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PROTECTION OF ELECTRICAL EQUIPMENT – V2

Introduction

Fire and Security Consulting Services (FSCS) is frequently consulted on the selection and suitability of electrical equipment in use in fire safety systems.

The selection of electrical equipment to be used in aggressive and / or hazardous environments should always take into consideration the expected conditions and the regulatory requirements.

Just as important is the longevity and appearance of equipment which can be seriously degraded leading to costly replacement.

Environments may include hazardous, marine, coastal, alpine, desert, elevated or any combination. Accordingly the design must consider the proper selection of the equipment.

It is important to note that electric equipment may be required to be suitable for both “hazardous” areas as well as aggressive areas. An example of this is the installation of fire detection and alarm systems in petrochemical facilities.

For fire protection and detection systems, the equipment will invariably include Fire Indicator Panels, detectors, remote indicators, call points, bells and alarms, EWIS phones, flow and pressure switches, solenoid valves, valve monitoring proximity switches, electro-magnetic door hold open devices (including those being integral to a door closer), battery installations ¶, cable and conduit, fixing s and brackets and the like.

Other equipment that may fall within the remit of an installation by fire eservices contractors are EXIT signs, emergency lighting, smoke exhaust fans, motorised smoke dampers etc.

¶ Refer to the FSCS paper entitled “*Battery Charging Facilities in Buildings V2*” on the FSCS web site – http://fscs-techtalk.com

Whilst the majority of building professionals will focus on the requirements in the BCA, it should be remembered that the Queensland Work Health and Safety (WHS) Regulation addresses safety in workplaces and is the primary legislation covering the operations within a building or on a work site.

Designers and Contractors are reminded that they have a legal responsibility for compliance with the Statutory Acts, Regulations, Codes and Standards referenced below.

Suitability for hazardous Areas

The hierarchy of compliance for the installation of electrical equipment is listed below and include, for Queensland installations **#** and for all of Australia the referenced Australian Standards.

1. The Queensland Workplace Health and Safety Regulation **#**; and
2. AS3000 – Wiring Rules **§** and all other relevant Standards referenced therein which address electrical installations in hazardous areas; and
3. AS/NZS 60079.10.1–Explosive Atmospheres Classification of areas **Ъ**; and
4. AS/NZS 60079.14 – Explosive Atmospheres Electrical installations design, selection and erection **Ъ**; and

§ Additional information is provided in AS3000 (Wiring Rules).

Ъ Note that both the AS/NZS Standards referenced above are derived from the original EN Standards

Ъ Many practitioners will be familiar with the AS2430 superseded series of Standards where classification of hazardous areas was effected by assessment of the estimated frequency of flammable gas release rates; however the current requirement is a more realistic classification of hazardous areas using AS/NZS 60079.10.1.

#	The Queensland Work Health and Safety (WHS) Regulation addresses safety in workplaces and is the primary legislation covering operations within a building or on a work site.

The WHS regulation Part 51(2) (c) defines a hazardous atmosphere as one where the concentration of flammable gas in the atmosphere exceeds 5% of the Lower Explosive Limit (LEL) of the flammable gas Ħ.

Part 61 (1) sets out the duties of designers and suppliers which include for the elimination of hazardous materials or tasks.

Part 64 (1) sets out the duties of designers and suppliers to eliminate or minimise risk

Ħ	Note that hazardous areas also include those where combustible dust are present such as four milling facilities and the like.

Note that unless otherwise indicated, the applicable dates of the Standards have been omitted and the intent is that persons using and / or referencing this paper should use the date of publication of this paper being June 2016.

The Certifier may not always be conversant with all aspects of compliance; issues like the Queensland Workplace Heath and Safety Regulations and the Queensland Electrical Safety Regulations and associated Standards listed above may be new to them; in that case the Certifier may rely on the recommendations and documented designs from the appropriate systems designers.

For design of hazardous area installations, the design(s) shall be reviewed by appropriate RPEQ engineers with their review report being submitted with the Building Approval submission to Queensland Fire and Emergency Services (QFES).

Electrical Equipment

Where electrical equipment is used in hazardous areas, the requirements for that equipment are addressed under the (Queensland) Electrical Safety Act and Regulations which cite AS3000 and the other Australian Standards referenced above.

The Standards contains the specific requirements for the design, selection and installation of electrical installations in hazardous areas.

Table 1 below shows the applicable “zone” designations which drive the equipment approval; requirements.

SELECTION OF APPARATUS	
ZONE 0	
Ex ia	Intrinsic safety
Ex s	Special protection (approved for Zone 0)
ZONE 1	Zone 0 protection techniques
Ex d	Flameproof
Ex ib	Intrinsic safety
Ex p	Pressurisation for Zone 1
Ex p1	Purging for Zone 1
Ex m	Encapsulation
Ex e	Increased safety
Ex v	Ventilation for Zone 1
Ex s	Special protection for Zone 1
ZONE 2	Zone 0 and Zone 1 protection techniques
Ex n	Non incendive
Ex p	Pressurisation for Zone 2
Ex p1	Purging for Zone 2
Ex v	Ventilation for Zone 2
Ex s	Special protection for Zone 2

Table 1 – Electrical Equipment Designations

For a Zone 0 area, intrinsically safe equipment is required as discussed later.

For a Zone 1 area, Flameproof equipment is usually used for wiring connections, junction boxes, certain heat detectors, power switches, lighting, door release solenoids, Emergency Lighting **,** EXIT signs, occupant warning horns , ventilation fan motors ***(Note 1,*** and the like and the enclosures meet the Standard by providing a "flameproof" enclosure to the standard "Ex-d".

This is essentially obtained by a robust enclosure with jointing surfaces of such a nature that if a gas permeated into the enclosure and was ignited by a spark within that enclosure, it will not rupture, nor will flame and heat escape via the joints.

These enclosures are usually fitted with unusually shaped bolts or fixings requiring a special key to undo the access points. The enclosure will be marked as complying with AS 2380.1 Ex-d or similar acceptable standard.

Note 1 - Ventilation fans (in exhaust mode) are required to have flameproof motors, or have the fans outside the compartment with adequate shaft seals. One thing often forgotten is the requirement for the fan to have non sparking blades.

Where fire detection systems are installed, it should be noted that detectors are generally not available as Ex d. Consequently Intrinsically Safe detectors are required to be used.

Intrinsic safety

Intrinsic Safety should be regarded in a different light from the other protection methods. It differs from the various "enclosure" methods in that instead of attempting to minimise the chance of electrical ignition or contain its effects, the design intent is that by getting well below an established parameter we can substitute zero for a probability. Figure 1 below shows the principle.

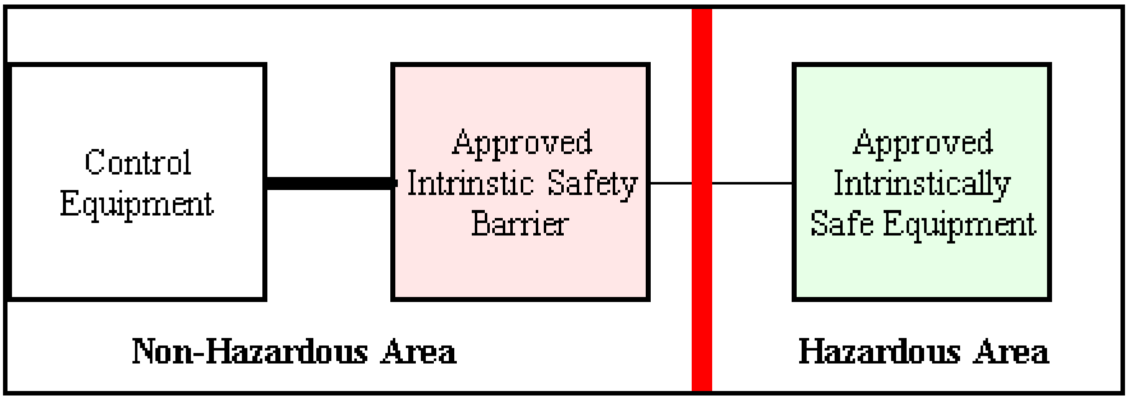

Figure 1 – Intrinsic Safety Principle

The safety device used in an intrinsically safe circuit uses a Zenner Diode Barrier which, in essence, is an ultra high speed switch and monitoring device. This barrier monitors the current drawn by the device in the hazardous area, if the current exceeds the rated maximum for the device - usually about 40-50 mA - the circuit is interrupted with the cores of the outgoing cables are switched to earth. This all occurs within micro-seconds thus preventing a spark of sufficient energy level from occurring.

As well as the device in the hazardous area needing to be able to function with a current consumption below the barrier switching threshold, the length of cable (especially MIMS) after the barrier must be limited so as not to exceed the inductance and capacitance limits.

The other problems which must be addressed in circuits requiring to be monitored (such as fire detection) are:

- The *end of line resistor* must either be in a safe area or a separate box conforming to Ex-d, this is because of the possibility of exceeding the temperature rise limits for hazardous areas.
- It is unlikely that existing Fire Indicator Panels can be reconfigured for intrinsically safe circuits. Most low voltage barriers have an internal resistance exceeding 300 ohms, and with the combination of resistances in the completed circuit place the total circuit resistance outside the monitoring and alarm threshold values of the panel.

- The barriers <u>must</u> be housed in a separate enclosure to the fire alarm or instrumentation panel and the chassis rails to which the barriers are affixed <u>must</u> be earthed back to the centre of the star winding of the local distribution transformer.

- Circuits must be in a conduit separate from any other wiring.

In consideration of the above, only certain low current equipment can be used such as smoke and heat detectors, some low current piezo sounders and “Metron ®)” MJC piston actuators in multiple jet controls. The equipment will be marked as complying with AS 2380.1 **Ex-ia** or **Ex-ib** or similar acceptable standard.

Ex-ia listing means that the barrier monitors and switches both outgoing circuits and is the preferred methodology. Examination of Figure 2 shows the circuit meets the criterion for an Ex-ia installation because both cables are protected by barriers as indicated with a blue square.

Ex-ib listing means that the barrier monitors and switches only the positive outgoing circuit and as indicated in Table 1, is only suitable for Zone 1 installations. This type of protection may be found on older installations for Zone 0 installations.

FSCS emphasises that ongoing AS1851 compliance inspections may be extremely difficult to carry out because of the complexity of the system.

Regardless of the presumed safety of intrinsically safe circuits, it is emphasised that the design shall conform to the approved and listed equipment criteria *in-toto*!

FCSC is aware of one case where subsequent to an explosion at a foil mill, it was found that the power supply for a general public address amplifier was connected to the Fire Indicator Panel batteries. This caused the breakdown of the intrinsic safety design because the commercial amplifier had a negative to earth connection. Furthermore, the intrinsic safety design was only Ex-ib with the combination of the negative earthed amplifier and the unprotected negative circuit in the barrier completed a live circuit within the hazardous area and was the cause of an explosion!

Figure 2 below shows a typical Intrinsically Safe circuit for a fire detection application.

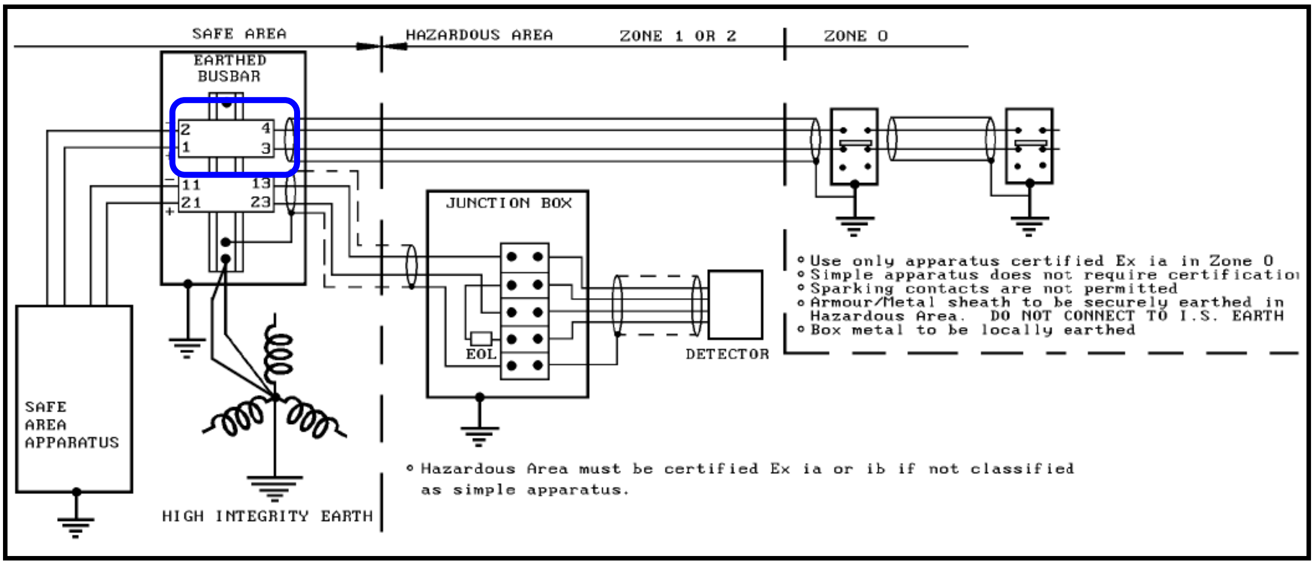

Figure 2 Typical Intrinsically Safe Circuit for Fire Detection Equipment

Suitability in Marine and Coastal Environments

FSCS considers that the design and installation of fire safety systems should incorporate the best possible quality and longevity of the equipment being used with the word “adequate” not being acceptable.

The primary concern in humid or salt mist atmospheres is corrosion which can render the equipment inoperative with a secondary concern for the effects of physical penetration of solid objects, water and dust.

For corrosion issues, refer to the FSCS paper “*Corrosion Issues in Fire Systems*” on the FSCS web site **http://fscs-techtalk.com**

When considering what an aggressive environment is, FSCS considers that any location:-

- In or outside any commercial or residential building at or near the coast; and
- In a refinery, mining site, and the like; and
- In a rail or vehicle tunnel; and
- In any sports stadia where there is significant covered areas with open sides; and
- On any ship, ferry, boat, oil / gas platform; and
- At shipyards, marinas and the like; and
- Environments where there is significant unfiltered outside air ventilation.

From legal standpoint, all equipment installed as part of a fire safety system should comply with State and Commonwealth legislation as “suitable for intended use”. Not only does that mean that it has to comply and perform in accordance with the Codes and Standards under which it was installed, but also must meet the client’s reasonable expectations of appearance, quality, longevity, reliability and lawful compliance.

Proper attention to determining the environment in which the equipment is to be installed should be high on the list for designers and contractors and whilst market competition may put pressure on contractors to reduce costs by ignoring quality, FCSC considers that this does not mean that a “suitable for intended use” position should be overlooked.

Ingress Protection

The environment in which the equipment to be installed drives the selection of equipment and AS1939 – *Degrees of protection provided by enclosures for electrical equipment (IP Code)* provides the baseline for equipment selection.

Where an aggressive environment is considered likely, selection of equipment with the appropriate “IP” rating should be used. AS1939 provides criteria to which manufacturers test and list their equipment with the resulting equipment being marked accordingly. Furthermore, “IP” certificates should be provided. Table 2 below summarises the various AS1939 "IP" ratings for equipment.

IP stands for Ingress Protection. The IP rating specifies the strength of the enclosure that houses the equipment and is determined by a series of tests. Australian Standards AS1939 and EN60529 have detailed IP ratings by two or three distinct digits.

1. The first digit measures the degree of protection provided by the enclosure against ingress of solid objects and includes protection of persons against contact with, or approach to, live or moving parts (other than smooth, rotating shafts and similar mechanisms).
2. The second IP rating digit measures the level of protection provided by the enclosure against ingress of liquids.
3. The third digit measures the level of protection provided against mechanical impact damage. This third digit is often left out leaving a two digit IP rating covering solid objects and liquids only.

Provision of “IP” listed equipment does NOT mean it is suitable for hazardous areas as discussed at the beginning of this paper.

Protection Against Solid Bodies Data Table			Protection Against Liquids Data Table		
0	**Tests**	**No Protection**	**0**	**Tests**	**No Protection**
1	∅ 50 mm	Protected against solid bodies larger than 50 mm (eg. accidental contact with the hand)	1		Protected against vertically-falling drops of water (condensation)
2	∅ 12.5 mm	Protected against solid bodies larger than 12.5 mm (eg. finger of the hand)	2	15°	Protected against drops of water falling at up to 15° from the vertical
3	∅ 2.5 mm	Protected against solid bodies larger than 2.5 mm (eg. tools, wires)	3	60°	Protected against drops of water falling at up to 60° from the vertical
4	∅ 1 mm	Protected against solid bodies larger than 1 mm (eg. fine tools, small wires)	4		Protected against projections of water from all directions
5		Protected against dust (no harmful deposit)	5		Protected against jets of water from all directions
6		Completely protected against dust	6		Completely protected against jets of water of similar force to heavy seas
			7	15 cm	Protected against the effects of immersion
			8		Protected against effects of prolonged immersion under specific conditions

Table 2 – IP Ratings

In marine or coastal environments, the next step is to consider the effects of humidity. Note that equipment having an IP rating does not necessarily mean that the equipment is suitable for humid condensing or non condensing environments. Condensing occurs when the temperature of the equipment is below the dew point and is most pronounced where there is little or no ventilation.

Most manufacturers advise their equipment limits in % terms and as either condensing or non condensing, a typical example for a smoke detector is shown below in Figure 3.

Operating Temperature Range:	0ºC to 49ºC
Relative Humidity:	10% to 93% Non-Condensing

Figure 3 – Typical Environmental Statement

Where detectors are used in the marine or offshore environments, corrosion and vibration test data as well as EMC (Electro Magnetic Compatibility) data as shown in Figure 4 below is provided.

Operating temperature	-25 to 70°C
Humidity	Up to 96% RH (non-condensing)
Vibration	Exceeds requirements of prEN54-3 Marine & UL268
Corrosion	Hydrogen Sulphide - UL 464 Salt Mist - Marine
EMC	BS-EN 50130-4 Exceeds pr EN54-3

Figure 4 – Typical Marine Listing

It should be noted that junction boxes and conduit will "breath" with temperature and humidity changes and invariably draw in moisture from the point where it terminates in an open connection. Accordingly suitable arrangements should be made to prevent this occurring.

In marine and coastal environments the effects of corrosion must also be considered. Again, having an IP rating indicative of being able to withstand splash or immersion, does not necessarily mean that the equipment will not corrode. Likewise, suitability for humid areas does not indicate corrosion resistance.

Any water or condensation on exposed printed circuit boards or terminals will certainly promote corrosion and equipment faults and failure. Only where the equipment is especially manufactured to withstand Lloyds' or MilSpec test criteria, using hot water "salt mist" tests, can the equipment be considered to have reliability suitable for humid applications.

This is usually achieved by the encapsulation of the electronics and electrical terminals by a method called "conformal coating" with most major manufacturers have equipment suitable for marine, coastal and humid condensing environments.

In closing, readers might like to see my photo of one of the testing regimes for the selection of detectors in the Sydney Harbour tunnel; the remit was to select a detector that could withstand high pressure water spray as well as being immune to false alarms.

In this test in the Kings Cross tunnel, a detuned (smokey) diesel Volvo truck was positioned so that its exhaust stack was adjacent to four candidate detectors replicating a scenario where such a vehicle was located directly under a detector..

Figure 5 – Detector Testing

I trust that this paper provides useful information on the protection of electrical equipment in hazardous and / or aggressive marine / coastal environments.

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