Hazardous Locations: Electrical Safety

by

Johannes Auret, Explolabs and CERTEX

December 2012

EXPLOLABS Explosion Prevention Services CONSULTING

– Testing and Certification – Certification Mark for Explosion Protected (Ex) Equipment –
– Area Classification / Explosion Risk Assessment – Inspection of New or In-service Ex Equipment & Installations – Management System for Ex Installations – Consultation – Presentations & Workshops –
– Training Courses –

INDEX

TOPICS **Page**

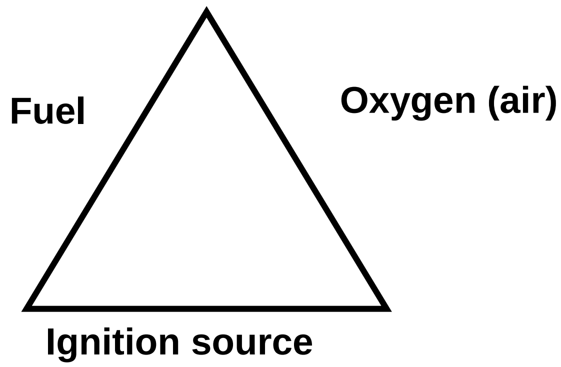
1. Introduction

What is Explosion Prevention ?

Explosion prevention can be defined as the technology for preventing explosions caused by flammable materials/articles/substances in gas, vapour of dust.

The flammable material has to be exposed to atmospheric oxygen and a suitable ignition sources, for ignition and an explosion to occur.

The combustion triangle (below) illustrates these three elements. Explosion prevention requires one of these elements to be eliminated.



Example 1 Good ventilation may prevent the formation of explosive atmospheres.
Example 2 Explosion protected equipment may be used, as such equipment will prevent ignition of explosive atmospheres.

The consequences of insufficient explosion prevention are illustrated below:

Dust explosion in a grain mill in October 2000.

Explosion of hydrogen coolant gas in an electric generator in 2003.

Destruction caused by solvent vapour explosions in 2006 and 2007

Coal mine explosion

Sapref fire/explosion 2011 LPG explosion in restaurant 2011

Who is affected by the explosion hazard ?

Not only industrial applications such as SHEQ practitioners, technical staff, insurance companies, and DOL inspectors are all required to have an understanding of explosion prevention.

BUT also an interface with public through vehicle re-fuelling stations, spray-painting operations, restaurants.

2. Classification of Hazardous Areas

2.1 Background

A so-called "explosive atmosphere" is an explosive mixture of two of the explosion element, a flammable material and oxygen.

Area classification has two aims:

a) To establish if explosive atmospheres occur; and
b) To determine the total duration (probability) of explosive atmospheres

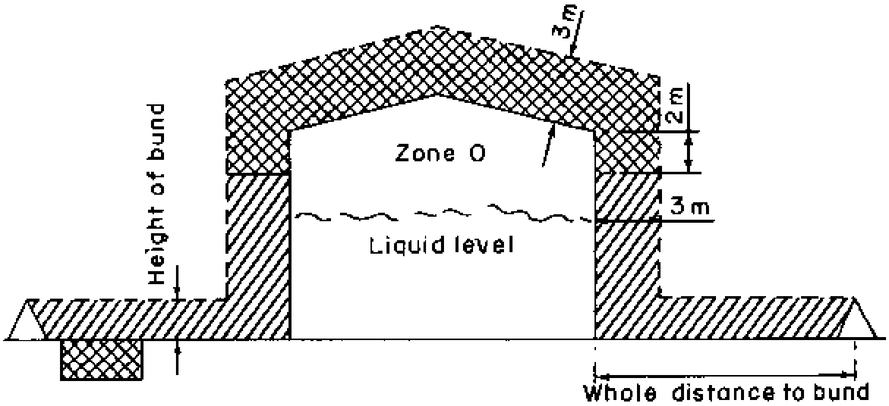
Practical area classification is simplified if one of the following 2+ methods is followed, where possible:

A Classification of hazardous locations by DIRECT EXAMPLE, which is a method that applies to standard installations, a few examples of which are given in clause 4.2

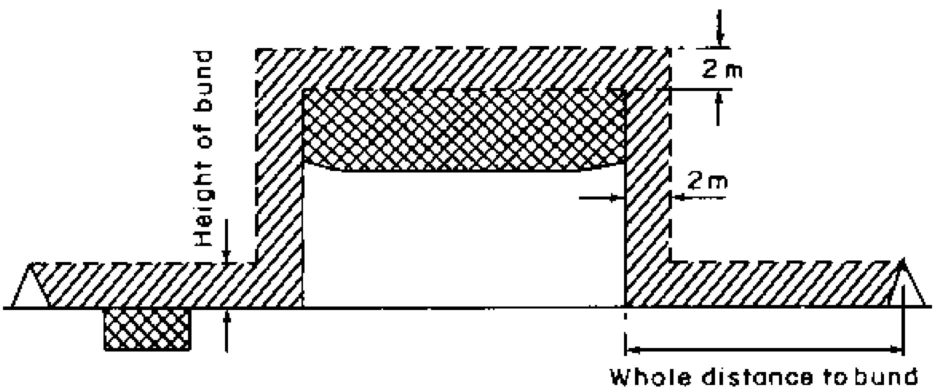
NOTE - Care should be taken to ensure that, same products and conditions apply.

<u>Examples</u>

- ♦ Rail car and road tanker loading and unloading
- ♦ Container filling
- ♦ Filling station forecourts
- ♦ Bulk storage tanks



Cone or dome roof tank



Floating roof tank

OR

B1 POINT SOURCE APPROACH with hazard radius based on DISPERSION THEORY (Point Source approach).

<u>Example</u>

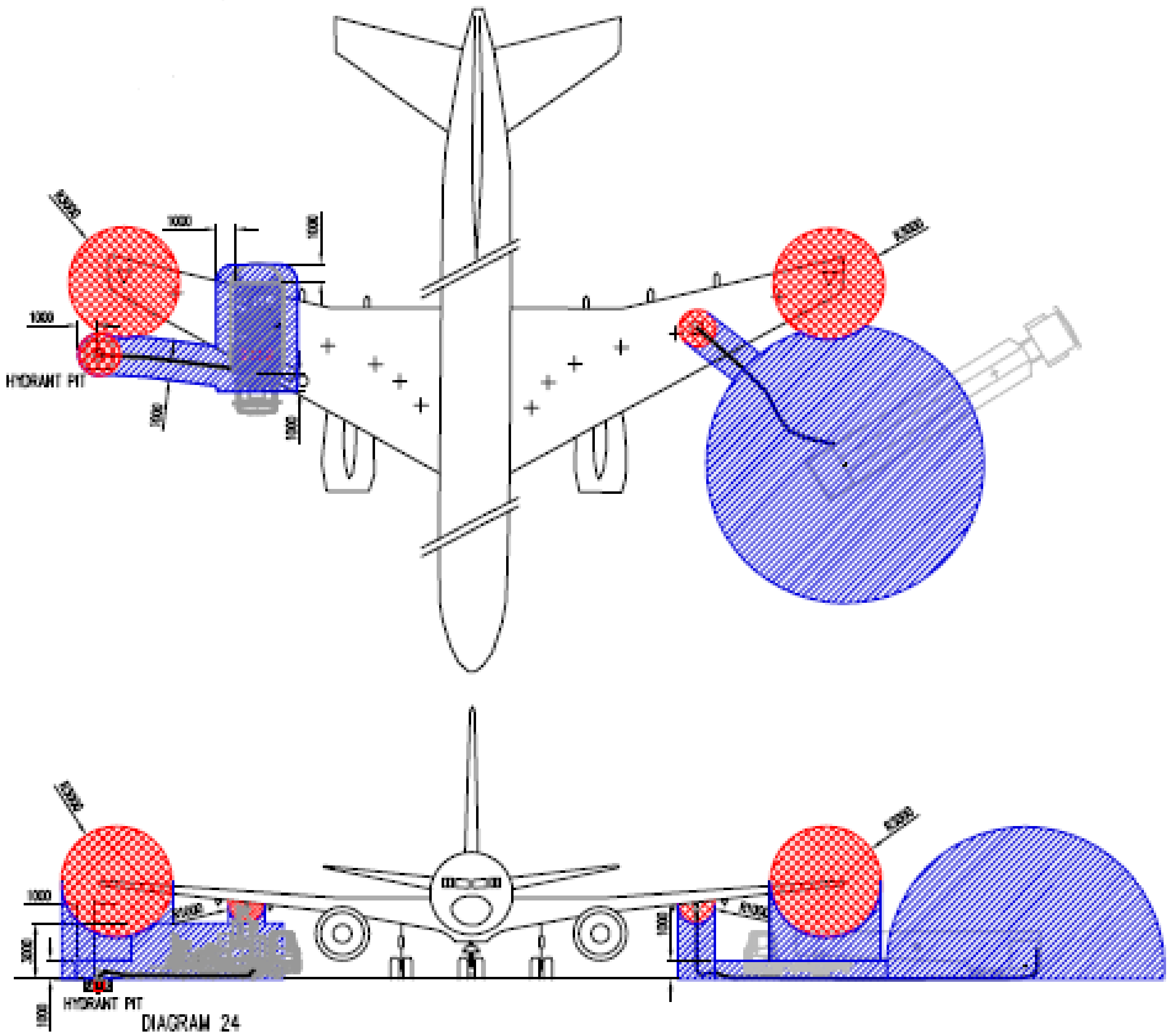


DIAGRAM 24
TYPICAL COMPOSITE HAZARDOUS AREA AROUND A FUELLER AND DISPENSER DURING REFUELLING
(ZONES APPLICABLE FOR TEST RIGS)

OR

B2 POINT SOURCE APPROACH combined with hazard radius based on a RISK-BASED CALCULATION of release rate, if the release rate for secondary sources of release in B1 cannot be determined.

2.2 Point Source approach

In practice, the following eight steps can be followed.

1. **List of flammable materials**
2. **Select those present in significant quantities**
3. **Determine sources of release**
4. **Determine grades of release**
5. **Determine zones (0/1/2)**
6. **Size (hazard radius) and shape of zones (dispersion theory or risk-based approach)**
7. **Rationalize**
8. **Properties of explosive atmospheres**

Example: dispersion modeling

Table 5.2 Hazard radii (R_1) for drains and liquid sample points

Fluid category	Pressure (Bar(a))	Hazard radius R_1(m)			
		Diameter 2 mm	Diameter 5 mm	Diameter 10 mm	Diameter 20 mm
A	100	5	11	22	†
B	100	4	10	20	†
C	100	5	12	22	†

† For this diameter the radius exceeds 30 m. The size of the potential release is greater than normally considered for hazardous area classification and should be avoided.

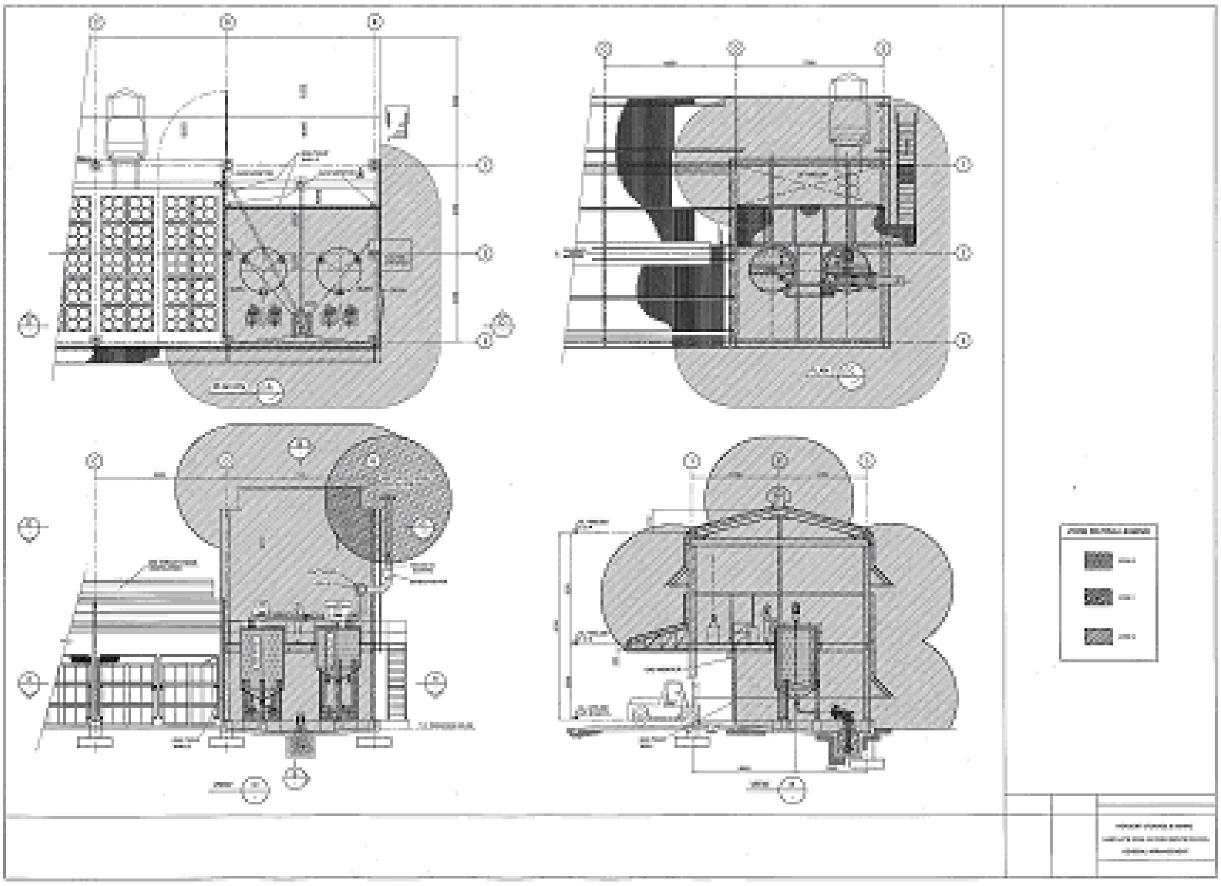
Example: risk-based calculation

Table 5.1(a) Hazard radii (R_1) for standard pumps without throttle bushes

Fluid category	LEVEL I		LEVEL II		LEVEL III	
	Hole size (mm) i.e. 0,23SD	R_1 (m)	Hole size (mm) i.e. 0,1DP	R_1 (m)	Hole size (mm) i.e. 0,3DP	R_1 (m)
A	5,75	10	10	16	30	†
B	5,75	10	10	16	30	†
C	5,75	10	10	17	30	†

SD = shaft diameter (mm)
DP = diameter of discharge pipe (mm)
† For this release, the hazard radius exceeds 30 m. The release is greater than that normally considered for hazardous area classification and should be avoided.

Below, a typical area classification drawing using the Point Source approach is shown.



3. Determine the Ignition Properties of a Hazardous Area

Explosive atmospheres are divided into 3 GROUPS according to the location of the explosive atmosphere. Group II gases are subdivided into 3 SUBGROUPS according to their minimum spark ignition energies (MIEs). Likewise Group III dusts are subdivided into 3 SUBGROUPS according to the type of dust. See table below.

Environment	Gas, vapour or dust (sub)division	Typical flammable material	Minimum ignition energy (MIE)
Fiery Mines	Group I	Methane (firedamp)	250 μJ
Surface gases and vapours	Group IIA	Propane	180 μJ
	Group IIB	Ethylene	60 μJ
	Group IIC	Acetylene & Hydrogen	20 μJ
Surface dusts	Group IIIA	Combustible flyings	Least ignitable (high MIE) ↓ Most ignitable (low MIE)
	Group IIIB	Non-conductive dusts	
	Group IIIC	Conductive dusts	

Group II gases are also divided into 6 TEMPERATURE CLASSES according to their auto-ignition temperature (heat ignition properties):

Temperature class	Auto-ignition temp of gas / vapour
T1	> 450 °C
T2	> 300 °C ≤ 450 °C
T3	>200 °C ≤ 300 °C
T4	> 135 °C ≤ 200 °C
T5	> 100 °C ≤ 135 °C
T6	> 85 °C ≤ 100 °C

4. Select the right Explosion Protected Electrical Equipment for a Hazardous Area

<u>Terms used</u>

International Electotechnical Commision (IEC): Equipment for use in explosive atmospheres

SANS 10108: (a) Explosion protected (Ex) apparatus

(b) Explosion protected apparatus (EPA)

4.1 Information required

In order to select the appropriate electrical equipment for hazardous area caused by gases, vapours or dusts, the following information is required (the discussion will focus on flammable gas/vapour:

- Classification of the hazardous area including the equipment explosion protection level (EPL) requirements where applicable;
- Gas, vapour or dust layer/cloud ignition properties (expressed by gas or dust subgroup or minimum ignition energy, and temperature class or ignition temperature;
- External influences and ambient temperature.

4.2 Selection according to EPL

Equipment Protection Level (EPL)

Each explosion protection technique has at least one Equipment Protection Level (EPL) which is related to its. The EPL ranges from a = "Very High" to b = "High" to c = "Normal" protection and distinguishes between explosive gas (G), dust (D) and underground mine (M) atmospheres.

STATISTICAL approach – based on PROBABILITY of an explosion

In this approach, only the **probability** of an explosion is considered and a direct relationship exists between the zone and the Equipment Protection Level (EPL) exists:

Group	Zone	Minimum Equipment Protection Level (EPL)	Examples of Suitable Ex Equipment
I	In underground mines, within 180m from working faces, return airways etc.	Ma Equipment remains functioning when explosive atmosphere present	Ex ia, Ex ma, Ex d+e
		Mb Equipment isolated when explosive atmosphere present	Above plus Ex ib, Ex mb, Ex d, Ex e, Ex py, Ex q
II	0	Ga	Ex ia, Ex ma, Ex d+e
	1	Gb	Above plus Ex ib, Ex mb, Ex d, Ex e, Ex py, Ex q
	2	Gc	Above plus Ex ic, Ex pz, Ex nA, Ex nR, Ex nC
III	20	Da	Ex tD, Ex iD, Ex mD
	21	Db	Above
	22	Dc	Above plus Ex pD

RISK-BASED approach – based on PROBABILITY and CONSEQUENCE of an explosion

Example: A typical example is of two neighbouring plants of similar design, but due to differences in the materials being handled, the one is Zone 1 and the other Zone 2. One can use respectively Ex d (flameproof) and Ex nA (non-sparking) motors in the plants. Some engineers will carry out a risk assessment and conclude that the risk of accidentally installing an Ex nA motor in the Zone 1 plant during a breakdown is too large and will opt to only stock Ex d motors.

NOTE – It should not be concluded that the author is in favour of using the highest available EPL equipment at all times. This can lead to unnecessary costs and a perception that the equipment is less dependent on good maintenance.

4.3 Selection according to equipment grouping

The electrical equipment shall be so selected that its spark energy will not reach the ignition energy of any gas or vapour which may be present OR that it will prevent the escape of an internal explosion (inside the equipment enclosure).

Relationship between gas/vapour subdivision and equipment subgroup

Environment	Gas, vapour or dust (sub)division	Permitted equipment group
Underground mines	I	I
Gas and vapour, Surface	IIA	II, IIA, IIB or IIC
	IIB	II, IIB or IIC
	IIC	II or IIC
Dust, Surface	IIIA	IIIA, IIIB or IIIC
	IIIB	IIIB or IIIC
	IIIC	IIIC

4.4 Selection according to the ignition temperature of the gas or vapour

The electrical equipment shall be so selected that its maximum surface temperature will not reach the ignition temperature of any gas or vapour which may be present.

Relationship between the equipment temperature classes and surface temperatures and ignition temperature

Temperature class required by the area classification	Ignition temperature of gas or vapour (°C)	Maximum surface temperature of equipment (°C)	Suitable equipment temperature class
T1	>450	450	T1 - T6
T2	>300	300	T2 - T6
T3	>200	200	T3 - T6
T4	>135	135	T4 - T6
T5	>100	100	T5 - T6
T6	>85	85	T6

Action comprising careful scrutiny of an item carried out either without dismantling, or with the addition of partial dismantling as required, supplemented by means such as measurement, in order to arrive at a reliable conclusion as to the (**suitability** and) **condition** of an item.

4.5 Environment

Each plant has a unique set of environmental requirements, including the natural environment as well as the conditions created by the plant itself. Again, the compatibility of new Ex equipment with this environment needs to be considered in view of ease of operation and cost of ownership.

Environmental issues include:

- Ambient temperature
- Hosing down, UV, chemicals
- Level of maintenance
- Stock keeping policy (brand/type, minimum gas group/temp class, type of connection to supply; simplification of replacements control and maintenance)

5. Regulations and Standards

Legal requirements are summarized in the table below.

Industry: **Surface** Law: **Occupational Health and Safety Act (Act 85 of 1993)**			
Regulation	**Aspect**	**Standard**	**Who is responsible**
EIR Definition of **specialized electrical installations**. EMR 9(1).	Area classification	SANS 10108	Delegated by Plant Management to Technical team including specialist
EIR Definition of **specialized electrical installations**. EMR 9(2).	Selection of Ex equipment	SANS 10108	Delegated by Plant Management to technical staff
EIR Definition of **specialized electrical installations**. EMR 9(3).	Certification of Ex equipment and systems	ARP 0108	*Approved* Test Laboratory (ATL)
EIR 9(1) and definition of **registered person**. EMR 9(4) and 9(7).	Ex installations	SANS 10086-1 SANS 10142-1	Delegated by Plant Management to technical staff, Certificate of Compliance must be issued by Master Installation Electrician (MIE)
EIR Definition of **specialized electrical installations**. EMR 9(5), 9(6), 9(8) and 9(9).	Use, inspection and maintenance of Ex equipment	SANS 10086-1 SANS 10142-1	Delegated by Plant Management to technical staff
EIR Definition of **specialized electrical installations**. EMR 9(4).	Repair of Ex equipment	SANS 10086-3 (SANS 10242-1, SANS 10227 etc.)	Accredited Repairer, or re-test by ATL
EIR = Electrical Installation Regulations EMR = Electrical Machinery Regulations			

NOTE that this presentation is based on the above national standards. Individual companies may have stricter requirements.

<u>Points for Discussion</u>

1. Should an area classification expert have set competence criteria and have to obtain a legal appointment ?
2. Should instrumentation be included in the COC ?
3. When is a COC required
   - Replacing a light with an identical one (maintenance) ?
   - Adding a machine to a pre-1991 installation (only the new machine) ?
   - Is a Visual two-yearly inspection enough ?

6. A Quick Guideline for the Less-Than-Expert

To conclude this presentation, what is your best strategy as a non-expert to ascertain if the explosion prevention of a plant is in a reasonable condition ? A few pointers are:

1. Check if flammable materials are present. Most flammable materials can explode, as follows:
   - Gases.
   - Liquids that are handled above their flash points.
   - Solids in the form of fine powders, or containing a substantial amount of fines upon arrival as raw materials, or creating fines (dust) during operation.

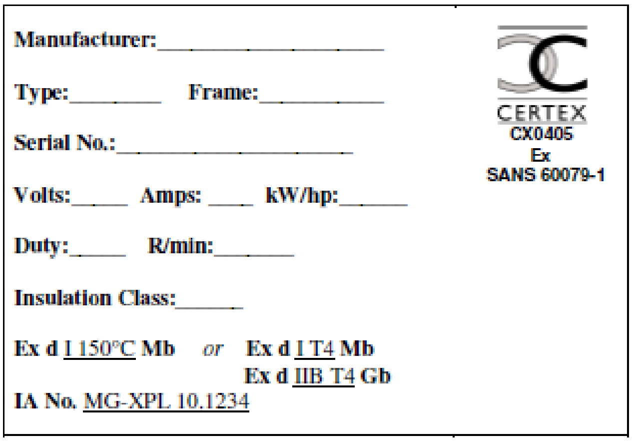
   Ask for the Material Safety Data Sheet (MSDS). It will indicate whether the product is flammable/combustible. If a material has an auto-ignition temperature or a flash point (the actual value may not be known), it can be assumed to be flammable.

   Flammable materials are typically organic, i.e. rich in carbon (e.g. LPG, petrol, liquid solvents such as hexane, and any grain, sugar or coal dust).

   Mixtures of flammable and non-flammable materials may be flammable.

2. If flammable materials are indeed present in reasonable quantities (more than in domestic situations), there must be proof that an area classification has been carried out. It should be a team effort involving plant staff to provide equipment and process information, and a specialist in the application of the appropriate area classification standards (normally a consultant). Typically, there will be a drawing or report describing where zones are to be found. Check if the area classification captures recent changes, upgrades and additions.

3. All zoned areas must contain explosion protected electrical equipment and instrumentation (EPA or Ex equipment). Ex equipment is recognized by compulsory labelling, e.g.



Equipment installed after 2005 must have a label with a certificate issued locally (i.e. issued by a local ATL. Prior to 2007, some overseas certification could be directly accepted, but not for use in underground mines.

Copies of the IA (equipment) certificates must be available.

4. For all installations of explosion protected electrical equipment and instrumentation, electrical Certificates of Compliance (COCs) must be available. The annex for hazardous areas must be present and completed by a Master Installation Electrician (MIE):

SECTION 7 CERTIFICATE OF COMPLIANCE FOR HAZARDOUS LOCATION

Certificate no.:	
Date of issue:	

7.1	**Classification of hazardous location**			
	Hazardous location classification:			Date:
	List of hazardous substances:			
	Gas group:	Max. permissible temp.: (T1 to T6)		Zone(s):
	Classified by:		Print name:	Position:
	Signature			
	Accepted by:		Print name:	Position:
	Signature			

6.2	**Visual inspections**			
	No.	**Item(s)**	**Yes**	**No**
	7.2.1	Is all explosion protected equipment correctly selected?		
	7.2.2	Is all explosion protected equipment correctly installed?		
	7.2.3	Is all explosion protected equipment correctly certified and documented?		
	7.2.4	Is all explosion protected equipment correctly labeled and marked?		
	7.2.5	Are all cable glands correctly selected and installed?		
	7.2.6	Is all equipment correctly protected against overload, overheating and intensive sparking?		
	7.2.7	Are all intrinsically safe circuits at least 50mm clear of, or well protected from all power circuits?		
	7.2.8	Do all intrinsically safe circuits have adequate lightning protection?		
	7.2.9	Are approved loop diagrams available for all intrinsically safe circuits?		
	7.2.10	Is there sufficient earthing and bonding to all explosion protected equipment, exposed and extraneous metal parts and structures in the hazardous area to prevent incendive sparking caused by static electricity, stray currents and lightning (see SABS 086-1)?		
	7.2.11	Is all sleeve-piping sealed where it exits the hazardous locations?		

NOTE: Take special care when testing circuits. Not all intrinsically safe circuits may be tested.

It is certified herewith that the above hazardous location complies with the requirements of 7.14 of SABS 0142-1

ACCREDITED PERSON	REGISTRATION NO	DATE

5. There must be records (e.g. a register) of Ex inspections by competent persons. Such competent persons must have knowledge of
   - the various types of protection;
   - installation practice;
   - relevant rules and regulations; and
   - the general principles of area classification.

6. Ex equipment must be repaired by an accredited repairer or assessed by an ATL before being put back in operation.

I trust you will use these to good effect !