Ex Management for Explosive Atmosphere, an EPC Contractor point of view

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Abstract –

Managing explosion risk in our industry is a must have. It is not a question of choosing the right equipment for a given risk, but also to deeply understand the context in order to mitigate all possible risks.

This paper will present the organization put in place in an EPC contractor to cover both the competency management along the complete supply chain and the procedures attached in order to control the job down to the establishment of the verification dossier required by IEC 60079-14.

I. INTRODUCTION

Ensuring safety of an EX installation start from design and continue all along the life of the plant by ensuring proper operation and maintenance.
Cost impact of compliance correction at late phase of the project like the startup phase can cost millions of dollars, including change of equipment due to missing certificates or total reinspection of packages component by component due to impossibility to formally prove competency of the different person involved in the different phase of inspection.

The verification dossier is a set of documents showing the compliance of electrical equipment and installations; the guideline is given in section 4.2 of IEC60079-14. Depending on local regulations, it is the base of regulatory inspections all along the life of the plant.
So far, the verification dossier has been considered out of EPC scope of work, in particular the records of the initial inspection and records of installer's/qualified person's declaration. The initial inspections must be performed before plant or equipment is brought into service.

On one of our offshore projects, client Operation & Maintenance team was in charge. The team was mobilized on site just before the plant start-up; and EPC Contractor scope was completed before at mechanical acceptance.

In order to improve the project overall schedule, and also to consider the impact of modularized construction, the records of inspection for assemblies in vendor workshop or pre-installed items in construction yard can be accepted as part of initial inspection records instead of final inspection onboard once construction completed. Thus, Client has requested EPC Contractor to build the verification dossier all along the construction phases.

Unfortunately, and also on other recent projects, it has been identified:

- A lack of knowledge even in our teams with the requirements of IEC 60079 series.
- A lack of Competence in Ex equipment of vendors installers.
- A lack of Inspection requirements (competencies, ressources, ITPs, …)
- A lack of Vendor Surveillance.

Then, a lot of non-conformities to ATEX/IECEx schemes were identified at a late stage of the project, significantly impacting the production start-up date.

So, it has been decided to develop an assessment methodology of the competency of people involved on Ex matters on the projects.

An internal organization and typical procedures and tools have been set up to meet Client expectations and IEC requirements for both competency assessment and verification dossier establishment.

II. EX ORGANIZATION WITHIN EPC

First, a function of "Ex compliance Coordinator" has been created at project level as it is a transverse activity. Its role is to coordinate all actions related to Ex matters management. A split of responsibility within the organization defines the activities to be performed by Ex compliance coordinator, Discipline engineers and Inspection department.

Ex Compliance Coordinator
profile is decided project wise. He/She could be E&I expert, Compliance Manager or Project Engineer.
He/She is a key people in front of authorities, clients, partners and vendors.
He/She is responsible for the overall ATEX/IECEx compliance.

III. ENGINEERING DELIVERABLES

A number of documents need to be elaborated during design phase.

First of all, in order to apply rules of the IEC 60079 and especially comply with the IEC 60079-14 for installation, Engineering/Safety and Loss Prevention shall provide **hazardous area classification** documents (see IEC 60079-10-1) with plans showing the classification and the extent of the hazardous areas including the zoning.

"**Ignition Source Management Execution Plan**" is a guidance document issued by HSED (Health Safety and Environnemental Design) department that describes the procedures, standards and methods used to identify potential ignition sources (not only Equipment subject to Ex classification) appearing within the project. They identify all elements or phenomena that can lead to creation of the spark or hot spot that can ignite the potential Ex atmosphere.

"**Material Job Specification for Supply**" identify the selected protection method to be used according to each zone on the project.

"**E&I Installation specification**" provides the rules and method for safe installation of electrical and instrumentation equipment's, including the cable gland selection guideline (not as simple as it could appear) and other interfaces between zone or devices.

Those last two documents must be communicated to vendors and construction contractor even during the bidding phase in order for them to integrate those constraints in their costs and schedule.

IV. EX PROJECT PROCEDURES

EX MANAGEMENT PLAN :

The purpose of this document is to describe Contractor organization to ensure the Project compliance with Ex requirements (with the IEC 60079 suite of standard, and the ATEX directive requirements, when applicable), for the Engineering, Procurement and Construction.
It also defines the strategy, associated actions and assigned personnel to ensure that the Project will be executed to reach the final compliance to Ex requirements applicable.

INSTRUCTION TO EQUIPMENT VENDORS FOR EXPLOSIVE ATMOSPHERES:

This document defines the requirements applicable to VENDORS in relation to equipment suitable for operation in explosive atmospheres.
This document covers VENDOR's responsibility for compliance from design through procurement, manufacturing and factory inspection and tests.
These requirements shall be used throughout all the project by all parties with scope of work including Electrical and Non-Electrical Equipment for hazardous areas/explosive atmospheres

It must be issued at very early stage of the project, so it can be part of the vendor selection criteria to ensure final compliance of materials.

The typical contents is:

- Main project requirements for Ex material selection.

- Vendor Personnel competency and qualification requirements
- Vendor documentation including: verification dossier summary, Ex register template, list of test reports….
- Check sheet templates,
- Vendor clarification questionnaire

CONTRACTOR VERIFICATION DOSSIER

This is the compilation of the dossiers prepared by vendors for each Purchase Order which contains copies of all engineering documents referenced in the Ex register including but not limited to :

Relevant location drawings,
Certificates of Conformity,
Classification drawings,
Schedules,
Installation and maintenance instructions,
Calculations,
Wiring drawings.
…/…

The database is required to form a traceable set of documentation according to IEC 60079-14 section 4.2, IEC 60079-17 sections 4.1 and 4.2.

V. VENDOR'S MANAGEMENT

VENDORS PERSONNEL COMPETENCY AND QUALIFICATION

- VENDOR and their associated sub-vendors in charge of the design, selection and installation of equipment for explosive atmosphere shall fulfil the competencies and qualification requirements set out in IEC 60079-14 (section 4.5 and Annex A: Knowledge, skills and competencies of responsible persons, operatives/technicians and designers).

- VENDOR shall be able to demonstrate evidence of their personnel attaining the knowledge and skill requirements specified in IEC 60079-14, relevant to the type of protection and/or types of equipment involved.

- An Assessment and Declaration of knowledge, skills and competencies (IEC 60079-14) shall be provided for each employee involved in the project.

- VENDOR's personnel in charge of installation and cabling work shall be suitably trained. Certification of training by cable gland manufacturers is a must.

- VENDOR Quality Manager shall issue an Assessment and Declaration of knowledge, skills and competencies (IEC 60079-14) for the employee(s)/foremen in charge of assessing others.

- VENDOR may hire competent third party service supplier as per above requirements to validate - on their behalf – the design, selection and installation of equipment for explosive atmosphere if they cannot prove competencies of their own team.

- For Inspection, VENDOR shall be able to demonstrate evidence of their inspectors attaining the knowledge and skill requirements specified in IEC 60079-17, relevant to the type of protection and/or types of equipment involved.

VENDOR VERIFICATION DOSSIER SUMMARY

- 'Ex Register' i.e. a schedule of all Electrical and Non Electrical Equipment used in explosive atmosphere
- IEC Ex Certificates of Conformity (or other applicable as per local regulation, ie ATEX in Europe , Gost in Russia, UL in US…)
- 'Ex' Inspection Check-sheets for all tagged equipment for explosive atmosphere within the VENDOR's scope of work
- Records of Maintenance, Repair, and Modification of equipment for explosive atmosphere where applicable
- Personnel Competency Records of Inspectors who signed the check sheets
- Hazardous Areas Calculations :
  - Maximum Power Dissipation
  - Pressurization Calculation
  - Heat tracing Descriptive Documentation
  - IS Descriptive [System] Design Documentation
  - Simple Apparatus Assessment Document
- Engineering Assessments
- Cable Test Results
- Manufacturers (OEM) Manuals

EX REGISTER

A schedule of Electrical Equipment for explosive atmosphere or “Ex Register” shall be provided by each VENDOR to capture all data for identification of ALL electrical, telecommunication and instrument/automation items which will be suitable for use in explosive atmosphere even if they are not located/installed in hazardous area.
Non-Electrical Equipment shall be identified on a separate table, using the same format.

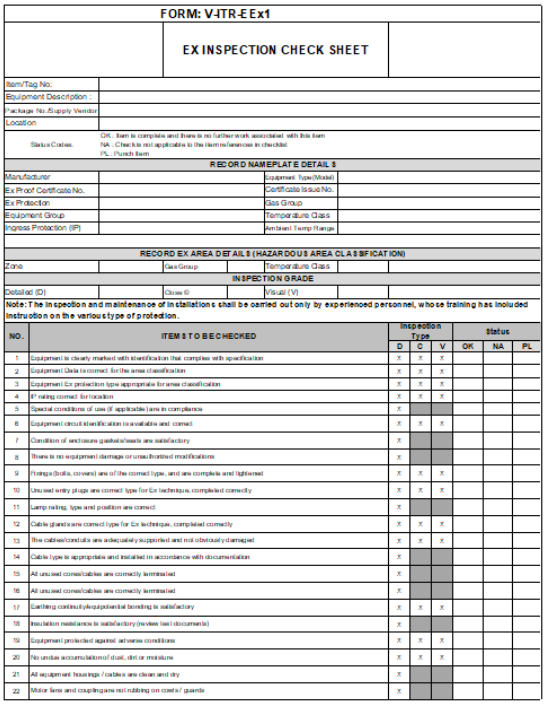
Each item shall be entered, as an individual row, identified according to the project numbering/tagging procedures.

The untagged bulk items (cable glands, reducers, etc.) shall be entered on a separate table with generic reference per model applied.

The Ex register shall provide the reference of the associated “Ex” certificate of Conformity for each item.

EX INSPECTION CHECK SHEET

Typical check sheet are established by type of equipment at the beginning of the contract to ensure that all required data can be collected during execution. Depending on criticality of equipment, different level of examination shall be indicated from Detailed to Verification.



FORM: V-ITR-E Ex1

EX INSPECTION CHECK SHEET

Item/Tag No:	
Equipment Description :	
Package No./Supply Vendor	
Location	

Status Codes: OK : Item is complete and there is no further work associated with this item
NA : Check is not applicable to the item references in checklist
PL : Punch Item

RECORD NAMEPLATE DETAILS

Manufacturer		Equipment Type/Model	
Ex Proof Certificate No.		Certificate Issue No.	
Ex Protection		Gas Group	
Equipment Group		Temperature Class	
Ingress Protection (IP)		Ambient Temp Range	

RECORD EX AREA DETAILS (HAZARDOUS AREA CLASSIFICATION)

Zone		Gas Group		Temperature Class	

INSPECTION GRADE

Detailed (D)		Visual (V)	

Note: The inspection and maintenance of installations shall be carried out only by experienced personnel, whose training has included instruction on the various type of protection.

NO.	ITEMS TO BE CHECKED	Inspection Type			Status		
		D	C	V	OK	NA	PL
1	Equipment is clearly marked with identification that complies with specification		X	X			
2	Equipment Data is correct for the area classification		X	X			
3	Equipment Ex protection type appropriate for area classification		X	X			
4	IP rating correct for location		X	X			
5	Special conditions of use (if applicable) are in compliance		X				
6	Equipment circuit identification is available and correct		X	X			
7	Condition of enclosure gaskets/seals are satisfactory		X				
8	There is no equipment damage or unauthorised modifications		X				
9	Fixings (bolts, covers) are of the correct type, and are complete and tightened		X	X			
10	Unused entry plugs are correct type for Ex technique, completed correctly		X	X			
11	Lamp rating, type and position are correct		X				
12	Cable glands are correct type for Ex technique, completed correctly		X	X			
13	The cables/conduits are adequately supported and not obviously damaged		X	X			
14	Cable type is appropriate and installed in accordance with documentation		X				
15	All unused cores/cables are correctly terminated		X				
16	All unused cores/cables are correctly terminated		X				
17	Earthing continuity/equipotential bonding is satisfactory		X	X			
18	Insulation resistance is satisfactory (review test documents)		X				
19	Equipment protected against adverse conditions		X	X			
20	No undue accumulation of dust, dirt or moisture		X	X			
21	All equipment housings / cables are clean and dry		X				
22	Motor fans and couplings are not rubbing on cowls / guards		X				

VENDOR CLARIFICATION QUESTIONNAIRE

CONTRACTOR shall assess the competency of VENDOR’s team prior to issue of purchase order. Reviewing responses to the EEA (Equipment for Explosive Atmosphere) Vendor Clarification Questionnaire will help to ensure this.

	Score table for IECEx vendor assessment ranking
Score	Installation
4	IECEx CoPC Ex 003
3	Compex, ISM ATEX, EEHA or equivalent
1	Self declaration
0	no declaration
Score	Inspection
5	IECEx CoPC Ex 008
4	Recognized Third Party
3	IECEx CoPC Ex 007, Compex, ISM ATEX, EEHA or equivalent
1	Self declaration
0	no declaration
Score	Ex instruction to Vendor check list
3	Fully filled and compliant
1	not fully filled
0	no answer
Score	Previous vendor Experiences with IECEx
4	Major project vendor
2	Other similar project
0	no experience

The total score evaluation is part of the vendor selection process.
The level of vendor surveillance by CONTRACTOR will be adjusted based the vendor score.

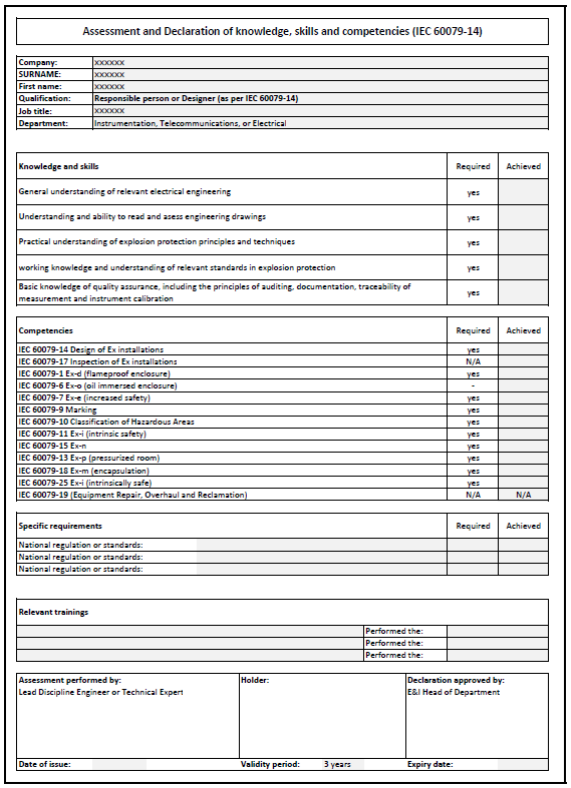
VI. EPC CONTRACTOR PERSONNEL COMPETENCY

Selected E&I and Telecommunications engineers (responsible persons) or designers (specifying, requisitioning, or reviewing technical vendor documentation) with apparatus located in a hazardous area shall be able to demonstrate their competencies and to provide evidence of attaining the knowledge and skill required to select and design installation of Ex equipment.

The competencies and qualifications of personnel involved in “Ex” equipment shall fulfill the requirements specified in the IEC 60079-14 (Annex A: Knowledge, skills and competencies of responsible persons, operatives and designers) relevant to the types of protection and/or types of equipment involved.

A competency Matrix allows the identification of potential gaps to be filled in for ensuring competence of the engineers (responsible persons), operatives, designers, dealing with “Ex” equipment on Project.

An example of competency matrix is given below:



Assessment and Declaration of knowledge, skills and competencies (IEC 60079-14)

Company:	xxxxxx
SURNAME:	xxxxxx
First name:	xxxxxx
Qualification:	Responsible person or Designer (as per IEC 60079-14)
Job title:	xxxxxx
Department:	Instrumentation, Telecommunications, or Electrical

Knowledge and skills	Required	Achieved
General understanding of relevant electrical engineering	yes	
Understanding and ability to read and asess engineering drawings	yes	
Practical understanding of explosion protection principles and techniques	yes	
working knowledge and understanding of relevant standards in explosion protection	yes	
Basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration	yes	

Competencies	Required	Achieved
IEC 60079-14 Design of Ex installations	yes	
IEC 60079-17 Inspection of Ex installations	N/A	
IEC 60079-1 Ex=d (flameproof enclosure)	yes	
IEC 60079-6 Ex=o (oil immersed enclosure)	-	
IEC 60079-7 Ex=e (increased safety)	yes	
IEC 60079-9 Marking	yes	
IEC 60079-10 Classification of Hazardous Areas	yes	
IEC 60079-11 Ex=i (intrinsic safety)	yes	
IEC 60079-15 Ex=n	yes	
IEC 60079-13 Ex=p (pressurized room)	yes	
IEC 60079-18 Ex=m (encapsulation)	yes	
IEC 60079-25 Ex=i (intrinsically safe)	yes	
IEC 60079-19 (Equipment Repair, Overhaul and Reclamation)	N/A	N/A

Specific requirements	Required	Achieved
National regulation or standards:		
National regulation or standards:		
National regulation or standards:		

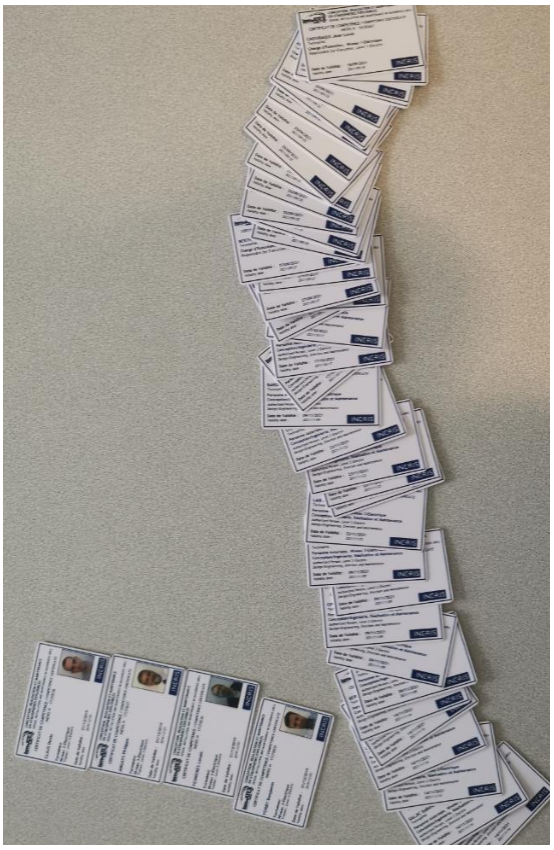
Relevant trainings		
	Performed the:	
	Performed the:	
	Performed the:	

Assessment performed by: Lead Discipline Engineer or Technical Expert	Holder:	Declaration approved by: E&I Head of Department
Date of issue:	Validity period: 3 years	Expiry date:

Competency will be assessed by the Lead Discipline Engineer and/or Technical Expert, and approved by the E&I Head of Department.

A pool of 4 Experts have been trained to be trainers based on a recognized Certified Body referential. Trainers hold the Certified Body certificates.

More than 100 engineers have been trained within three years, mainly E&I engineer but also non-technical personnel like project or quality managers, and each of them has received a nominated Certified Body certificate valid for two years.



For Inspection activities, it is recommended to select a recognized certified personnel IECEx CoPC Ex08, Compex Ex04, or equivalent. But this mainly driven by customer requirement according to its own procedures.

VII. EX EQUIPMENT INSPECTION

Prior to Inspection, Ex register and Verification Dossier shall be in place and approved, as per Inspection and Test Plan requirements.

Moreover, in order to detect and fix any “Ex” related issues, EPC CONTRACTOR should, at different stages of the project, check through surveys and inspections, that the construction, installation, and inspection of these Ex Equipment are in accordance with the “Ex” requirements. Inspection plan should reflect with adequate Hold points.

Ex Inspector shall get from Engineering all relevant documents to perform the Inspection.

Prior to the final inspection (before shipping), Vendor Inspectors shall use Initial Detailed Inspection (IDI) Ex check sheets identical to the ones provided in IEC 60079-17 - Tables 1,2,3 or using the project template to assess the compliance with regard to the IEC 60079 (series) requirements for each Ex item.

The inspections shall be based on the "D" detailed grade of inspection columns from Tables 1,2,3."

Level of sample inspection check by CONTRACTOR Inspectors will be set based on:

- previous experience with the selected vendor regarding Ex matters,
- level of competency of Vendor Inspectors,
- level of quality of Ex information on Engineering vendor documents.

Some of the items which need to be systematically addressed during the final inspections with EPC CONTRACTOR are listed below:

- During (or prior to) this inspection, the manufacturers shall also provide satisfactory evidence that they have put in place some specific action / carried out detailed inspections for ensuring that the Ex rated Electrical, Instrumentation, Telecommunications equipment, components and Instruments of the package have been installed / integrated in the package according to the “Ex” requirements and Project specifications.
- “Ex” register with regard to the Equipment actually installed in the package, including all relevant documentation and vendor redline markups.
- Temperature range of marking in accordance with project ambient temperature range
- For cables glands, sample inspection of the glands can be a first step. But if too much non-conformities are found, a more detailed inspection would provide a clear status of the manufacturer’s quality/performance for cable glanding.
- Cables insulation measures
- Cables wiring into Junction Boxes
- Earth bonding according to project standards

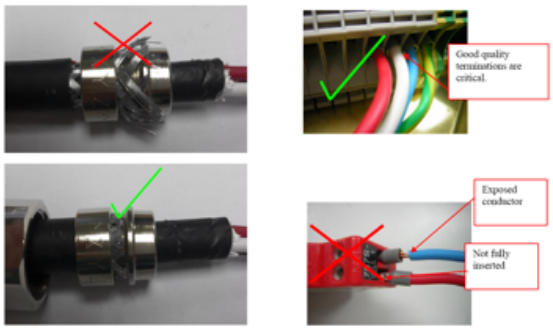
The following guide should be used when transferring a non-compliance to the Punch List during an Ex Inspection. If the non-compliance affects the integrity of the Ex protection technique and where the non-compliance increases the risk that the integrity of the Ex protection technique is affected, this shall be defined as a Punch List Category "A" and the inspection check sheet won't be signed off.

Such examples of a punch list Category "A" could be, but not limited to, the following:

- Damaged equipment affecting the IP rating / Ex protection technique
- Heat Dissipation Calculation and/or IS Calculation / Simple Apparatus Assessment not completed
- Cable glanding not completed correctly or internal seal damaged
- IECEx CoC not available or ATEX declaration not provided
- Broken terminals
- Thread Sealant used on Ex-d flame paths
- Incorrect crimping
- Damaged Flame paths on Ex d
- IP seals damaged or missing on Ex e
- Incorrect fasteners or covers' screws/bolts missing, damaged or of incorrect type
- Not compliant to special condition "x" of certificate
- Missing Ex certified plugs on free opening
- Missing or wrong Ex nameplate
- Where a temporary cable for the space heater is connected, Ex inspection will be accepted for subsystem construction completion but a final inspection will be carried out before the energization.

If a non-compliance does not affect the integrity of the Ex protection technique and there is no risk that the integrity of the Ex protection technique could be affected, then this shall be defined as a punch list "B" or "C" and the inspection check sheet can be signed off.

This should be carefully evaluated on a case by case basis and it is a major reason for using certified and experienced inspector to make this evaluation.



VII. COMPLETION DATABASE

During Construction and Commissioning activities, Ex documents are collected and maintained in the completion database.

Where initial detailed inspections have been completed and signed off during the project completion phases, no further inspections are required for at least three years after the Ex equipment is actually put in service i.e. energized and the areas of the facility have become hazardous; as defined in IEC60079-17.

Typical examples of number of Ex tags in completion databases:

- North Sea Platform: 28 000 tags
- FPSO: 65 000 tags
- FLNG: 88 000 tags

VIII. CONCLUSION

Management of Ex matters in project is a complex and transverse activity, impacting all stages of the project from specification and procurement to final inspection and start up.

The EPC Contractor scope of work and its limit for management of explosive atmosphere matters shall be clearly identified in the contract and dully agreed with customer from the very beginning.

Then, a number of competent people dully confirmed shall be assigned to the project to ensure full compliance to ATEX/IECEx schemes. However standard do not define the way this competency must be certified. So from the beginning of the project, method for this assessment shall be agreed between contractor, customer and also notified body or local

authorities in charge of final plant acceptance for operation.

The cost and schedule impacts of Ex matters for EPC Contractor shall be carefully integrated in the overall costs of the project as it can be quite significant, but anyway less than complete reinspection of a fully complete plant as inspections on basic package or vendor competency has been incorrectly managed.

IX. REFERENCES

[1] IEC 60079-14 Explosive atmospheres - Part 14: Electrical installations design, selection and erection.

[2] IEC 60079-17 Explosive atmospheres - Part 17: Electrical installations inspection and maintenance

X. VITA

Lénaïc Fesnières has more than 20 years' experience in the field of instrument installation engineering & detailed studies, in particular in Chemicals, Petrochemicals, Oil Refining, Gas Treatment, LNG trains and onshore & offshore units LSTK projects.
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