MYTH OF EXPLOSION PREVENTION CONFIGURATION IN HAZARDOUS AREA

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A project report submitted in partial fulfilment of the requirements for the award of Master of Engineering (Electrical)

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **“MYTH OF EXPLOSION PREVENTION CONFIGURATION IN HAZARDOUS AREA”** was prepared by **YEONG CHIN HAO** has met the required standard for submission in partial fulfilment of the requirements for the award of Master of Electrical at Universiti Tunku Abdul Rahman.

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ABSTRACT

Explosion preventions play a very important role in all kinds industry in this modern world, especially in the oil & gas industry. An explosion can cause major damage to the building and loss of human life. Recently there was a huge explosion that happened in Lebanon Beirut cause hundreds of death and a lot of property and building was damaged and an estimated few hundred thousand people were homeless due to a large amount of ammonium nitrate without proper storage and safety measurement. Therefore, explosion prevention is very important no matter in what kind of industry. With the correct method of prevention explosion in the hazardous area, it may reduce the percentage of the explosion incident that happen and by applying this in the industry it may save a lot of life and cost.

Explosion prevention or protection shall accordance with the IEC 60079 standard to design or install the equipment in the hazardous area. Unfortunately, human is the main cause of making mistake during the design stage or installation of equipment in hazardous area which is not according to the IEC 60079 standard.

The main objective of this research is to enhance the method and use the suitable method to prevent the explosion in the hazardous area. Besides that, also reduce the mistake and error made by a human during design and installation.

Based on the case study and IEC standard model an electronic field device such as an Intrinsic safety barrier and compare with energy curve. Based on the case study and calculation to identify the suitable protection method to avoid the explosion.

The expected outcomes of this research, based on the analysis we can identify the reliability of the electronic device which suitable to operate in the hazardous area and reduce the engineering and operation cost.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS / ABBREVIATIONS

Co	Capacitance
Lo	Inductance
mA	Milliampere
mW	Milliwatt
Pi	Power
Po	Output Power
Ui	Allowed Voltage
Uo	Output Voltage

ABF	Asean Bintulu Fertilizer
ANSI	American National Standards Institute
API	American National Standards Institute accredited process
CEC	Canadian Electrical Code
DCS	Distributed Control System
FPSO	Floating Production Storage and Offloading
I	Current
IEC	International Electrotechnical Commission
IP	Ingress Protection
LED	Light Emitting Diodes
LEL	Lower Explosive Limit
NEC	National Electrical Code
NFPA	National Fire Protection Association
RTD	Resistance Temperature Detectors
SPD	Surge Protection Device
UEL	Upper Explosive Limit
V	Voltage

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 General Introduction

The oil and gas industry is one of the most highly flammable and explosive environments. The hazardous areas consist of any gas leak or spill it may cause an explosive and dangerous environment. To protect the personal and plant, precautions and safety always come first place in the oil and gas industry. In the past, pneumatic controls have been used in such areas to avoid the risk that an electrical spark may pose (Gullo, G. and Selli, B., 2004). Following the growth of the technology and research from the international standard organization such as International Electrotechnical Commission (IEC), National Electrical Code (NEC), etc. As per the IEC 60079 standard and guideline, currently, we can install the electronic equipment or device in hazardous areas following IEC or NEC standards.

1.2 Importance of Study

The research purposes are to provide informative discovery based on the calculation and identify the latest technology datasheet available in the market and accordance with the IEC standard requirement.

Based on the working environment, most of the time the engineer and designer do not follow the IEC standard and do not understand how to apply the suitable explosion protection method in the hazardous area in the oil and gas industry.

Most of the time the design is over design and causes the high project cost.

1.3 Problem Statement

Intrinsic safety (Ex i) protection method the disadvantages that are not able to use for all application such as the motor and lighting fixtures due to the intrinsic safety barrier limited the current and voltage at the hazardous areas. Therefore, combination with other explosion prevention methods is required such as explosion-proof equipment or enclosures, and purging or pressurization of the device are required due to the limitation of the intrinsic safety barrier(Perkon, 2018).

Design and Installation for the fields instrumentation in the hazardous area shall be according to the IEC60079 standard. Even the expert in this field may make mistakes and overlook the standard and requirements change. It shall check all the components to ensure they are suitable for use in the hazardous area. Each of the field's components is critical when installing the field's equipment in hazardous areas such as the type of cable, cable gland, junction box, proper grounding, etc.

1.4 Aims and Objectives

The project aims to analyze and identify the method of explosion protection in hazardous areas.

1. Identify the type of protection method as per IEC 60079.
2. Based on the calculation on the Intrinsic Safety (IS) Barrier to identify the limitation and design philosophy.
3. Case study to evaluate and identify the suitable explosion protection method used in hazardous areas.

1.5 Scope and Limitation of Study

This research is focused on the Intrinsic Safety Barrier which can install in hazardous areas. Based on the safety barrier and field instrumentation datasheet to perform the case study and calculation to identify the safety barrier are suitable to install at the hazardous areas as per the IEC 60079.

In this study, the research methodology chapter explained the related step and study on the safety devices for explosion protection. Besides, the literature review was used as part of the references for the studies.

The limitation in this research will involve a lot of major equipment such as a distribution control system, safety barrier, junction box, etc. Therefore, not able to construct the complete control loop from the safe area to the hazardous area.

1.6 Contribution of Study

The project outcome can produce informative data based on the studies and be able to apply to the current industry during the project execution stage by using the effective method to reduce the risk of an explosion happening in the industry.

On the other hand, with all the data able to reduce the design cost and space, in the oil and gas industry, the Offshore space is limited.

1.7 Outline of the Report

This project is divided into 4 sections. The first section of the project will be the study on the IEC standard requirement for explosion protection, identifying and gathering all the methods of prevention of explosion.

The second part will be to study and gather on the current market available Intrinsic Safety (IS) Barrier type and design.

To proceed to the third part, gather all the information from the Intrinsic Safety Barrier and field instrumentation to perform the calculation.

The final part of the project would be the analytical works with all the gathered data and results. The obtained result will be discussed and compared from different types of Intrinsic Safety Barrier and understand the limitation. Based on the data, identify the suitable protection method in different kinds of hazardous environments and project limitations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The oil and gas industry is one of the most highly flammable and explosive environments. hazardous areas consist of any gas leak or spill it may cause an explosive and dangerous environment. To protect the personal and plant, precautions and safety always come first place in the oil and gas industry. In the past, pneumatic controls have been used in such areas to avoid the risk that an electrical spark may pose (Gullo, G. and Selli, B., 2004).

Following the growth of the technology and research from the international standard organization such as International Electrotechnical Commission (IEC), National Electrical Code (NEC), etc. As per the IEC 60079 standard and guideline, currently, we can install the electronic equipment or device in hazardous areas following IEC or NEC standards.

2.2 Explosion Triangle

In recent years, many explosion incidents are happening daily in the industry around the world. An explosion can cause huge damage and loss to an industry or country. Recently happened in Lebanon Beirut Explosion caused by the huge amount of ammonium nitrate stored at the port of the city and the explosion caused major damage on the building and lost.

Explosive causes require three elements to cause an explosion. It consists of three elements: oxygen, fuel/gas, and an ignition source. All elements must be present at the same time to cause the explosion. Figure 1 below shows that the explosion triangle. (Muchatuta, N.A. and Sale, S.M, 2007).

Figure 2.1: Explosion Triangle (International, 2021)

2.3 Fire/ Explosion Tringle

The fire/Explosion triangle consists of 3 elements there is Oxygen(O2), Fuel, and Ignition Source.

Oxygen (O2) is the second-highest chemical element in the atmosphere which contains 20% of the dry air surrounding our environment. Most fires or explosions are required 16% of the Oxygen (O2) content to burn. Oxygen supports the chemical reaction during a fire.

Fire or explosion without material or fuel to burn the fire which cannot occur. Fuel/material will be referring to that any source it can burn such as flammable gas or liquids, paper, etc. Normally all type of fuel has their burning point before it ignites (Fogler, H. Scott, 2018).

Ignition sources may come from the hot gases, electrical or mechanical equipment spark. The lightning strike is also considered as one of the ignition sources.

When the 3 elements meet at the same time fire/explosion might occur, once remove one of these components the fire/explosion triangle will collapse, and the fire will be extinguished.

2.4 Explosion Disaster Incident history

Pipe Alpha is an oil and gas offshore platform located in the North Sea, Scotland. In July 1988, Piper Alpha massive explosion killed 167 people on board and an estimated loss of 1.4 billion USD. It took 3 weeks to control the fire and the oil spill damage the marine life nearby. The Pipe Alpha disaster is one of the most major explosion disasters that happen in the oil and gas industry. Pipe Alpha disaster until today is a very good example and lesson learned for the oil and gas industry as the awareness.

Figure 2.2: Pipe Alpha Disaster 1988 (Piper Alpha: How we survived North Sea disaster, 2013)

One of the most recent explosions happen is at Beirut, Lebanon. In August 2020 due to improper storage and handle a large amount of ammonium nitrate at the Port of Beirut and cause a huge explosion. This incident was killed 218 people and an estimated 15 billion USD property damage.

Figure 2.3: Beirut Explosion (Massive Beirut Explosion Shows Mushroom Clouds Aren't Just for Nukes, 2020)

All the incidents above might be able to prevent and avoid if following the proper procedure and method of prevention as per the international standard such as IEC, NEC/CEC.

2.5 Explosion Protection

The explosion protection is to prevent one out of three elements which are oxygen(O2), fuel/gas & ignition source in Figure 2.1. Explosion protection is to ensure the safety or protection of the personnel, damage property, and environment. Most of the explosion happens due to human design error and mistake. Therefore, the International Electrotechnical Commission (IEC) & National Electrical Code/ Canadian Electrical Code (NEC/CEC) develop a standard and guideline for the explosion protection equipment. IEC standard is normally used in the European country and the NEC/CEC standard is normally applied in America and North America.

Explosion protection is widely used in the mining industry, refineries, gas processing plants, oil & gas platform, petrochemical plant, grain handling, and storage facilities.

The oil & gas industry in Malaysia widely follows the IEC 60079 standard as the guideline for design, operation, and installation on the explosion-proof equipment install in the hazardous area (IEC 60079-0, 2004).

2.5.1 Explosive Limit

The first factor that causes an explosive atmosphere is the amount of combustible material mixed with the combustible material, in other words, the concentration of combustible material in the air. The concentration of the combustible material within a certain range of values creates an explosive mixture.

There are two limits to the mixture concentration above which an explosion cannot occur:

(i) As the concentration of combustible material in the mixture decreases, the energy required for ignition gradually increases to the point where ignition cannot occur because of the lack of combustible material. This point is called the lower explosive limit (LEL) and represents the concentration of combustible material in the air below which the atmosphere is not explosive. (Cortem, 2012)

(ii) As the concentration of combustible material in the mixture increases, the energy required for ignition increases in the same manner as in the previous point, up to the point where ignition cannot take place because of the lack of combustible material. This point is called the upper explosive limit (UEL) and represents the concentration of combustible material in the air at which the atmosphere is not explosive. (Cortem, 2012)

Figure 2.4 below is the sample of the explosive range limit for the natural gas, different types of material or gas may have different LEL & UEL. Refer to table 2.1 show the explosive limit for different kind of gases.

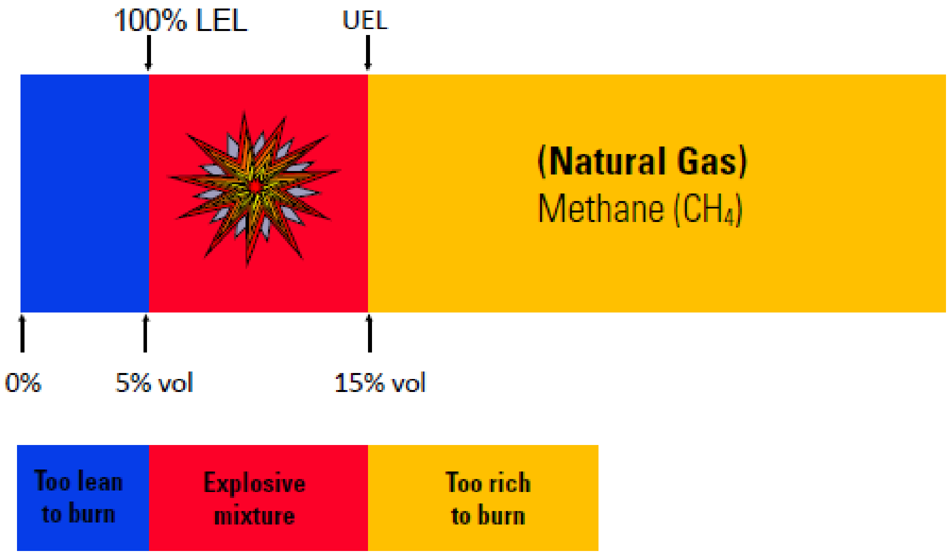


Figure 2.4: Explosive range for Natural Gas (LEL of Combustible Gases | Lower Explosive Level | Industrial Scientific, n.d.)

Table 2.1: Explosive range for gases (InstTools)

Common Combustible Gas LEL's and UEL's			
		LEL	UEL
Acetone	(CH3)2CO	2.15%	13.0%
Acetylene	C2H2	2.5%	100%
Benzene	C6H6	1.2%	8.0%
Butadiene	C4H6	1.1%	12.5%
Ethane	C2H6	3.0%	15.5%
Ethyl Alcohol	CH2H5OH	3.3%	19.0%
Ethyl Ether	(C2H5)2O	1.7%	36.0%
Ethylene	C2H4	2.7%	36.0%
Hexane	C6H14	1.1%	7.5%
Hydrogen	H2	4.0%	75.6
IsoButane	C4H10	1.8%	8.5%
Isopropyl Alcohol (IPA)	(CH3)2CHOH	2.0%	12.7%
Methane	CH4	5.0%	15.0%
Methanol	CH3OH	6.0%	36.0%
Pentane	C5H12	1.5%	7.8%
Propylene	C3H6	2.0%	11.1%
Toluene	C7H8	1.2%	7.0%

2.5.2 Hazardous Area Classification

When electrical or electronic equipment is used in or near an area containing combustible gases or vapours, flammable liquids, combustible dusts, or combustible sources, there is always a risk that a fire or explosion may occur. Therefore, there is a possibility of fire or explosion in this area due to a mixture of explosive elements or gases, which is called a hazardous area.

Hazard zone classification is a systematic method of identification, analysis and classification for the oil and gas industry in onshore or offshore production. Based on IEC 60079, hazardous areas are defined in the zone system, but according to the

ANSI /NFPA 70 NEC in classes. Both standards are almost the same, differ only in certain parts and are used in different countries.

For IEC standards are widely used in the European country and for ANSI/NFPA 70 NES are widely used in American and North American. Refer to table 2.1 below is the comparison table for the Zoning and Class.

A hazardous area is defined based on the type of elements consist of such as gas, vapour, or dust. According to the IEC 60079 hazardous area segregate into 3 zones for Gas & Vapour there are Zone 0, 1 & 2. For ANSI/NFPA 70 NEC are segregated into 3 classes there are Class I, II & III.

Table 2.2: Comparison table between IEC and ANSI/NFPA 70 NEC for Zone and Class

Zones & Devision			
IEC 60079		**ANSI/NFPA 70 NEC Article 500**	
Gas & Vapours		Class (nature of the material)	
Zone 0	Flammable atmosphere highly likely to be present - may be present for long periods or even continuously	Class I	Hazardous because flammable gases or vapors are present in the air in quantities sufficient to produce explosive or ignitable mixtures
Zone 1	Flammable atmosphere possible but unlikely to be present for long periods	Class II	Hazardous because combustible or conductive dusts are presen
Zone 2	Flammable atmosphere unlikely to be present except for short periods of time - typically as a result of a process fault condition	Class III	Hazardous because ignitable fibers or flying's are present, but not likely to be in suspension in sufficient quantities to produce ignitable mixtures
Dust		Division (probability of material being present)	
Zone 20	Dust cloud likely to be present continuously or for long period	Division 1	The substance referred to by class is present during normal conditions
Zone 21	Dust cloud likely to be present occasionally in normal operation	Division 2	The substance referred to by class is present only in abnormal conditions, such as a container failure or system breakdown
Zone 22	Dust cloud unlikely to occur in normal operation, but if it does, will only exist for a short period		

The explosion group defines the type of hazardous material or elements in the surrounding atmosphere.

Table 2.3: Comparison table between IEC and ANSI/NFPA 70 NEC for explosion group

Explosion Group					
	IEC		NEC/CEC		
Inflammable material	Zone	Group	Class	Division	Group
Gas and Vapours					
Acetylene	0,1 or 2	II C	I	1 or 2	A
Hydrogen	0,1 or 2	II B+H_2	I	1 or 2	B
Propylene oxide Ethyl oxide Butadiene	0,1 or 2	II B	I	1 or 2	B
Cyclopropane Ethly ether Ethylene	0,1 or 2	II B	I	1 or 2	C
Acetone,Benzene,Butane,Hexane,Paint solvents,Natural gas	0,1 or 2	II A	I	1 or 2	D
Dusts					
Metal dust		III C	II		E
oal dust		III C	II		F
Grain dust		III B	II		G
Wood Paper Cotton		III A	III		

Temperature classification is to identify the element ignition temperature, for example, in Temperature class T1 the ignition temperature point shall be more than or equal to 450 ℃.

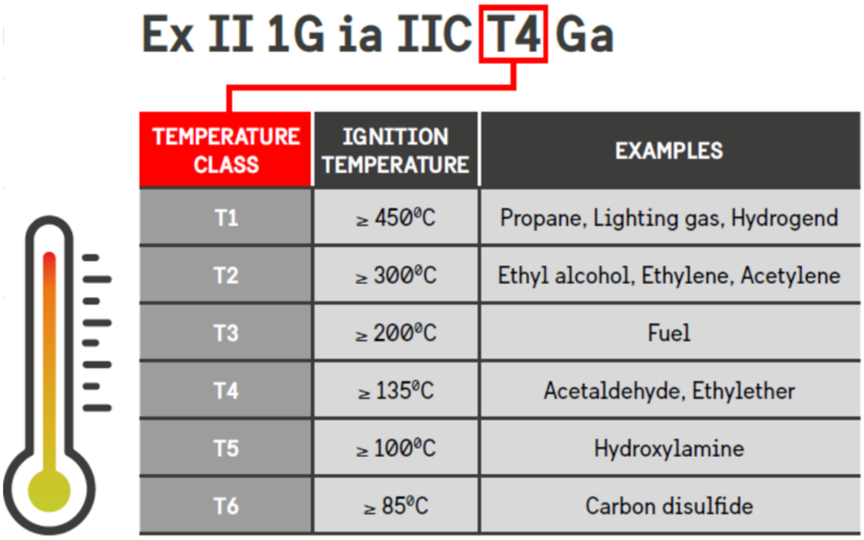


Figure 2.5: Temperature Class

Based on the zone system, explosion group, and temperature classification data it allows an optimum selection of electrical apparatus or equipment installed in the hazardous area following IEC 60079 and NEC standards. IEC and NEC standards classify the explosive area into Zone, Gas Group, and Temperature Class.

2.5.3 Ingress Protection (IP) Rating (IEC 60529)

The IP rating classifies the degree of protection against ingress of solid objects, dust, accidental contact, and water into electrical enclosures. The IP rating is very important in a harsh environment exposed to dust or water.

In some cases, the selection of electrical apparatus or equipment shall refer to the IP rating. Most of the time in offshore environments most of the outdoor equipment or junction box shall me minimum of IP65. Refer to figure 2.7 below is the IP rating guide as per IEC 60529 for European country. For North America will refer to NEMA and NEC standard.

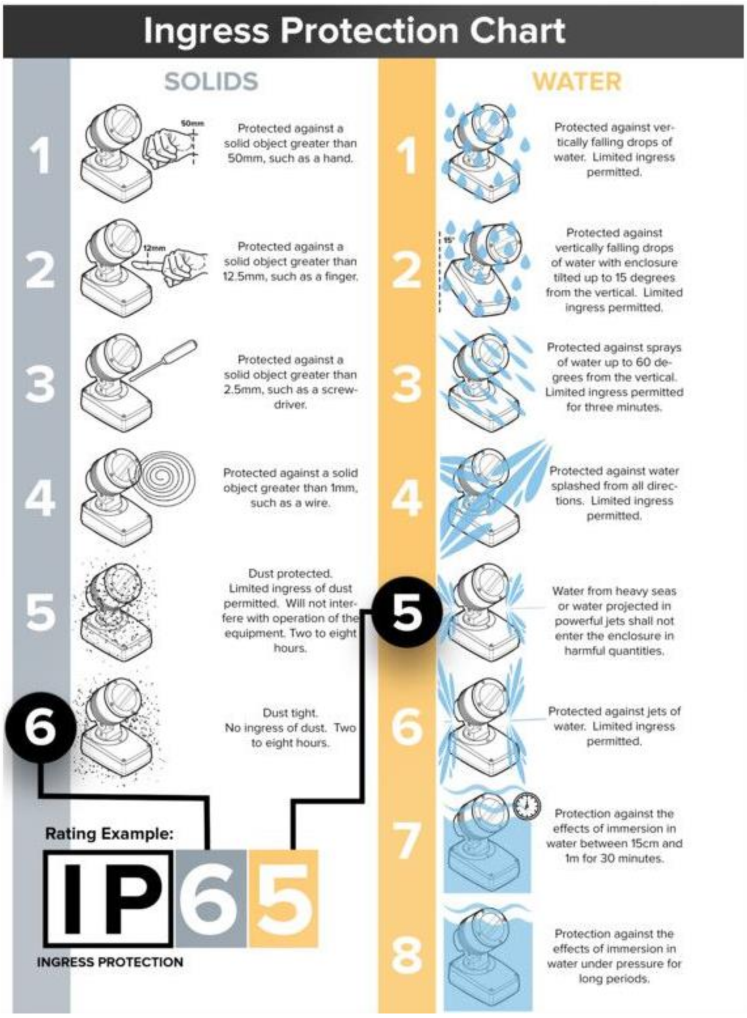


Figure 2.6: IP Rating Guideline (Lumascape.com)

2.6 Method for Classification of Hazardous Area

Hazardous zone classification shall be following API-505 and IP15. There are a few basic elements to determining the hazard zone type:

(i) Identification of the sources the release
(ii) Determination of the degree of release.
(iii) Determination of the rate of release, velocity, etc.
(iv) Determination of the type of area (openness).
(v) Extend and availability of ventilation
(vi) Use of appropriate code or calculations to determine the extent of the zone.

A release source is a point or location from which a gas, vapour, mist, or liquid may be released into the atmosphere such that an explosive gas atmosphere may be formed. A release source may result in one of these degrees of release, or a combination of several.

The degrees of release are classified into 3 basic degrees of release in order of decreasing frequency and probability of occurrence of an explosive gas atmosphere.

(i) Continuous degree of release > 1000 h
(ii) Primary degree of release 10 – 1000 h
(iii) Secondary degree of release 1 -10 h

In the open-air, normal practices as per the API 505 & IP15, normally for Zone 0 for continuous-release, Zone 1 for primary release and Zone 2 for secondary release. The following figure is an example of the zone system for petrol stations.

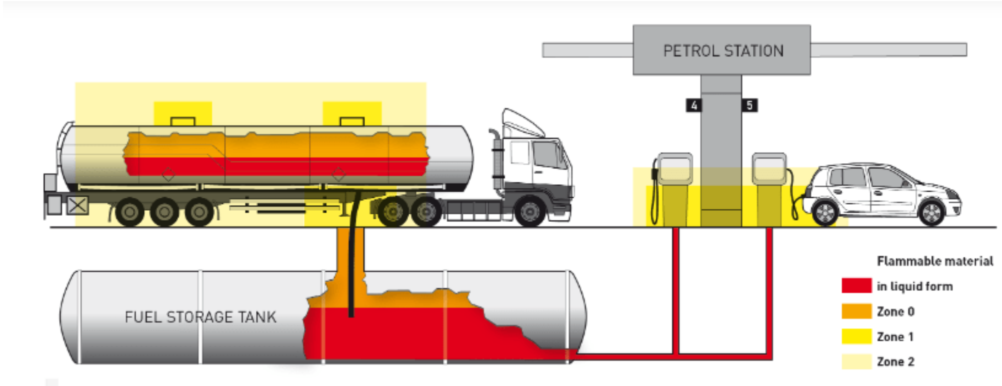


Figure 2.7: Sample of Zoning System in Petrol Station (SenConsulting, 2020)

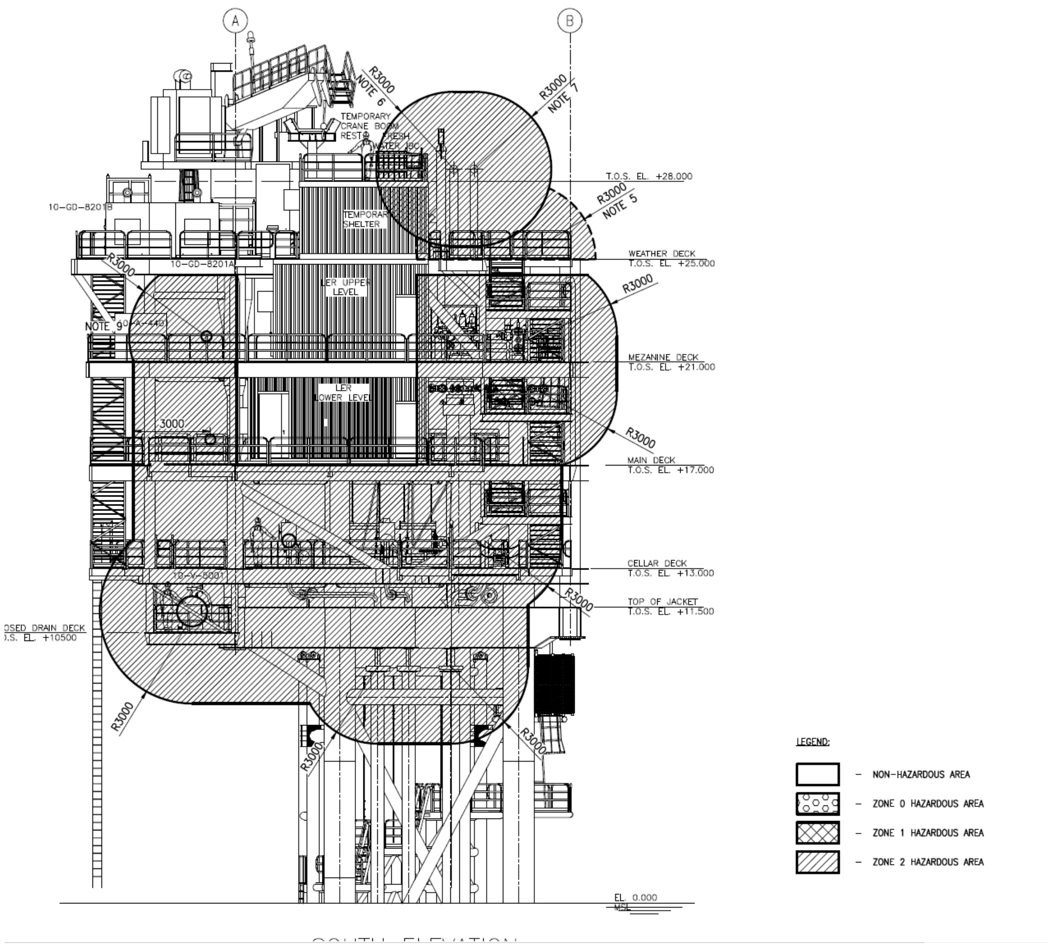


Figure 2.8: Sample of Wellhead Platform Area Classification Drawing

In the oil and gas industry, area classification drawing is a very important drawing to identify the location of the zone of hazardous area. Based on this drawing, the engineer can select the suitable electrical apparatus or equipment installed at the hazardous area following IEC 60079.

Due to current deep-water oil well exploration technology, zone 0 hazardous areas are reducing on the wellhead platform. Because all the wellhead and production manifold shift from above the sea facility to the seabed and name it as subsea production systems.

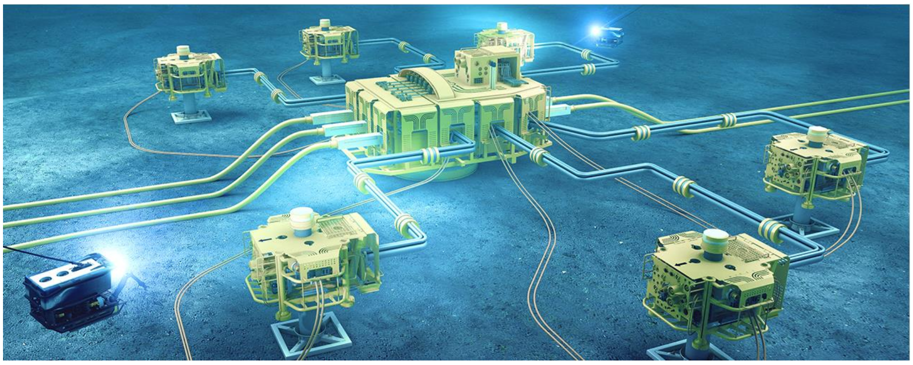


Figure 2.9: Subsea Production Systems (AkerSolutions, n.d.)

2.7 Explosion Protection Techniques and Method

According to IEC 60079, various protection techniques and methods have been developed to reduce the potential risk of explosion or fire from electrical equipment in the hazardous area.

Eliminate one of the elements from the fire triangle, to avoid the three of the condition fulfilled at the same time. In the petrochemical plant or oil and gas refinery plant the oxygen in the air and the fuel surrounding uncontrollable. Therefore, the only element able to control is the ignition source.

Ignition source most frequent could happen as below source:

(i) Electrical spark and arcs (Electrical Circuits, Motors, and Switches)

(ii) Mechanical Spark (from friction and falling objects)

(iii) Hot Surface (hot work, hot processing equipment, and electrical equipment)

(iv) Chemical Reaction

(v) Lightning Strikes

2.7.1 Method of Explosion Protection

Below is the protection method which is always used in the Oil and Gas industry according to the IEC60079 standard. There is various type of protection method developed but not all are applicable in the industry. Some of the equipment may combine multiple types of protection.

(i) Flameproof Ex da, db, dc (IEC60079-1)

A type of protection in which an enclosure withstands the pressure of an explosion of the mixture within and prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure. In the "Ex d" type of protection, the surrounding explosive gas is not ignited.

(ii) Increased Safety Ex eb (IEC60079-7)

This protection is intended to ensure that impermissibly high temperatures and sparks or electric arcs inside and on the external part of the electrical equipment, which do not occur during normal operation, are reliably prevented.

(iii) Intrinsically Safe Ex ia, ib, ic (IEC60079-11)

The intrinsically safe circuit is the circuit in which no spark or thermal effect occurring under the test conditions specified in the standard can ignite the explosive atmosphere of subgroups IIA, IIB and IIC listed in Table 2.2. Lower permissible load of the components than in ordinary industrial application via voltage related to electrical strength and current related to heat.

2.7.2 Flameproof Enclosures Ex da, db, dc (IEC60079-1)

The basic design philosophy of the Ex d flameproof the enclosure is strong and tough enough to withstand the explosion inside the enclosure and stop any flames, sparks, and hot gases escaping into the surrounding atmosphere should an internal explosion occur. Ex d enclosure may install the electrical equipment such as termination block, relays, power supplies, radio devices, and other electrical equipment with potentially generate heat.

Flameproof enclosures suitable for use in zone 1 & zone 2 only. The joints on the cover or openings for the flameproof enclosures are protected by the flame path. The flame path is a gap within the enclosure, when the internal explosion occurs to ensure the time of the flame has reached the end of the flame path it has been cooled down.

A solid obstruction such as a wall, steel structure, pipe, fixture, or weather protection or other electrical devices near the opening of the joint may, in the event of an internal explosion, reduce the efficiency of the flame path sufficiently to cause ignition of the external gas or vapour. The minimum distance between the flamepath opening and the obstruction must be in accordance with IEC 60079-14.

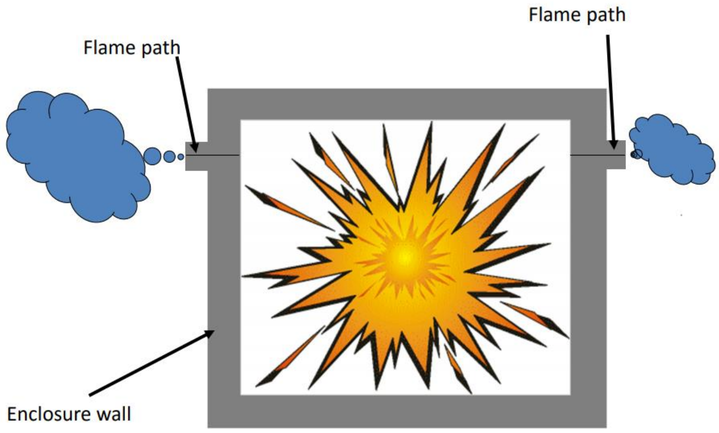


Figure 2.10: Flame path for Flameproof Enclosures (Ex Protection Concepts, 2016)

Group	Distance
IIA	10mm
IIB	30mm
IIC	40mm

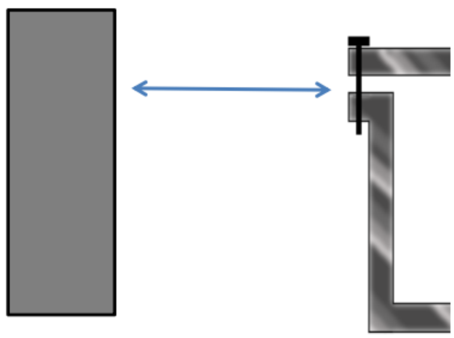


Figure 2.11: Flame Path Opening and Obstruction Distance (Ex Protection Concepts, 2016)

2.7.3 Increased Safety Ex eb (IEC 630079-7)

The principle of increased safety, Ex eb, is to ensure reliable prevention of impermissibly high temperatures and sparks or arcs on both the internal and external parts of electrical equipment where impermissibly high temperatures, sparks or arcs do not occur during normal operation.

The general requirement for Ex e enclosures with increased safety is at least IP54 and additional tests for the non-metallic part, including thermal resistance,

resistance to solvents, ultraviolet light, surface conductivity and mechanical resistance to shock of either 4 or 7 joules, depending on the size of the enclosure.

The terminal block or connection for the enclosures with increased safety must be generously sized for the intended connection and ensure that the conductors are securely fastened. The specified creepage distance is in accordance with IEC 60079-7 for the degree of insulation material (CTI) and the resulting maximum rated voltage.

Increased safety Ex e is only suitable for use in zones 1 and 2. Most often Ex e is used as a junction box in the field for control signal termination. In most cases, the Ex e termination is supplied together with the cable gland.

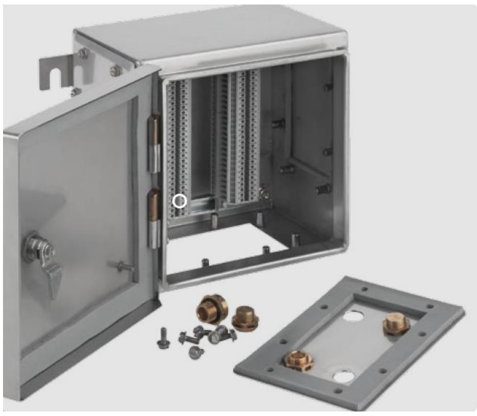


Figure 2.12: Ex e Junction Box

2.7.4 Intrinsically Safe Ex ia, ib, ic (IEC 60079-11)

The principle of intrinsically safe electrical equipment includes only circuits that meet the requirements for intrinsically safe circuits. The intrinsically safe circuit is used for control to reduce the potential spark energy. This low energy signalling technology prevents an explosion by ensuring that the energy transferred into the hazardous area is well below the ignition curve.

Typically, application with Ex I protection is for the field instrumentation signal, control circuit, and other low power apparatus such as CCTV.

There are three major principles of intrinsically safe design. First to limit the voltage entering the hazardous area. Secondly is the limit the current entering the hazardous area and lastly is to limit store of electrical energy in the hazardous area.

The great advantage of intrinsic safety is that it provides a solution to all problems in potentially explosive atmospheres and is the only technique that meets this criterion. The intrinsically safe explosion-proof method is suitable for use in zones 0, 1 and 2.

Intrinsic Safety is the only IEC method of protection that allows live working on the field wiring, able to perform maintenance work on the energized equipment.

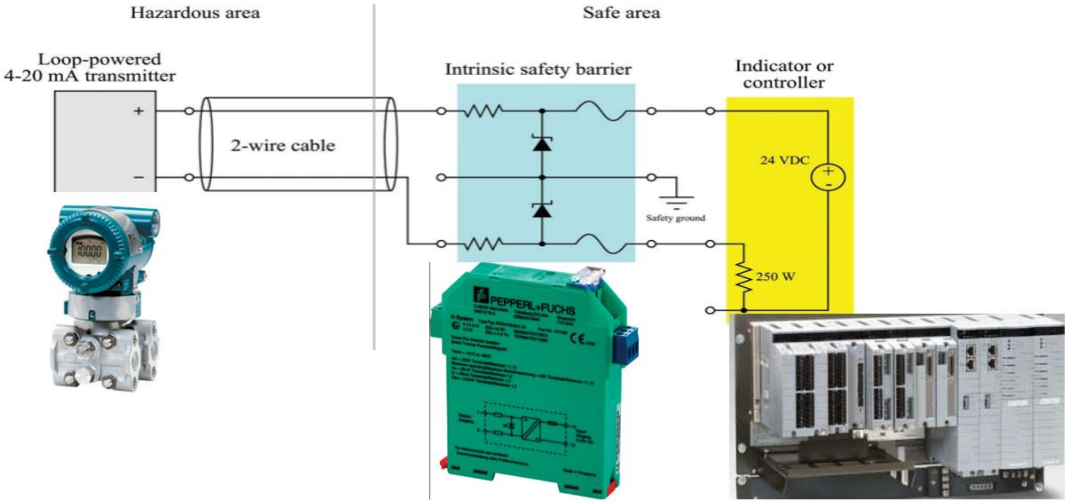


Figure 2.13: Intrinsically Safe System Configuration

Based on data from the IECE, Intrinsically Safe protection is the most common method used in the industry to prevent the explosion.

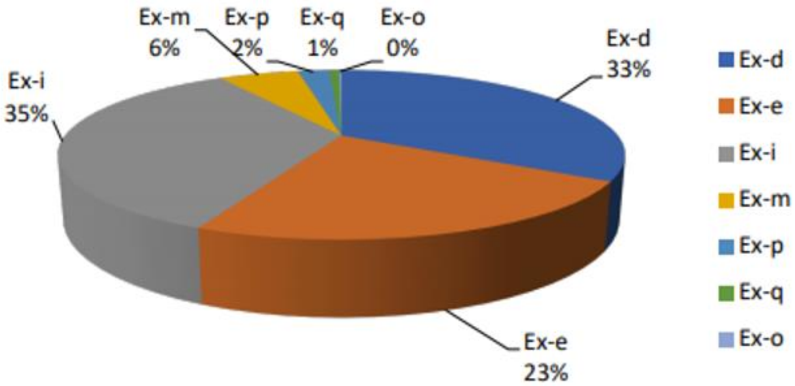


Figure 2.14: Percentages of Usage of the Type of Protection in The Industry (IECEX)

2.8 Four (4) Main Keys for Intrinsic Safe Design

First, the voltage and current required for the device are within the limits imposed by the resistance/ignition curve. The maximum capacitance of the circuit is within the limits specified in the capacitive curve.

Finally, the inductance is within the limits specified in the inductive curve and the design of the device allows for the increase in surface temperature required for T-classification.

2.8.1 Ignition Curve

The minimum ignition energy of the test cases used for each gas group has been established experimentally using spark test under IEC 60079-11 standard. The lower the energy band it might be easier it for it to ignite. It is normally possible to access the safety of intrinsically safe apparatus by reference to these ignition curves without the need to carry out the additional test. From the ignition curve below, for a particular gas group and any combination of the current and voltage which fall below the curve will not likely cause an ignition. If the value is above the curve, it can cause ignition.

Table 2.4: Ignition Energy Gas Group

Apparatus Group	Representative Gas	Energy Band (µJ)
I	Methane	200
IIA	Propane	>180
IIB	Ethylene	>60
IIC	Hydrogen	>20

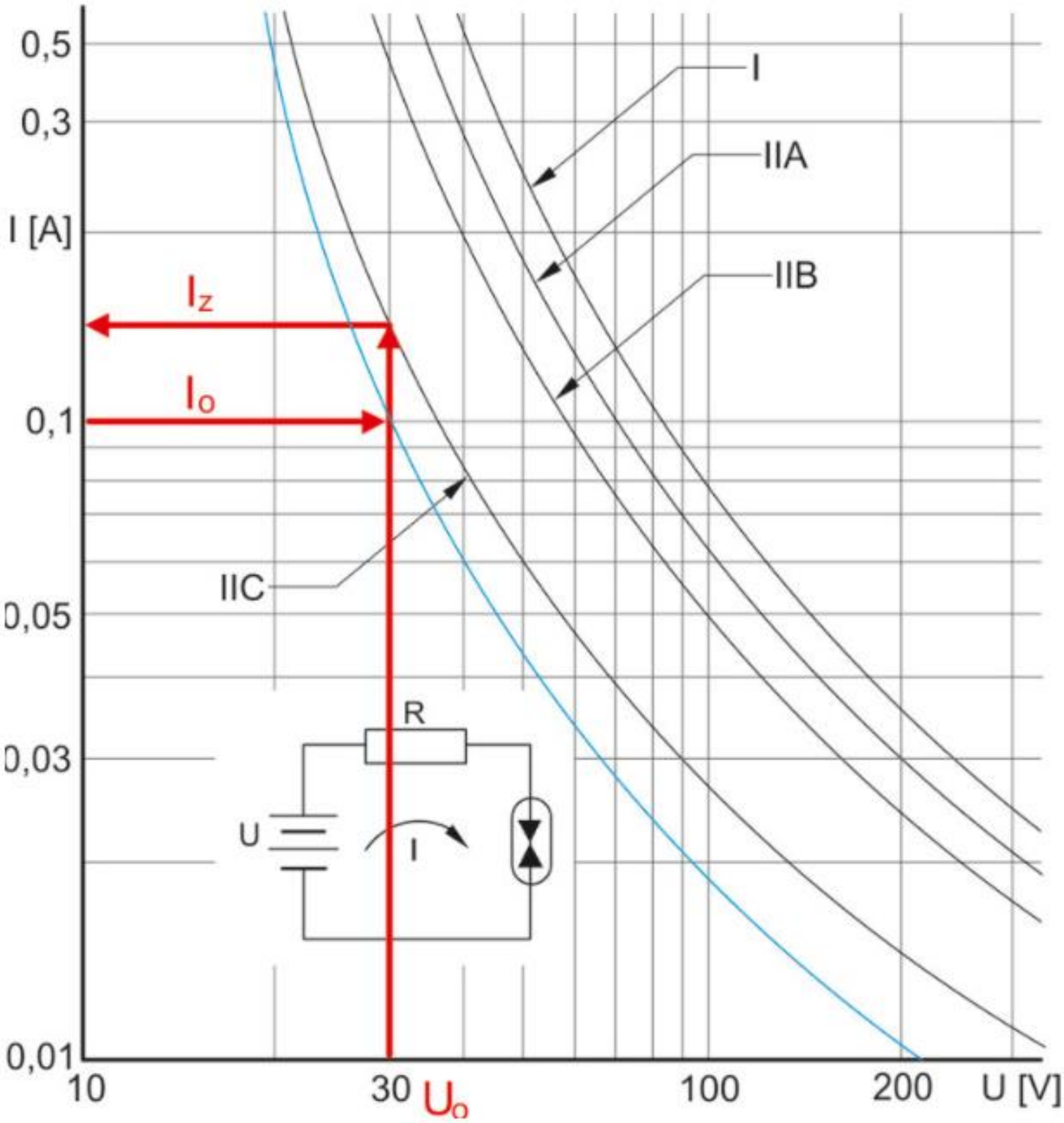


Figure 2.15: Ignition Curve (Resistive) (Intrinsic Safety Type of Protection, 2021)

Base on the ignition curve above, if the voltage or current above the apparatus group explosion could happen.

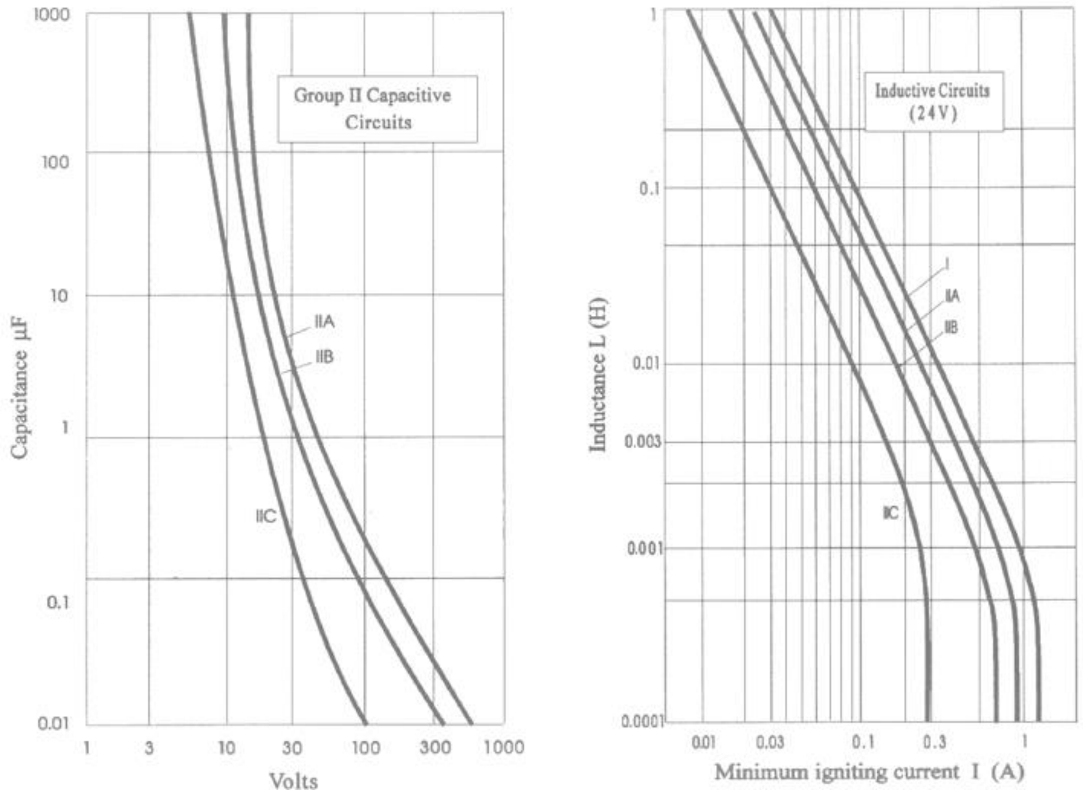


Figure 2.16: Ignition Curve (Capacitive & Inductive)

2.9 The Intrinsically Safe System

An intrinsically safe system is a system concept, the overall system consists of associated apparatus, cables, junction boxes, and field apparatus. The intrinsic safety, the associated apparatus, and all the equipment connected to its hazardous area terminals can affect the intrinsic safety of the whole circuit loop or control loop.

For example, if there are some field apparatuses
contain capacitance and have been certified as being intrinsically safe at a voltage of 28V. It will not be considered intrinsically safe (IS) if it is connected to a source with 100V.

Intrinsically safe (IS) system normally consists of simple apparatus which are the instrument transmitter which install and located at the hazardous area, next will be the associate apparatus is the Intrinsically Safe (IS) barrier which located in the safe area such as control room or panel room. Normally IS barrier install in the control system cabinet such as a Programmable Logic Controller (PLC) or Distribution Control System (DCS).

The oil and gas industry is wide using the distributed control system to control and monitor the plant process.

2.9.1 Simple Apparatus

The simple apparatus itself does not need to be certified but require to be connected to the certified associated apparatus to meet the intrinsically safe condition as per IEC 60079-11 standard.

Simple apparatus is a passive component, the passive component that consumes energy but does not produce energy. A device that does not store or generate energy that is more than 1.5V, 0.1A, or 25mW such as switches, junction boxes, thermocouples, light-emitting diodes (LED), connectors, and resistance temperature detectors (RTDs).

2.9.2 Non-Simple Apparatus (Energy Storing Apparatus)

The energy storing apparatus itself must be certified intrinsically safe. The associated apparatus is nevertheless required because the maximum power available throughout the circuit must be controlled.

Non-simple apparatus in other words name it as energy storing apparatus. Normally it refers to the solenoid, instrument transmitters install at the hazardous area.

The apparatus could generate or store electrical energy, in which case it will certainly affect the system consideration in an intrinsically safe manner (IS). Such a device will not be a simple device.

For example, the solenoid for the control valve has an inductance almost greater than the maximum allowed under inductive ignition curves. The inductive energy must be suppressed in some way. In addition, the transmitter always contains capacitors in the devices.

2.9.3 Associated Apparatus

The associated apparatus is an interface between a safe area device and a hazardous area device.

All the associated apparatus electrical require mounting in a safe area, there are some cases the apparatus electrical mount is in the hazardous area but require providing separated certification according to IEC 60079. In this case, there will be a combined protection method to fulfil the requirement. The associated apparatus installs inside the Ex d enclosure when located at the hazardous area.

The associate apparatus in the system is referring to the safety barriers, safety barriers is the interface between the safe and hazardous area.

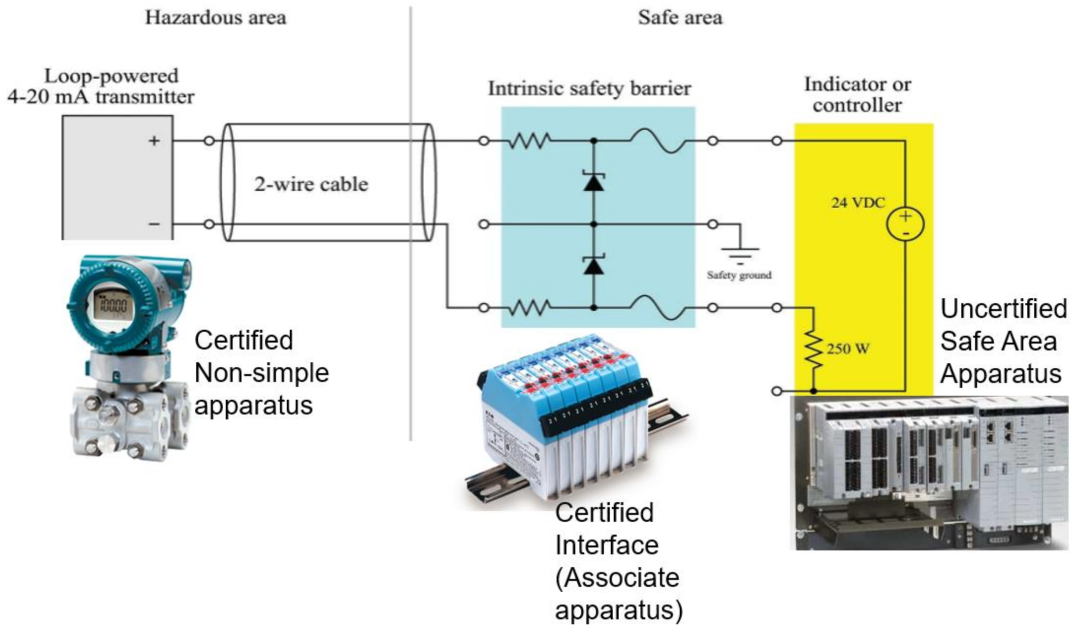


Figure 2.17: Sample of Combination of Simple Apparatus, Associate Apparatus, and Non-Simple Apparatus

2.10 Intrinsic Safety

In the current market, there are two types of intrinsic safety interfaces, the first type is named Zener Barrier/Shunt Diode Barrier/Safety Barrier, and the second type is the Isolating Barrier/IS isolator/Galvanic Isolator.

2.10.1 Shunt Diode Barrier/ Zener Barrier

The working principle for the shunt diode barrier/ Zener barrier, these barriers can be used for energy diversion during the normal condition, the device is passive and allows the intrinsic safe apparatus to function properly. During the fault condition, the barrier will divert any excess voltage and current to the ground to protect the field devices and reduce the risk of explosion.

Referring from the ignition curve on a particular gas group or any combination of the current and voltage which falls below the curve will reduce the chance of ignition occurring. However, if any value above the curve is capable to cause ignition, an explosion may occur in the hazardous area.

A circuit is known to be intrinsically safe if the I_{sc} and V_{oc} form a pair of values that plotted on the ignition curve lies below the curve by a safety factor of 1.5.

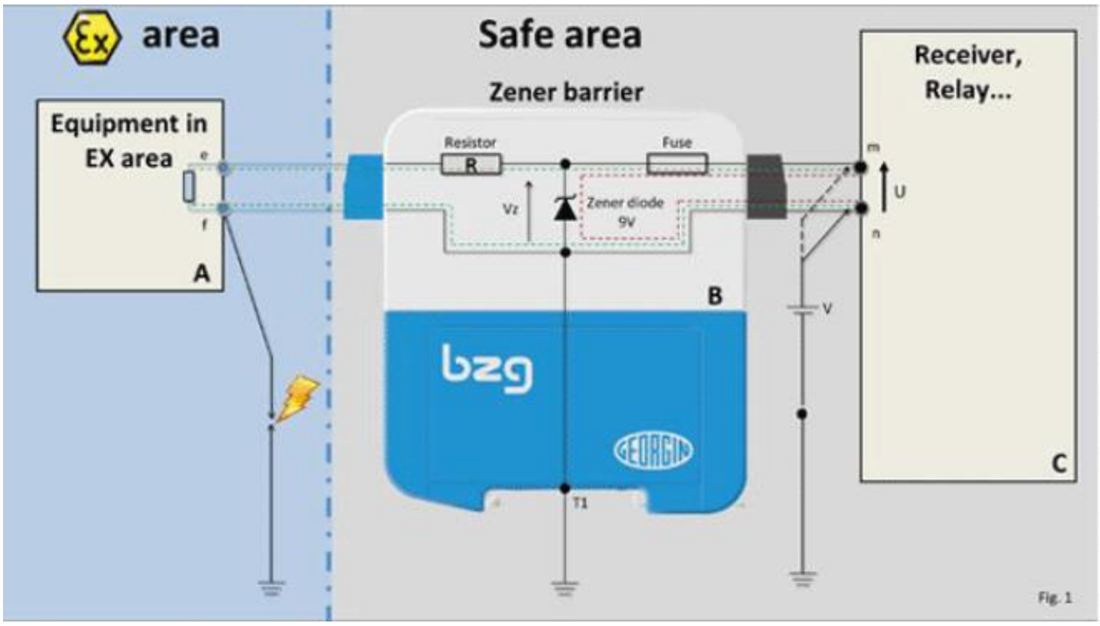


Figure 2.18: Sample Circuit Shunt Diode Barrier/ Zener Barrier (BZG)

Base on the shunt diode/ Zener barrier circuit above is consists of a resistor, fuse, and Zener diode. Each of the components has its function to protect the equipment in the hazardous area.

The resistor is to limit the maximum current entering the hazardous area, the maximum output current is always smaller or equal to V_Z/R and the maximum output voltage is always smaller or equal to V_Z.

The function of the fuse in the circuit is to limit the maximum current flow through the diodes. Next is the function for the Zener diode is to limit the voltage between the earth and the signal line (Limit Voc). Lastly, is the high integrity earth connection diverting current back to the source.

From the circuit above is the basic and minimum design for the shunt diode barrier/ Zener barriers. To increase the reliability of the Zener barrier, it is common that additional diodes are added to increase the safety level. Table 2.4 below is the requirement and standard as per IEC 60079-10.

Table 2.5: Intrinsic Safety Level of Protection

Level of Protection	Zone of Use	Safety Level	IEC 70079-10
Ex ia	0,1,2	Safe with 2 faults	3 Diodes / 2 Diodes (additional test require)
Ex ib	1,2	Safe with 1 fault	2 Diodes
Ex ic	2	Safe with no fault (Normal Operation)	1 Diodes

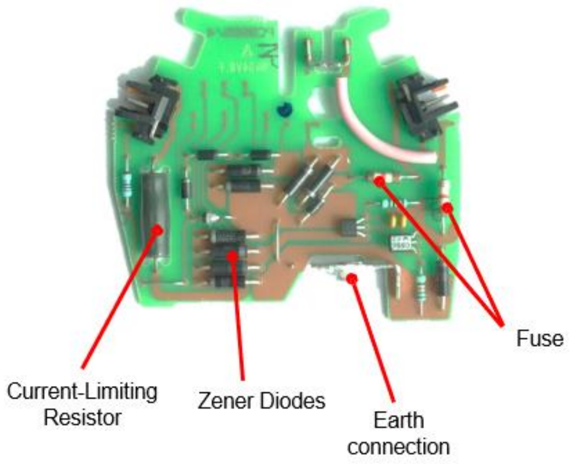


Figure 2.19: Actual Circuit for MTL7707+ 2 Channel Zener Barrier for 4-20mA (MTL)

2.10.2 Galvanic Isolating Barrier

The primary function of an intrinsically safe isolator is the same as a more zener barrier and is to protect the apparatus in the hazardous area. Isolation is the key function in isolating barriers. There is a defined separation between the circuit on the safe area and the hazardous area. The isolation barrier diverts excess energy to earth. The advantages of isolation barriers application are the earthing and can replace the limitation of Zener barrier.

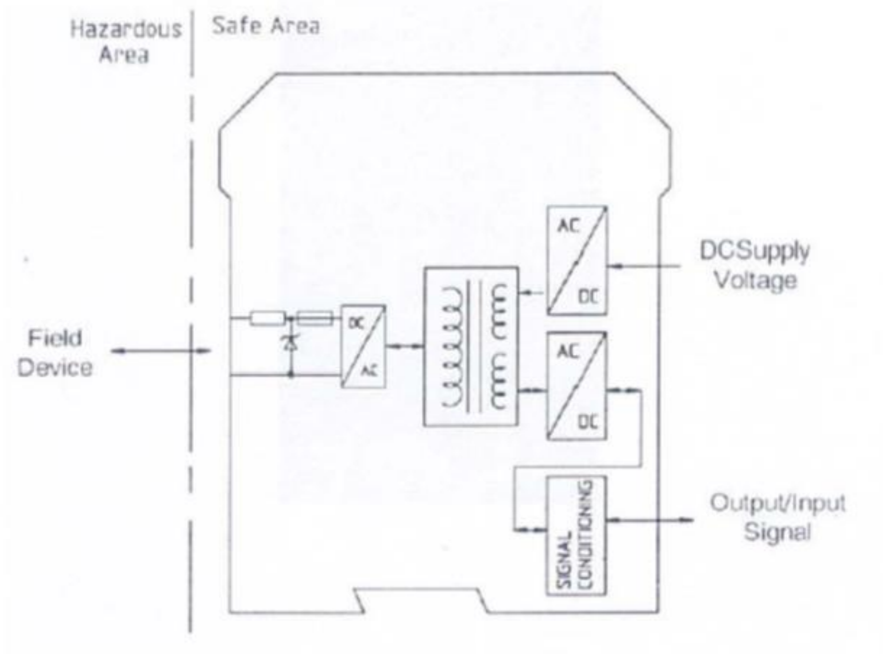


Figure 2.20: Sample Circuit Diagram for Isolating Barrier (MTL)

The isolating barrier circuit diagram above there is consists of a few components which are transformer, Zener barrier, and static inverter.

The function of the certified transformer is to provide complete isolation between the safe and hazardous areas. Zener barrier functions are similar to the Zener barrier to limit voltage and current entering the hazardous area but for isolation barrier, it doesn’t require intrinsic safe earth. Static Inverter function is to convert the DC to AC passed it through the transformer a then convert AC back to DC.

The galvanic isolation barrier can be used for both digital and analogue signals for the control system. Intrinsically safe circuits are usually completely ungrounded or grounded at one point. The reason for this is that if a circuit is grounded at more than one point, the difference in potential between the two points will cause an undefined current to flow through an unknown source of induction.

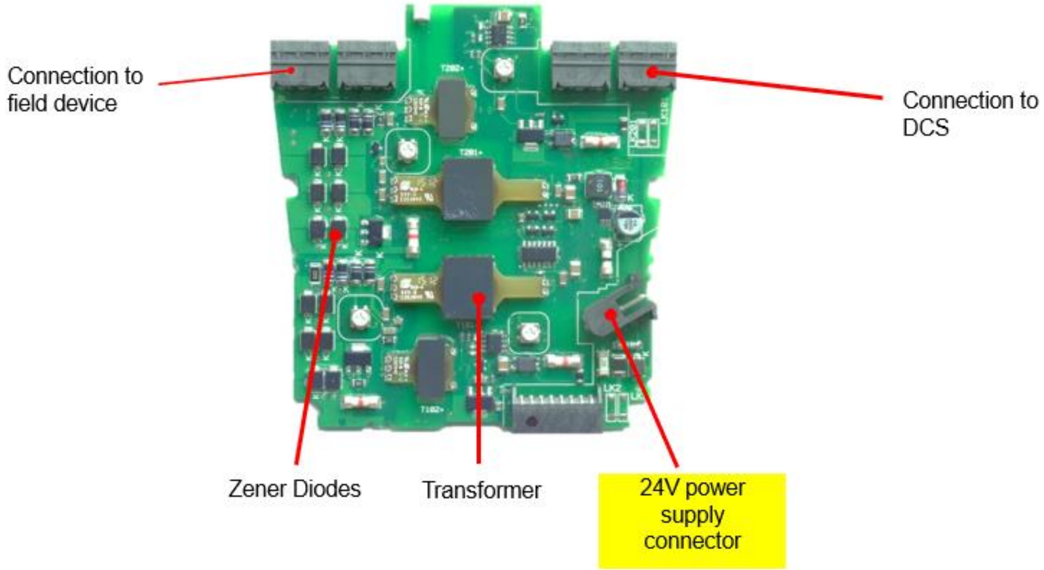


Figure 2.21: MTL5544 Dual Channel Galvanic Isolator (MTL)

2.11 Hazardous Area Certified Equipment

Any instruments or equipment to be installed in hazardous areas, or associated apparatus, must comply with all explosion protection procedures used.

In Malaysia, most projects follow the European standard, therefore all equipment must be ATEX or IECEx certified. Certifications should be carried out by a notified body and should demonstrate compliance with the relevant standards and protection methods.

The certification contains important information about the product, including the notified body, certificate number, reference standard, applicable part numbers, product description, product marking requirements, electrical data, certificate history, etc. (Cortem, 2012)

IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification System for Explosive Atmospheres
for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.:	**IECEx BAS 19.0018X**	Page 1 of 4	Certificate history:
Status:	**Current**	Issue No: 4	Issue 3 (2020-11-12) Issue 2 (2020-02-12) Issue 1 (2019-08-30) Issue 0 (2019-06-20)
Date of Issue:	2021-03-15		
Applicant:	**Eaton Electric Limited** Great Marlings Butterfield Luton Bedfordshire LU2 8DL **United Kingdom**		
Equipment:	**MTL SUM5 Universal Isolator**		
Optional accessory:			
Type of Protection:	**Intrinsic Safety**		
Marking:	**[Ex ia Ga] IIC (-40°C ≤ Ta ≤ +70°C)** **[Ex ia Da] IIIC (-40°C ≤ Ta ≤ +70°C)** **[Ex ia Ma] I (-40°C ≤ Ta ≤ +70°C)**		

Approved for issue on behalf of the IECEx Certification Body:	**R S Sinclair**
Position:	**Technical Manager**
Signature: (for printed version)	
Date:	15.3.2021

1. This certificate and schedule may only be reproduced in full.
2. This certificate is not transferable and remains the property of the issuing body.
3. The Status and authenticity of this certificate may be verified by visiting www.iecex.com or use of this QR Code.

Certificate issued by:

SGS Baseefa Limited
Rockhead Business Park
Staden Lane
Buxton, Derbyshire, SK17 9RZ
United Kingdom

Figure 2.22: Sample of IECEx Certificate for MTL SUM5 (SUM5)

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, the standards and methods are discussed. Based on the data collected and perform the calculation on the intrinsically safe accordance to IEC 60079-14. In this research and study will be selected the MTL Zener barriers data and the MTL Sum5 for the case study.

3.2 Standards

In the oil and gas industry, Malaysia is following the IEC standards as a guideline to perform the detailed engineering design. Explosion protection following the IEC 60079 standards. The IEC 60079 standard, there is consists of a few subtopics which are related to the method and installation guideline for explosion protection. This research and study all are based on the IEC standards.

3.3 Safety Compatibility for Intrinsically Safe Barrier

According to IEC 60079-14 the value of maximum input voltage (U_i), input current (I_i), and input power (P_i) shall be greater than or equal to the maximum output voltage (U_o), output current (I_0), and output power (P_o) of the source of power respectively.

The total inductance and capacitance of all the connected apparatus included in the system and any cable inductance and capacitance shall be less than or equal to L_o and C_o for the source of power.

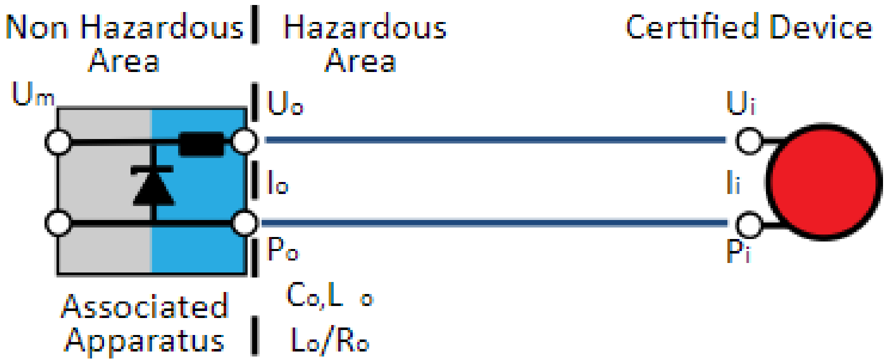


Figure 3.1: Circuit Diagram for the Associated Apparatus and Intrinsically Safe Apparatus

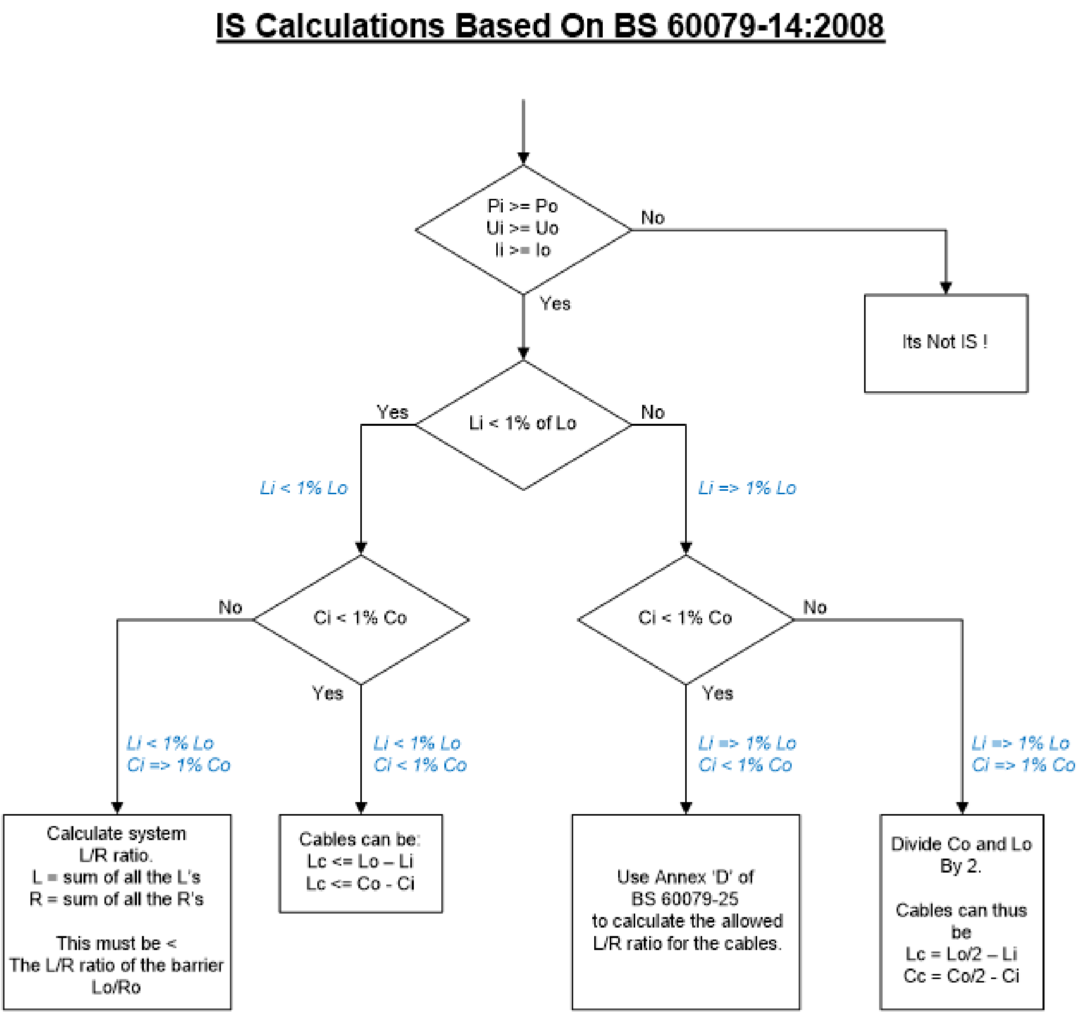


Figure 3.2 Flow Chart for Intrinsically Safe as per IEC 60079-14

The flow chart above is the guideline for the selection of the intrinsically safe barrier following the IEC 60079-14 safety parameter. Based on the flow chart easily can identify and selection of suitable safety barriers.

3.4 Equipment Marking

All the certified apparatus used in the hazardous area shall be consist of the mandatory marking. Equipment marking is normally will be printed on the equipment or from the datasheet or Ex certificate. The marking on all equipment indicates the information for use in a potentially explosive environment should provide all essential information for safe operation and easy identification of the device.

Equipment marking is very important and method to avoid the explosion happening before the installation and operate in the hazardous the field engineer can check and confirm the devices is suitable to use in the Zone. For example, the Sum5 MTL4-BSIS IS terminal base is certified for use in safe area/ Zone 2 IIC T4 but the field engineer installs it at Zone 1 which is not acceptable. Figure 3.12 provides a self-explanation of the marking according to ATEX and IECEx certification scheme.

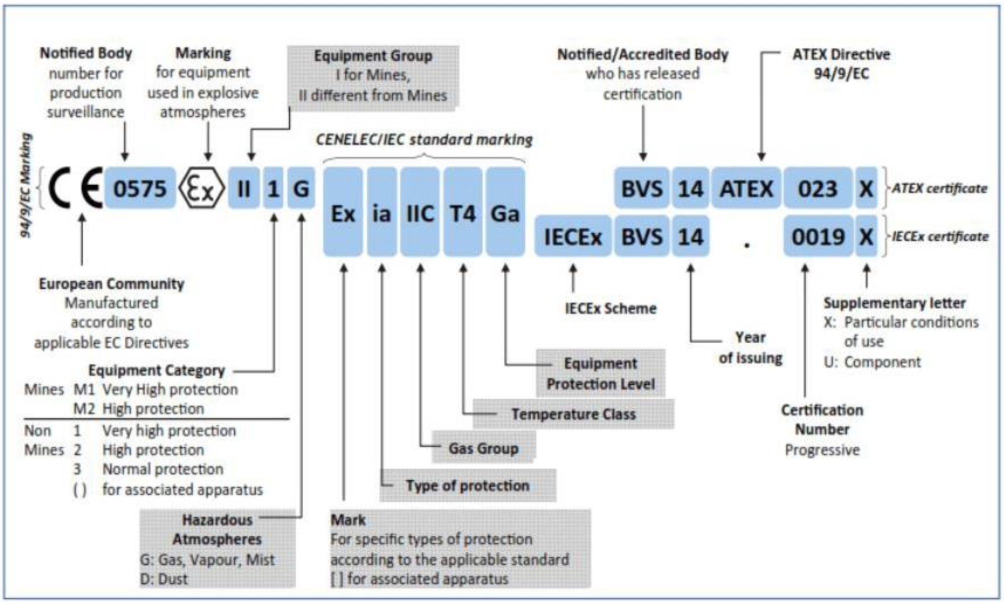


Figure 3.3: Summary of Apparatus Marking According to ATEX and IECEx Certification Scheme (Kuan, Chew and Chua, 2020)

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Overview of Result Chapter

In this chapter, there are different case studies were discussed and analyzed. The first case is studying the type of method of prevention of the explosion-proof which is more suitable use in the oil and gas industry.

While next is to identify the intrinsically safe loop based on the calculation on the field instrumentation. Lastly is studying the latest model of the MTL SUM5 compared to the ordinary safety barriers.

After completing the cases study and researchable to identify the best solution prevention of explosion and able reduce the project cost.

4.2 Result

4.2.1 Explosion Protection Method

According to the IEC 60079, there are many ways or methods to prevent explosions in hazardous areas. Each of the methods has its pros and cons, the most frequent use in the oil and gas industry is an intrinsically safe method because it provides a solution to all the problems of hazardous areas. In some cases, their mixture of protection may happen in the industry. Such as a Safety barrier install in the increased safety junction box or remote IO cabinet.

Intrinsically safe method cost is cheaper than the explosion-proof method and also the weight will be much lighter. Normally the Ex d junction box is very heavy and expensive. The explosion-proof method may increase the project cost and be difficult to maintain during the plant is operating.

4.2.2 Identify Intrinsically Safety Loop

According to 60079-14, the intrinsic safety loop calculation shall be following the requirement as below:

(i) Checking of the voltage: Uo (barrier) ≤ Ui (equipment in the hazardous area)

(ii) Checking of current: Io (barrier) ≤ Ii (equipment in the hazardous area)

(iii) Checking of power: Po (barrier) ≤ Pi (equipment in the hazardous area)

(iv) Checking of capacitance: Cc (cable) + Ci (equipment in the hazardous area) ≤ Co (Barrier)

(v) Checking of inductance: Lc + Li (equipment in the hazardous area) ≤ Lo (Barrier)

Table 4.1: Result of the Case Study for Safety Barrier

Certified Device (Intrinsically Safe Apparatus) ABC Brand Transmitter		**Safety Barrier (Associated Apparatus)**		**Criterion (IEC60079-14)**
Allowed Voltage (U_i)	28V	Output Voltage (U_o)	28V	$U_o \leq U_i$
Allowed Current (I_i)	94.3mA	Short Circuit Current (I_o)	83.97mA	$I_o \leq I_i$
Power (P_i)	0.66 W	Output Power (P_o)	0.58 W	$P_o \leq P_i$
Capacitance (C_i)	0.026 µF	Capacitance (C_o)	0.083µF	$C_o > C_i$
Inductance (L_i)	600 µH	Inductance (L_o)	5042µH	$L_o > L_i$

Assume the cable data as below:

Resistance per unit length: 10 Ohms/Km

Capacitance per unit length: 0.02 µF/Km

Inductance per unit length: 1000 µH/Km

Length: 700 meters

Checking of capacitance: Cc (cable) + Ci (equipment in the area) ≤ Co (barrier)

(0.02 µF x 0.7 km) + 0.026 µF ≤ 0.083 µF

0.04 µF ≤ 0.083 µF

Checking of inductance: Lc + Li (equipment in the hazardous area) ≤ Lo (barrier)
(1000 µH x 0.7 km) + 600 µH ≤ 5042.58 µH
1300 µH ≤ 5042.58 µH

As per the calculation above the capacitance and inductance value of the instrumentation in the hazardous area are compatible with the maximum external value of the associated equipment.

Based on the data above and assuming the diode rated voltage is 28V and added 10% of tolerance, therefore, the maximum rated voltage may go to 30.8 V. Refer to the ignition curve class IIC 30.8V lead to 139mA. When the voltage goes to 30.8V then the current shall limit to 139mA to avoid explosion occurring.

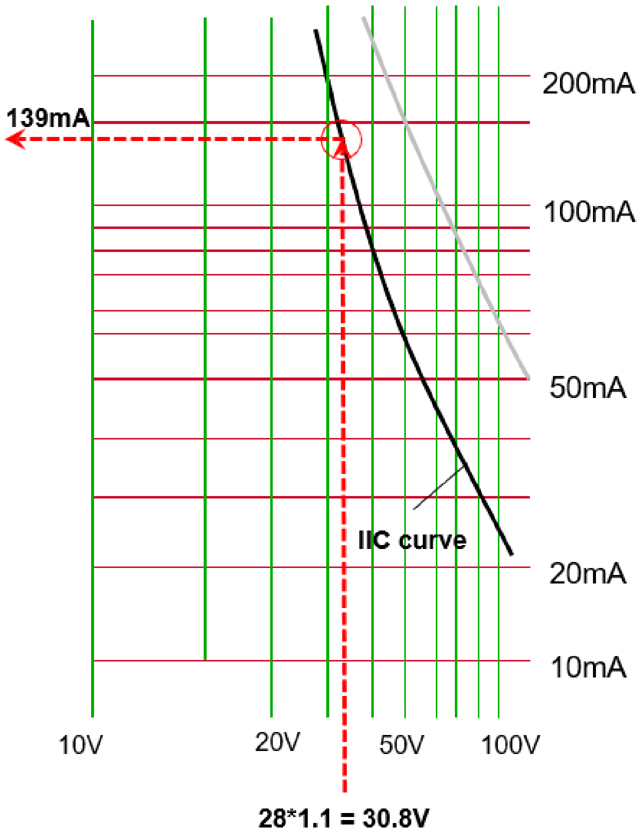


Figure 4.1: Ignition Curve Result

Apply safety factor to the current at 1.5:
139 mA/1.5 =92 mA
Therefore, the current limiting resistor in the safety barrier:
R= V/I = 28/0.092
= 304 ohms

4.3 Case study and Analysis on Intrinsically Safe Barrier

Based on the datasheet from MTL Analog output Zener Barrier (MTL 7728+) refers refer to the termination 1 & 2 which is located at safe area connections and for V_z is refer to the termination 3 & 4 which output to the field for Hazardous area connection to the solenoids valve.

From the barrier datasheet the safety parameter and the operation parameter are given as below:

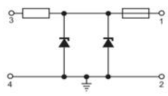
Model No.	Safety description [1]			Polarities available [2]			Application	Basic circuit	Max. end-to-end resistance [3]	Vwkg at 10µA or (1µA) [4]	Vmax [5]	Fuse rating [6]
MTL	V	Ω	mA	+	–	ac		Hazardous Safe	Ω	V	V	mA
7728+	28	300	93	✓			6V dc & 4V ac systems 12V systems 12V dc systems 18V dc systems Controller outputs, solenoids Transmitters Controller outputs, solenoid valves Controller outputs, solenoid valves IIB		333	25.9	26.5	50

Figure 4.2: Datasheet and parameter for MTL Analog Output Zener Barrier (MTL)

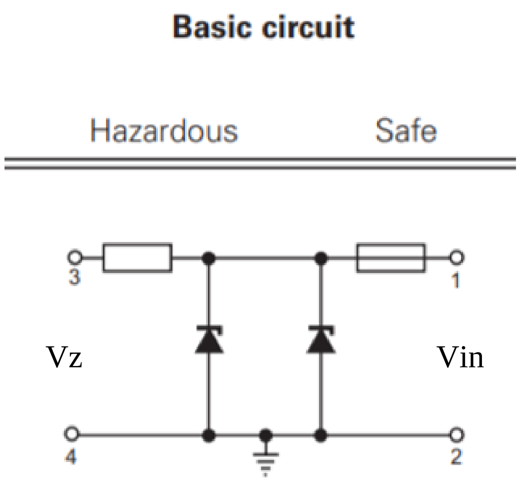


Figure 4.3: Sample Circuit from Zener Barrier

When the V_z is greater than V_{in} then the maximum voltage U_o = 28 V and the maximum short circuit current I_o= 93 mA .The maximum open circuit voltage U_o = 28 V is the maximum voltage a barrier can deliver to the hazardous area in the case of a fault.The maximum short circuit current $I_o = 93\ mA$ is the maximum current a barrier can deliver to the hazardous area in a fault situation.

Assume the diode rated voltage is 28 V. In fact, may not get exactly 28 V, maybe we add 10% tolerance, where the max rated voltage may go to 30.8 V. Refers to the ignition curves, IIC, 30.8 V leads to 140 mA. Meaning to say, if the voltage goes to 30.8 V, then the current shall limit to 140 mA to avoid explosion.

Apply 10% upper tolerance to voltage

28 x 10% = 30.8 V

Read maximum permissible current from IIC curve:

140 mA

Apply 1.5 Factor of Safety to Current:

140/1.5 = 93 mA

Calculate value of Current-Limiting Resistor:

R = V/I = 28/0.093 = 300 Ω

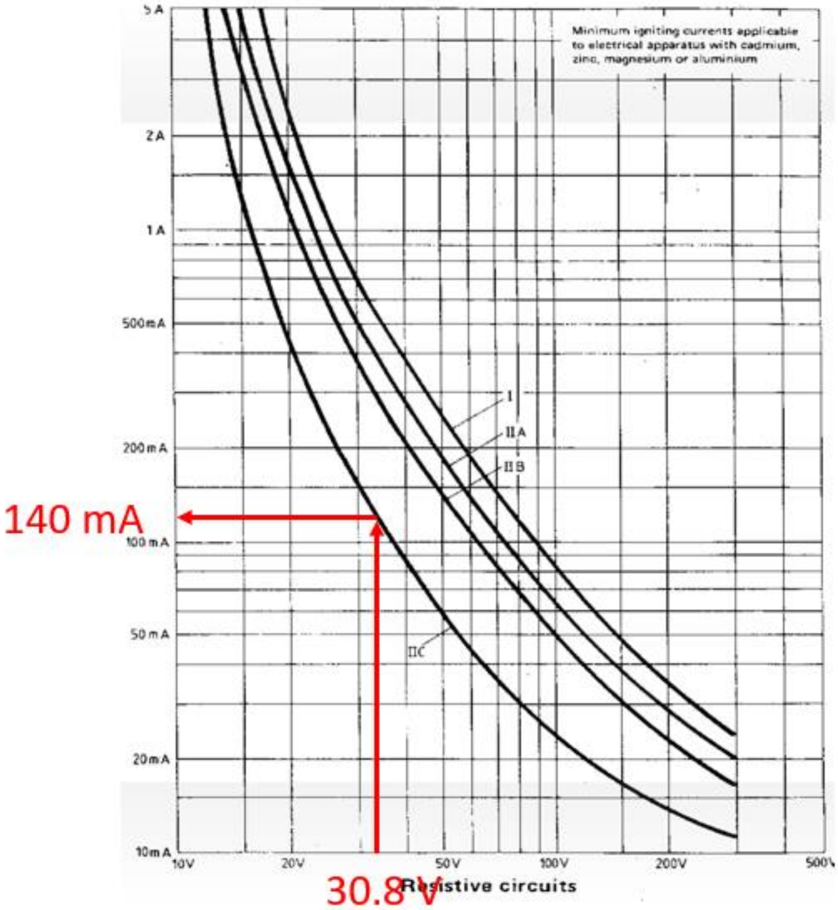


Figure 4.4: Ignition Curve (Resistive)

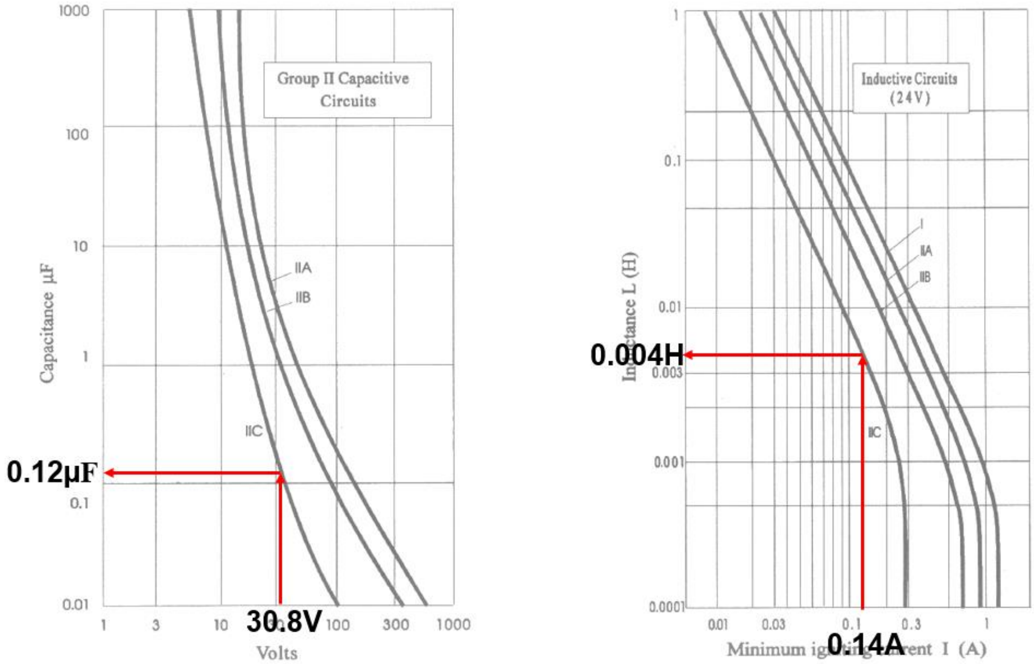


Figure 4.5: Ignition Curve (Capacitive & Inductive)

Table 4.2: Result of the Case Study

Certified Device (Intrinsically Safe Apparatus) Yokogawa EJA Pressure Transmitter		Safety Barrier (Associated Apparatus)		Criterion (IEC60079-14)
Allowed Voltage (U_i)	30V	Output Voltage (U_o)	28V	$U_o \leq U_i$
Allowed Current (I_i)	225mA	Short Circuit Current (I_o)	93mA	$I_o \leq I_i$
Power (P_i)	0.9 W	Output Power (P_o)	0.65 W	$P_o \leq P_i$
Capacitance (C_i)	22.5 nF	Capacitance (C_o)	0.083µF	$C_o > C_i$
Inductance (L_i)	730 µH	Inductance (L_o)	4200µH	$L_o > L_i$

After access to the safety compactivity of associated apparatus and field devices has been confirmed, the contribution of the cable to the circuit needs to be considered. As the circuit has a maximum allowed capacitance and inductance then clearly limits the installation of the cable length.

Assume the cable specification as below:

Capacitance 0.2nF/meter, Inductance 25 µH/meter and Inductance to Resistance (L/R) ration 25 µH/Ω

Maximum cable capacitance allowed = 0.083 µF (Max allowed) – 22.5 nF (Field apparatus) = 60.5 nF max

Cable inductance = 4.2 mH – 730 µH = 3.47 mH max.

Allow cable length = 3.47 mH/25 µH = 138.8 m

The maximum cable run for this loop in IIC environment shall not more than 138 meters.

4.4 Case Study & Analysis Operational Parameters

In the actual details of engineering design, identifying based on safety parameters to design the electrical circuit is still not sufficient. Operational parameters for the control system and field instrumentation are required to consider in the design.

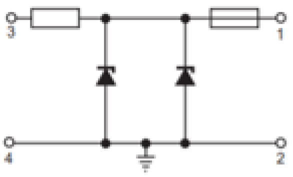
Basic circuit Hazardous Safe	Max. end-to-end resistance [3] Ω	Vwkg at 10µA or (1µA) [4] V	Vmax [5] V	Fuse rating [6] mA
	333	25.9	26.5	50

Figure 4.6: Datasheet and parameter for MTL Analog Output Zener Barrier (MTL 7728+)

Based on the datasheet parameter above the if the voltage is less than 25.9 V then the leakage current is guaranteed to be less than 10µA. The V_{max} is referred to the maximum voltage that the safety barrier can carry without blowing the fuse.

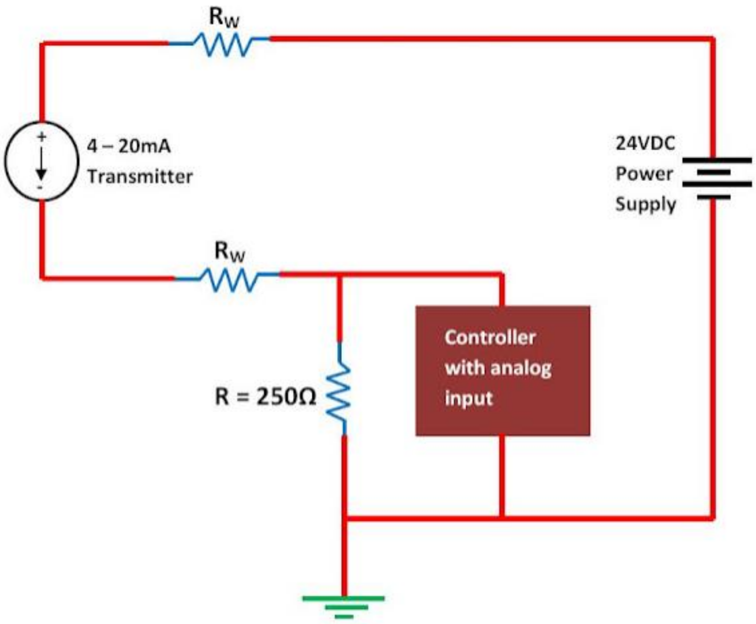


Figure 4.7: Schematic of 4-20mA current loop (Basics of The 4 - 20mA Current Loop, n.d.)

Control systems and field instrumentation transmitters commonly use 4-20mA for sensor signalling. The current loop is ideal for data transmission due to the inherent insensitivity to electrical noise. The common power supply voltage for 4-20mA is 36Vdc, 24Vdc 15Vdc, and 12Vdc. The most common power supply is the 24Vdc. From the diagram above the receiver resistor (R) is a 250ohm resistor because the voltage will be 1Vdc at 4mA and 5Vdc at 20mA of the loop current. The most common receive resistor in a 4-20mA loop is 250ohm.

Based on the datasheet from 7728 safety barrier the end-to-end resistor R=333ohm and the operating voltage for the transmitter normally work on a 10.8V supply.

By applying Ohm's law to calculate the voltage drop at 20mA.

V=20mA x 333Ω =6.67 V

Transmitter =10.8V

Instrument (DCS) = 20mA x 250Ω = 5 V

Total Voltage = 6.67V + 10.8V + 5V = 22.47 V

Hence, the power supply must be more than 22.47 V but lesser than $25.9V_{working}$ excluding the voltage drop for the cable.

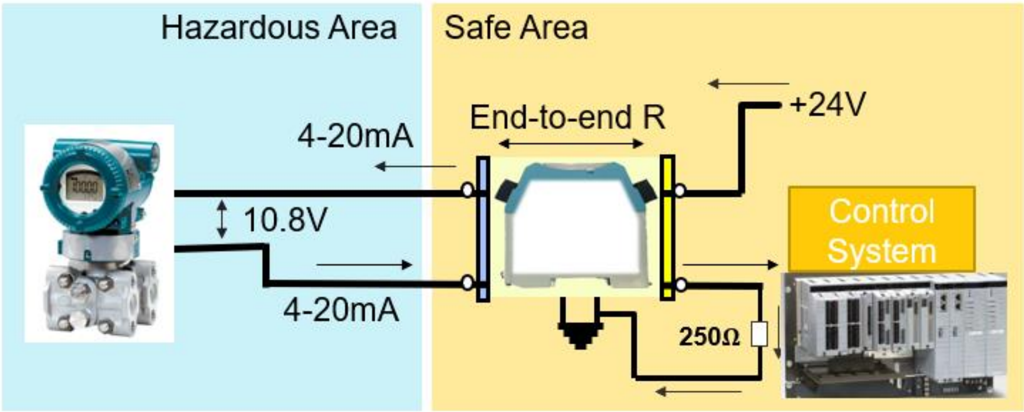


Figure 4.8: Complete 4-20mA control loop

4.5 Case study and analysis on MTL Sum5

Based on the datasheet from the MTL Sum5 shown in table 3.2 and using the same field transmitter data earlier. The maximum output voltage, short circuit current, and output power were reduced compared to the Zener Barrier because for Sum5 module was able install in the Zone 2 area. Based on the ignition curve the lower voltage and current at the field might reduce the chance of ignition at the hazardous area.

Table 4.3: Result of the Case Study for Sum5

Certified Device (Intrinsically Safe Apparatus) Yokogawa EJA Pressure Transmitter		MTL SUM5 (Associated Apparatus)		Criterion (IEC60079-14)
Allowed Voltage (U_i)	30V	Output Voltage (U_o)	26.5V	$U_o \leq U_i$
Allowed Current (I_i)	225mA	Short Circuit Current (I_o)	90mA	$I_o \leq I_i$
Power (P_i)	0.9 W	Output Power (P_o)	0.60 W	$P_o \leq P_i$

The intrinsically safe calculation is a method to ensure that selection of a combination of intrinsically safe apparatus (Field Transmitter), associated apparatus (Safety Barrier), and field/system cable are forming an intrinsically safe loop that can be used in the hazardous area.

4.6 MTL SUM5 Smart Universal Marshalling Solution

Based on the current oil and gas industry and market, most oil companies are trying to reduce the Capex and Opex in the upcoming new project or brownfield modification project. Field instrumentation and control system is a must for all Offshore platform or floating production storage and offloading (FPSO) projects. For instrumentation, applying the MTL SUM5 smart universal marshalling solution able to reduce to cost of the project.

MTL SUM5 is a solution that combines five marshalling functions into one configurable device there are intrinsically safe isolators, signal conditioning, relay interfaces, surge protection, and loop disconnect. This kind of configuration can reduce the number of marshalling cabinets and components in the control room or cabinet room. Furthermore, weight control is also another challenger in the oil and gas project. Because nowadays most of the designs are going for lightweight platforms or FPSO. The SUM5 solution not only reduces the cost of the project but also reduces the weight of the project because of the reduction of the marshalling cabinet. Estimation one of the marshalling cabinets with front and rear door access is approximately 400 kg. In the oil and gas industry each of the projects has its specific weight and is not able to excess if the design is overweight as specified in the contract, the contract may find a few thousand US dollars per ton or kg.

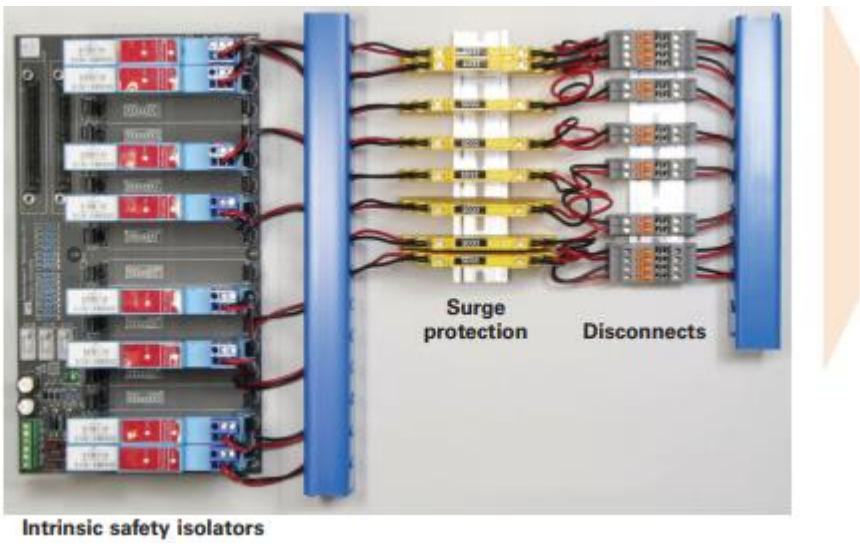


Figure 4.9: Ordinary Marshalling cabinet configuration without DCS connection (SUM5)

Figure 4.10: Marshalling cabinet configuration with Sum5 and Yokogawa IO card

Figure 4.10 above is a combination of MTL Sum5 and Yokogawa DCS universal IO card which use in my previous project for the 3rd Boiler project Asean Bintulu Fertilizer (ABF) a PETRONAS subsidiary. This is the first project to use the Sum5 in Malaysia Oil and Gas industry. Each base plate consists of 16 channels, each channel only connects to one field instrumentation.

Figure 4.11: Complete configuration Sum5 with Yokogawa DCS

Figure 4.11 above is the complete configuration MTL Sum5 with Yokogawa DCS with IS loop. According to IEC 60079-14, all the cable and cable trays for intrinsically safe loop shall use light blue. Furthermore, installation for intrinsically safe cable shall be segregated from the non-intrinsically safe loop.

Figure 4.12: MTL Sum5 terminal base for one channel

The output voltage and current for MTL Sum5 are slightly lower compared with the MTL Zener barriers because the MTL Sum5 is certified with Zone 2 therefore the manufacture reduces the output voltage and current to minimize the risk of explosion and below the ignition curve.

4.6.1 Surge Protection Device (SPD)

A surge protection device (SPD) protects electrical equipment, such as a control system or electronic transmitter, that is in the field from power surges or surges. Normally, the surges are caused by lightning. When the overvoltage occurs, the SPD is immediately tripped and discharges all excessive current to ground. (Kuan, Chew and Chua, 2020)

SPD is seldom used on the oil rig or platform. Most of the time SPD is widely used in the Onshore refinery plant. The MTL Sum5 SPD is mounted on top of the terminal unit, and it will not be interrupting the process control when removing or replacing the SPD on the live running process.

Ordinarily, the SPD is installed in the marshalling cabinet and consumes the additional space in the marshalling cabinet. By using the MTL Sum5 it may save a lot of space when the loop is requiring SPD protection and reduce the maintenance time.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From the research that was carried out, there are various methods to prevent the explosion by the IEC 60079 standard. Each of the protection methods got a limitation. There are three most common protection methods was used in the oil and gas industry, intrinsically safe, explosion-proof and increased safety. Among the three methods, intrinsically safe is the most economical method and easy for maintenance. For some cases, it might require combining two explosion-proof methods to meet the requirement at the hazardous area, such as the safety barrier install inside the explosion-proof enclosure at the hazardous area but there was a condition that the enclosure shall not open during the plant is running. Intrinsically safe barrier preferable install at the safe area and the installation method shall accordance to IEC 60079.

Figure 5.1: Remote DCS IO Cabinet

Figure above is the remote DCS IO cabinet install at the Zone 2 area at the offshore wellhead platform, the cabinet is Ex e certified and inside the components are Ex i.

Training and education shall continuously conduct to all the engineers by their organization or society to provide awareness on the explosion-proof protection method according to IEC 60079.

There are two different types of intrinsic safety barriers, Zener barrier and isolator barrier. The Zener Barrier is a simple component compared with the isolator, but Zener Barrier requires safe earth for the installation. Furthermore, Zener barriers are not able to convert a passive current signal to an active signal for isolated barriers which able to make this conversion.

Due to the current improvement of technology, SUM5 technology is the combination of the Zener barrier and isolator barrier. SUM5 technology can install at Zone 2 with Ex 'e' enclosure but is recommended installed in a safe area. Based on the previous project experience finding, the SUM5 is a good design for those projects with space limitations. It may save a lot of space and reduce the weight with the SUM5 technology installation. There are always have two sides to the coin, SUM5 terminal base generates heat on the card due to the compact design and are not suitable to install in hazardous area and fields. Because base on IEC 60079 standard, the enclosure design for the hazardous area installation shall not install the ventilation fan in the enclosure. Without the ventilation fan installed in the enclosure, the SUM5 terminal base life span may reduce and affect the performance and accuracy of the measurement.

5.2 Recommendations for future work

Recommendations for the manufacturer to improve and reduce the heat and temperature generated from the SUM5 terminal base, although the specification state suitable install at Zone 2 but in Malaysia offshore or onshore the outdoor ambient temperature is higher compared with other European countries. The heat of the device may affect the lifespan and the accuracy of the measurement.

On the other hand, the manufacturer shall consider improving and certifying more Zone is available to install in hazardous areas such as Zone 1. In the coming years, most of the Oil and gas projects may go for lightweight and reduce the size of the platform, space limitation might be a major challenge.

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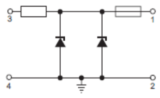
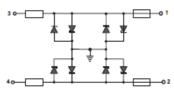
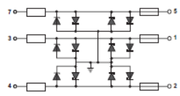
APPENDICES

APPENDIX A: Datasheets for MTL Barrier

SPECIFICATIONS

'Key' barriers shown in blue

For notes 1 to 7 see 'Terminology' (later in this section)

Model No.	Safety description[1]			Polarities available[2]			Application	Basic circuit	Max. end-to-end resistance[3]	Vwkg at 10μA or (1μA)[4]	Vmax[5]	Fuse rating[6]
MTL	V	Ω	mA	+	–	ac		Hazardous Safe	Ω	V	V	mA
7706+	28	300	93	✓			Transmitters	See 'HOW THEY WORK' and 'ACTIVE / ELECTRONICALLY PROTECTED BARRIERS'	See additional specification		35	50
7707+	28	300	93	✓			Switches				35	50
	28	diode									35	50
7707P+	28	164	171	✓			Transmitters, switches, controller outputs IIB				35	50
	28	diode	–								35	50
7710+/-	10	50	200	✓	✓				75	6.0	7.0	50
7710P+	10	33	300	✓					41	7.9	9.5	200
7715+	15	100	150	✓			6V dc & 4V ac systems		119	12.0	13.1	100
7715P+	15	50	291	✓			12V systems		64	12.3	13.4	100
7722+/-	22	150	147	✓	✓		12V dc systems		174	19.6	20.2	50
7728+	28	300	93	✓			18V dc systems Controller outputs, solenoids		333	25.9	26.5	50
7728-	28	300	93		✓		Transmitters		333	25.9	26.5	50
7728ac	28	300	93			✓	Controller outputs, solenoid valves		333	25.0	25.9	50
7728P+	28	234	119	✓			Controller outputs, solenoid valves IIB		252	24.9	25.9	100
7729P+	28	164	170	✓					184	24.9	25.9	100
7772ac	22	300	73			✓			333	17.7	21.5	50
774X	10	—	19				Prox sw input, solid state output and line fault detect	See 'ACTIVE / ELECTRONICALLY PROTECTED BARRIERS'	—	—	30/35	50
7751ac	1	10	100			✓	Sensors		20	0.3	2.0	250
	1	10	100			✓			20	0.3	2.0	250
7755ac	3	10	300			✓	2- or 3-Wire RTDs (floating bridge)		19.0	(1)	3.4	250
	3	10	300			✓			19.0	(1)	3.4	250
7756ac	3	10	300			✓	3-Wire RTDs (grounded bridge)		19.0	(0.7)	2.7	250
	3	10	300			✓			19.0	(0.7)	2.7	250
	3	10	300			✓			19.0	(0.7)	2.7	250
7758+/-	7.5	10	750	✓	✓		Gas detectors		17	6.0	7.3	200
	7.5	10	750						17	6.0	7.3	200
7761ac	9	90	100			✓			107	6.0	7.0	100

Note 3. Operation

- Keep the "WARNING" nameplate attached to the transmitter.
  WARNING: OPEN CIRCUIT BEFORE REMOVING COVER. FACTORY SEALED, CONDUIT SEAL NOT REQUIRED. INSTALL IN ACCORDANCE WITH THE USERS MANUAL IM 01C25.
- Take care not to generate mechanical sparking when accessing to the instrument and peripheral devices in a hazardous location.

Note 4. Maintenance and Repair

- The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation is prohibited and will void Factory Mutual Explosionproof Approval.

c. FM Intrinsically Safe Type/FM Explosionproof Type

EJX/EJA-E Series pressure transmitters with optional code /FU1 or /V1U1 can be selected the type of protection (FM Intrinsically Safe or FM Explosionproof) for use in hazardous locations.

Note 1. For the installation of this transmitter, once a particular type of protection is selected, any other type of protection cannot be used. The installation must be in accordance with the description about the type of protection in this instruction manual.

Note 2. In order to avoid confusion, cross out unnecessary markings on the label other than the selected type of protection when the transmitter is installed.

2.9.2 CSA Certification

a. CSA Intrinsically Safe Type

Caution for CSA Intrinsically safe and nonincendive type. (Following contents refer to "DOC No. ICS013-A13")

Note 1. EJX/EJA-E Series differential, gauge, and absolute pressure transmitters with optional code /CS1 are applicable for use in hazardous locations

Certificate: 1606623

Applicable Standard:

C22.2 No.0
C22.2 No.94
C22.2 No.157
C22.2 No.213
C22.2 No.61010-1
C22.2 No.61010-2-030
CAN/CSA-C22.2 60079-0:07
CAN/CSA-E60079-11:02
CAN/CSA-E60079-15:02
CAN/CSA-C22.2 No.60529
ANSI/ISA-12.27.01

[For Devision system]

- Intrinsically Safe for Class I, Division 1, Groups A, B, C & D, Class II, Division 1, Groups E, F & G, Class III, Division 1
- Nonincendive for Class I, Division 2, Groups A, B, C & D, Class II, Division 2, Groups F & G, Class III, Division 1
- Enclosure: Type 4X
- Temp. Code: T4
- Amb. Temp.: –50* to 60°C
  * –15°C when /HE is specified.
- Process Temperature: 120°C max.

[For Zone system]

- Ex ia IIC T4, Ex nL IIC T4
- Ambient Temperature: –50* to 60°C
  * –15°C when /HE is specified.
- Max. Process Temp.: 120°C
- Enclosure: IP66/IP67

Note 2. Entity Parameters

- Intrinsically safe ratings are as follows:
  Maximum Input Voltage (Vmax/Ui) = 30 V
  Maximum Input Current (Imax/Ii) = 200 mA
  Maximum Input Power (Pmax/Pi) = 0.9 W
  Maximum Internal Capacitance (Ci) = 10 nF
  Maximum Internal Inductance (Li) = 0 μH
- Type "n" or Nonincendive ratings are as follows:
  Maximum Input Voltage (Vmax/Ui) = 30 V
  Maximum Internal Capacitance (Ci) = 10 nF
  Maximum Internal Inductance (Li) = 0 μH
- Installation Requirements
  Uo ≤ Ui, Io ≤ Ii, Po ≤ Pi,
  Co ≥ Ci + Ccable, Lo ≥ Li + Lcable
  Voc ≤ Vmax, Isc ≤ Imax,
  Ca ≥ Ci + Ccable, La ≥ Li + Lcable
  Uo, Io, Po, Co, Lo, Voc, Isc, Ca and La are parameters of barrier.

APPENDIX C: Datasheets for MTL SUM5

8 APPENDIX A

The following information is taken from the sgs baseefa limited examination certificate. For full details refer to certificate number Baseefa19ATEX0022X on the Eaton-MTL website http://www.mtl-inst.com

8.1 I/O Parameters – MTL4-BSIS IS Module Base & MTL4-ADIO Interface Module

Non-Hazardous Area Connector CON1, Pins 1 to 6 & 9 to 12

Um = 30V

The non-hazardous Connector CON1, pins 1 to 6, & 9 to 12 are designed to operate from a d.c. supply voltage of up to 30V supplied from either safety extra low-voltage (SELV) or protective extra low-voltage circuits, for example equipment complying with the requirements of either the IEC 60950 series, IEC 61010-1 or a technically equivalent standard.

Digital O/P Configuration - Hazardous Area Terminals 4 w.r.t. 3
(IS Power Jumper Link not Fitted)

Uo = 26.5V   V Ci = 0
Io = 90mA   Li = 0
Po = 0.6W

Digital O/P Configuration - Hazardous Area Terminals 4 w.r.t. 3
(IS Power Jumper Link Fitted)

Uo = 26.5V   Ci = 0
Io = 136mA   Li = 0
Po = 0.9W

Analogue O/P Configuration – Hazardous Area Terminals 4 w.r.t. 2
(IS Power Jumper Link not Fitted)

Uo = 26.5V   Ci = 0.5nF
Io = 90mA   Li = 0
Po = 0.6W

Analogue O/P Configuration – Hazardous Area Terminals 4 w.r.t. 2
(IS Power Jumper Link Fitted)

Uo = 26.5V   Ci = 0.5nF
Io = 136mA   Li = 0
Po = 0.9W

Digital I/P Configuration – Hazardous Area Terminals 2 w.r.t. 3

Uo = 10V   Ci = 0.5nF
Io = 0.13mA   Li = 0
Po = <1mW

The hazardous area terminals 2 w.r.t. 3 are also considered suitable for the connection of an external intrinsically safe source with a Uo = 30V and Io = 100mA. When an intrinsically safe source is connected to these terminals the capacitance and either the inductance or inductance to resistance ratio (L/R) of the hazardous area connections must not exceed the values detailed in the certificate of the intrinsically safe source.

Hazardous area terminals 1 & 4 must not be used when a source is connected to these terminals.