

# Explosion Protection for the Process Industry: Ex Equipment, Standards and Certification

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Safety Case  
Symposium 2018  
Singapore

# Topics

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- Hazardous Area and Explosion
- Explosion Prevention & Protection
- Safety Case Relevant to Explosive Atmospheres
- Ex Equipment
- International Standards for Ex Equipment
- ATEX and IECEx Certification for Ex Equipment

# Hazardous Area and Explosion

- **Hazardous area**

area in which an [explosive atmosphere](#) is present or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment

- **Explosive atmosphere**

mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, dust, fibres, or flyings, which, after ignition, permits self-sustaining flame propagation

- **Explosion (in process industry)**

An explosion is defined as the process in which combustion occurs and spreads so rapidly as to create a high pressure, it forms a blast wave which travels outwards from the source, the blast wave has flame and high temperatures.



video: [gas explosion](#)



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video: [gas explosion](#)



# Hazardous Area and Explosion

## Typical industries with hazardous area

- Oil refineries, rigs – onshore/offshore
- Drilling ships and FPSOs
- Chemical processing plants
- Printing industries, paper and textiles
- Aircraft refueling and hangars
- Sewerage treatment plants
- Surface coating industries
- Grain handling
- Woodworking areas
- Sugar refineries
- Light metal working
- Underground coalmines



# Principles of an Integrated Approach to Explosion Safety

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- Prevention of the formation of explosive atmospheres
- Avoidance of the ignition of explosive atmospheres
- Mitigation of the detrimental effects of an explosion so as to ensure the health and safety of workers
  - by halting the explosion, or
  - by limiting the consequences of the explosion



# Hazardous Areas as per IEC, EN 60079-10-1/ 60079-10-2

Hazardous areas (**Gas** or **Dust**) are classified into three zones;

## **Zone 0/ Zone 20:**

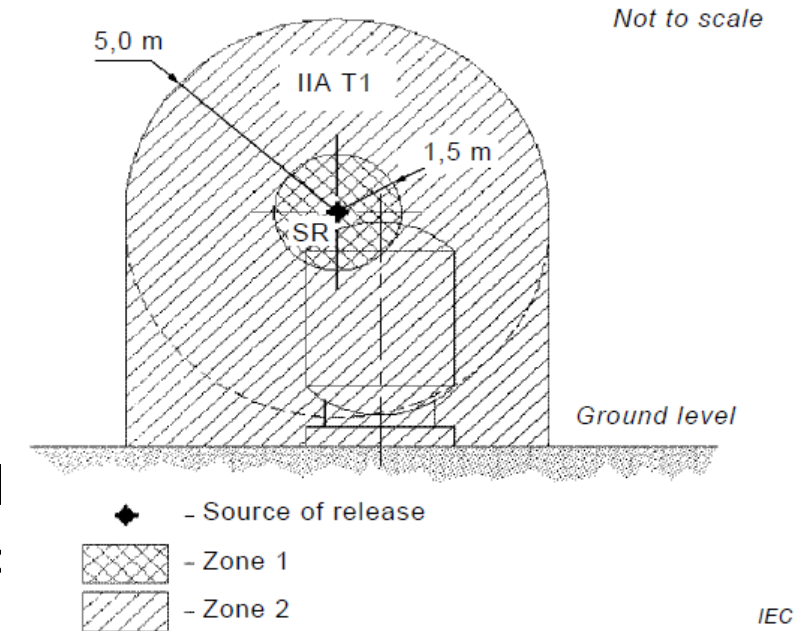
an explosive gas/ dust atmosphere (in the form of cloud dust in air) is **continuously present, or present for long periods.**

## **Zone 1/ Zone 21:**

an explosive gas/ dust atmosphere is **likely to occur in normal operation occasionally.**

## **Zone 2/ Zone 22:**

an explosive gas/ dust atmosphere is **not likely to occur in normal operation** and, if it does occur, it is likely to do so infrequently and will exist for a short period only.





# Ignition Sources (ref. EN 1127-1)

- Hot surfaces
- Flames and hot gases/particles
- Mechanically generated sparks
- **Electrical apparatus**
- Stray electric currents, cathodic corrosion protection
- Static electricity
- Lightning
- RF Electromagnetic waves
- Electromagnetic radiation
- Ionising radiation
- Ultrasonics
- Adiabatic compression and shock waves
- Chemical/exothermic reactions



# Safety Case Technical Guide: Adequate Safety and Reliability in Design

## Design key issue 10: systems for identifying locations where flammable substances could be present

- 199 MHIs shall explain how potentially hazardous (flammable and explosive atmosphere) areas have been identified and classified. This may have been through an area classification study in which those areas where a risk exists, owing to the normal, occasional or accidental release of process materials to atmosphere, have been designated in accordance with recognised standards.
- 200 Sources of ignition for flammable atmospheres may include electrical equipment, naked flames or hot surfaces, and static electrical discharge. MHIs shall indicate how the likely sources of ignition have been considered in the design, for example:
- electrical equipment selection for defined hazardous areas;
  - avoidance of hot surfaces or naked flames, or sparks associated with equipment, such as
- 202 Equipment selected for use in hazardous areas shall be suitable for use in these areas under all foreseeable operating conditions, including normal operation, start-up, shutdown, emergency, cleaning, or any other expected condition throughout the life of the installation.



Updated: Oct 2016

# Safety Case Assessment Guide: for Electrical, Control, Instrumentation

## The General Approach to EC & I Assessment

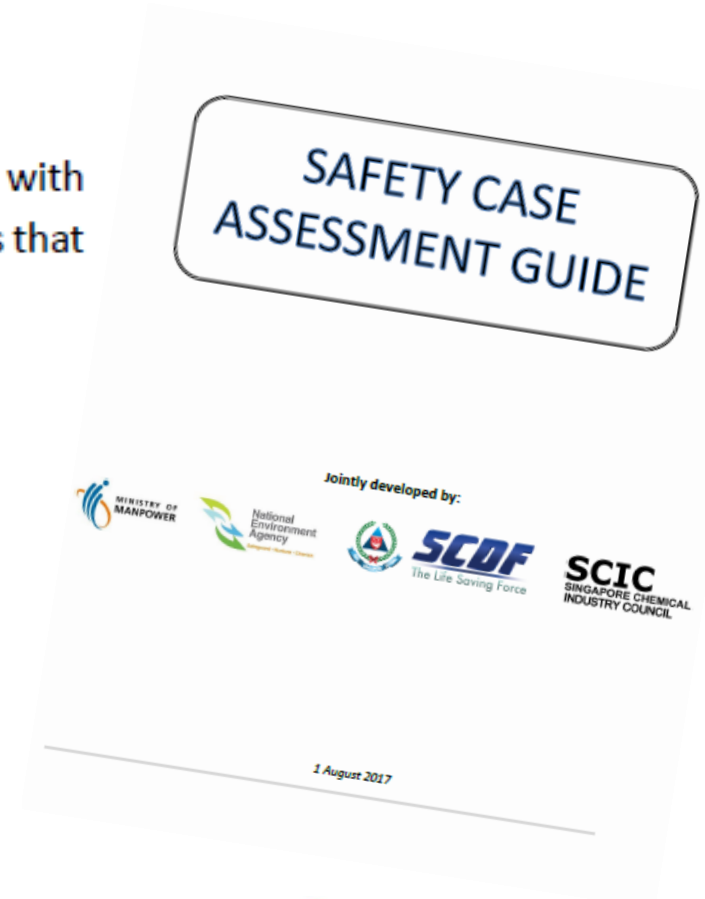
### Explosive and/or Flammable Atmospheres

2.4. In the context of EC&I inspection, explosive and/or flammable atmospheres are concerned with the management, design, installation, operation, maintenance and modification of systems that reduce the risk of electrical sources of ignition arising from:

- electrical and instrumentation equipment;
- lightning;
- static;

and the mitigation of releases using:

- flammable gas detection;
- fire detection.



# Safety Case Assessment Guide: for Electrical, Control, Instrumentation

To meet requirement:

- Application of E&I design standard: Singapore Standard, **Commonly used international standards** (e.g. EN, BS, API, ISO, IEC), Other national standards, Industry standards, ...
- ✓ The standard applied to the **design and selection of explosion protection (Ex) equipment**
- ✓ The standards applied to the **construction verification of explosion protected (Ex) equipment**
- ✓ The standards applied to **the maintenance and inspection of equipment** in explosive and/or flammable atmospheres, including fixed and mobile equipment
  - e.g. periodic Ex inspection records for Ex d, e, n, i, tD from IEC 60079/ 61241.
- How it has been assured that **competent persons are involved in the selection and installation** of equipment and protective systems designed to be safe in explosive and/or flammable atmosphere.
- How the maintenance and inspection of equipment in explosive and/or flammable atmospheres, including fixed and mobile equipment is managed, and also record of **competence of the persons who carried out the inspection.**

# Ex Equipment (apparatus): Electrical

**Ex Equipment:** apparatus, fittings, devices, components, and the like used as a part of, or in connection with, an electrical installation in an explosive atmosphere

| Code - Ex         | Type of protection    | Technique               | Zone    | Ref. Standards        |
|-------------------|-----------------------|-------------------------|---------|-----------------------|
| Ex da, d/db, dc   | Flameproof enclosure  | Explosion containment   | 0, 1, 2 | IEC, EN 60079-1       |
| Ex e/eb, ec       | Increased safety      | Avoid spark, hi-temp    | 1, 2    | IEC, EN 60079-7       |
| Ex ia, ib, ic     | Intrinsic safety      | Energy limitation       | 0, 1, 2 | IEC, EN 60079-11, -25 |
| Ex ma, m/mb,mc    | Encapsulation         | Exclusion (enclosed)    | 0, 1, 2 | IEC, EN 60079-18      |
| Ex nA, nL, nR, nC | Non-sparking          | Avoid ignition          | 2       | IEC, EN 60079-15      |
| Ex o/ob, oc       | Oil/Liquid immersion  | Exclusion (immersed)    | 1, 2    | IEC, EN 60079-6       |
| Ex pxb, pyb, pzc  | Pressurized enclosure | Exclusion (pressurized) | 1, 2    | IEC, EN 60079-2       |
| Ex q              | Powder filling        | Exclusion & quenching   | 1, 2    | IEC, EN 60079-5       |



# Ex Equipment (apparatus): Electrical

| Code - Ex                 | Type of protection           | Technique                        | Zone                  | Ref. Standards                             |
|---------------------------|------------------------------|----------------------------------|-----------------------|--|
| Ex op_(is, pr, sh)        | Optical radiation            | Radiation/transmission protected | any (0,1,2, 20,21,22) | IEC, EN 60079-28                           |
| Ex tD,<br>Ex ta, tb, tc   | Dust protection by enclosure | Exclusion (dust, limit temp)     | 20, 21, 22            | IEC, EN 61241-1 (old)<br>IEC, EN 60079-31  |
| Ex iD<br>Ex ia, ib, ic    | Intrinsically safe           | Energy limitation                | 20, 21, 22            | IEC, EN 61241-11 (old)<br>IEC, EN 60079-11 |
| Ex mD<br>Ex ma, mb, mc    | Encapsulation                | Exclusion (enclosed)             | 20, 21, 22            | IEC, EN 61241-18 (old)<br>IEC, EN 60079-18 |
| Ex pD<br>Ex pxb, pyb, pzc | Pressurized enclosure        | Exclusion (pressurized)          | 21, 22                | IEC, EN 61241-4 (old)<br>IEC, EN 60079-2   |
| Ex sa, sb, sc             | Special protection           | Not a recognized type            | any                   | IEC, CLC/TR 60079-33                       |

# Ex Equipment (apparatus): Non-electrical

| Code - Ex | Type of protection          | Technique                                | Zone        | Ref. Standards                     |
|-----------|-----------------------------|--|-------------|------------------------------------|
| fr        | Flow restricting enclosure  | Exclusion (reduce ingress of atmosphere) | 2, 22       | EN 13463-2                         |
| d         | Flameproof enclosure        | Explosion containment                    | 1, 2, 21,22 | EN 13463-3                         |
| p         | Pressurized enclosure       | Exclusion (pressurized)                  | 1, 2, 21,22 | EN 60079-2                         |
| c<br>Ex h | Constructional safety       | Constructional measures                  | 1, 2, 21,22 | EN 13463-5<br>IEC, EN ISO 80079-37 |
| b<br>Ex h | Control of ignition sources | Avoid ignition                           | 1, 2, 21,22 | EN 13463-6<br>IEC, EN ISO 80079-37 |
| k<br>Ex h | Liquid immersion            | Exclusion (immersed)                     | 1, 2, 21,22 | EN 13463-8<br>IEC, EN ISO 80079-37 |

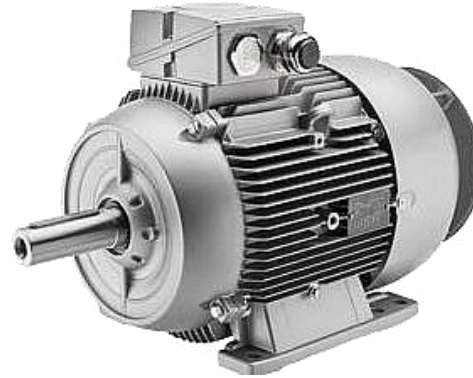
# Samples of Ex Equipment



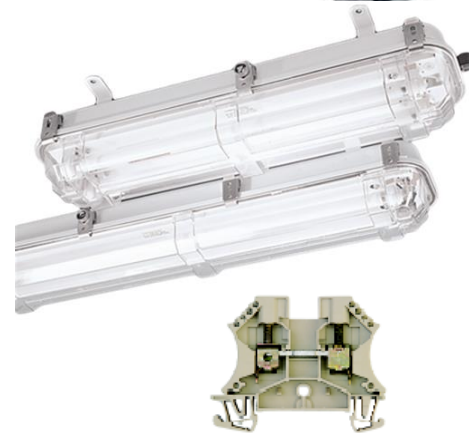
**Ex d**  
**Flameproof**



**Ex e**  
**Increased Safety**

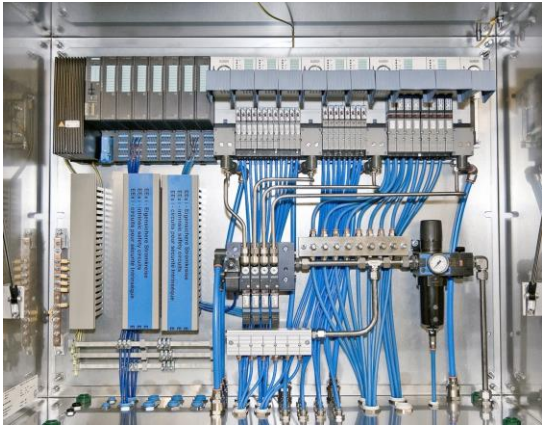


**Ex n**  
**Non-sparking**



**Ex p**  
**Pressurized enclosure**

# Samples of Ex Equipment



**Ex i**  
**Intrinsic Safety**

**Ex m**  
**Encapsulation**

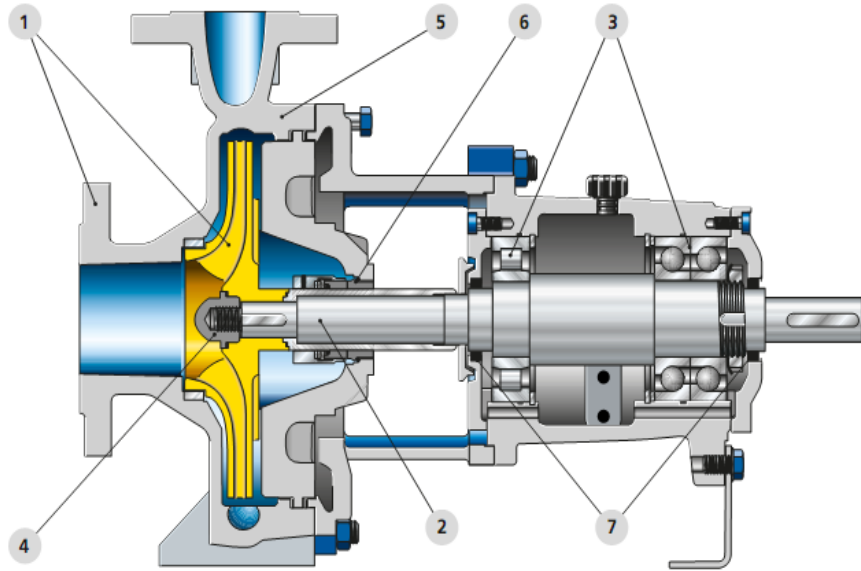
**Ex o**  
**Oil Immersion**

**Ex t/ tD**  
**Dust protection**



# Samples of Ex Equipment: Non-electrical

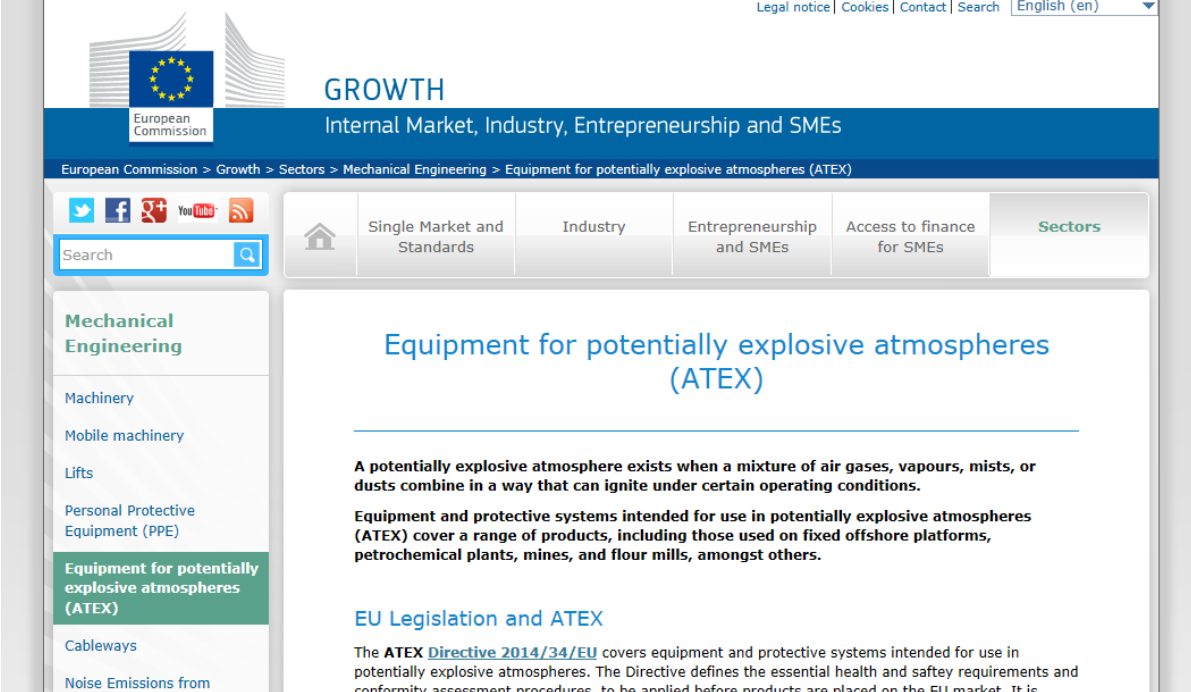
CPKN – Standardised Chemical Pump to EN 22858 / ISO 2858 / ISO 5199 and Directive 94/9/EC (ATEX 100)





# European Equipment Directive

The **ATEX [Directive 2014/34/EU](#)** covers equipment and protective systems intended for use in potentially explosive atmospheres. The Directive defines the *essential health and safety requirements* and *conformity assessment procedures*, to be applied before products are placed on the EU market. It is aligned with the “New Legislative Framework” policy, and it is applicable from 20 April 2016, replacing the previous Directive 94/9/EC.



The screenshot shows the European Commission website page for 'Equipment for potentially explosive atmospheres (ATEX)'. The page is part of the 'GROWTH' section, which focuses on the 'Internal Market, Industry, Entrepreneurship and SMEs'. The breadcrumb trail indicates the path: 'European Commission > Growth > Sectors > Mechanical Engineering > Equipment for potentially explosive atmospheres (ATEX)'. The page features a search bar, social media icons, and a navigation menu with options like 'Single Market and Standards', 'Industry', 'Entrepreneurship and SMEs', 'Access to finance for SMEs', and 'Sectors'. The main content area is titled 'Equipment for potentially explosive atmospheres (ATEX)' and includes a definition of a potentially explosive atmosphere and a list of products covered by the ATEX Directive. A sidebar on the left lists various categories under 'Mechanical Engineering', with 'Equipment for potentially explosive atmospheres (ATEX)' highlighted in green.

[https://ec.europa.eu/growth/sectors/mechanical-engineering/atex\\_en](https://ec.europa.eu/growth/sectors/mechanical-engineering/atex_en)

# European Equipment Directive 2014/34/EU (ATEX)

## Directive, Harmonised Standards & Notified Bodies for ATEX

29.3.2014 EN Official

### DIRECTIVE 2014/34/EU OF THE

on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 114 thereof,

Having regard to the proposal from the European Commission,

After transmission of the draft legislative act to the Member States and the parliaments,

### EUROPEAN COMMISSION

Commission communication in the framework of the implementation of Directive 2014/34/EU of the European Parliament and of the Council on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially

(Publication of titles and references of harmonised standards under Union harmonisation)

(Text with EEA relevance)

(2017/C 298/01)

| ISO (*) | Reference and title of the standard (and reference document)   | First publication of | Reference document |
|---------|--|----------------------|--------------------|
| (1)     | (2)  | (3)                  |                    |
| CEN     | EN 1010-1:2004+A1:2010<br>Safety of machinery — Safety requirements for the design and construction of printing and paper converting machines — Part 1: Common requirements  | 8.4.2016             |                    |
| CEN     | EN 1010-2:2006+A1:2010<br>Safety of machinery — Safety requirements for the design and construction of printing and paper converting machines — Part 2: Printing and varnishing machines including pre-press machinery | 8.4.2016             |                    |
| CEN     | EN 1127-1:2011<br>Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and   | 8.4.2016             |                    |

**EUROPEAN COMMISSION**  
GROWTH  
Internal Market, Industry, Entrepreneurship and SMEs

European Commission > Growth > Single Market and Standards > Tools and Databases > Notified bodies Nando > Legislation

Notified bodies Nando  
Country  
Legislation  
Body  
Construction products  
Free search  
Mutual Recognition Agreements  
CETA Protocol on Conformity Assessment  
Notifying Authority - Notification procedures  
Accreditation Body

**Bodies** Found : 70

Search criteria :

Legislation : 2014/34/EU Equipment and protective systems intended for use in potentially explosive atmospheres (recast)

Procedure / Article or annex : ALL

Products : ALL

**Search**

Withdrawn/Expired/Suspended Notifications/NBs are not displayed in this list, you can find them in the Body module under the hyperlink "[Withdrawn/Expired/Suspended Notifications/NBs](#)"

| Body type | Name   | Country |
|-----------|--|---------|
| ▶ NB 0026 | <a href="#">VINCOTTE sa/nv</a>                       | Belgium |
| ▶ NB 0029 | <a href="#">APRAGAZ A.S.B.L.</a>                     | Belgium |
| ▶ NB 0035 | <a href="#">TÜV Rheinland Industrie Service GmbH</a> | Germany |

# Standards, Conformity Assessment for ATEX Equipment

## Standardisation for ATEX

EU harmonised standards are produced by the EU Standardisation Organisations:

- the [European Committee for Standardization \(CEN\)](#) and
- the [European Committee for Electrotechnical Standardization \(CENELEC\)](#)

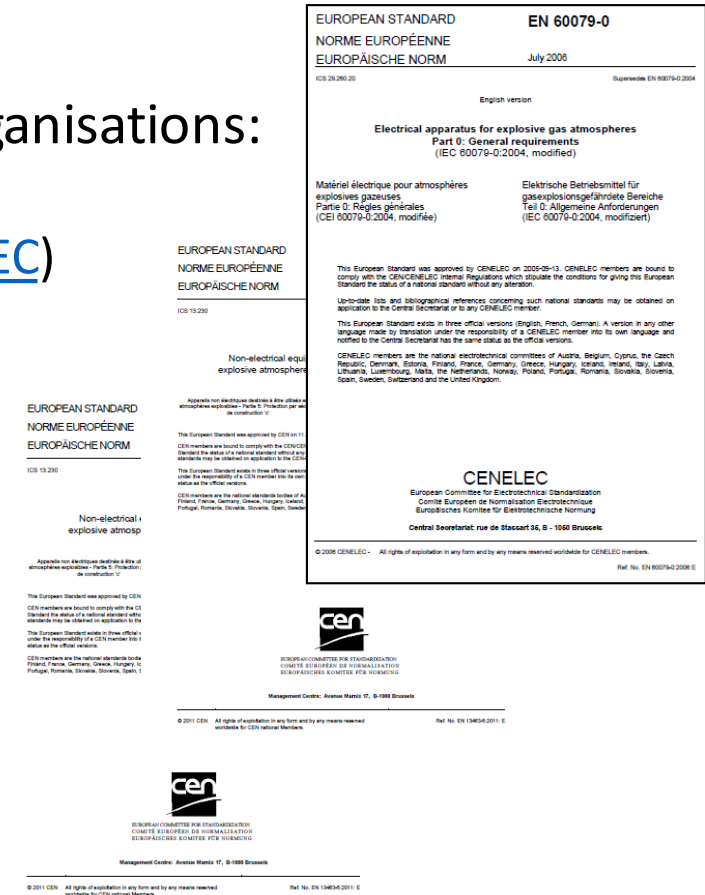
## Conformity Assessment

- by **Harmonised standards**, and/ or
- by **Technical solutions which meets the requirements of the EHSR**

**Electrical** => EN 60079 series (identical to IEC 60079 series)

**Non-electrical** => EN 13463 series and EN ISO 80079 series

**QS for Mfg.** => EN ISO/IEC 80079-34 (old standard: EN 13980)



# ATEX Equipment - Groups , Categories



## Equipment - Group I

- Category **M1**: for use in mines **endangered** by firedamp and/or combustible dust  
=> 2-faults/ very high level protection, leave on
- Category **M2**: for use in mines **likely to be endangered** by firedamp and/or combustible dust  
=> ensuring a high level protection, de-energized

## Equipment - Group II

- Category 1 (**1G/ 1D**) : for use in areas in which explosive atmospheres are **present continuously**, for long periods or frequently => 2-faults/ very high level protection
- Category 2 (**2G/ 2D**) : for use in areas in which explosive atmospheres are **likely to occur**  
=> 1-fault/ high level protection
- Category 3 (**3G/ 3D**) : for use in areas in which explosive atmospheres are **unlikely or occur only infrequently** and for a short period => ensuring a normal level protection

# Directive 2014/34/EU (ATEX): Conformity Assessment

| Annex in Directive                       | Category | 1/ M1 | 2/ M2<br>Electrical | 2/ M2<br>Non-electrical | 3    |
|--|----------|-------|---------------------|-------------------------|------|
| Annex III - EU-Type Examination          |          | NB    | NB                  |                         |      |
| Annex IV - Production QA                 |          | NB    |                     |                         |      |
| Annex V - Product Verification           |          | NB    |                     |                         |      |
| Annex VI - Conformity to Type            |          |       | NB + M              |                         |      |
| Annex VII - Product QA                   |          |       | NB                  |                         |      |
| Annex VIII - Internal Production Control |          |       |                     | M<br>(+ deposit file)   | M    |
| Annex IX - Unit Verification             |          | (NB)  | (NB)                | (NB)                    | (NB) |



# Directive 2014/34/EU (ATEX): Equipment Marking , Certificate

- ATEX marking

C € 0035  II 2 G and/or D

- Standard marking acc. to EN 60079-0

Ex d e IIC T4

(1) **TYPE-EXAMINATION CERTIFICATE** 

(2) Equipment and Protective Systems intended for use in Potentially Explosive Atmosphere - **Directive 94/9/EC**

(3) Type-Examination Certificate Number

**TÜV 15 ATEX 7687 X**

(1) **EU-TYPE EXAMINATION CERTIFICATE** 

(2) Equipment and Protective Systems intended for use in Potentially Explosive Atmosphere - **Directive 2014/34/EU**


(3) EU-Type Examination Certificate Number

**TÜV 16 ATEX 7958 X** Issue: 01


(4) Equipment: **Solenoid Valves type VERDE 6G-EX and type VERDE 6M-EX**

(5) Manufacturer: **MARINE CONTROL SYSTEMS COMPANY**

(12) The marking of the equipment shall include the following

 II 3 G Ex pz IIC T4 Gc

TÜV Rheinland ExNB for explosion protected equipment



Dipl.-Ing. Klauspeter Graffi

This Type-Examination Certificate without signature and stamp shall not be valid.  
This Type-Examination Certificate may be circulated only without alteration. Extracts or alterations are subject to approval by the TÜV Rheinland Notified Body of TÜV Rheinland Industrie Service GmbH, Am Grauen Stein 51105 Köln  
Tel. +49 (0) 221 806-0 Fax. + 49 (0) 221 806 114

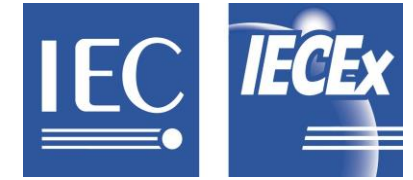
www.tuv.com



10/2011 4.08 E A4 © TÜV, TÜV and TÜV are registered trademarks. Utilisation and application



# IECEX Scheme within IECEX System



## IECEX System Objective

The objective of the IECEX System is to facilitate international trade in equipment and services for use in explosive atmospheres, while maintaining the required level of safety:

- reduced testing and certification costs to manufacturer
- reduced time to market
- international confidence in the product assessment process
- one international database listing
- maintaining International Confidence in equipment and services covered by IECEX Certification



<http://www.iecex.com/>

# Scheme within IECEx System



**IECEx System**  
www.iecex.com

**IECEx Equipment Scheme**  
Certification of Ex Equipment + QS

- Choice between:**
- IECEx Certificate of Conformity
  - IECEx Component Certificate
  - IECEx Unit Verification Cert.

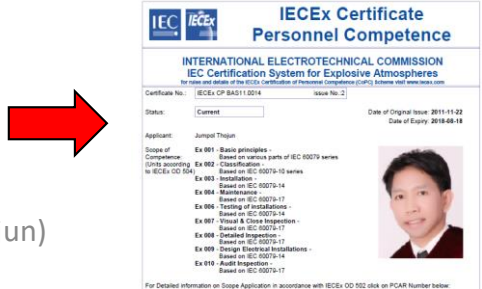
**IECEx Conformity Mark License Scheme**



**IECEx Service Facilities Scheme**  
Certification of Ex Service Providers e.g. Repair and overhaul, Ex Installation, Ex Inspection and MN



**IECEx Certified Persons Scheme (CoPC)**  
Competency to work in Ex field



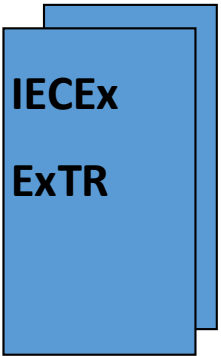
Ex-protection: Equip-Std-Cert (by Jampol Thojun)



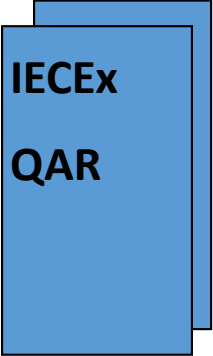
# IECEx Certified Equipment Scheme

IECEx Certificate of Conformity according to OD 009

Product Assess/Testing



Factory Audit + surveillance

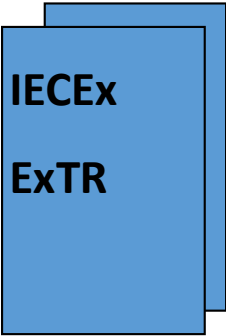


IECEx CoC



IECEx Unit Verification Certificate according to OD 033

Product Assess/Testing



# IEC Standards for Explosive Atmospheres

## Conformity Assessment

verification and tests of Ex Equipment with reference to applicable IEC, ISO standards

**Electrical** => IEC 60079 series

**Non-electrical** => ISO 80079 series

**QS for Mfg.** => ISO/IEC 80079-34





# IECEx Certified Equipment: Equipment Marking

- Standard marking acc. to IEC 60079-0

Ex d IIC T6 Gb

Ex tb IIIC T85°C Db

Equipment: ExConnection Rail Series T04  
*Optional accessory:*

Type of Protection: d, tb, ia, ib, op is, op pr, mb and e



Marking:  
 Basic marking:  
 Ex d IIC T6 Gb  
 Ex tb IIIC T85°C Db IP66  
 Optional and additional Type of Protection markings for all Types see attachment.

#### STANDARDS:

The electrical apparatus and any acceptable variations to it specified in the schedule of this certificate and the identified documents, was found to comply with the following standards:

|                                      |   |
|--------------------------------------|---|
| IEC 60079-0 : 2011<br>Edition:6.0    | Explosive atmospheres - Part 0: General requirements  |
| IEC 60079-1 : 2014-06<br>Edition:7.0 | Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"                         |
| IEC 60079-11 : 2011<br>Edition:6.0   | Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"                             |
| IEC 60079-18 : 2009<br>Edition:3     | Explosive atmospheres - Part 18: Equipment protection by encapsulation "m"                                |
| IEC 60079-28 : 2015<br>Edition:2     | Explosive atmospheres - Part 28: Protection of equipment and transmission systems using optical radiation |
| IEC 60079-31 : 2008<br>Edition:1     | Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t"                      |
| IEC 60079-7 : 2006-07<br>Edition:4   | Explosive atmospheres - Part 7: Equipment protection by increased safety "e"                              |

*This Certificate does not indicate compliance with electrical safety and performance requirements other than those expressly included in the Standards listed above.*

|  |   |   |   |
|--|---|---|---|
|   |   | <b>IECEx Certificate<br/>of Conformity</b>  |   |
| INTERNATIONAL ELECTROTECHNICAL COMMISSION<br>IEC Certification Scheme for Explosive Atmospheres<br><small>for rules and details of the IECEx Scheme visit <a href="http://www.iecex.com">www.iecex.com</a></small> |   |   |   |
| Certificate No.:   | IECEx TUR 16.0025X  | Issue No: 0   | Certificate history:<br>Issue No. 0 (2016-07-06)                                      |
| Status:  | Current   | Page 1 of 3   |   |
| Date of Issue:   | 2016-07-06  |   |   |
| Applicant:   | SAMCON Prozessleittechnik GmbH<br>Schlierstraße 17,<br>D-35102 Lohra-Altenvers<br>Germany |   |   |
| Equipment:<br><i>Optional accessory:</i>   | ExConnection Rail Series T04  |   |   |
|  |   | tb, ia, ib, op is, op pr, mb and e  |   |
|  |   | Basic marking:<br>Ex d IIC T6 Gb<br>Ex tb IIIC T85°C Db IP66<br>Optional and additional Type of Protection markings for all Types see attachment. |   |
|  |   | IECEx   | Dipl.-Ing. Klaus Peter Graf<br><br>Head of Certification Body                         |
| Only be reproduced in full.<br>and remains the property of the issuing body.<br>certificate may be verified by visiting the Official IECEx Website.  |   |   |   |
|  |   | Service GmbH<br>Stein<br>agne<br>Germany  |  |

# Equipment Protection Level - EPL

**EPL:** level of protection assigned to equipment based on likelihood of becoming a source of ignition

| IEC/ EN 60079-0 |       | Directive 2014/34/EU |                    | IEC/ EN 60079-10-x | Explosive Atmosphere |
|-----------------|-------|----------------------|--------------------|--------------------|----------------------|
| EPL             | Group | Equipment Group      | Equipment Category | Zones              |                      |
| Ma              | I     | I                    | M1                 | -                  | Mines                |
| Mb              |       |                      | M2                 | -                  |                      |
| Ga              | II    | II                   | 1G                 | 0                  | Gases<br>Vapours     |
| Gb              |       |                      | 2G                 | 1                  |                      |
| Gc              |       |                      | 3G                 | 2                  |                      |
| Da              | III   | II                   | 1D                 | 20                 | Dusts                |
| Db              |       |                      | 2D                 | 21                 |                      |
| Dc              |       |                      | 3D                 | 22                 |                      |

# Fundamental Disciplines in Ex-field

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- Hazardous area classification => IEC, EN 60079-10-x
- Equipment conformance => IEC, EN 60079-xx, ISO 80079-xx
- Installation conformance => IEC, EN 60079-14
- Operation, Inspection and maintenance => IEC, EN 60079-17
- Repair and overhaul => IEC, EN 60079-19
- Knowledge, skills and competence of people involved

# Thanks for your attention

## Q & A

**Jumpol Thojun**

**Manager, Electrical Engineering**

**Explosion Protection Service**

**TÜV Rheinland Thailand Ltd. Email: [jumpol.thojun@tuv.com](mailto:jumpol.thojun@tuv.com)**



**Safety Case  
Symposium 2018  
Singapore**

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