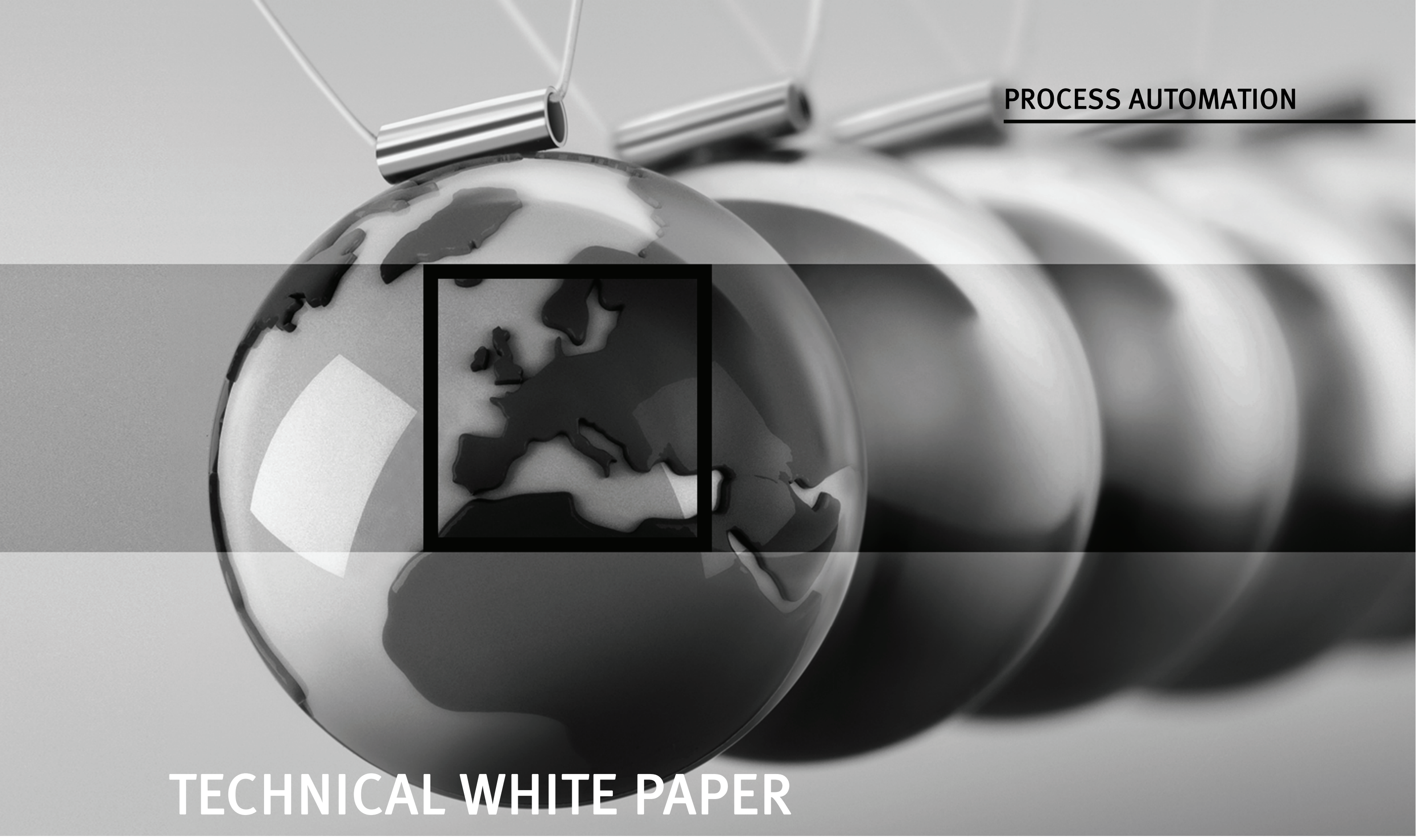


PROCESS AUTOMATION

TECHNICAL WHITE PAPER

MAINTAINING INSTALLATIONS IN HAZARDOUS AREAS

Flameproof enclosure (Ex d) and intrinsic safety (Ex i) are very common equipment protection methods in Process Automation. One reason to use Ex d is the amount of energy which could not be provided via Ex i. This disadvantage has gone with the introduction of intrinsically safe, dynamic methods of arc prevention such as DART or Power-i. This white paper shows that when using intrinsic safety, installation, maintenance and inspection costs will be reduced.

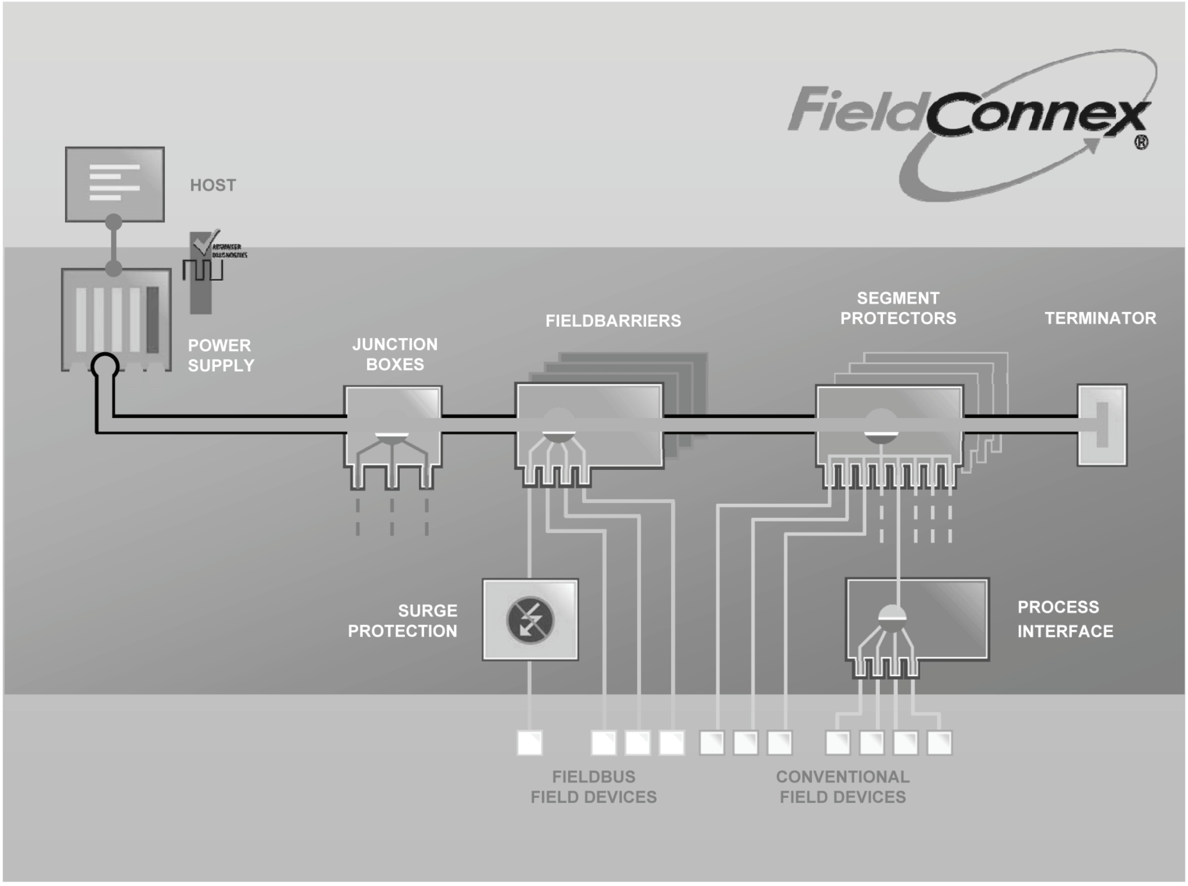
This paper addresses decision makers and professionals responsible for automation systems in hazardous areas. A good understanding of the principles of explosion protection is required.

Prepared by:

Thomas Klatt
Business Development Manager Fieldbus Systems

Andreas Hennecke
Product Marketing Manager FieldConnex

PEPPERL+FUCHS
PROTECTING YOUR PROCESS



Pepperl+Fuchs is the proven market leader for innovative and highly available components for your fieldbus according to IEC 61158-2. With quality components to fit your process automation system and demands in the field our highly reliable and energy-efficient design allows you to focus on the task at hand. Knowing that your fieldbus is running.

The innovation leader: As experts in explosion protection Pepperl+Fuchs invented the High-Power Trunk Concept and re-invents how we do intrinsic safety. DART, short for Dynamic Arc Recognition and Termination, is a means to provide high power while maintaining intrinsic safety.

The High-Power Trunk Concept: Connect the maximum number of devices to the same fieldbus trunk; and at the same time make use of maximum cable lengths. You are free to work on field devices without hot work permit.

Advanced Diagnostics: Take control of your fieldbus installation. This latest innovation brings transparency to fieldbus. Speed up commissioning with automated documentation. Measure fieldbus performance and detect changes in the control room before they become critical to your plants operation.

Our promise: You can rely on products built to serve your every need in fieldbus for process automation. You can gain from the experience of knowledgeable engineers to create your fieldbus solution. You can be at ease with products and solutions from Pepperl+Fuchs.

Table of Contents

1 Introduction

Methods of equipment protection 'flameproof enclosure' (Ex d) and 'intrinsic safety' (Ex i) are very common in Process Automation. The main reason why Ex d is used is the availability of more power in the field. This advantage becomes obsolete in Process Automation with the introduction of DART (Dynamic Arc Recognition and Termination) to the market.

More information regarding DART technology is provided at http://www.technology-dart.com

There are significant differences in all aspects of handling Ex d and Ex i with implications for both, Capital (CapEx) and Operational Expenditures (OpEx). This paper describes the differences from a user's point of view and answers the question: What are the benefits of intrinsic safety compared to flameproof enclosure?

Operating procedures in hazardous areas are governed by IEC 60079-17. Individual chapters describe the relevant requirements and constraints in clear language for installation, inspection and maintenance and the respective impact on practical work. It describes for example which kind of inspection has to be done for which part of the installation depending on the chosen equipment protection method. The Annex in chapter 6 describes these requirements in all detail giving a comparison between methods Ex d and Ex i

2 Methods of equipment protection

In order to reduce the risk of explosion, elimination of one or more of the components of the ignition triangle is necessary. There are three basic methods of protection – explosion containment, segregation, and prevention.

- Explosion containment: The only method that allows the explosion to occur but confines it to a well-defined area, thus avoiding the propagation to the surrounding atmosphere. Flameproof and explosion proof enclosures are based on this method.
- Segregation: A method that attempts to physically separate or isolate the electrical parts or hot surfaces from the explosive mixture. This method includes various techniques, such as pressurization, encapsulation, etc.
- Prevention: A method that limits the energy, both electrical and thermal, to safe levels under both normal operation and fault conditions. Intrinsic safety is the most representative technique of this method.

This chapter describes the basic principles of methods for explosion protection.

2.1 Flameproof and Explosion Proof Enclosure

This protection method is the only one based on the explosion-containment concept. In this case, the energy source is permitted to come in contact with the dangerous air/gas mixture. Consequently, the explosion is allowed to take place, but it must remain confined in an enclosure built to resist the excess pressure created by an internal explosion, thus impeding the propagation to the surrounding atmosphere.

The theory supporting this method is that the resultant gas jet coming from the enclosure is cooled rapidly through the enclosure's heat conduction and the expansion and dilution of the hot gas in the colder external atmosphere. This is only possible if the enclosure openings or interstices have sufficiently small dimensions. Additionally the enclosure must withstand the increased internal pressure.

2.2 Intrinsic safety

An electrical apparatus and its associated circuits have to be designed in a manner that will prevent the generation of arcs, sparks, or thermal effects that could ignite a potentially dangerous substance, during both normal and fault conditions of the circuit in this respect.

3 Installation

When selecting the protection method flameproof enclosure (Ex d) all cables must be protected against intentional or unintentional disconnect. Typically this requirement is solved by the use of Ex e terminals and armoured cables. IEC 60079-14 prescribes that cabling must be protected from

- mechanical damage
- chemical influences
- corrosion
- effects of heat

Intrinsic safety (Ex i) on the other hand does not have this requirement. From the point of view of explosion protection this means, when using intrinsic safety, armoured cables can be replaced by standard industrial grade cables.

2011-01-05 EDM TDOCT-2391_ENG

The advantage is much lower installation costs (CapEx) due to:

- standard insulated cables are less expensive than armoured cables
- standard insulated cables are easier to install (time saving)
- standard insulated cables are much easier to handle when installing cable glands (time saving)[1]
- cable glands for standard insulated cables are significantly less expensive than cable glands for armoured cables (up to 90%).
- standard insulated cables require less space which can enable smaller and therefore less expensive cable channels or cable trays to be adopted.

An additional advantage for offshore applications is the lower weight of standard insulated cables.

4 Inspection and maintenance requirements

Inspection and maintenance requirements for application in hazardous areas are specified in IEC 60079-17. According to this standard an inspection is ‘an 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 condition of an item.’ This means in clear and easy to understand text “An inspection is a verification of the equipment in a way that it is ensured that the requirements regarding

- Zone of installation are fulfilled
- the explosion protection method employed are matched

4.1 Types of Inspections

IEC 60079-17 prescribes the following methods for plant upkeep ensuring the continued reliability. This section describes the terminology as defined in the standard. For better readability some phrasing has been changed. Please always refer to the IEC-standard as the guiding document. Additional local rules and regulations may apply

Initial inspection
An inspection of all electrical equipment, systems and installations before they are brought into service

Visual Inspection
An inspection which identifies, without the use of access equipment or tools, those defects, such as missing bolts, which will be apparent to the eye.

Close Inspection
An inspection which encompasses those aspects covered by a visual inspection and, in addition, identifies those defects, such as loose bolts, which will be apparent only by the use of access equipment, for example steps, (where necessary), and tools.

Detailed Inspection
An inspection which encompasses those aspects covered by a close inspection and, in addition, identifies those defects, such as loose terminations, which will only be apparent by opening the enclosure, and/or using, where necessary, tools and test equipment

Continuous Supervision
Frequent attendance, inspection, service, care and maintenance of the electrical installation by skilled personnel who have experience in the specific installation and its environment in order to maintain the explosion protection features of the installation in satisfactory condition

An initial inspection has to be done before the plant or the equipment is brought into service. Initial inspections are used to check that the selected type of protection and its installation are appropriate. They are to be detailed inspections in accordance with the tables shown in clause 7.1 to 7.3.

4.2 Inspection types compared

In comparison to an Ex i solution the Ex d solution requires a physical check of bolts, cable entries and blanking elements. It must be physically checked whether these elements are complete and tight. Additionally it must be checked if the gap dimensions are within the permitted values. These measurements are not required when going for intrinsic safety.

When going for Ex-i the proof of intrinsic safety has to be validated and it has to be checked if the safety barrier units and other energy limiting devices are of the approved type, installed in

[1] An example: The required time to strip off the cable insulation with standard insulated cables is much shorter compared to armoured cables.

2011-01-05 EDM TDOCT-2391_ENG

accordance with the certification requirements and securely earthed where required. This kind of action is not required when going for Ex d.

It can be safely assumed that a larger effort and cost are required for checking the Ex d installation compared to validating and checking out the Ex i application.

For applications utilizing conventional interface technology the effort of validating many circuits is solved through typicals. For fieldbus application a simplified proof of intrinsic safety can be done in case one of the following is true:

- all Ex i fieldbus components are FISCO certified or
- all Ex i fieldbus components are Entity certified in acc. with the FOUNDATION™ fieldbus profile 111, 112, 121 or 122 or
- a system approval can be provided by the vendor.

Such a simplified proof of Ex i will reduce the required workload to prepare these proofs dramatically.

To ensure that an Ex d or Ex I installation located in a hazardous area remains in satisfactory operating condition the following criteria have to be met:

1. either regular periodic inspections
2. or continuous supervision by skilled personnel,
3. and maintenance where necessary

4.3 The difficulties with continuous supervision

In accordance with the IEC 60079-17 the only way to avoid the required effort of regular periodic inspections is continuous supervision by skilled personnel. Precondition for this supervision is that the installation is visited on a regular basis, in the normal course of work.

However, this is typically in contradiction to the requirement to reduce time on site to a minimum! (NB: One reason to use fieldbus or HART communication is that a lot of work can be done from the control room without going on site.)

Additionally a person who is personally authorized to perform such continuous supervisions is typically a very well trained technician that

1. 'has to be aware of the process and the environmental implications on the deterioration of the specific equipment in the installation and
2. 'is required to carry out visual and/or close inspections as part of their normal work schedule as well as detailed inspections as part of any replacement'

This means in practice significant cost of operations (OpEx), because :

- the site has to be visited very often by
- very skilled persons with
- excellent knowledge about the specific installation

These are the reasons why most plant managers will select the regular periodic inspection approach.

4.4 Inspection requirements

During operation the plant and/or equipment has to be inspected periodically due to the reasons explained in the previous chapter.

IEC 60079-17 defines that the interval between periodic inspections shall not exceed three years without seeking expert advice. In case of exceeding the 3-year interval this should be based on an assessment 'with relevant information'.

The inspection schedule is split into 3 sections:

- Inspection schedule for equipment
- Inspection schedule for installation
- Inspection schedule for environment

When comparing the inspection requirements for Ex d and Ex i the main difference can be found in the inspection schedule for equipment and installation.

NB: The tables in chapters 7.1 to 7.3 are showing the full requirements for both explosion protection methods.

2011-01-05 EDM TDOCT-2391_ENG

4.4.1 Inspection requirements for Ex d equipment

For Ex d equipment a 'detailed inspection' for bolts, cable entries and blanking elements is required. This inspection is very time consuming due to the requested physical check out.

The same is valid for flange gap dimensions for this equipment because these must be measured.

In case these gaps are too small, e. g. due to dirt on the gaps or too large because they were not properly closed, the devices are not explosion protected anymore. A narrow gap may result in similar consequences as an explosion may result in a burst and uncontrolled release of large amounts of energy into the hazardous area. The flange gap is the Achilles Heel of explosion protection method Ex d.

This means that the same points have to be checked as during the initial inspection.

These inspections are not required for Ex i.

4.4.2 Inspection requirements for Ex i equipment

There are only few inspections required for Ex i equipment:

- The safety barrier units and other energy limiting devices are of the approved type, installed in accordance with the certification requirements and securely earthed where required.
- The printed circuit boards are clean and undamaged.

The first point is exactly the same check which was required during the initial inspection. So in case the equipment has passed the initial inspection the only point which needs to be checked is the tightness of earthing clamps because there is a probability of self-opening due to vibrations. Additionally this equipment is typically located in the control room, which means a trip to the field is not required.

These checks to not apply to Ex d equipment. It can be safely assumed that the time and cost required to conduct inspections for Ex i equipment are less compared to those for Ex d.

4.4.3 Inspection requirement installation

The complete comparison of requirements for Ex d and Ex i installations are provided in chapter 7.2

For Ex d installations the fault loop impedance (TN systems[2]) or earthing resistance (IT systems[3]) have to be satisfactory. For Ex i circuit earthing has to be satisfactory. The required time for either measurement is most likely equal.

4.4.4 Inspection schedule for the environment

Please refer to chapter 7.3 for a complete comparison of Ex d and Ex i installation.

For Ex d installation it must be checked if the electrical insulation is clean and dry. This is not necessary for Ex i installation which leads to an additional time saving.

4.5 Maintenance

One advantage of intrinsic safety over flame proof enclosure is the capability of live maintenance without the requirement for a hot work permit.

Even when arguing that maintenance people always have to talk to operations people before they touch an instrument and they always have to have a gas sniffer available to ensure human and equipment safety, the workload and therefore the time required to stay in the field is always higher with Ex d compared to Ex i.

[2] TN-System (french:Terre Neutre) is a low voltage supply system in acc. with IEC 60364 where the star point of the feeding transformer is earthed. TN-Systems are subdivided into

- TN-S (separate protective earth (PE) and neutral (N) conductors from transformer to consuming device, which are not connected together at any point after the building distribution point.)
- TN-C (combined PE and N conductor all the way from the transformer to the consuming device.)
- TN-C-S (combined PEN conductor from transformer to building distribution point, but separate PE and N conductors in fixed indoor wiring and flexible power cords.)

[3] IT-System (french: Isolé Terre) is a low voltage supply system in acc. with IEC 60364 where the distribution system has no connection to earth at all, or it has only a high impedance connection. In such systems, an insulation monitoring device is used to monitor the the distribution system has no connection to earth at all, or it has only a high impedance connection. In such systems, an insulation monitoring device is used to monitor the impedance.

2011-01-05 EDM TDOCT-2391_ENG

The reason is again the gaps. When closing the housing of an Ex d device it must be ensured that the required gap size is within the limits. This requires a more accurate working procedure and perhaps a measurement.

5 Conclusion

When using intrinsic safety instead of flameproof enclosure method the installation costs (CapEx) as well as costs for maintenance and inspection (OpEx) will be lower. Every time when Ex d equipment must be accessed the time requirement to do so is higher compared to that of Ex i devices.

The main advantages of intrinsic safety compared to flameproof enclosure regarding installation and maintenance are:

- no need for armoured cables
- therefore reduced installation time due to easier handling of:
  - the cable itself as well as
  - the accessories such as cable glands
- reduced installation costs due to less expensive equipment and reduced installation time
- reduced time and costs for inspections
- reduced time on site for maintenance purposes.

6 References

[1] Interface Technology Engineer’s Guide Edition 3.1 (2010) – Publisher: Pepperl+Fuchs Group

[2] IEC-Standard 60079. Part 17: : Electrical installations inspection and maintenance “

2011-01-05 EDM TDOCT-2391_ENG

7 Annex

This Annex compares the points to be inspected during an initial and periodic inspection for

- equipment
- installation and
- environment

of an Ex d solution against an Ex i solution. It should show the different requirements, especially which kind of inspection is required for Ex d and not required for Ex i and vice versa.

7.1 Comparison of inspection schedule for equipment:

A) Equipment	Ex d grade of Inspection			Ex i grade of Inspection		
	Detailed	Close	Visual	Detailed	Close	Visual
Equipment is appropriate to the EPL[4]/Zone requirements of the location	X	X	X	X	X	X
Equipment group is correct	X	X		X	X	
Equipment temperature class is correct	X	X		X	X	
Equipment circuit identification is correct	X			X	X	
Equipment circuit identification is available	X	X	X			
Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	X	X	X	X		
There are no unauthorized modifications	X			X		
There are no visible unauthorized modifications		X	X		X	X
Safety barrier units, relays and other energy limiting devices are of the approved type, installed in accordance with the certification requirements and securely earthed where required				X	X	X
Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight						
– physical check	X	X				
– visual check			X			
Flange faces are clean and undamaged and gaskets, if any, are satisfactory	X					
Flange gap dimensions are within maximal values permitted	X	X				
Electrical connections are tight	X			X		
Lamp rating, type and position are correct	X					
Motor fans have sufficient clearance to enclosure and/or covers	X					
Breathing and draining devices are satisfactory	X	X				
Printed circuit boards are clean and undamaged				X		

[4] EPL = Equipment protection level. is a new classification of equipment acc. to IEC 60079-0

2011-01-05 EDM TDOCT-2391_ENG

A) Equipment	Ex d grade of Inspection			Ex i grade of Inspection		
	Detailed	Close	Visual	Detailed	Close	Visual
Equipment is appropriate to the EPL/Zone requirements of the location	X	X	X	X	X	X
Equipment group is correct	X	X		X	X	
Equipment temperature class is correct	X	X		X	X	
Equipment circuit identification is correct	X			X	X	
Equipment circuit identification is available	X	X	X			
Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	X	X	X	X		
There are no unauthorized modifications	X			X		

7.2 Comparison of inspection schedule for installation

B) Installation	Ex d grade of Inspection			Ex i grade of Inspection		
	Detailed	Close	Visual	Detailed	Close	Visual
Type of cable is appropriate	X					
Cables are installed in accordance with the documentation				X		
Cable screens are earthed in accordance with the documentation				X		
There is no obvious damage to cables	X	X	X	X	X	X
Sealing of trunking, ducts, pipes and/or conduits is satisfactory	X	X	X	X	X	X
Stopping boxes and cable boxes are correctly filled	X					
Integrity of conduit system and interface with mixed system is maintained	X					
Earthing connections, including any supplementary earthing bonding connections are satisfactory (for example connections are tight and conductors are of sufficient cross-section)						
– physical check	X					
– visual check		X	X			
Fault loop impedance (TN systems) or earthing resistance (IT systems) is satisfactory	X					
Insulation resistance is satisfactory	X					
Earth continuity is satisfactory (e.g. connections are tight, conductors are of sufficient cross-section) for non-galvanically isolated circuits.				X		
Earth connections maintain the integrity of the type of protection				X	X	X
Intrinsically safe circuit earthing and insulation resistance is satisfactory				X		

2011-01-05 EDM TDOCT-2391_ENG

B) Installation	Ex d grade of Inspection			Ex i grade of Inspection		
	Detailed	Close	Visual	Detailed	Close	Visual
Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common distribution boxes or relay cubicles				X		
As applicable, short-circuit protection of the power supply is in accordance with the documentation				X		
Automatic electrical protective devices operate within permitted limits	X					
Automatic electrical protective devices are set correctly (auto-reset not possible)	X					
Specific conditions of use (if applicable) are complied with	X			X		
Cables not in use are correctly terminated	X			X		
Obstructions adjacent to flameproof flanged joints are in accordance with IEC 60079-14	X					
Variable voltage/frequency installation in accordance with documentation	X	X				
Type of cable is appropriate	X					
Cables are installed in accordance with the documentation				X		
Cable screens are earthed in accordance with the documentation				X		
There is no obvious damage to cables	X	X	X	X	X	X
Sealing of trunking, ducts, pipes and/or conduits is satisfactory	X	X	X	X	X	X
Stopping boxes and cable boxes are correctly filled	X					
Integrity of conduit system and interface with mixed system is maintained	X					

7.3 Comparison of inspection schedule for environment

C) Environment	Ex d grade of Inspection			Ex i grade of Inspection		
	Detailed	Close	Visual	Detailed	Close	Visual
Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	X	X	X	X	X	X
No undue accumulation of dust and dirt	X	X	X	X	X	X
Electrical insulation is clean and dry	X					

2011-01-05 EDM TDOCT-2391_ENG