standards on primary codes or standards.

Appendix B is believed to be a complete listing of relevant codes, standards, and guidelines that should be reviewed and understood prior to applying gas turbine driven equipment in hazardous areas. The reference list will supplement these documents with an adequate commentary on the subject matter.

Appendix C is a table that can serve as a cross reference for several European codes that have the same content yet different country oriented document titles. CENELEC (The European Committee for Electrotechnical Standardization) has established a uniform code to help improve trade throughout Europe. These codes are based on the IEC code and are called Euronorm Standards. They carry the designation EN500XX as noted in the table.

APPLICATION OF FIRE AND GAS CODES AND STANDARDS
The intent of the majority of the codes and standards that apply to enclosed gas turbine driven hydrocarbon compressors have been incorporated in the logic diagrams shown in figures 7, 8, and 9. Modifications to these diagrams can and should be made to accommodate specific company policies or specific local approval agency requirements.

It is recommended that gas detectors be mounted in pairs, although most codes do not require this. Each zone or area should be protected separately including duct inlets that are required to transport purge air from a non-hazardous area. This will ensure that the air source has not been contaminated by hazardous gas originating from a ruptured pipe or vessel, a vent, or a relief valve. The example presented in Figure 7 implies that the enclosure purge air and the gas turbine inlet air have originated from the same inlet duct and filtration system. The two gas detectors shown located in the plenum will accomplish the intent to ensure that the enclosure purge air remains free of hazardous gas concentrations. The two gas detectors mounted inside the enclosure will detect any fuel leaks. The logic will check for gas detector component faults, loop integrity, alarm status and shutdown status. Enclosure fans are turned on automatically if the enclosure gas detector alarm is activated but not if the plenum (or purge air source) alarm is activated. If a shutdown is activated due to both detectors in the same zone failing the health check or any one of the detectors reaching the 40 % LEL setpoint, a shutdown will be initiated and within 30 minutes all equipment not suitable for the area must be de-energized.

The fire detection system logic presented in figure 8 only addresses the area inside the gas turbine enclosure. The total system is comprised of two rate compensated access door is open, and warning labels at each personnel entrance to caution personnel that automatic agent release could take place if proper safety procedures are not followed. The hazards of the suppression agent must also be advised on these warning labels. The suppression system should be provided with a primary fast discharge system and also an extended slow discharge system to prevent fire restart after initial discharge. In remote locations it would be advantageous to have a 100% spare supply of suppression agent.

The equipment enclosure should also be fitted at the ventilation inlet and exhaust with fire shutters that close upon fire detection to isolate the enclosure and prevent dilution of the fire agent by the ventilation system. Fire shutter activation can be by electric motor, electro-pneumatic operator or a spring loaded device operated when the agent is released. The equipment enclosure ventilation fans should be stopped when a fire is detected. The fire suppression discharge piping should be provided with a pressure switch to confirm that the suppression agent has been released as intended. Properly located manual release stations will allow the local personnel to override the automatic detection system if necessary. The suppression agent has been released as intended. Properly grounding to prevent buildup of electrostatic charge.
APPENDIX A

CODE AND STANDARD SUMMARY

Many of the codes, standards, and guidelines contain disclaimers that deserve acknowledgment at this point. All such documents are expected to be used by individuals skilled in the particular art that they address. There is no substitute for careful planning, diligence and safety analysis. The authors of the codes, standards, and guidelines, and subsequently the authors of this paper, cannot be responsible for misapplication of intentions or subsequent damage to equipment or personnel when applying this information.

NFPA 12, NFPA 496 and CSA 22.1 are used as base lines; duplicated requirements from the other codes or standards are not listed.

1. NFPA 12 (2/12/93) Carbon Dioxide Extinguishing Systems

1-4.2.2 Fire agent release nozzles must be metal and electrically grounded.
1-5.1, 1-9.2.3 Safety relief valves that discharge CO2 must be piped away for personnel safety.
1-5.1.1 A pre-discharge alarm is required to ensure that personnel are not trapped in an enclosed area when the CO2 is released. Prompt evacuation of the enclosure must be possible. Recommends the provision of self-contained breathing apparatus for rescue purposes.
1-5.1.4 A time delay prior to release of the fire suppression agent is required.
1-5.1.5, 1-7.5 Audible and visual alerts are required in the area that the fire agent will be released prior to the actual release of the agent.
1-5.1.6 A fire agent release lock out is required.
1-6.3 The installed system must be inspected and tested for satisfactory operation prior to being placed in service.
1-7.3.8 On detection of a fire, all sources of fuel must be isolated including the gas turbine fuel or compressed process gas. Consideration should be given to the appropriate termination of lubricating oil flow. It is logical to terminate lubricating oil after equipment rotation has ceased.
1-7.4, 1-7.5.3 An audible and visual alarm must be annunciated upon circuit supervision failure. End of line devices should be used to ensure complete circuit integrity.
1-7.5.1 A fire agent released alarm is required to ensure that the operator is reminded to recharge the system.
1-7.6 A back up power source with 24 hour capacity is required to have automatic transfer capabilities in the event the primary power source fails.
2-2.2.1 Ventilation openings must be closed prior to or simultaneously with the release of the fire agent.
2-2.2.2 Gas turbine enclosure ventilation fans must be stopped prior to or simultaneous with the release of the fire agent to ensure the desired concentration levels are achieved and maintained. 2-3.5 allows for alternatives if this is not possible.

2. NFPA 37 (2/5/90) Stationary Combustion Engines and Gas Turbines

1-1.1 The standard is limited to engines 7500 horsepower and less.
3-2.1(b) Requires an automatic low oil pressure shutdown.
3-3.1 Requires an automatic overspeed shutdown, high lube oil temperature shutdown, a remote stop, a remote fuel shut off, and for engines less than 1000 horsepower a remote lube oil pump shut off.
3-4 Identifies the need for automatic speed control, exhaust over temperature protection, isolation of the fuel source, and the employment of a purge cycle during the start sequence.

3. NFPA 69 (2/10/92) Explosion Prevention Systems

1-1.1 The standard applies to systems intending to prevent deflagration explosions.
1-2 The standard outlines the minimum requirements for the installation of systems designed to prevent explosions in enclosures containing combustible gases or vapors.

4. NFPA 72 (8/17/90) Installation, Maintenance, and Use of Protective Signaling Systems

1-1 This standard deals with signaling systems designed to preserve life and property.
2-5.2.2(a) Fire detection systems shall be tested monthly.
2-5.2.2(b) Alarms, indicating alarms and annunciators shall be tested annually.
5-3.1 Requires three sources of power defined as the primary, secondary (24 hour capacity battery system or engine driven generator), and trouble supply.
5-3.4 Allows the use of the secondary power supply to function as the trouble supply in the event of a primary supply failure.

5. NFPA 72E (8/17/90) Automatic Fire Detectors

1-1.1 This standard provides minimum requirements for the operation of automatic fire detectors. It also is an excellent tutorial on detector principals of operation.


1-2.1 This code provides minimum requirements for fire safety in buildings and structures.
1-4.1 The code objective is to provide a reasonable level of safety by combining prevention, protection and egress requirements to reduce the probability of injury due to a fire.
4-1.9 Identifies this application as Industrial.
4-2.2.4 Identifies this application as a high hazard content.
6-2 Defines fire barrier ratings in the event they apply to the enclosed equipment.
28-2.3.1, 30-2.3.1 Excludes unoccupied spaces, such as equipment enclosures surrounding the rotating equipment, from the means of egress requirements.
28-3.2 Exempts industrial hazardous areas from smoke resistant construction if protected by an automatic fire extinguishing system.
28-3.4.1 Requires the installation of an automatic and manually operated fire system.
28-3.4.3.1 Requires that the fire system sound an alarm in a continuously attended location.
7. NFPA 496 (2/6/89) Purged and Pressurized Enclosures for Electrical Equipment

1-1 Defines applicability of the standard for purged and pressurized enclosures for equipment located in hazardous areas and for electrical equipment containing sources of flammable gas or vapors.

1-4 Defines a Type Y purge as a means for reducing a hazardous area from a Division 1 to Division 2 and a Type X purge as a means for reducing a hazardous area from a Division 1 to non-hazardous.

2-1 Applies to equipment enclosures less than 10 cubic feet (.3 m³) in volume.

3-1 Applies to control rooms.

4-1 Applies to equipment rooms larger than 10 cubic feet (.3 m³) in volume.

4-1.2(b) Defines Ventilated equipment as requiring air flow to dissipate heat generated as well as prevent the entrance of hazardous gas.

4-2.2, 4-3.4 Requires the source of purge air to be non-hazardous.

4-2.4 Requires that 10 volume changes of air take place while at a positive pressure of 1" H₂O (25 Pa) prior to energizing equipment not rated for Division 1.

4-2.6.1, 4-3.9 Requires that an alarm be sounded at an attended location on loss of purge. Thought must be given to removal of power from non-Division 1 components and the associated hazards.

4-2.9, 4-3.8 Restricts the maximum surface temperature of any device within the enclosure to be 80% of the auto ignition temperature of the flammable vapor or gas but allows for testing by exception.

4-3.2 Requires the ventilation equipment be suitable for the hazardous area prior to the purge.

4-3.5 The air discharged from the enclosure must be to a Division 2 or non-hazardous area.

5-1, 6-1, 7-1 Applies to Class II equipment.

5-1, 6-1, 7-1 Applies to instrument housings.

8-1 Applies to rooms or buildings with process liquids or gas piped to the equipment within the enclosure.

9-2.6 Ventilation must be sufficient to dilute leakage from the largest single failure to less than 25% LEL.

9-3.5 All process streams require a shutoff valve outside of the enclosure.

8. NFPA 497M (2/8/91) Classification of Gases, Vapors, and Dust for Electrical Equipment in Hazardous (Classified) Locations

2-3 Defines the auto ignition temperature of methane gas as 999°F (630°C).


1-1 This standard makes recommendations for fire systems installed on electric generating units 7500 horsepower and larger.

3-4.2.6 Fresh air inlets should be arranged so that they do not draw products of combustion from vents of other fire areas.

4-6.3 Inhibit switches should be located near the area of fire agent coverage to allow maintenance personnel to disable the system when necessary. When in the inhibit mode, a system alarm should be activated.

5-7.2.1, 6-5.3.2 Recommends that hydraulic control systems employ fire resistant oil or automatic water or foam/water protection systems.

5-7.3.1 Recommends the use of a vapor extractor on lube oil systems vented to a safe location.

5-7.4.2 Recommends protecting bearings with a manual or automatic sprinkler system. If a manual system is employed, it should be supplemented with an automatic gaseous system.

5-7.4.3 Recommends protecting lube oil lines above grade with an extinguishing system.

5-7.4.4 Recommends protecting lube oil reservoirs and lube oil handling equipment with an automatic system.

6-3.1.2 Equipment layout should consider potential damage from debris such as rotating disks.

6-4.1.4 In the event of an unmanned station, the fire signaling panel should be located at the station entrance.

6-5.2.1 Flame detectors are recommended for the combustion section of the gas turbine.

6-5.2.2 Controls for gas turbines should include overspeed protection, vibration protection, exhaust temperature protection.

6-5.2.3 Two shutoff valves should be used for fuel termination. In gas fuel applications, a vent should be installed between the two shutoff valves.

6-5.3.3 Recommends the use of combustible gas detectors in the gas turbine enclosure if gas fuel is used.

6-5.4.3.2 Recommends that fire agent concentrations be held below the auto ignition level.

10. ISA-S12.4-1970 Instrument Purging for Reduction of Hazardous Area Classification

2.1 This standard defines a technique for reducing the hazard of an instrument enclosure by purge.

2.4 The intent of this standard has been incorporated in NFPA 496.

4.1.1 This standard applies to enclosures less than 10 cubic feet (.3 m³) in volume.

11. API RP 500 (First Edition, 6/1/91) Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities

1.1.2 The purpose and scope of this RP is to provide guidelines for determining the area classification for permanent and temporary electrical installations. To adequately address the variety of applications encountered by industry, additional sections exist. Section A is devoted to locations handling flammable gases and liquids. Section B applies to drilling rigs and marine fixed and mobile platforms. Section C applies to onshore and offshore flammable gas and liquid delivery facilities. Section D is an exhaustive listing of industry codes, guides and standards.

3.4 Discusses flammable gases that are lighter than air. Generally, the gas will disperse in an open installation however when the leak is contained by an enclosure the degree of hazard is increased.
15. CSA TIL NO. E-13A Requirements for Purged and Pressurized Enclosures

The purpose of this technical letter is to provide consistency throughout Canada when applying the principles of C22.1 and NFPA 496 to purged and pressurized enclosures.

16. RP C102 (1/87) Area Classification and Ventilation, Det Norske Veritas Offshore Standards

1.1.1 This RP provides guidelines for the area classification and ventilation of equipment installed offshore.
1.2.5 Considers mechanical ventilation of 12 air changes per hour to be adequate.
2.3.1 When employing mechanical ventilation of adjacent areas, the area of highest hazard should be the lowest in pressure.
2.3.4 Ventilation inlets should be located in non-hazardous areas and be protected by gas detectors. Gas detectors should alarm at 25% LEL and shutdown equipment at 75% LEL.

7.1.1 Section 7 applies specifically to natural gas fueled gas turbines.
7.4.2 A turbine hood (or turbine enclosure) will be considered adequately ventilated if the turbine skin temperature does not exceed 200°C during operation and there are 12 air changes per hour. The enclosure will be considered Zone 2 as long as ventilation exists and Zone 1 in the event it stops.
7.4.4 If turbine skin temperatures attain levels above 60% of the ignition temperature of the fuel gas or energized electrical equipment inside the turbine enclosure does not meet Zone 2 requirements, the ventilation system must be able to provide sufficient flow that hazardous gas leaks are diluted. Redundant fans are required with the capability of 90 air changes per hour. Injection of Halon during turbine shutdown is considered an acceptable alternative to ventilation.
7.4.5 Another means of declassifying the turbine enclosure during shutdown is to block and vent fuel gas from the enclosure and turbine.
7.5.1 The turbine enclosure should be protected by gas detectors that shut the unit down when gas is detected.
7.5.3 Turbine enclosure ventilation should continue after a shutdown until the turbine skin temperature is below 80% of the ignition temperature of the fuel.
APPENDIX B

RELEVANT INDUSTRY CODES, STANDARDS AND GUIDELINES

1. American Petroleum Institute (API)
   API RP 14G "Recommended Practice for Fire Prevention and Control on Open Type Offshore Production Platforms"
   API RP 500 "Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities"
   API RP 500A "Classification of Locations for Electrical Installations in Petroleum Refineries"
   API RP 500B "Recommended Practice for Placement of Electrical Equipment on Production Leases"
   API RP 500C "Classification of Locations for Electrical Installations at Pipeline Transportation Facilities"

2. British Standards
   BS4683 Electrical Apparatus for Explosive Atmospheres
   BS5345 Code of Practice for the Selection, Installation and Maintenance of Electrical Apparatus for use in Potentially Explosive Atmospheres
   BS5501 Electrical Apparatus for Potentially Explosive Atmospheres

3. Canadian Standards Association (CSA)
   C22.1 Canadian Electric Code, Part I
   C22.2 No. 213-M1987 "Non-incendive Electrical Equipment for use in Class I, Division 2 Hazardous Locations"
   CAN/CSA-Z184-M92 "Gas Pipeline Systems"
   TIL No. E-13A "Requirements for Purged and Pressurized Enclosures"

4. Instrument Society of America (ISA)
   ISA RP 12.1 "Definitions and Information Pertaining to Electrical Instruments in Hazardous Locations"
   ISA S12.4 "Instrument Purging for Reduction of Hazardous Area Classification"
   ISA RP 12.6 "Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations"
   ISA S12.12 "Electrical Equipment for Use in Class I, Division 2 Hazardous (Classified) Locations"
   ISA S12.13, Part I "Performance Requirements, Combustible Gas Detectors"
   ISA RP 12.13, Part II, "Installation, Operation, and Maintenance of Combustible Gas Detection Instruments"

5. International Electrotechnical Committee (IEC)
   Electrical Apparatus for Explosive Gas Atmospheres
   IEC 79-0 General introduction
   IEC 79-1 Construction and Test of Flameproof Enclosures of Electrical Apparatus
   IEC 79-2 Pressurized Enclosures
   IEC 79-3 Spark Test Apparatus for Intrinsically Safe Circuits
   IEC 79-4 Method of Test for Ignition Temperature
   IEC 79-5 Sand Filled Apparatus
   IEC 79-6 Oil Immersed Apparatus
   IEC 79-7 Construction and Test of Electrical Apparatus, Type of Protection Increased Safety
   IEC 79-8 Classification of Maximum Surface Temperatures
   IEC 79-9 Product Marking
   IEC 79-10 Classification of Hazardous Areas

6. National Fire Protection Association (NFPA)
   NFPA 12 "Carbon Dioxide Extinguishing Systems"
   NFPA 30 "Flammable and Combustible Liquids Code"
   NFPA 37 "Standard for Installation and Use of Stationary Combustion Engines and Turbines"
   NFPA 69 "Explosion Prevention Systems"
   NFPA 70 "National Electric Code"
   NFPA 72 "Installation, Maintenance, and use of Protective Signalling Systems"
   NFPA 72E "Automatic Fire Detectors"
   NFPA 101 "Life Safety Code"
   NFPA 321 "Standard on Basic Classification of Flammable Combustible Liquids"
   NFPA 325M "Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids"
   NFPA 493 "Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous Locations"
   NFPA 496 "Standard for Purged and Pressurized Enclosures for Electrical Equipment in Hazardous (Classified) Locations"
   NFPA 497A "Recommended Practice for Classification of Class I Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas"
   NFPA 497M "Manual for Classification of Gases, Vapors, and Dusts for Electrical Equipment in Hazardous (Classified) Locations"
   NFPA 850 "Fire Protection for Fossil Fueled Steam and Combustion Turbine Electric Generating Plants"

7. Det Norske Veritas
   RP C102 "Area Classification and Ventilation"
APPENDIX C
EUROPEAN CODE CROSS REFERENCE

<table>
<thead>
<tr>
<th>CONTENT/ METHOD OF PROTECTION</th>
<th>IEC PUBLICATION</th>
<th>EURONORM</th>
<th>VDE SPECIFICATION</th>
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<td>&quot;d&quot; FLAMEPROOF</td>
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CONCLUSION
A thorough study of safety system requirements for the installation of gas turbine driven hydrocarbon compressors has been presented. The numerous applicable codes, standards and guidelines have been reviewed, summarized, and discussed in detail. The application of these standards is recognized as being a complex issue and is open to user interpretation. A practical interpretation of the standards has been included in a manner that can serve as a starting point for new installations.

LIST OF REFERENCES
SOURCE OF GAS IN AN ADEQUATELY VENTILATED NON-ENCLOSED AREA

FIGURE 1

SOURCE OF GAS IN AN ADEQUATELY VENTILATED ENCLOSED AREA

FIGURE 2
SOURCE OF GAS IN AN INADEQUATELY VENTILATED ENCLOSED AREA

FIGURE 3

ADEQUATELY VENTILATED ENCLOSURE WITHIN AN ADEQUATELY VENTILATED BUILDING

FIGURE 4
5 FEET
UNPIERCED WALL
PIERCED OR UNPIERCED WALL - EQUIPMENT ENCLOSURE
GRADE LEVEL
SOURCE OF GAS

DIVISION I
DIVISION 2
SAFE AREA

ADEQUATELY VENTILATED OR PURGED ENCLOSURE WITHIN AN ADEQUATELY VENTILATED BUILDING

FIGURE 5

DIVISION I
DIVISION 2
SAFE AREA

INADEQUATELY VENTILATED EQUIPMENT ENCLOSURE WITHIN AN ADEQUATELY VENTILATED BUILDING

FIGURE 6
GAS DETECTOR LOGIC

FIGURE 7
FIRE DETECTION LOGIC

FIGURE 8
ENVELOPE PURGE LOGIC

FIGURE 9

NOTE: ALL SIGNALS GO HIGH ON ALARM
ENERGIZE PURGE FAN MOTOR(S)

ENERGIZE NON DIVISION EQUIPMENT

ENCLOSURE DPLOW SHUTDOWN ALARM

ENCLOSURE DPLOW ALARM ENCLOSURE DOOR OPEN

ENCLOSURE PURGE SYSTEM INHIBITED SHUTDOWN ENCLOSURE PURGE SYSTEM TIMED OUT

NOTE: ALL SIGNALS GO HIGH ON ALARM

ENCLOSURE PURGE LOGIC

FIGURE 9