THE USE OF VAPORTIGHT BARRIERS AS BASIS FOR HAZARDOUS AREA CLASSIFICATION DESIGN

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Abstract - This paper explores the use of vaportight barriers as basis for classifying hazardous locations. It reviews the industry accepted definition of "vaportight" in accordance with standards and recommended practices and provides considerations for the specification, design and construction of a vapor barriers. It also provides a test criteria and methods for verifying the integrity of a vapor barrier and provides guidance on installing doors, conduit, cables and piping penetrations through vapor barriers. A case example is provided to illustrate implementation of the concepts covered.

Index Terms — Hazardous Area Classification, Vaportight Barrier, Air Barrier

I. INTRODUCTION

Vapor barriers may be used to separate non-hazardous locations from classified hazardous locations. The concept is based on using an air-tight physical barrier to prevent the migration of flammable gases or vapors from a classified location to an unclassified location. The use of this concept often raises the questions "What design specifications and performance criteria are appropriate for a vaportight barrier installation?", and "How should the installation be constructed and tested for safety and integrity?" These issues are not fully addressed in the relevant hazardous area classification standards and recommended practices. It is left up to the user to employ engineering judgment to determine the appropriate design criteria for installation and to decide the appropriate tests for the application. The intent of this paper is to provide guidance in the application of vaportight barriers in the context of a hazardous area classification design.

II. VAPOR VS. AIR BARRIERS

Vapor barriers as referenced by building codes and standards are designed to retard the migration of water vapor. Vapor barriers in this context are not intended to retard the migration of air. Air barriers provide this function.

The definition and purpose of a vapor barrier in the context of a hazardous area classification is different. It is designed to segregate a classified from non-classified location and prevent the migration of flammable gas/vapors through a wall, floor or building partition. In most cases, an air barrier as defined by the building codes and standards will meet the criteria of a vaportight barrier as defined by the relevant hazardous area classification standards and recommended practices.

III. VAPOR BARRIERS IN THE CONTEXT OF A HAZARDOUS AREA CLASSIFICATION

A non-hazardous location may be located adjacent to a hazardous location where flammable gases or vapors may be present provided the locations are separated by a wall, floor and/or partition incorporating a vaportight barrier. Fig. 1 illustrates the use of the concept in the context of a modularized skid.

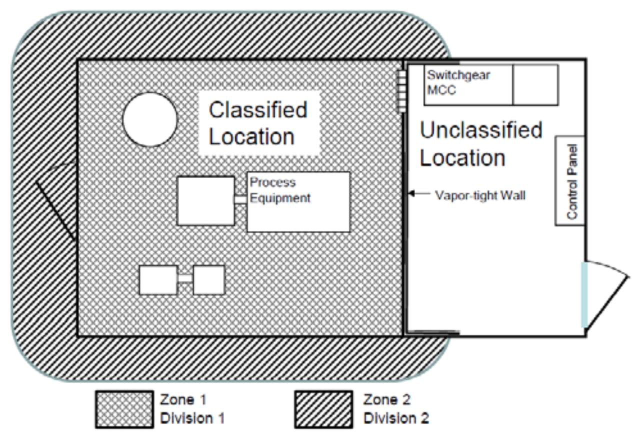

Fig. 1 Vaportight Wall Application

A. API RP 500 and API RP 505

API RP 500[1] and API RP 505[2] discuss the use of vaportight barriers as a means to segregate non-hazardous areas from classified areas near a source. Fig. 2, sourced from API RP 500 illustrates how vapor tight barriers can be used to limit the migration of flammable gases or vapors from a classified area into an enclosed non-hazardous location.

Fig. 3 illustrates the same situation without the use of a vaportight barrier. The interior of the enclosed space is classified because flammable gasses or vapors from the source could migrate into the enclosed area through the non-vaportight barrier.

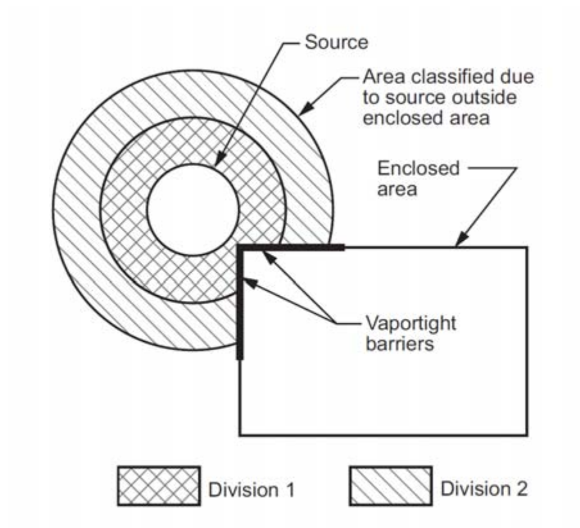

Fig. 2 Excerpt from API RP 500 – Enclosed Area Adjacent a Classified Area (Section 6.4.2)

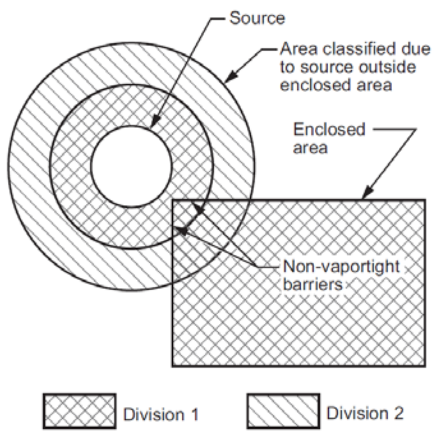

Fig. 3 Excerpt from API RP 500 – Enclosed Area Adjacent a Classified Area (Section 6.4.3)

Similarly vaportight barriers can be used to segregate classified buildings from adjacent non-hazardous locations. There are several examples in both API RP 500 and API RP 505 where vaportight barriers are used to limit the migration of flammable gas and/or vapors from a classified enclosed area into the surrounding area. The vapor barrier limits the extent of the enclosed classified area as illustrated in Fig. 4.

The formal definition for a vaportight barrier as defined in the 2012 version of API RP 500 is as follows: "*a wall or other obstruction that will limit the passage of gas or vapor at atmospheric pressure, thus preventing the accumulation of vapor-air or gas-air mixtures in concentrations above 25% of their lower flammable (explosive) limit, LFL (LEL)*".

The definition is performance based; meaning that instead of providing specific construction techniques or materials the definition describes the intent of the vaportight barrier which is to limit migration of the air from the classified area to the non-hazardous area and prevent accumulations of vapor-air or gas-air mixtures above 25% LFL (Lower Flammable Limit). The 25% LFL criteria for defining an unclassified area is used in clause 5.4.1(4) of NFPA 497-2012[3] and is intended to provide a safety factor when dealing with flammable materials with respect to hazardous locations.

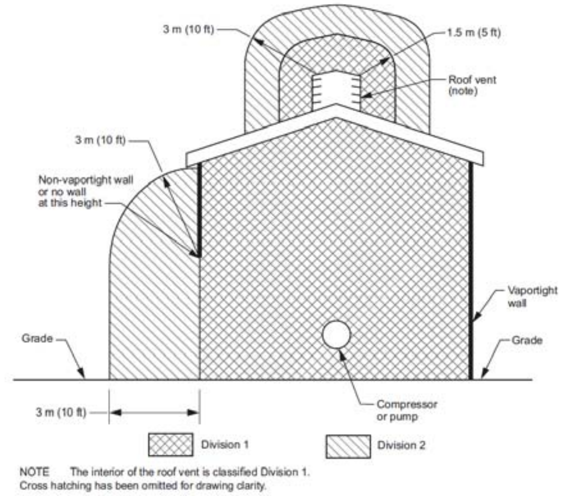

Fig. 4 Excerpt from API RP 500 – Compressor or Pump in an Inadequately Ventilated Enclosed Area (Section 10.9.3)

B. IEC 60079-10-1

IEC 60079-10-1[4] recognizes the use of "physical barriers" as a means to limiting the extent of a hazardous area classification. The document however, does not formally define what a "physical barrier" is and it is left to the user to make that determination. The document does provide some guidance when dealing with openings such as doors or ventilation louvers between classified and non-hazardous locations which can be useful in determining the appropriate specification for a door or wall opening. Refer to section V of this document for more information on this topic.

C. ANSI/ISA 60079-10-1

A definition for vaportight barrier was incorporated into the ANSI/ISA 60079-10-1[5], which is the US adoption of IEC 60079-10-1. The definition is identical to the text used in API RP 500 to define a vaportight barrier.

IV. SPECIFICATION, DESIGN AND CONSTRUCTION

The definition of a vaportight barrier with respect to a hazardous area classification is performance based. There are no hard specifications given in the reference documents on construction materials and installation methods. This often creates a problem when trying to convey the design intent to a third party for implementation.

A. Material Specifications

One simple way of conveying the design intent is to specify construction materials and installation methods that conform to the definition of "air-tight" or "air barrier", as referenced in the national building codes and standards. The International Energy Conservation Code (IECC)[6] defines air barrier requirements to US standards. The National Building Code of Canada (NBC)[7] incorporates specifications and testing requirements for air barriers used in building envelopes. The UK and European building codes and standards also incorporate similar requirements for air barrier design and construction. The following design criteria is based on standard building code requirements for air barriers and will meet or exceed the performance specification for a vaportight barrier in the context of an area classification design:

1) Materials: materials used for an air barrier system shall have an air permeance not to exceed 0.02 l/s·m^2 @ 75 Pa (0.004 cfm/ft^2 under a pressure differential of 0.3 in. water column) when tested in accordance with ASTM E 2178.
2) Assemblies of materials and components: shall have an air permeance not to exceed 0.2 l/s·m^2 @ 75 Pa (0.04 cfm/ft^2 under a pressure differential of 0.3 in. water column) when tested in accordance with ASTM E 2357.
3) The entire building: The air leakage of the entire building shall not exceed 2.0 l/s·m^2 @ 75 Pa (0.4 cfm/ft^2 under a pressure differential of 0.3 in. water column) when tested according to ASTM E 779

The following is a list of building materials that conforms or exceeds the material “air barrier” specification defined above:

1) Plywood-minimum 10mm (3/8 in.)
2) Oriented strand board-minimum 10mm (3/8 in.)
3) Extruded polystyrene insulation board-minimum 19mm (3/4 in.)
4) Foil back urethane insulation board-minimum 12mm (1/2 in.)
5) Gypsum board-minimum 12mm (1/2 in.)
6) Cement board-minimum 12mm (1/2 in.)
7) Portland cement/sand parge (or gypsum plaster minimum 16mm (5/8 in.)
8) Cast in place concrete
9) Fully grouted concrete block masonry
10) Sheet steel
11) Metal sandwich panel wall construction consisting of a single thermal insulation layer connecting the internal and external metal surfaces together

B. Installation Requirements

A vapor barrier must be installed in a manner that maintains the integrity of the building material used. This includes:

1) Products installed as boards or sheets must have all seams sealed.
2) Caulking must not be water soluble, must be UV resistant and be able to bridge at least 6mm (1/4 in.) gaps. Caution is advised when using room temperature vulcanizing (RTV) silicone caulking materials in the vicinity of catalytic bead gas detectors as the RTV silicon volatiles can “poison” a gas detection head rendering it blind to the presence of hydrocarbons.

V. VAPORTIGHT BARRIER PENETRATIONS

In many installations, there are requirements for the vaportight barrier to be penetrated by doors, access panels, piping, cable and electrical conduits. Under such circumstances, the vaportight integrity of the wall must be maintained. Following are some considerations related to vapor barrier penetrations.

A. Openings between Adjacent Areas

In certain situations, a door may be installed between the classified and the unclassified location as illustrated in Fig. 2.

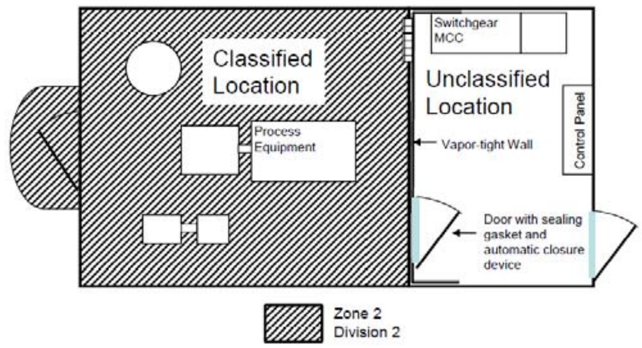

Fig. 5 Vaportight Wall Application incorporating a Door between Classified and Non-hazardous Location

IEC 60079-10-1 provides some guidance in classifying an adjacent area where door, window or access panel openings may exist. The document incorporates an evaluation procedure for determining the appropriate area classification of adjacent areas where openings may be present. The procedure requires that opening between adjacent areas be classified in accordance with the following criteria:

Type “A” openings are those that do not conform to the characteristics of a type B, C or D opening. Typical examples of such openings are open passages for access, ventilation outlets, and unsealed penetrations in walls for piping, cables and conduits.

Type “B” openings are those that are normally closed and infrequently opened. A standard door with a self-closing mechanism would be considered a Type B opening.

Type “C” openings are similar to Type B openings except that they incorporate a “gasket” seal around the perimeter of the closure device. A door with a full gasket seal coupled with an automatic closure device would meet this criteria. Two Type B” doors in series would also meet the criteria of a Type “C” opening.

Type “D” openings are Type “C” openings that are normally closed and can only be opened by special means or in an emergency. A Type “C” door incorporating an alarm circuit would meet a type “D” opening criteria.

To determine the appropriate specification for a wall penetration, the zone classification of the adjacent location needs to be considered in the context of the table illustrated in Fig. 6.

Zone upstream of opening	Opening type	Grade of release of openings considered as sources of release
Zone 0	A	Continuous
	B	(Continuous)/primary
	C	Secondary
	D	Secondary
Zone 1	A	Continuous
	B	(Primary)/secondary
	C	(Secondary)/no release
	D	No release
Zone 2	A	Secondary
	B	(Secondary)/no release
	C	No release
	D	No release
NOTE: For grades of release shown in brackets, the frequency of operation of the opening should be a consideration in the design.		

Fig. 6 Excerpt from IEC 60079-10-1: Effects of Openings on Grade of Release

For example, the design criteria for a door between a Zone 2 classified area and a non-hazardous enclosed location as illustrated in Fig. 5 would involve applying the following rational:

The zone upstream of the door opening is Zone 2. The grade of release required for a non-hazardous location is "No release". The applicable openings are types C and D. For access between the two locations, the only feasible option is a type "C" opening. Applying a type "C" criterion to the door specification requires the door incorporate a gasket and a self-closing mechanism.

Note that using the IEC criteria, it would not be feasible to apply a door opening to a non-hazardous location adjacent a Zone 1 location unless the door was only used for emergency purposes.

B. Cable and Piping Penetrations

Similar to a door, window or ventilation opening, a cable, pipe or conduit entry must also be properly designed and sealed to maintain the vaportight integrity of the wall or partition. Many alternative methods for sealing cable and pipe penetrations have been used and evidence suggests that the vaportight integrity of the sealing method is often compromised during installation and on-going operations and maintenance activities. The addition of new cables, conduits or pipes to a building requires an existing vaportight entry to be opened. After opening, it is critical that the vaportight integrity of the entry be restored. Fig. 7 illustrates situations where a vaportight cable seal has been compromised. Note the large holes or multiple gaps which would compromise the integrity of a vapor barrier.

Common methods for sealing entries for cable, pipe and conduit include soft products, such as expandable foam or fire bricks. Another common practice is the use of more "permanent" solutions such as compounds, caulks or concrete to seal cable and pipe entries, as shown in Fig. 8. These permanent solutions will meet the performance demands for vaportight barriers during the initial installation but will require extensive modifications and rework should a future cable or pipe addition be required.

Fig. 7 Example of cable entries which have been compromised

Fig. 8 Example of the use of compound as a vaportight barrier to seal the opening of cable entry.

Other options for cable and pipe penetrations include the use of multi cable transit devices (MCT's) as shown in Fig. 9. MCTs are certified components that will meet air barrier and fire rating specifications as defined by the various building code standards. They are impervious to degradation by aging, hydrocarbons, corrosion and ultraviolet (UV) radiation and are water and rodent resistant. A key advantage of using a MCT is when properly designed, installed and maintained, an MCT will allow cable or piping modifications over the life of a facility without compromising the integrity of a vaportight barrier.

Fig. 9 Shows use of multi cable transit devices to provide vaportight barriers where cables or pipe enter buildings

Design considerations for MCT-based cable and pipe entries should include: proper sizing of aperture openings, consideration of spare capacity for future cable or piping modifications, temperature and environmental conditions, and building code related requirements such as fire, blast or pressure ratings.

In addition to providing a vapor tight seal surrounding a cable or conduit installation, cables and conduits may also require internal seals to prevent the migration of gas from a classified to an unclassified area in accordance with the appropriate hazardous location installation codes and standards.

VI. APPLICATION OF A VAPORTIGHT BARRIERS IN BLANKET CLASSIFIED LOCATIONS

Section 6.5 of API RP 500 references the use of vaportight barriers in conjunction with gas detection to designate an area non-hazardous when completely surrounded by a Zone 2/Division 2 classified location. The concept is illustrated in Fig. 10. The API criteria necessary to implement the concept are as follows:

1) The interior of the building does not contain a source of flammable gas or vapor.
2) The building is of a vaportight construction.
3) Penetrations are minimized – normally limited to personnel entry door(s), electrical cable entries and appropriately certified HVAC units.
4) The building contains no windows that can be opened and personnel entry door(s) are provided with adequate gaskets or weather stripping.
5) Opening for air conditioning units and windows should be adequately caulked or otherwise made vaportight.
6) HVAC equipment must not introduce outside air into the building.
7) Entries for cables and other services are made in a vaportight manner.
8) The building incorporates an adequate number of stationary and permanently mounted gas detectors. Upon detection of a 20% LFL, a local alarm will be activated. Upon detection of a 40% LFL or a gas detector system malfunction, an alarm activates and initiates the automatic disconnection of power to all electrical devices not certified for installation in a Zone 2/Division 2 location.

The application of this concept requires engineering judgment as there are some key limitations; the first being that there can be no air from a classified location used for HVAC purposes. The design of the HVAC system must be a closed air exchange system that is certified for use in a hazardous location. This limits the size and the suitability of the building to accommodate operations personnel on a continuous basis. Frequent ingress/egress of the building by operations personnel is also a consideration. The concept may be suitable for buildings housing electrical equipment that requires operations or maintenance access on an infrequent basis for short periods of time. For situations where frequent access is necessary, a building incorporating a purge design in accordance with NFPA 496[8] or IEC 60079-13[9] may be more appropriate.

The use of the concept may also require approvals of the authority having jurisdiction (AHJ) as local installation codes will take precedence over the recommended practices in API. It is prudent that a consensus be reached with the AHJ to insure that there is no misinterpretation of the code requirements.

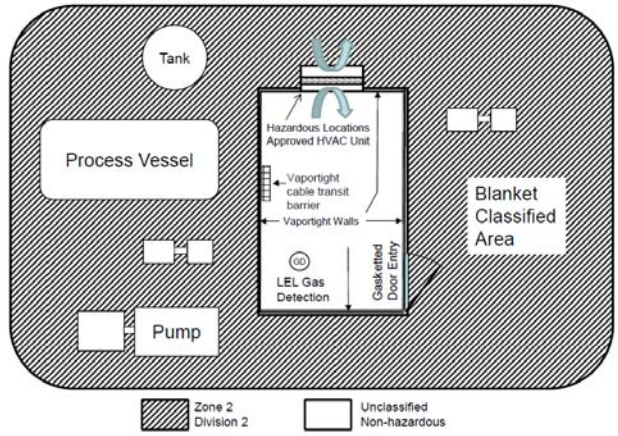

Fig. 10 Non-hazardous Vaportight Building Surrounded by a Classified Area

VII. PERFORMANCE TESTING OF VAPORTIGHT BARRIERS

The decision to performance test a vaportight barrier should be based on the adjacent zone or division classification to the non-hazardous area, the potential for any pressure differences between a classified and non-hazardous location, and if the non-hazardous area is surrounded by a classification similar to Fig 10.

A. Visual Inspections

In all cases, a visual inspection should be performed. This consists of visually inspecting seams and joints during construction of vapor barrier to ensure full coverage of adhesive sealants and verifying that there are no breaks or gaps. Particular attention should be given to the wall/floor joints.

In situations where a non-hazardous location is segregated from Zone 2/Division 2 classified location with both locations at ambient pressures, a visual inspection is all that is required. This is based on the premise that a flammable atmosphere is "unlikely to exist and will exist for a short time only" in the Zone 2/Division 2 location and the probability of flammable gas/vapors migrating across a vapor barrier at atmospheric pressure conditions is very low.

B. Smoke Test

In situations where a Zone 1 or Division 1 location is operating at a higher pressure differential to a non-hazardous location, smoke or fog can be used to identify leaks in a vapor barrier. Commercially available foggers emitting a non-contaminating vapor consisting of distilled or de-ionized water droplets allow for easy visual identification of leak points. Other methods use CO2 or other tracer gas in conjunction with a hand held gas detector to locate leaks.

C. Air tightness Test

In situations where a designated non-hazardous building is completely surrounded by a classified area, an air tightness test commonly used to test building envelopes in accordance with the relevant building codes may be appropriate. The test procedures are outlined in ASTM E779-10[10] and CAN/CGSB-149.10[11]. The tests are usually performed using door mounted fans and will determine if a building envelop can maintain the 75Pa pressure envelope consistent with the building code specifications.

VIII. CARE AND MAINTENANCE OF VAPORTIGHT BARRIERS

The care and maintenance of the vapor-barrier over the life of the facility is critical to the safety of the installation. Improper penetration of the barrier, deterioration of the barrier from weather related elements and operational procedures can compromise the integrity of a vaportight barrier. Following are some guidelines to help maintain the integrity of a vapor-barrier.

A. Identification of Vapor-Barriers on Key Drawings

Vapor barriers for area classification purposes need to be clearly marked on all hazardous area classification and building construction drawings. Notes indicating that the integrity of the barrier must be maintained at all times and no unauthorized penetrations are permitted without engineering approval will avoid any uncontrolled modifications to a vapor barrier.

B. Physical Identification of Vapor-Barriers in the Facility

Wherever possible, signs indicating that a wall, floor or separation is required to be maintained vaportight for area classification purposes will prevent problems in the field. Other signs such as "Door must be remain closed at all times" will also help in maintaining the integrity of the installation where doors separate classified from non-hazardous locations.

C. Maintenance

Gaskets and door closure mechanisms must be inspected to insure that they perform as expected. Where vapor barriers are exposed to cold weather or UV radiation, the barriers should be examined to insure that no cracks result in the barrier being compromised. All doors should also be inspected to ensure the weather stripping or other gaskets are in good working condition. Piping, conduit and cable transits should remain properly sealed within their frame openings.

IX. CASE STUDY

A modularized natural gas meter station was designed with the entire facility on one skid to minimize the amount of field work that would be required when the skid was installed at site. The skid package required a non-hazardous location for electrical and instrumentation equipment as illustrated in Fig. 11.

A vaportight barrier was used to create a non-hazardous location adjacent the classified areas. The wall construction specification incorporated two metal panels sandwiching a foam insulation board. All screws and fasteners were sealed using silicone sealant and all wall joints were caulked with silicone as shown in Fig 12.

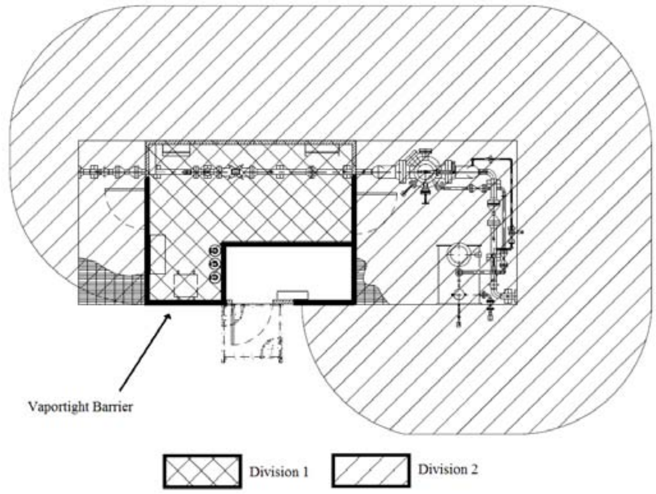

Fig. 11 Area Classification Drawing for a Meter Skid

Fig. 12 Walls Showing joints With Caulking

Piping penetrations were sealed with silicone, as shown in Fig. 13. The method of sealing around pipes proved difficult to maintain over time as the pipe moves independent of the walls. The sections of wall with pipe penetrations were later considered non-vapor tight for this reason.

The doors used were self-closing, weather type, sealed and gasketed, as shown in Fig. 14.

Fig. 13 Pipe Wall Penetration Sealed

Fig. 14 Self Closing Door with Gasket Seal

The interior of process skid building was classified Division 1 based on the potential sources of release and the inadequate level of ventilation. All ventilation louvers into the Division 1 classified room were located on the opposite side of the skid from the non-hazardous classified room. The wall was deemed non-vaportight and a Division 2 area extended beyond the skid edge. All instrumentation vents from inside the building were tubed outside to a Division 2 location. Ventilation air for the non-hazardous room is from a non-hazardous location adjacent the door.

Prior to placing the facility in service a smoke bomb test, similar to the one described in section VII, was performed. Any leaks were sealed. A maintenance plan was put in place to inspect the integrity of the vapor tight barriers using a smoke bomb test every two years.

X. CONCLUSIONS

When properly designed and constructed, vaportight barriers are an effective way of segregating classified areas from non-hazardous locations. Vaportight barrier materials and construction methods specified in accordance with air barrier specifications in the relevant building codes will usually meet the performance specifications of a vapor barrier for area classification purposes. Door, piping and cable/conduit penetrations need to be properly managed to maintain the integrity of the vaportight barrier. The criteria and method of testing should be based on the level of risk associated with the area classification and the potential for pressure differentials between the locations. Vaportight barriers should be clearly identified on building construction and area classification drawings and physically identified in the field. A preventative maintenance program should also be established to ensure that integrity of the barrier is maintained over the life of the facility.

XI. REFERENCES

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XII. VITA

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