Whitepaper

Modular Integration of Process Equipment Packages for Oil and Gas Facilities

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Abstract

An integrated design approach to a modular process equipment package is discussed. By incorporating the electrical, instrumentation and control equipment on the same platform as the process equipment, a higher level of modular integration is achieved. The benefits include a reduced number of on-site equipment terminations and the ability to precommission equipment prior to installation resulting in lower installed costs. The area classification, installation and transit barrier requirements for an integrated modular design approach are reviewed.

Index Terms – cable termination, hazardous area classification, modular integration, process building design, cable transit, vapor barrier.

Introduction

Prefabricated modular buildings are extensively used for skid packages in both upstream and downstream oil and gas facilities. A typical skid package may incorporate process vessels, compressors, pumps manifolds and other miscellaneous equipment handling flammable materials. In most cases, the interiors of such buildings are classified as Class I hazardous locations in accordance with Articles 500/505 of NFPA 70 (National Electrical Code) or Section 18 of the CEC (Canadian Electrical Code).

Once a process module has been classified as a hazardous location, the certification of electrical equipment and the wiring methods are impacted. Switchgear, motor control centers and process control equipment are typically designed for installation in an unclassified location. This requires that the major instrumentation, protection and control equipment must be located off-skid, usually in a remote building location. The electrical equipment connections are then completed on-site when the skid modules are set in place. This approach requires that the interconnection, commissioning and testing of the systems be performed on-site. This is both expensive and time consuming and typically requires specialized personnel to fully commission a process system.

What if the process equipment and the protection, instrumentation and control equipment could be installed on the same skid assembly? This would permit the wiring connections to be completed at the fabrication facility and allow the pre-commissioning of process equipment in a controlled environment. It would reduce on-site labor, allow for quicker implementation and improve quality by performing the majority of work in a factory controlled environment. This would ultimately reduce overall installation costs. Is there some way of promoting this design concept?

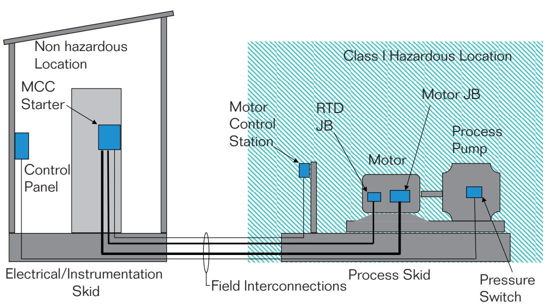
There are several options with respect to the area classification design, building layout, and the construction methods used to implement the integrated design concept. This paper looks at ways of executing an integrated process package design where both process equipment and electrical, instrumentation and control equipment are installed on a common skid package.

Standard modular process package concept

A typical oil and gas process skid package usually incorporates only the process equipment. This is primarily due to the requirement to classify the immediate area surrounding the process equipment. Depending on the probability of a flammable release, the duration of a release and the level of ventilation available, a process skid may be classified Class I, Division 1 or 2 using the division method of area classification, or Class I, Zone 1 or Zone 2 under the Zone method of area classification.

Once the process module is classified, the electrical and instrumentation equipment must be certified for the hazardous location. Hazardous location certified equipment is typically more costly and often of limited availability. For this reason, the majority of the electrical and control equipment is located off-skid in an unclassified location with only the end device sensors located on the process skid. The result is a large number of wiring interconnections that must be completed in the field. Fig. 1 illustrates a typical design approach to a modular oil and gas process package.

Fig 1



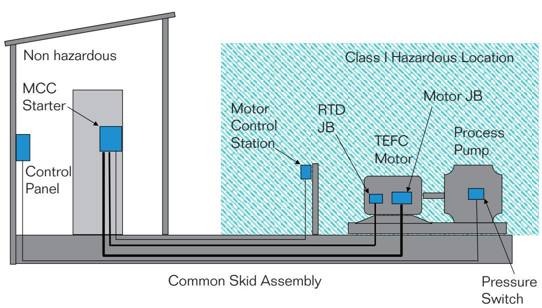
Standard Modular Process Skid Design Concept

Integrated modular process package concept

The integrated modular design package concept incorporates all process, instrument, electrical and control systems on a common skid. To incorporate unclassified utility, electrical and control system equipment on a process skid handling flammable materials, a “safe” area must be created. The design of the safe area is part of the hazardous area classification design for the skid package. This can be accomplished in one of three ways.

1. Physically separate the unclassified area from the classified area on a common skid
2. Create a positive pressure zone within the classified area using air from an unclassified location
3. Incorporate the use of vapor -tight barriers to segregate the classified area from the unclassified area

Fig 2



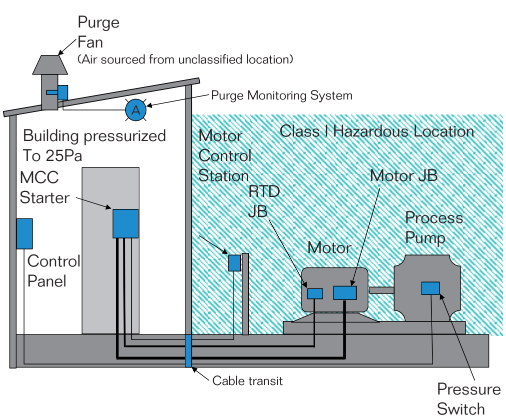
Option 1 – Integrated Design using Physical Separation

A. Option 1 – Physical Separation

Option 1 separates the classified area from unclassified area by distance. A building incorporating the electrical and control equipment is located outside the classified area associated with the process equipment. The distance between the buildings is determined by the area classification design for the process equipment. This is a function of the vapor density of the flammable materials handled and the level of ventilation within the immediate area. Fig. 2 illustrates this concept.

The primary disadvantage of separating the classified area from the unclassified area by distance is the resulting size of the skid package. This typically increases the size and weight of the building skid which could impact the size of the shipping envelope.

Fig 3



Option 2 – Pressurized Building within a Classified Location

B. Option 2 – Pressurized Control Building within a Classified Area

Option 2 involves creating an unclassified area within a process unit by a positive purge. An enclosed building is pressurized to a value slightly beyond normal ambient pressure to prevent any fugitive emissions from a classified location from entering the unclassified area.

The requirements for a pressurized building are defined in Chapter 7 of NFPA 496 "Standard for Purged and Pressurized Enclosures for Electrical Equipment". The basic requirements for a purged room or building are as follows:

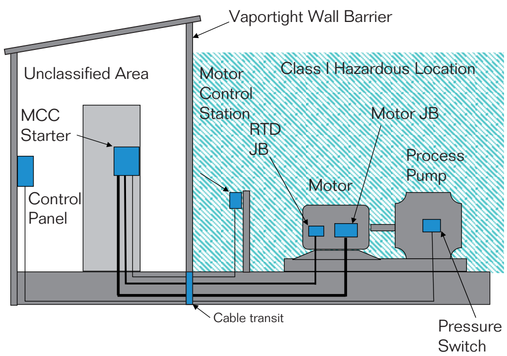
1. The air used to create the pressurized zone must be sourced from an unclassified location and contain no more than trace amounts of flammable gas.
2. The purge system air ducts must be constructed of non-combustible materials and protected against mechanical damage and corrosion. The purge system may be integral to the building HVAC system.
3. The positive pressure air system must provide 25pa (0.1 inch WC) of pressure with all openings closed. The system must also be capable of providing an outward air velocity of 0.305 m/sec (60 ft/min) through all openings capable of being opened. In many situations this requirement is often difficult to achieve without the use of an air lock entry system.
4. The operation of the purge system must be monitored by a pressure or flow switch. In the event of an interruption to the purge system, a procedure is required to test the atmosphere of the unclassified area prior to energizing any equipment not approved for a hazardous location. For this reason, any equipment that is essential to the operation of the purged system must be certified for use in a classified location.

Depending on if the unclassified room or building is located in a Class I, Division 1 (Zone 1) or Class I Division 2 (Zone 2) location, additional requirements will apply. Within a Division 2 location, a type 'Z' purge is required. A type 'Z' purge requires that the purge system be monitored in a constantly attended location. In the event of a purge system failure, an alarm must annunciate. There is no requirement to immediately shutdown any unclassified equipment located within the purged building. If the unclassified area is located within a Class I, Division 1 location, a failure of the purge system will require the de-energization of all equipment not approved for a Class I, Division 1 location. The equipment cannot be reenergized until the equivalent of 4 fresh air changes are purged through the room or building.

An alternate standard often used for the design of a purged buildings is IEC 60079-13 "Construction and Use of Buildings Protected by Pressurization". The requirements of IEC 60079-13 are similar to the requirements of NFPA 496.

A purged building is often used when the unclassified building or room is surrounded on all sides by a classified location. This is often the case where the unclassified location resides within the boundaries of a large refinery.

Fig 4

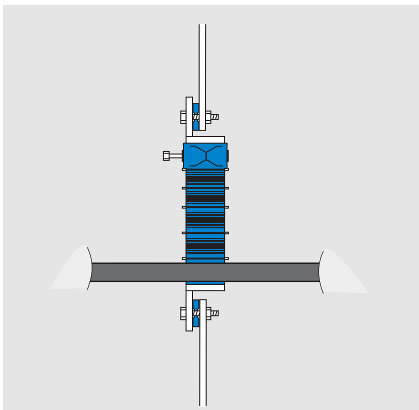


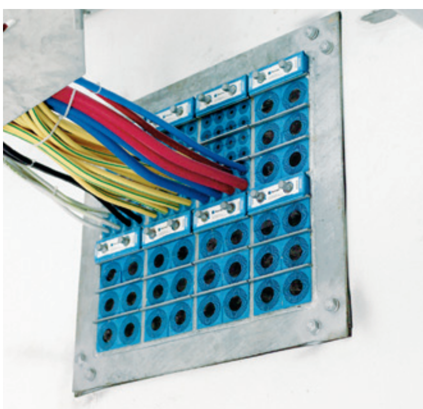
Option 2 – Pressurized Building within a Classified Location

C. Option 3 – Vaportight barriers as a means of segregation

An unclassified room or building may be installed adjacent to a classified area provided a vapor-tight barrier is placed between the hazardous location and the unclassified location. The design of the vapor barrier is such that it prevents the migration of fugitive emissions from the classified area to the unclassified area under normal ambient pressure conditions. Section 6 of API RP 500 and 505 discuss the use of classifying areas using vaportight barriers. Fig. 4 illustrates the use of a vaportight barrier in the context of an integrated skid module.

The primary advantage of using a vaportight barrier to segregate an unclassified area is the simplicity of design. There are no elaborate HVAC or interlocking schemes required to maintain the integrity of the non-hazardous area. All that is required is that the integrity of the vaportight barrier be maintained and no positive pressure differentials exist between the classified and the unclassified locations.





Piping and cable transit barriers

A transit barrier is an important element of an integrated module design. It allows the penetration of piping, conduits and cables through a wall that must be fireproof, vaportight or designed to maintain a pressurized environment. A transit barrier must be capable of being installed in a variety of wall constructions, must be equal to the fire rating of the constructed wall, must allow a variety of conduits and cable connections of various configurations to pass though, and allow for future changes and modifications. Fig 4 illustrates the use of a transit barrier in integrated modular application.

The Roxtec family of products is ideally suited to the integrated module concept. Roxtec manufactures a variety of transit frames that can be installed in concrete, steel or self framing structures. The multilayer technology used in the Roxtec modules simplifies both the design and the installation of pipes and cables passing through a wall partition. It is easily configured to a wide variety of pipe and cable diameters and provides a pressure seal around a cable or pipe penetration. This ensures the integrity of the vaportight wall and minimizes the loss of pressure in a purged location. Cable and pipes are easily installed and the Roxtec system can be opened or closed repeatedly as required to install new cable and pipe penetrations. This allows the flexibility of changes in the future without compromising the integrity of the segregation method used.

Conclusion

There are several advantages to integrating process, electrical and instrumentation equipment on a common skid package. It allows the wiring connections to be completed in a controlled fabrication environment, facilitates the pre-commissioning of instrumentation and control equipment prior to shipment to site, reduces on-site labor and reduces overall costs of ownership.

There are several ways to integrate the process and the electrical and instrumentation equipment. The instrumentation and electrical equipment may be enclosed in separate building on a common skid. Unclassified equipment may be protected using a pressurized building enclosure or segregated using a vaportight barrier.

The building envelope penetrations require careful consideration. They must facilitate the installation of piping and cables and must maintain the structural and fire integrity of the wall, the vaportight or pressurized building requirements and allow for future expansion. The Roxtec transit barrier design meets these requirements and incorporates innovations to reduce installation costs and facilitate future expansion. The Roxtec group of products is key to making the integrated equipment package concept a reality.

References

[1] API Recommended Practice 505, ‘Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2’, 1st Edition, November 1997

[2] NFPA 496, ‘Standard for Purged and Pressurized Enclosures for Electrical Equipment.’, 2003 Edition, Quincy, MA: NFPA.

[3] IEC 60079-13, ‘Electrical Apparatus for Explosive Gas Atmospheres – Part 13 Construction and Use of Rooms or Buildings Protected b y Pressurization’ 1982, International Electrotechnical Commission, Geneva, Switzerland.

H. Vita

Allan Bozek, P.Eng., MBA graduated from the University of Waterloo in 1986 with BASc in Systems Design Engineering and a MBA from the University of Calgary in 1999. He is a Principal with EngWorks Inc. providing consulting engineering services to the oil and gas sectors.

Roxtec International AB, the parent of Roxtec, Inc. was established in 1990 and is the global leader in modular cable and pipe sealing systems. Roxtec maintains more than 250 registered tests and approvals and serves the oil & gas, telecom, marine, industrial and OEM industries in more than 70 markets around the globe. Additional information about the company, products, applications and engineering data may be found by visiting www.roxtec.com.

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