



**HAL**  
open science

## Offshore Oil and Gas Safety: Protection against Explosions

Dejan Brkić, Zoran Stajić

► **To cite this version:**

Dejan Brkić, Zoran Stajić. Offshore Oil and Gas Safety: Protection against Explosions. Journal of Marine Science and Engineering, 2021, 9 (3), pp.331. 10.3390/jmse9030331 . hal-03173057

**HAL Id: hal-03173057**

**<https://hal.science/hal-03173057>**

Submitted on 18 Mar 2021

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Technical Note

# Offshore Oil and Gas Safety: Protection against Explosions

Dejan Brkić <sup>1,2,\*</sup> and Zoran Stajić <sup>1,3</sup>

<sup>1</sup> Faculty of Electronic Engineering, University of Niš, 18000 Niš, Serbia; zoran.stajic@elfak.ni.ac.rs

<sup>2</sup> IT4Innovations, VŠB—Technical University of Ostrava, 708 00 Ostrava, Czech Republic

<sup>3</sup> Research and Development Centre IRC Alfatec, 18000 Niš, Serbia

\* Correspondence: dejan.brkic@elfak.ni.ac.rs or dejanbrkic0611@gmail.com

**Abstract:** Offshore oil and gas operations carry a high risk of explosions, which can be efficiently prevented in many cases. The two most used approaches for prevention are: (1) the “International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres” (IECEX) and (2) European “Atmosphere Explosible” (ATEX) schemes. The main shortcoming for the IECEX scheme is in the fact that it does not cover nonelectrical equipment, while for the ATEX scheme, it is due to the allowed self-certification for a certain category of equipment in areas with a low probability of explosions, as well as the fact that it explicitly excludes mobile offshore drilling units from its scope. An advantage of the IECEX scheme is that it is prescribed by the US Coast Guard for protection against explosions on foreign mobile offshore drilling units, which intend to work on the US continental shelf but have never operated there before, with an additional requirement that the certificates should be obtained through a US-based Certified Body (ExCB). Therefore, to avoid bureaucratic obstacles and to be allowed to operate with minimized additional costs both in the US and the EU/EEA’s offshore jurisdictions (and very possibly worldwide), all mobile offshore drilling units should be certified preferably as required by the US Coast Guard.

**Keywords:** safety legislation; market access; explosions; ATEX; IECEX; offshore oil and gas; certified equipment; hazardous area classification; gas atmospheres; international standards



**Citation:** Brkić, D.; Stajić, Z. Offshore Oil and Gas Safety: Protection against Explosions. *J. Mar. Sci. Eng.* **2021**, *9*, 331. <https://doi.org/10.3390/jmse9030331>

Academic Editor: José A. F. O. Correia

Received: 24 February 2021

Accepted: 15 March 2021

Published: 16 March 2021

**Publisher’s Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



**Copyright:** © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

## 1. Introduction

The offshore oil and gas industry involves many risks of explosions for personnel and installations. Explosions can occur under certain conditions in the presence of a mixture of air and released hydrocarbon gases due to a number of different reasons, including blowouts, the use of inadequate equipment or its malfunction, negligence, lack of training, poor or incomplete maintenance, etc., while sources of ignition can include naked flames, electrical sparks, static electricity, hot surfaces, friction, ionizing radiation, ultrasound, hot gases, etc. (e.g., methane is capable to cause an explosion in concentration between 4.4% and 16.5% in its mixture with air, while the ignition temperature for methane should be  $\geq 595$  °C).

Protection against explosions on mobile offshore drilling units needs to be arranged through worldwide accepted regulations at the lowest possible cost, which will be accepted by most host countries, while on fixed platforms, it needs only to fulfill legislative requirements of the host country. Two main approaches for protection against explosions are the “International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres” (IECEX) [1] and the European “ATmosphere EXplosible” (ATEX) schemes (the ATEX approach can be treated as a regional European version of the IECEX approach, while certain differences can be noted) [2–4].

Offshore oil and gas operations typically start with a relatively short one-off drilling phase performed by mobile offshore drilling units [5], which is shortly after replaced with a long-lasting exploitation phase that can take several years and even decades and is performed from fixed production platforms. Legislative requirements for protection against

explosions on fixed platforms and offshore drilling ships are very often different (also, the legislatures treats a certain type of ships as fixed platforms, e.g., floating production storage and offloading units are typical ships in terms of shape, navigation, and propulsion, but they are treated as fixed facilities in terms of legislative requirements for protection against explosions because, as a rule, they are settled for a long time or even permanently at one place; although anchored in a similar way as ships).

The EU/EEA and the USA require different levels of protection against explosions for oil and gas mobile offshore drilling units compared with their related requirements imposed for fixed offshore platforms and offshore (Table 1). Both the ATEX and IECEx schemes provide a high level of protection against explosions but with some differences that are described in this note [6,7].

**Table 1.** Protection scheme against explosion on the US and the EU/EEA continental shelf <sup>1</sup>.

ATEX	IECEx
Fixed platforms (including equipment onboard) on the EU/EEA continental shelf	Mobile units (including equipment onboard) on the EU/EEA continental shelf <sup>2</sup>
Facilities and equipment onshore the EU/EEA	Foreign mobile units (including equipment onboard) on the US continental shelf <sup>3</sup>

<sup>1</sup> US onshore installations and US domestic mobile units (including equipment onboard) operating on the US continental shelf are covered through the US National Electrical Code (NEC) and need to be certified through a Nationally Recognized Testing Laboratory (NRTL). <sup>2</sup> Practically prescribed by the IMO MODU Code. “Code for the Construction and Equipment of Mobile Offshore Drilling Units” by the International Maritime Organization. <sup>3</sup> Need to be certified through a US-based “International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres” (IECEx) body if they intend to operate on the US continental shelf but had never operated before there (foreign mobile units with equipment onboard that frequently operate on the US continental shelf need to follow the same rules as US domestic vessels).

## 2. Main Certification Schemes for Protection against Explosions

The principles for the classification of equipment proofed for use in areas with a higher risk of explosions are similar in most countries, and they are based on requirements introduced by the International Electrotechnical Commission (IEC) [8]. Despite this fact, many local modifications and variants exist.

ATEX protection is described in Section 2.1 and IECEx in Section 2.2. Although based on the almost same principles but with some modifications, as described in Section 2.3, various certification schemes for protection against explosions are available and required for use in different countries. Section 2.3.1 describes the situation in the USA, Section 2.3.2 in Canada, Section 2.3.3 in the Eurasian Union (Armenia, Belarus, Russia, Kazakhstan, and Kyrgyzstan), Section 2.3.4 in China, Section 2.3.5 in Brazil, and Section 2.3.6 in Australia, together with New Zealand.

### 2.1. European “ATmosphere Explosible” (ATEX)

Two European ATEX directives are available for protection in explosive atmospheres (ATEX is a French acronym for “ATmosphere EXplosible”):

- (1) 1999/92/EC ATEX directive for the protection of the user (personnel and workers)—“Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres”;
- (2) 2014/34/EU ATEX directive for product safety—“Equipment and protective systems intended for use in potentially explosive atmospheres,” a new version of 94/9/EC.

Using the ATEX scheme, equipment shall be certified through one of the European notified bodies listed in the “New Approach Notified and Designated Organizations” (NANDO) database. The obligatory certification has been in force since 1 July 2003 through the 94/9/EC directive and since 20 April 2016 through the related recast 2014/34/EU of the previous directive. Both ATEX directives for product safety (2014/34/EU) and the protection of the user (personnel and workers) (1999/92/EC) are mandatory in the EU/EEA.

The new goal-oriented European approach [2], which has been in force since 2000, allows the use of any available technical standard that can assure application of the obligatory directives, such as ATEX. Instead of referring to a certain list of harmonized standards (the European Standards Committee (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) define the harmonized standards), the directives prescribe Essential Health and Safety Requirements (EHSRs) that shall be fulfilled. The use of harmonized technical standards gives only a presumption of conformity to the directives, while compliance only to the Essential Health and Safety Requirements (EHSRs) is considered full conformity (to achieve that, any appropriate available technical standard can be used).

The ATEX directive for product safety covers electrical equipment, nonelectrical equipment such as mechanical, hydraulic (pumps), and pneumatic equipment, including assemblies, protective systems, components (push button, relays, valves), controlling and regulating devices, etc. The ATEX directive for product safety deals with both electrical and nonelectrical equipment. Such equipment is divided into (i) Groups and (ii) Categories and can be placed in (iii) Zones, as shown in Table 2.:

**Table 2.** Groups, Categories, and Zones prescribed by the “ATmosphere EXplosible” (ATEX) directive.

<b>(i) Groups</b>	
Group I	Relevant to underground coal mines, where the occurrence of dust and methane firedamp is frequent [9–14]
Group II	Relevant to the oil and gas industry and refers to potentially gaseous explosive atmospheres
<b>(ii) Categories</b>	
Category 1	Most strict and intended for use in areas with the highest risk of explosions
Category 2	For use in areas in which explosive atmospheres are likely to occur
Category 3	For areas with a low probability for explosions
<b>(iii) Hazardous Zones</b>	
Zone 0	An explosive atmosphere is present continuously, for long periods, or frequently
Zone 1	An explosive atmosphere is likely to occur occasionally in normal operation
Zone 2	An explosive atmosphere is not likely to occur during normal operations (if it occurs, it only persists for a short period)

For Categories 1 and 2, the procedure to affix the CE marking following appropriate type-examination procedures shall be issued by a notified body, while for Category 3, the manufacturer can ensure full conformity. The European auxiliary “Ex” mark, together with the European general mark for conformity “CE,” shall be affixed on the certified equipment.

Group II of equipment for use in offshore oil and gas installations is divided into Categories, which can be used or installed in hazardous Zones, as given in Table 3.

**Table 3.** Use of Group II of equipment in Hazardous Zones depending on its Category.

Zone	Category
Zone 0	Category 1
Zone 1	Category 1 or 2
Zone 3	Category 1, 2, or 3

Categories of equipment and Hazardous Zones [15–19] can be determined by using any of the available technical standards. For electrical equipment, IEC 60079: Explosive atmospheres—CENELEC 60079 series can be used, and for nonelectrical equipment, EN 13463 series (EN ISO 80079) can be used. The types of protection are given in Table 4.

**Table 4.** Examples of types of protection for a certain Zone<sup>1</sup>.

Zone	Types of Protection	Technical Standard
Zone 0	Ex ia—Intrinsic safety (higher grade)	IEC EN 60079-11
	Ex s—Specifically designed for Zone 0	IEC 60079-33
Zone 0 and 1	Ex ib—Intrinsic safety (lower grade)	IEC EN 60079-11
	Ex d—Flameproof enclosures	EN 13463-3 and IEC EN 60079-1
	Ex e—Increased safety	IEC EN 60079-7
	Ex p—Pressurizations	IEC EN 60079-2 and 13
Zone 0, 1, and 2	Ex n—Type of protection	IEC EN 60079-15
	Ex o—Oil immersed	IEC EN 60079-6
	Ex q—Powder filled	IEC EN 60079-5

<sup>1</sup> Certain technical standards such as EN 13463-3 cover nonelectrical equipment, and such standards do not have an IEC equivalent, while certain such as IEC 60079-33 are not harmonized with the ATEX directive and hence not marked as EN (not developed by the CEN/CENELEC) but can be used if they meet the Essential Health and Safety Requirements of the ATEX directive.

Zones are determined by the grade of release: (1) continuous grade, (2) periodically or occasionally, and (3) normally not to expect; by the degree of ventilation: (1) high, (2) medium, and (3) low; and by availability of ventilation: (1) good, (2) fair, and (3) poor. The potentially explosive atmosphere can be prevented from igniting if the surface temperature of the item of equipment is lower than the ignition temperature of the surrounding gas, while the temperature classes for Europe and the USA are maximal ( $T_1 = 450\text{ °C}$ ,  $T_2 = 300\text{ °C}$ ,  $T_3 = 200\text{ °C}$ ,  $T_4 = 135\text{ °C}$ ,  $T_5 = 100\text{ °C}$ , and  $T_6 = 85\text{ °C}$  (subcategories exist in the USA)). The gas groups are I—methane, IIA—propane, IIB—ethylene, IIC—acetylene, and hydrogen, etc. (ignition energy is I—280 μJ, IIA—160 μJ, IIB—80 μJ, and IIC—20 μJ) [20,21].

Use of the 2014/34/EU directive for product safety is obligatory in the EU/EEA, both onshore and offshore, with the exception of mobile drilling units operated on the EU/EEA continental shelf. On the other hand, the 2013/30/EU directive for overall oil and gas offshore safety requires the use of all the best worldwide available technical standards [22] and prescribes the use of the IMO MODU Code, “Code for the Construction and Equipment of Mobile Offshore Drilling Units” by the International Maritime Organization, which, in practice, requires the use of the IECEx scheme for protection on mobile drilling units.

*2.2. “International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres” (IECEx)*

The “International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres” (IECEx) scheme is not mandatory [1], but it is widely used in the offshore oil and gas industry and especially on mobile offshore drilling units in the US and EU/EEA’s offshore jurisdictions.

The IECEx certification scheme is operated by International Electrotechnical Commission (IEC), and it is based on its technical standards [23–26]. Around 30 nations participate in the IECEx scheme for protection against explosions, and many are based on it, such as the already described European ATEX, as well as many others described in Section 2.3. A nation without its own national scheme for protection against explosions can adopt the IECEx scheme to fill its legislative gaps using a pretailored model for regulation in the sector of equipment used in environments with an explosive atmosphere through the United Nations Economic Commission for Europe (UNECE) [27].

The offshore oil and gas industry under the IECEx scheme uses the same classification of equipment as under the ATEX protective scheme: Groups, Categories of equipment, and Hazardous Zones (Technical Committee 31 of the IEC is responsible for equipment for explosive atmospheres). The IEC 60079 series of Technical Standards can be used, but in the offshore industry, the Recommended Practice by the American Petroleum Institute API505 “Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2” is more used (a similar approach is used in the US onshore industry through the NEC505, as described in Section 2.3.1) [16]. The requirements

between these two approaches for Hazardous Zones are similar; the IEC 60079 is more analytical, while the RP API505 is more prescriptive [6].

Certificates issued by the IECEx scheme are listed on its website; therefore, their validity can be verified in a very convenient way. Under the IECEx scheme, four types of certificates can be issued:

- (1) **Equipment**—Only technical standards issued by Technical Committee 31 “Equipment for explosive atmospheres” of the International Electrotechnical Commission (IEC) can be used for the certification of equipment (only electrical equipment can be certified), while the certification through an IECEx Certification Body (ExCB) is required for all Categories of equipment (Categories 1, 2, and 3 in IECEx Ga, Gb, and Gc, respectively) (ATEX allows for the self-certification of equipment by the manufacturer in Category 3);
- (2) **Service Facilities**—In addition to the certification of equipment, the IECEx scheme allows the certification of the repair and overhaul of equipment (nothing similar is available in the ATEX scheme);
- (3) **Persons**—Certification for qualified persons who were properly trained and meet the prerequisites to implement safety requirement required by the IECEx scheme (nothing similar is available in the ATEX scheme);
- (4) **Conformity Mark**—It is issued by approved IECEx Certification Bodies (ExCBs) for the equipment manufactured and tested using appropriate IEC technical standards.

### 2.3. Other Main Certification Schemes for Protection against Explosions

Possession of the IECEx or ATEX certifications cannot replace the obligatory certification imposed by most countries but can facilitate and support a procedure to apply for it. The IECEx Test Report is likely to be accepted as a base for national certification in the USA, Canada, Russia, Ukraine, Belarus, China, South Korea, India, Brazil, Argentina, Chile, South Africa, etc. Some countries, such as China, also accept the ATEX certificate as a base for its national certification. On the other hand, the ATEX Test Report can be used as a base for a national certificate in Hong Kong (special administrative region of China), Taiwan (de facto different legislation apply, but de jure part of China), Vietnam, Indonesia, etc. Finally, in some countries, such as in Japan, many domestic tests are required, and the IECEx or the ATEX Test Reports cannot facilitate the procedure.

#### 2.3.1. USA

The Occupational Safety and Health Administration (OSHA) requires certification against explosions through one of its Nationally Recognized Testing Laboratories (NRTLs). In the National Electrical Code and National Fire Protection Association prescript NEC/NFPA 70 for hazardous areas, NEC500 is based on a two-division classification of hazardous locations, while NEC505 is based on a three-zone classification. The three-zone area classification system is compatible with the IEC 60079 series of technical standards for explosive atmospheres; such an approach is compatible with the IECEx scheme and can be used as a basis for obtaining certification for the protection of equipment installed/or used on mobile offshore drilling units on the US offshore continental shelf. Certified equipment for use in areas protected against explosions shall be marked with a label of a Nationally Recognized Testing Laboratory (NRTL). In the offshore sector in the USA, the Bureau of Safety and Environmental Enforcement (BSEE) has authority over fixed platforms and the United States Coast Guard (USCG) over mobile units (ruling published in the Federal Register (Vol. 80, No. 61) on 31 March, 2015, and came into force on 2 April 2018). The IECEx certificates are not directly accepted under the National Electrical Code (NEC) in the USA, but the IECEx Test Report can facilitate appropriate US certification (only electrical equipment can be certified against explosions).

#### 2.3.2. Canada

Similar rules for protection against explosions as in the USA are in force in Canada. The Standards Council of Canada (SCC) requires certification through one of its recog-



nized certification bodies, while product approval related to electrical safety is under the jurisdiction of Provincial Governments. Classification of hazardous areas is based on the three-zone classification, as prescribed by the Canadian Electrical Code (CEC) (two-division classification is also accepted) and is compatible with the IEC 60079 series of technical standards for explosive atmospheres. Certified equipment shall be marked with a label of a recognized Canadian certification body. The IECEx certificate can be used as a basis for obtaining Canadian certification.

#### 2.3.3. Eurasian Union

The Eurasian Union (ex. Customs Union; Armenia, Belarus, Russian Federation, Kazakhstan, Kyrgyzstan) requires technical regulations GOST/CU-TR on the safety of equipment in explosion hazardous environments issued by the Euro-Asian Council for Standardization, Metrology, and Certification (EASC). Only electrical equipment can be certified (in practice, only equipment that satisfies at least the ATEX level of protection can be certified). The appropriate product conformity mark of the Eurasian Union shall be affixed on the certified equipment.

#### 2.3.4. China

The Chinese State Administration for Market Regulation (SAMR) requires a China Compulsory Certificate (CCC) Ex certification for protection against explosions (ATEX and IECEx certificates are not accepted, but if they exist, they can significantly reduce the work and preparation effort for the CCC certification). The China Compulsory Certificate mark, commonly known as a CCC mark, shall be affixed on the certified equipment.

#### 2.3.5. Brazil

The Brazilian Ministry of Development, Industry and Foreign Trade, requires a certification against explosions by the National Institute of Metrology, Standardization and Industrial Quality (INMETRO). Brazilian certification bodies accept IECEx tests as a base for the certificate [28]. The INMETRO mark shall be affixed on the certified equipment.

#### 2.3.6. Australia and New Zealand

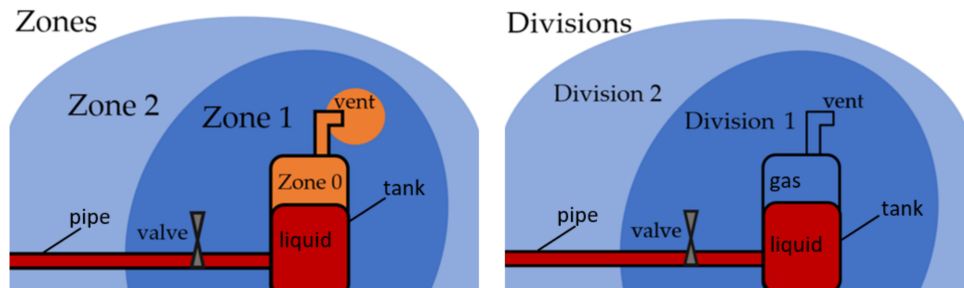
In Australia and New Zealand, an ANZEx certification against explosions is required. To obtain it, an IECEx certificate is sufficient, and only certain national differences need to be tested additionally (the IECEx certification will be directly accepted for Group II equipment).

### 3. Differences between the ATEX and IECEx Certification Schemes

Historically, the National Electrical Code (NEC), established in 1947 as a concept of areas with two Divisions, followed by the American Petroleum Institute (API), which started related work in 1951 on its area classification document API500 based on Divisions (API500A for electrical installations in petroleum refineries was finalized in 1955, initially without the suffix "A;" API500B for electrical installations at drilling rigs and production facilities on land and marine platforms was finalized in 1961; and API500C for electrical installations at pipelines was finalized in 1966. These merged in 1991 into a single API 500 document [29]). API 500 is based on a hazardous area classification based on two Divisions, while API 505, introduced in 1997 [30], is based on three Zones (both the ATEX and IECEx schemes are based on Zone classification) [31] (Table 5 and Figure 1). After these early efforts, which were made in the USA and followed by many countries, the first international system for protection against explosions is dated in 1996 when IECEx was established and in 2003 when the first certificates were issued (IEC-60079-10-1 is compatible with US API 505 for the classification of hazardous areas). In Europe, the history of ATEX directives started also in the 1990s.

**Table 5.** Zone and Division systems: a comparison.

API 505, IEC-60079-10-1	Zone 0	Zone 1	Zone 2
Presence of explosive gases	>1000 h/year	10 to 1000 h/year	<10 h/year
API 500	Division 1	Division 1	Division 2
Presence of explosive gases	>10 h/year	>10 h/year	<10 h/year



**Figure 1.** Zone and Division Systems: an illustrative example.

Categories of equipment in the ATEX and IECEx schemes are equivalent are given in Table 6, where G refers to gaseous potentially explosive atmospheres.

**Table 6.** Categories of equipment in the ATEX and IECEx schemes.

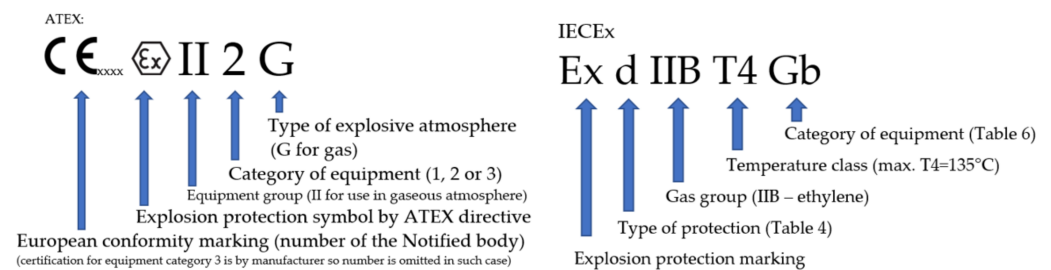
ATEX	Group 1G	Group 2G	Group 3G
IECEx	Group Ga	Group Gb	Group Gc

The main differences between the ATEX and IECEx protection schemes are:

- In the EU/EEA, the ATEX scheme is mandatory, and it is developed by the European Commission (government), while the IECEx scheme is operated by the International Electrotechnical Commission (IEC), i.e., regulated through an industry representative at international level.
- Safety of personnel is regulated under the ATEX scheme through the mandatory use of a separate directive, 1999/92/EC, while nothing similar is available through the IECEx.
- A certificate through an ATEX Notified Body is mandatory for equipment in Categories 1 and 2, while self-certification by the manufacturer is allowed for equipment in Category 3 (on the other hand, the IECEx scheme requires attestation of all categories of equipment through its Certified Bodies (ExCBs)).
- The ATEX scheme requires certification through any available technical standards that can meet Essential Health and Safety Requirements of the ATEX directives, while the IECEx requires use of the technical standards developed only by the International Electrotechnical Commission (IEC).
- Although the ATEX scheme uses terms “equipment” and “protective systems,” it covers both electrical and nonelectrical equipment (EN 13463 and EN ISO 80079 “Non-electrical equipment for explosive atmospheres”), while the IECEx covers only electrical equipment.
- Protection of certain Categories of equipment is sometimes different in the ATEX and IECEx schemes (every individual case should be studied if different protections are required) [32–34].
- The ATEX scheme explicitly does not include mobile offshore drilling units in its scope.

Different marking of equipment is required using the ATEX and IECEx schemes (Figure 2).





**Figure 2.** Marking according to the ATEX and the IECEx schemes for protection against explosions.

#### 4. Conclusions

All European Directives are designed to protect the European single market in the first place, but in respect to protection against explosion on mobile offshore units for oil and gas drilling in the EU/EEA offshore continental shelf, some concerns exist if the European market is fully protected. Furthermore, mobile units in the EU/EEA offshore jurisdiction are excluded out of the scope of the ATEX Directive 2014/34/EU-ATEX by Article 1, Section 2(e): “This Directive shall not apply to: seagoing vessels and mobile offshore units together with equipment on board such vessels or units.” On the other hand, the US market is fully protected due to the fact that the US Coast Guard requires the use of domestic protection scheme on the US offshore continental shelf for foreign mobile drilling units, while foreign-flagged vessels that have never operated, but intend to operate under the US offshore jurisdiction, should be certified through the IECEx scheme against explosions by a domestic US-based Certified Body (ExCB). In all other cases, full compliance with US regulations is obligatory.

No main differences between the ATEX and the IECEx systems for protection against explosions are detected. A shortcoming for the ATEX scheme is due to the allowed self-certification for the equipment Category 3, which should be placed in Hazardous Zone 2, while for the IECEx in the fact that it does not cover nonelectrical equipment.

Mobile offshore drilling units [35–38] should be preferably certified through a US-based Certified Bodies (ExCB)) using the IECEx protective scheme against explosions because such units will be allowed to operate with minimized additional costs, both in US and EU/EEA’s offshore jurisdictions (and very possible worldwide). On the other hand, fixed offshore platforms should be certified strictly following the rules of host countries.

**Author Contributions:** D.B. has extensive experience with offshore oil and gas operations and Z.S. in design and practical use of electrical equipment. D.B. and Z.S. in particular contributed to this article with: Conceptualization, D.B.; methodology, D.B.; validation, D.B. and Z.S.; formal analysis, D.B.; investigation, D.B. and Z.S.; writing—original draft preparation, D.B.; writing—review and editing, D.B.; supervision, Z.S.; project administration, D.B.; funding acquisition. Both authors have read and agreed to the published version of the manuscript.

**Funding:** The work of Z.S. and D.B. has been supported by the Ministry of Education, Science, and Technological Development of Serbia, and the work of D.B. has been supported by the Technology Agency of Czechia through the project “Center of Energy and Environmental Technologies” (CEET) TK03020027.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

#### The following are used in this paper:

1999/92/EC ATEX European directive: Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres  
2013/30/EU: European directive for safety of offshore oil and gas operations

2014/34/EU ATEX European directive (a new version of 94/9/EC): Equipment and protective systems intended for use in potentially explosive atmospheres

ANZEx: certification scheme against explosions in Australia and New Zealand

API: American Petroleum Industry

API500: "Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1, and Division 2;" API505a, b, and c merged in 1991 in a single API 500 document

API500A for electrical installations in petroleum refineries, finalized in 1955, initially without suffix A

API500B for electrical installations at drilling rigs and production facilities on land and on marine platforms, finalized in 1961

API500C for electrical installations at pipelines, finalized in 1966

API505: "Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2;" issued in 1997

ATEX: in French: ATmosphere Explosible

Brazilian Ministry of Development, Industry and Foreign Trade

BSEE: Bureau of Safety and Environmental Enforcement

Categories: Categories of equipment (1 or Ga—very high protection, 2 or Gb—moderate, 3 or Gc—lowest protection against explosions)

CCC Ex: Chinese mark for protection against explosions

CE: EU/EEA conformity mark

CEC: Canadian Electrical Code

CEN: European Standards Committee

CENELEC: European Committee for Electrotechnical Standardization

CENELEC IEC 60079 "Explosive atmospheres;" a series of technical standards

Coast Guard: deal with protections against explosion on mobile units in US waters; Federal Register (Vol. 80, No. 61) on 31 March 2015 and in force from 2 April 2018

EASC: Euro-Asian Council for Standardization, Metrology, and Certification

EEA: European Economic Area

EHSRs: Essential Health and Safety Requirements of a European directive

EN 13463 and EN ISO 80079 "Non-electrical equipment for explosive atmospheres": Technical standards

EU: European Union

Eurasian Union (ex. Customs union): Armenia, Belarus, Russia, Kazakh-stan, Kyrgyzstan

Ex: EU/EEA conformity mark for equipment certified for use in potentially explosive atmospheres

ExCB: IECEX Certification Body

GOST/CU-TR: Eurasian Union Technical Standards

Group: Group of equipment (I—dust and II—gas)

Hazardous Areas: probability of explosions; based on Zones or Divisions

IEC: International Electrotechnical Commission

IECEX: International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres

IMO MODU code: Code for the Construction and Equipment of Mobile Offshore Drilling Units by the International Maritime Organization

INMETRO: Brazilian National Institute of Metrology, Standardization, and Industrial Quality

ISO: International Technical Standards

NANDO database: New Approach Notified and Designated Organizations

NEC/NFPA 70: US National Electrical Code for hazardous areas

NEC500: related to the API500

NEC505: related to the API505

New Approach: goal-oriented European approach for the application of obligatory directives

NFPA: National Fire Protection Association

Notify Body: an ATEX certification body

NRTL: US Nationally Recognized Testing Laboratory

OSHA: US Occupational Safety and Health Administration  
 SAMR: Chinese State Administration for Market Regulation  
 UNECE: United Nations Economic Commission for Europe

## References

1. Towle, C. The IECEX Certification Scheme. *Meas. Control* **2003**, *36*, 154–155. [CrossRef]
2. Marangon, A.; Carcassi, M. ATEX Directives: The New Approach. In Proceedings of the Conference Valutazione e Gestione del Rischio Negli Insediamenti Civili ed Industriali, Pisa, Italy, 17–19 October 2006; Available online: <http://conference.ing.unipi.it/vgr2006/archivio/Archivio/2008/Archivio/2006/Articoli/700213.pdf> (accessed on 19 January 2021).
3. Leroux, P. New Regulations and Rules for ATEX Directives. *IEEE Ind. Appl. Mag.* **2007**, *13*, 43–51. [CrossRef]
4. Kaiser, M.J.; Snyder, B. The five offshore drilling rig markets. *Mar. Policy* **2013**, *39*, 201–214. [CrossRef]
5. Geng, J.; Murè, S.; Demichela, M.; Baldissoni, G. ATEX-HOF Methodology: Innovation Driven by Human and Organizational Factors (HOF) in Explosive Atmosphere Risk Assessment. *Safety* **2020**, *6*, 5. [CrossRef]
6. Tommasini, R.; Pons, E.; Palamara, F. Area Classification for Explosive Atmospheres: Comparison between European and North American Approaches. In Proceedings of the 60th Annual IEEE Petroleum and Chemical Industry Technical Conference, Chicago, IL, USA, 23–25 September 2013. [CrossRef]
7. Pommé, R.; Sijrier, H.J. IECEX Certification Schemes versus ATEX Directives. In Proceedings of the PCIC Europe 2010, Oslo, Norway, 15–17 June 2010; IEEE: Piscataway, NJ, USA, 2010; pp. 1–8. Available online: <https://ieeexplore.ieee.org/document/5525731> (accessed on 19 January 2021).
8. Johnson, B.; House, P.; Mulder, R.; Pijpker, T.; Pomme, R. Role of IEC Standards. *IEEE Ind. Appl. Mag.* **2008**, *14*, 14–20. [CrossRef]
9. Novák, P.; Kot, T.; Babjak, J.; Konečný, Z.; Moczulski, W.; Rodriguez López, Á. Implementation of Explosion Safety Regulations in Design of a Mobile Robot for Coal Mines. *Appl. Sci.* **2018**, *8*, 2300. [CrossRef]
10. Palazzi, E.; Currò, F.; Fabiano, B. Accidental Continuous Releases from Coal Processing in Semi-Confined Environment. *Energies* **2013**, *6*, 5003–5022. [CrossRef]
11. Hughes, A. Why Dust Explodes. *Meas. Control* **2012**, *45*, 271–272. [CrossRef]
12. Abbasi, T.; Abbasi, S.A. Dust explosions—Cases, causes, consequences, and control. *J. Hazard. Mater.* **2007**, *140*, 7–44. [CrossRef] [PubMed]
13. Eckhoff, R.K.; Li, G. Industrial Dust Explosions. A Brief Review. *Appl. Sci.* **2021**, *11*, 1669. [CrossRef]
14. Eckhoff, R.K. Differences and similarities of gas and dust explosions: A critical evaluation of the European ‘ATEX’ directives in relation to dusts. *J. Loss Prev. Process Ind.* **2006**, *19*, 553–560. [CrossRef]
15. Alves, J.J.; Neto, A.T.; Araújo, A.C.; Silva, H.B.; Silva, S.K.; Nascimento, C.A.; Luiz, A.M. Overview and Experimental Verification of Models to Classify Hazardous Areas. *Process Saf. Environ. Prot.* **2019**, *122*, 102–117. [CrossRef]
16. Rangel, E.; Luiz, A.M.; de P. M. Filho, H.L. Area Classification is Not a Copy-and-Paste Process: Performing Reliable Hazardous-Area-Classification Studies. *IEEE Ind. Appl. Mag.* **2015**, *22*, 28–39. [CrossRef]
17. Propst, J.E.; Barrios, L.A.; Lobitz, B. Applying the API Alternate Method for Area Classification. *IEEE Trans. Ind. Appl.* **2007**, *43*, 162–171. [CrossRef]
18. Stefanowicz, D. An Overview of Hazardous Areas. *Meas. Control* **2003**, *36*, 142–144. [CrossRef]
19. McMillan, A.J. Hazardous Areas—An Overview. *Meas. Control* **1986**, *19*, 6–9. [CrossRef]
20. Zhang, Q.; Li, W.; Zhang, S. Effects of spark duration on minimum ignition energy for methane/air mixture. *Process Saf. Prog.* **2011**, *30*, 154–156. [CrossRef]
21. Cui, G.; Li, Z.; Yang, C.; Zhou, Z.; Li, J. Experimental study of minimum ignition energy of methane–air mixtures at low temperatures and elevated pressures. *Energy Fuels* **2016**, *30*, 6738–6744. [CrossRef]
22. Brkić, D.; Praks, P. Proper Use of Technical Standards in Offshore Petroleum Industry. *J. Mar. Sci. Eng.* **2020**, *8*, 555. [CrossRef]
23. Thomas, G.A.N.; Reeve, P.T.N.; Spanhel, J.M. Sharing Information to Promote Oil and Gas Industry Standardisation in ISO. In Proceedings of the Offshore Technology Conference, Offshore Technology Conference, Houston, TX, USA, 1–4 May 1995. [CrossRef]
24. Reeve, P.T.N.; Johansen, A.R.; Lautier, J. International Standards for the Oil and Natural Gas Industries: A Review Paper. In Proceedings of the Offshore Technology Conference, Offshore Technology Conference, Houston, TX, USA, 2–5 May 1994. [CrossRef]
25. Arney, C.E. Toward One Set of International Standards for the Petroleum Industry Worldwide. In Proceedings of the Offshore Technology Conference, Houston, TX, USA, 4–7 May 1992. [CrossRef]
26. Wilson, D.E. Internationalization of Oil Industry Standards. In Offshore Technology Conference. In Proceedings of the Offshore Technology Conference, Houston, TX, USA, 4–7 May 1992. [CrossRef]
27. Agius, C.; Jachia, L. International IECEX System Evolution and Role of the United Nations, UNECE. In Proceedings of the 2012 Petroleum and Chemical Industry Conference Europe Conference Proceedings (PCIC EUROPE), Prague, Czech Republic, 19–21 June 2012; IEEE: Piscataway, NJ, USA, 2012; pp. 1–15. Available online: <https://ieeexplore.ieee.org/document/6243265> (accessed on 19 January 2021).
28. Rangel, E. Brazil moves from divisions to zones. In Proceedings of the Annual Petroleum and Chemical Industry Conference, New Orleans, LA, USA, 23–25 September 2002; IEEE: Piscataway, NJ, USA, 2002; Volume 49, pp. 23–30. [CrossRef]
29. Hamer, P.S.; Bishop, D.N.; Bried, F. API RP 500-Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities. In Proceedings of the 1992 Conference of Industry Applications Society 39th Annual Petroleum and Chemical Industry Conference, San Antonio, TX, USA, 28–30 September 1992; IEEE: Piscataway, NJ, USA, 1992; pp. 37–42. [CrossRef]

30. Bishop, D.N.; Jagger, D.M.; Propst, J.E. New area classification guidelines. In Proceedings of the Industry Applications Society 45th Annual Petroleum and Chemical Industry Conference, Indianapolis, IN, USA, 28–30 September 1998; IEEE: Piscataway, NJ, USA, 1998; pp. 9–19. [\[CrossRef\]](#)
31. Carlson, R.; Flanders, P.; Roussel, B. Conversion from Division to Zone electrical classification-why and how the world's largest oil company made the change. In Proceedings of the Industry Applications Society Forty-Seventh Annual Petroleum and Chemical Industry Technical Conference, San Antonio, TX, USA, 13 September 2000; IEEE: Piscataway, NJ, USA, 2000; pp. 1–9. [\[CrossRef\]](#)
32. Hamer, P.S.; Wood, B.M.; Doughty, R.L.; Gravell, R.L.; Hasty, R.C.; Wallace, S.E.; Tsao, J.P. Flammable Vapor Ignition Initiated by Hot Rotor Surfaces within an Induction Motor: Reality or Not? *IEEE Trans. Ind. Appl.* **1999**, *35*, 100–111. [\[CrossRef\]](#)
33. Muhammad Niazi, U.; Shakir Nasif, M.; Muhammad, M.; Khan, F. Investigating Vapour Cloud Explosion Dynamic Fatality Risk on Offshore Platforms by Using a Grid-Based Framework. *Processes* **2020**, *8*, 685. [\[CrossRef\]](#)
34. Zhu, R.; Li, X.; Hu, X.; Hu, D. Risk Analysis of Chemical Plant Explosion Accidents Based on Bayesian Network. *Sustainability* **2020**, *12*, 137. [\[CrossRef\]](#)
35. Jung, B.; Kim, J.H.; Seo, J.K. Investigation of the Structural Strength of Existing Blast Walls in Well-Test Areas on Drillships. *J. Mar. Sci. Eng.* **2020**, *8*, 583. [\[CrossRef\]](#)
36. Luo, F.; Zhang, S.; Yang, D. Anti-Explosion Performance of Composite Blast Wall with an Auxetic Re-Entrant Honeycomb Core for Offshore Platforms. *J. Mar. Sci. Eng.* **2020**, *8*, 182. [\[CrossRef\]](#)
37. Yu, G.; Zhang, L.; Jia, S.; Geng, Y.; Liu, J. Numerical Study on the Natural Convection of Air in a Cubic Cavity Subjected to a Yawing Motion. *J. Mar. Sci. Eng.* **2019**, *7*, 204. [\[CrossRef\]](#)
38. Yu, G.; Jia, S.; Geng, Y. Numerical Investigation into the Two-Phase Convective Heat Transfer within the Hold of an Oil Tanker Subjected to a Rolling Motion. *J. Mar. Sci. Eng.* **2019**, *7*, 94. [\[CrossRef\]](#)