WHITE PAPER

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Addressing Hazardous Areas Safety Requirements with Properly Designed Intrinsically Safe and Ex Approved HMIs and Panel PC Solutions for the Oil & Gas Industry

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Executive Summary:

This technical paper will explore the basics of fire and explosion safety issues, legislation, regulations and standards around the world, and compare the Class/Division Hazardous Location versus Zone Hazardous Area Classifications and Protections primarily for Oil & Gas Refineries, Chemical Processing and Transport Operations.

Moreover, this paper will present AIS's considerable expertise in designing industrial control and monitoring solutions for installation and use in hazardous areas and classified locations. AIS's broad range of Non-Incendive (NI), Intrinsically Safe (IS), and Explosion Proof Industrial Human Machine Interface (HMI) Embedded Systems, including Industrial Touch Panel PCs, Thin Clients and Ruggedized Monitors are designed, manufactured, tested, certified, UL listed and CE Ex marked for use in hazardous areas and classified locations in Oil & Gas, Petro-Chemical Processing & Refining Operations.

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Abstract:

Safety issues are of the most serious concern in all companies. Industrial plants, oil and gas refineries, oilfield equipment and services and other types of facilities all around the world put forth a massive effort and investment to prevent safety issues at all costs, especially in hazardous areas and classified locations. Areas with the storage of combustible gases, vapors, mist and dust create dangerous environments. Some electrical equipment by its nature, when combined with certain conditions pose dangers in hazardous areas where gases, vapors and dust might be present in sufficient quantity or volume.

At the top of the list of all safety issues to prevent in plants are fires and explosions. To this end, AIS invests a tremendous amount of capital, energy and resources to earn certifications and comply with electrical equipment regulations and standards set forth by different countries, testing centers and governing bodies for designing and manufacturing electronic control, operation and monitoring equipment for use specifically in hazardous area and classified locations.

1. Understanding the Basic Requirements for an Explosion

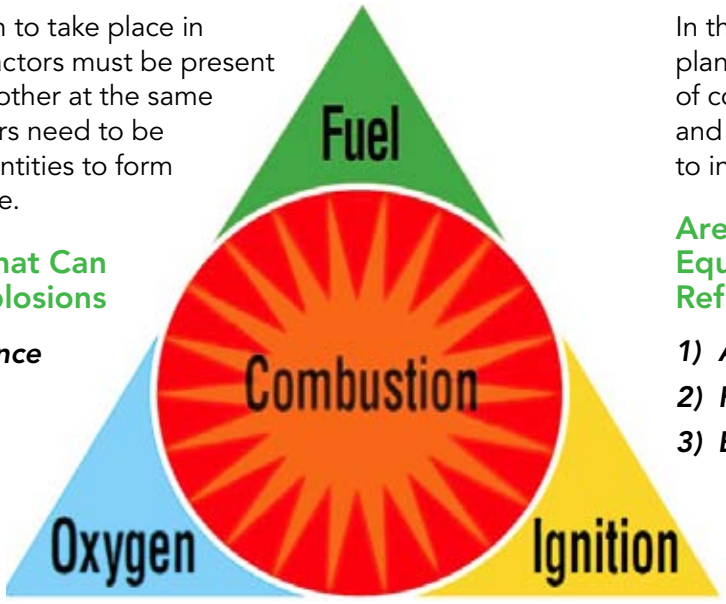
Legislation for standards revolve around educating, guiding and enforcing manufacturers and plant owners to design and produce electrical equipment that adhere to acceptable levels of electrical safety to help prevent explosions in areas that are deemed hazardous. More specifically, these regulations and standards also aim at minimizing the contributing factors that lead to causing fires or explosions in plants and facilities. Some products by their basic nature have incendive properties. Non-incendive circuits are those that may spark under normal operating conditions, but may not release enough energy to cause ignition. Consider a basic light switch in a home may emit a small harmless, visible spark. In a normal atmosphere, this arc is of no concern or immediate danger. In an atmosphere filled with flammable gases, vapors or combustible dust, this arc may ignite a fire or cause an explosion. Electrical equipment intended for use in chemical plants, oil and gas refineries and operations are designed to either contain an explosion within the device, or not release sufficient energy to trigger and/or ignite an explosion.

Before delving into the depths of legislation standards and codes, let us gain an understanding on the basics of the topic regarding "explosions". First, what is an explosion, what causes them and where do they commonly occur? An explosion is defined as a sudden reaction involving a rapid physical or chemical oxidation reaction or decay generating an increase in temperature, or pressure or both simultaneously.

In order for an explosion to take place in atmospheric air, three factors must be present and coincide with each other at the same time. The first two factors need to be present in sufficient quantities to form an explosive atmosphere.

The Three Factors that Can Cause Fires and Explosions

1) ***Flammable substance***
2) ***Oxygen (air)***
3) ***Source of Ignition***



In the world of industrial facilities and plants, there are three primary areas of concern with electrical equipment, and what they may produce or lead to in a hazardous environment.

Areas of Concern for Electrical Equipment in Plants and Refineries that Produce

1) ***Arcs and sparks***
2) ***High temperatures***
3) ***Electrical equipment failure***

2. Legislative Basis and Standards for Explosion-Proof Electrical Equipment Around the World

Technical standards for the area of explosion protection and safety are legislated worldwide. Explosion protection standards are established by legislatures of individual countries for their respective localities and regions. Therefore, manufacturers of HMIs, OITs, displays, panel PCs and other electrical products have to address and consider each of these standards and incorporate the necessary safety features in order to make their products suitable for installation and use worldwide. It is also important to note, technical standards are subject to constant review and modification, due in part to advances in technology and the ever increasing demands for better safety in the work place. Suffice to say, HMI companies and other manufacturers of other electrical equipment must be steadfast in staying abreast of the latest changes and revisions and incorporate them and modify their products as needed.

There are several marks and/or stamps of approval that represent where electrical products have been tested, certified and approved and meet proper standard codes of safety as published by various regulating bodies, groups and testing centers.

From an overview perspective, the governing regulating bodies or groups for setting standards for electrical safety and explosion protection by area of region or country include:

REGION/COUNTRY	MARKING	LEGISLATIVE BASIS AND STANDARDS
International	IEC Ex	IEC Ex System, Ex areas can be known by different names such as "Hazardous Locations," "Hazardous Areas," "Explosive Atmospheres," and the like relate to areas where flammable liquids, vapours, gases or combustible dusts are likely to occur in quantities sufficient to cause a fire or explosion.
Europe	CE Ex	The standards for explosion protection valid in the European Union are created on the basis of the EU directives under the leadership of the European committee for Electrotechnical Standardization (CENELEC 60 079). EN 60079 and EN 61241 specifically cover the area of explosion protection. CENELEC only define standards in parallel with the IEC. The CE mark is complemented with the Ex mark, followed by indication of the Group, Category, and if Group II equipment, the indication relating to gases (G) or dust (D). There are also ATEX directives. These EU directives describe what equipment and work is allowed in environments with an explosive atmosphere. ATEX 95 equipment directive 94/9 EC is for equipment and ATEX 137 workplace directive 99/92/EC is for worker safety.
North America	c UL us LISTED	In North America, testing for electrical equipment deemed suitable for hazardous areas are performed by nationally recognized testing laboratories such as UL, MET, FM, CSA or Intertek (ETL). The label will always list the Class(es), Division(s) and may list the Group(s) and temperature Code. Directly adjacent on the label one will find the mark of the listing agency. The American National Standard Institute (ANSI) is a non-profit organization that coordinates US standards with international standards, so that American products can be used worldwide. Other important published standards for electrical equipment include: API RP 505 (zone system) and OSHA for the USA.

3. Design Regulations for Explosion-Proof Electrical Equipment

While there seems to be much crossover in definition and meaning, a distinction should be made between regulations and standards. Regulations are mandatory by law, where standards are typically voluntary, but often demanded and/or strongly encouraged.

However, failing to comply with an established standard may lead to a host of problems which may be regulatory compliance, legal and liabilities issues. Regulations for hazardous locations by means of the Class/Division system have now been formulated by the NEC, CEC, OSHA, and the National Fire Protection Association (NFPA).

Manufacturers and operators of electrical equipment must comply and strictly adhere to these regulations. Compliance to these regulations are monitored by accredited test houses such as UL and many other testing houses previously listed. Regulations are created to help companies design, engineer and manufacture safe, explosion-protected electrical equipment. Once a company successfully completes and passes all testing, test centers issue conformity certifications. The conformity certificates state that uniform safety conditions have been met for explosion protected electrical equipment and the equipment manufacturer can now proceed to production.

ANSI/ISA - 12.12.01-2012 Non-Incendive Standard Defined for Electrical Equipment

American National Standards Institute (ANSI) and the International Society of Automation (ISA) have worked on defining the ANSI/ISA - 12.12.01-2012 Non-Incendive Standard for electrical equipment for use in specific hazardous locations.

This standard provides the minimum requirements for the design, construction and marking of electrical equipment or parts of such equipment for use in Class I and Class II, Division 2 and Class III, Division 1 and 2 hazardous (classified) locations.

The equipment may contain electronic components that operate at incendive levels and may also have field wiring that is incendive. In normal operation, the equipment is not capable of causing ignition of the surrounding atmosphere under the conditions prescribed in the standard.

In addition, it is the intent of this ANSI/ISA standards document to establish uniformity in test methods for determining the suitability of the equipment and associated circuits and components as they relate to potential ignition of a specific flammable gas or vapor-in-air mixture, combustible dust, easily ignitable fibers, or flyings.

In addition, the standards apply only to equipment, circuits, or components designed and assessed specifically for use in Class I, Division 2, hazardous locations, as defined by the National Electrical Code NFPA No. 70.

4. Definitions and Comparisons of Class/Division vs. Zone System

In the United States and North America, most manufacturers generally follow the standard as established by the National Electric Code (NEC). The NEC categorizes hazardous locations (also referred to has "Hazlocs") into Classes and Divisions. Most other countries follow standards detailed by the International Electrontechnical Commission (IEC).

The IEC classifies "Hazlocs" by specific Zones. Again, Europe (EU) has its own classification system based on the IEC classifications, known as ATEX directives.

Shown below are a basic description, summary and comparison of the Class/Division system and the Zone system.

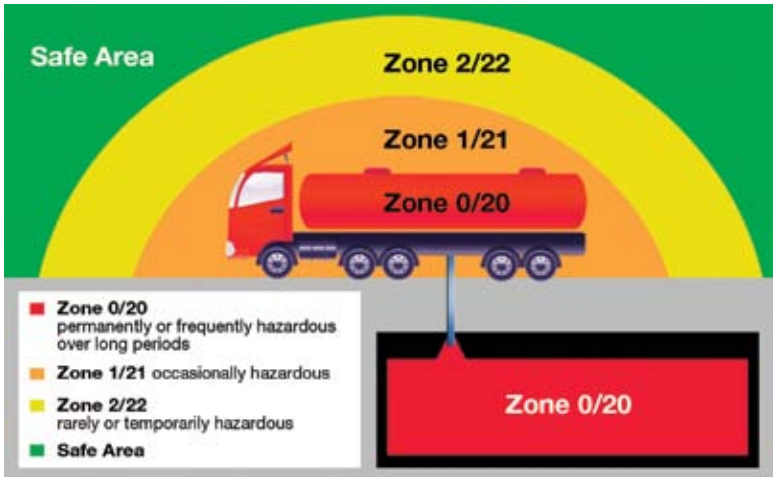
Class/Division Systems Basics

The Class/Division standards are the dominant method for designing and manufacturing products in North America. The explanation and details of this system are comprehensive and more complex that what will be covered in this paper. There are five definitions that summarize Classes/Divisions. Here are brief descriptions and explanations for each category.

CLASS/DIVISION SYSTEMS	DEFINITION
Area	Provides a brief description of the hazardous material that may be present and the probability that it is present. The proper equipment may be selected and safe installation practices may be followed.
Class	Three categories of hazardous materials are designated by Classes and are defined by the NFPA Publication 70, NEC and CEC. The Classes define the type of explosive or ignitable substances which are present in the atmosphere.
	Class I: Locations where flammable vapors and gases may be present
	Class II: Locations where combustible dust may be found
	Class III: Locations where ignitable fibers or flyings may be present
Division	The classes described above are subdivided into two Divisions for further clarification, classification and identification: Divisions I and Division II. The two divisions define the likelihood of the hazardous material being present in a flammable concentration.
Group	Class I and Class II Divisions are further subdivided into Groups of hazardous material considering air mixtures of gases, vapors, or dusts vary. The Groups define substances by rating their flammable nature in relation to other known substances.
Temperature Class	The temperature class definitions are used to designate the maximum operating temperatures on the surface of the equipment, which should not exceed the ignition temperature of the surrounding atmosphere.

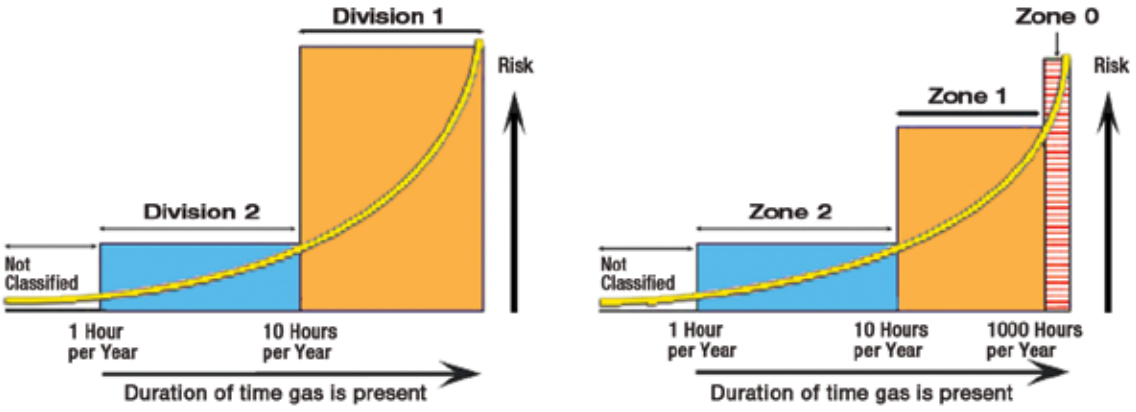
Zone System Basics

As mentioned, the Class/Division system is predominantly used in North America to designate and define hazardous conditions and locations and provide guidelines for the design and manufacture of electrical equipment. Outside North America, the Zone system is more commonly used and followed. Similar to the Class/Division system, it has definitions and categories of hazardous atmospheric situations and environments.



ZONE SYSTEM	DEFINITION
Flammable Gases and Vapors	Flammable gases and vapors, it defines or separates them into three dimensional spaces or regions. Therefore, there are three primary zones or categories in the Zone system. It designates them as hazardous locations on account of the explosive gas atmosphere that is expected to be present. Each zone requires different considerations and precautions for the design, construction, installation and use of the electrical equipment in these hazardous areas. Based upon the frequency of occurrence and duration of an explosive gas atmosphere, the hazardous areas are divided into three separate zones.
	Zone 0: An explosive gas atmosphere that is almost continuously present and for long periods of time.
	Zone 1: An explosive gas atmosphere will likely to occur in normal operation on a consistent basis.
	Zone 2: An explosive gas atmosphere that is not likely to occur in normal operation, but if it does occur, it will most likely appear for only a short period of time.
	A fourth zone is designated as a non-hazardous area. It is a safe area or location where an explosive atmosphere is not expected and most likely is not present.
Flammable Dust	Flammable dust when suspended in air can explode. For this reason, the following has been established for hazardous areas in which an explosive atmosphere in the form of a cloud of combustible dust in the air may be present and considered dangerous.
	Zone 20: Present continuously, or present for long periods time or frequently.
	Zone 21: Likely to occur, occasionally, in normal operation.
	Zone 22: Not likely to occur in normal operation, but if it does occur, it will persist for a short period only.

Similar to the Class/Division system, there is another range of qualifiers that subdivide each of the zones. Since combustion will only occur if the flammable mix of fuel (gases and vapors) and air (oxygen) is within certain dangerous limits, they are further divided into two specified limits or ranges. The Lower Explosive Limit (LEL) sometimes called Lower Flammability Limits (LFL) and the Upper Explosive Limit (UEL). As indicated the whole range from low to high is considered dangerous, but vary in levels of severity. Let it also be known there is class system for temperature as well.

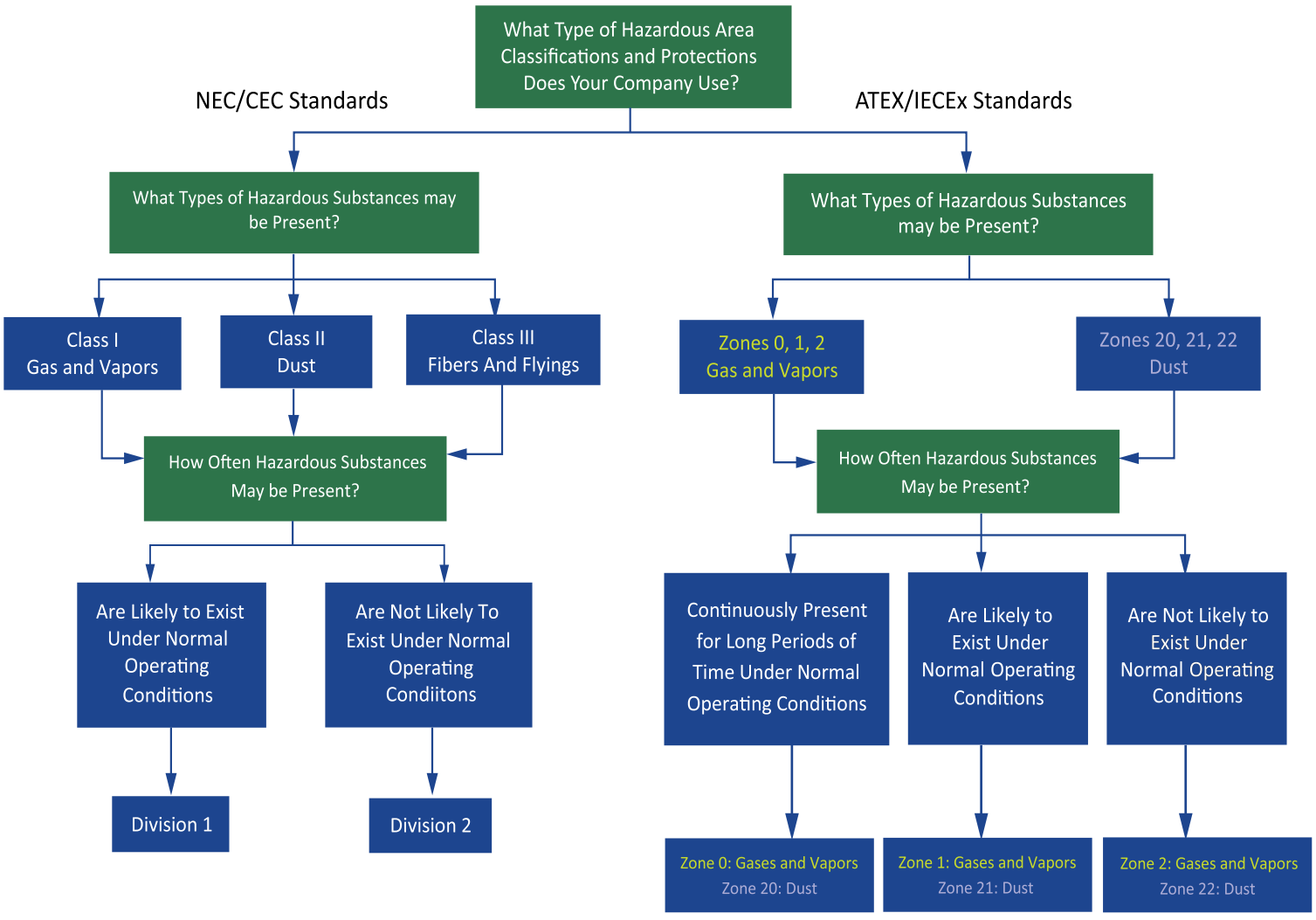


The illustrations above compare the Division and Zone systems in terms of risk assessment.

Finally, with regard to comparing the Classes/Divisions vs. the Zones system, the obvious question one may have is whether one system may be better, or more suitable and comprehensive than the other? The definitive answer is "no". Both systems are professional regulations and standards that are designed to accomplish the same safety goals for hazardous locations, but offer different language, definitions, classifications and categorizations. They are primarily separated by their geographical preferences and locality.

Comparing Classes/Divisions System with Zone System

To simplify understanding the differences and similarities between the two systems used in North America, Europe and other parts of the world, below is a diagram visually identifying the various atmospheric situations and environments in hazardous areas. The diagram also shows how the Class/Division system and the Zone system classify and define them.



5. Installing and Operating Electrical Equipment in Hazardous Areas

Manufacturers, installers and plant owners each have tasks and obligations in their mission to achieve maximum safety in the facility. Without all three working harmoniously toward these goals, safety issues and problems are likely to occur in hazardous locations.

Obligations of HMI Manufacturers, Installers and Plant Owners

- **Manufacturers: Develop HMI equipment for intended use in hazardous areas**
- **Installers: Select and install properly approved HMI equipment for the application**
- **Plant Owners: Conduct safe operation, monitoring and maintenance of HMI equipment**

There are a few primary considerations when installing and operating electrical equipment in hazardous areas. First, installation and erection regulations and standards as specified in EN60079-14 and national regulations apply and need to be followed. As for more specifics on installation, three installation systems are used for electrical systems in hazardous areas and locations.

Finally, planned and scheduled service, monitoring and maintenance to maintain the safety of electrical systems in hazardous areas within a plant is critical in minimizing risks.

Suggested Plant Operator Service and Maintenance Guidelines

1. The operator must maintain systems at a proper operating state
2. Continuously monitor the electrical system for performance or faults
3. Immediately execute any maintenance measures required to remedy problems
4. Properly operate the system within stated limits of operation
5. Cease operations immediately in case a problem becomes an eminent hazard

For cable and conduit equipment installation in hazardous areas, installers must observe proper procedures for inserting/running cable systems with indirect cable inlets, direct cable inlets and/or conduit systems.

"Intrinsically Safe" Equipment Defined and Categories

"Intrinsic Safety" is a type of protection where electrical equipment does not have a sufficient amount of energy to ignite a potentially explosive atmosphere. In an intrinsically safe circuit, no sparks or thermal effects occur in operation, or in the event of a fault will not ignite a fire or explosion. Intrinsic safety is achieved by limiting the current and voltage in a circuit. This is primarily the case for lower voltage type products, such as control technology and industrial HMI monitors and displays.

Other Key Things to Know About Intrinsically Safe Designed Products

- **Intrinsically safe products and parts are divided into categories for safety levels**
- **Safety levels depend on the safety requirements when designing the equipment**
- **Isolating transformers and amplifiers between intrinsic and non-intrinsic equipment provide the necessary limiting to minimize the possibility of ignition**
- **All devices in an intrinsically-safe circuit must correspond to the intrinsically safe type of protection.**
- **Typically transmitters, sensors and the wiring requires that the characteristic electrical values are maintained to ensure intrinsic safety**

6. Oilfield Equipment and Service Market

According to a new market report published by Transparency Market Research Oilfield Equipment Market; Drilling Equipment, Field Production Machinery, Pumps and Valves and Other – Global and US Industry Analysis, Size, Share, Growth, Trends and Forecast, 2012–2018, the global market for oilfield equipment was valued at US$93.74 billion (B) in 2012 and is expected to reach US$117.37B in 2018, growing at a CAGR of 3.8% from 2012 to 2018.

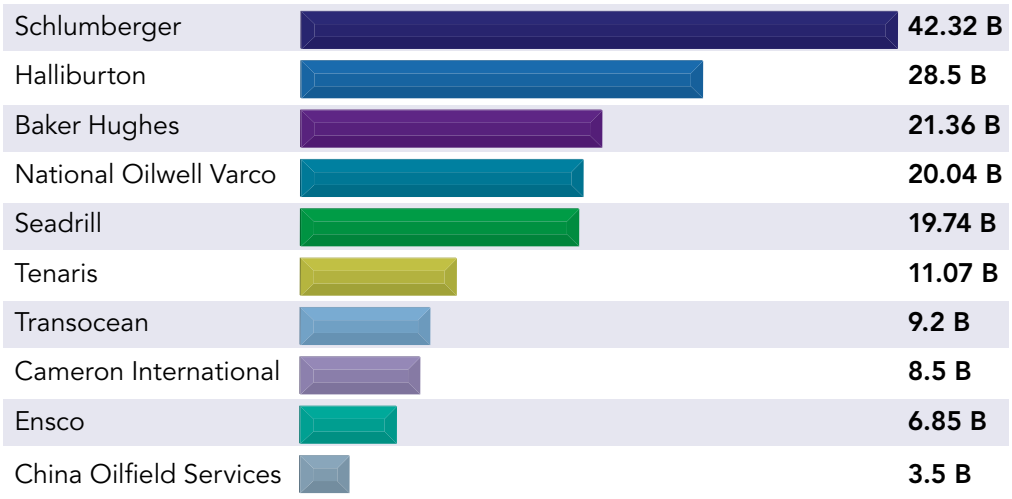
Driven primarily by the rising oil extraction and refining activities coupled with increasing regional consumption and its growing demand across the globe, the demand for oilfield equipment is expected to grow. A shift toward unconventional oil fields, such as shale gas, has been driving the demand for oilfield equipment in both developed economies such as the US and Europe and in emerging markets such as Asia Pacific and Latin America. This trend is expected to drive the demand over their forecast period.

Drilling equipment was the largest market segment, accounting for over 70% of the total oilfield equipment consumption in 2012. According to the report, North America emerged as the leading consumer of oilfield equipment and accounted for over 40% of the global demand in 2012. US market for oilfield equipment was

valued at US$29.05B in 2012 and is expected to reach US$36.66B in 2018, growing at a CAGR of 3.9% from 2012 to 2018.

Asia Pacific is expected to be the fastest growing market for oilfield equipment, growing at a CAGR of 4.3% from 2012 to 2018. The growth of exploration and production in China, the implementation of licensing bidding in India, and the introduction of new policies in Indonesia have been major factors driving market growth in the region.

The World's Biggest Publicly Traded Oil Service and Equipment Companies Revenues in Billions



Driving Factors in the Oil and Gas Industry and Market Through 2018

- 2013 demand for oil in the developing world will overtake that in industrialized countries for the very first time, driven particularly by strong demand from China, India and other developing nations across Asia which continue to see strong economic growth.
- The shale revolution had transformed the US energy sector, and is now sweeping the wider world too. If its impact elsewhere is anything like we have seen in the US – in just a decade shale gas has risen from 2 percent of natural gas production to 37 percent – then the ramifications are going to be significant.
- Regulatory policies and geopolitical issues are some of the major concerns that are expected to affect the oilfield equipment market.
- Global production of gas is already growing at roughly twice the rate of oil, while global demand for gas could rise by as much as 50 percent between 2010 and 2035.
- Technological advances such as horizontal drilling and hydraulic fracturing, along with 3D seismology are now also making it possible to develop oil in reserves previously thought of as commercially unavailable.

- In particular "directional drilling" has transformed the fortunes of many oilfields, while the industry has also seen huge strides in the scale and sophistication of subsea pipeline systems and deep-water production.
- Oilfield services market represents $750 billion a year and the growth of its leading players continues to be driven by a mix of technological breakthroughs, the willingness of oil majors to outsource production and reduce their exposure to aging reserves, and by increasing demand from state-owned oil firms.
- The oil and gas market will continue to remain a very attractive play for M&A activity this year, particularly as companies look to expand.

7. AIS Oil and Gas HMI Solutions Overview for Use in Hazardous Areas and Classified Locations

AIS offers a wide range of Non-Incendive (NI), Intrinsically Safe (IS), and Explosion Proof Industrial Human Machine Interface (HMI) Embedded Systems, including ruggedized monitors and integrated display computers. As reference, other HMI terminology include: industrial panel PCs, industrial panel computers, operator interface terminals, thin clients, industrial monitors and displays with rugged touch screen interface and/or multi-touch Projected Capacitive Touch (PCT or PCAP) technology. Take your HMI, control and monitoring solutions to the next level with open embedded architecture, advanced performance and connectivity, in an all-in-one and rugged industrial design, all of which AIS manufactures in-house for hazardous areas and classified locations.

These industrial HMI embedded systems, monitors and displays for hazardous areas are constructed with completely sealed, stainless steel type 4/4X, IP 65/66, NEMA 4/4X enclosures with environmental ratings (UL 50 or IEC 529) on the entire system including fully sealed I/O ports.

The hazardous area panel PC supports wide operating temperatures from -20 to 60°C (-4 to 140°F), and comes with pre-installed Windows Embedded or Linux operating system; and is powered by high-performance and low power consumption (TDP 3.5W) Intel® embedded processors in fanless, industrial-grade, high bright LCD flat touch screen panels (with option for sunlight readable LCD displays).

AIS Non-Incendive (NI), Intrinsically Safe (IS), and Explosion Proof panel PCs, thin clients, and industrial monitors with HMI open platforms are designed and certified to meet NEC/CEC Class/ Division, ATEX Directive 94/9/EC, and IECEx Zone standards for increased safety in industrial HMI touch screen PCs in Division 2 and Zone 2 operator control and monitoring applications.

AIS offers UL Class I Division 2 (C1D2 or Class I Div 2), Groups A, B, C, D, T4, ATEX 94/9/EC Zone 2 Category 3, and IECEx Zone 2, Ex "nA" and Ex "ic", T4 certification on its Hazardous Areas panel PCs & monitors and Hazardous Locations (Hazlocs) panel computers & displays which are primarily designed for the demanding Environmental, Health and Safety (EHS) requirements, and volatile & harsh environments of Oil, Gas, and Petrochemical manufacturing industries; oilfield equipment & services, drilling systems automation, drilling control rooms, drill monitors, drilling management systems, local instrument rooms, machinery control systems, process control systems, intelligent well systems, upstream, midstream and downstream automation, remote monitoring and control panel applications that provide accurate, economical, intuitive and user-friendly systems control, operation and monitoring.

Features:

- UL Listed to Safety Standards: ANSI/ISA 12.12.01, 2012, Nonincendive Panel PC for Use in Class 1, Division 2 Groups A, B, C, D Hazardous (Classified) Locations and CAN/CSA C22.2 No. 213-M1987 for Use in Class 1, Division 2 Hazardous Locations: UL File # E365958
- UL Listed to Safety Standards: UL 60950-1 and CSA C22.2 No. 60950-1-07: UL File # E320439
- CE Ex Marked: Explosive Atmospheres (ATEX)-Directive 94/9/EC: Complying with the Essential Health and Safety Requirements that relate to the design of Category 3 Zone 2 Panel PC, certified to ATEX Protection Classes- "CE Ex mark" II 3 G Ex nA ic IIA T4
- Compliance with the Essential Health and Safety Requirements has been assured by Compliance with IEC 60079-0, IEC 60079-11, and IEC 60079-15

Benefits:

- Hazardous areas panel PC for improved environment for operators
- Hazardous locations panel PC for improved operator safety
- High-availability integrated rig HMI panel PC for managing, controlling, and monitoring rig floor equipment in independent and activity-based operation
- The panel PC is ideal for operator control and monitoring, measuring and testing as well as data collection, communication and other applications in hazardous zones 2
- Open HMI with pre-configured operating system for all types of software applications
- Fanless, streamline enclosure design for highly efficient heat dissipation

Common Applications Include:

- Oilfield Equipment & Services
- Drilling Systems Automation, Control Rooms, Drill monitors and Drilling Management Systems
- Local Instrument Rooms
- Machinery Control Systems
- Process Controls Systems

Standard or custom HMI applications are designed to meet Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations (North American Classification), and Zone 1/21 and 2/22 Hazardous Areas (European and IEC Classification) specifications.

Certifications/Approvals

- **North American Approvals: Underwriters Laboratories (UL) and Canadian Standards Association (CSA)**
- **European Approvals: ATEX 95 equipment directive 94/9/EC**
- **International Approvals: IEC Ex System, Ex areas can be known by different names such as "Hazardous Locations," "Hazardous Areas," "Explosive Atmospheres," and the like and relate to areas where flammable liquids, vapours, gases or combustible dusts are likely to occur in quantities sufficient to cause a fire or explosion. IEC System for Certification to Standards relating to Equipment for use in Explosive Atmospheres**

AIS "Intrinsically Safe" Industrial Panel PC and Monitor Are Suitable For These Hazardous Area Classifications and Protections

CATEGORY	REGION	CLASS/DIVISION/ZONE RATING	TEMPERATURE
Industrial Panel PC [1]	United States "UL Listed"	Class I Division 2, Groups A, B, C, D T4 Class I Zone 2, IIA, T4	-20°C to 60°C (-4°F to 140°F)
	Canada "UL Listed"	Class I Division 2, Groups A, B, C, D T4 Class I Zone 2, IIA, T4	
	Europe "CE Ex Marked"	ATEX II 3 G, Ex nA ic IIA Gc ATEX Zone 2 Category 3 Gas	
Industrial Monitor [1]	United States "UL Listed"	Class I Division 2, Groups A, B, C, D T4 Class I Zone 2, IIA, T4	-20°C to 60°C (-4°F to 140°F)
	Canada "UL Listed"	Class I Division 2, Groups A, B, C, D T4 Class I Zone 2, IIA, T4	
	Europe "CE Ex Marked"	ATEX II 3 G, Ex nA ic IIA Gc ATEX Zone 2 Category 3 Gas	

[1] Model Series HAR15XXXXXXXXXXXXX (X=A~Z, a~z, 0~9, "-", Blank or Slash for marketing purpose only, and no impact safety related constructions and critical components)

Classification of hazardous areas	
	Rare or temporary hazard
USA NEC 500 Class I (gas)	Division 2

Classes and groups according to NEC 500		
Typical types of gas	Group	
Acetylene	Class I	Group A
Hydrogen	Class I	Group B
Ethylene	Class I	Group C
Propane	Class I	Group D

Temperature classes	
Maximum surface temperature	USA (NEC 500)
135 °C	T4

NEC 500	Class I	Division 2	Groups A, B, C, D	T4	
IEC		Ex	nA, ic	IIA	T4	G
CENELEC	Ex II 3 G	Ex	nA, ic	IIA	T4	G

Explosion groups according to CENELEC, IEC, NEC 505	
Explosion group	Typical gas
II A	Propane

Classification of gases and vapors in explosion groups and temperature classes	
	T4
II A	Acetyl aldehyde Ethyl ether

Temperature classes	
Maximum surface temperature	CENELEC IEC USA (NEC 505)
135 °C	T4

Zone classification		
		Rare or short-term hazard
CENELEC/IEC		Zone 2
USA	NEC 500 Class I (gas)	Zone 2

Equipment group II (other hazard areas)	
	Category 3
Hazard level	Rare or short-termhazard
Application in	Zone 2
Atmosphere G = gas	G
	Gc
Protection level	Increased protection level
Use in	Zone 2

Protection types for electrical equipment in explosive gas atmospheres					Use in Zone/equipment protection level		
Type of protection	Ex	Standard	Title	Scope	Ga	Gb	Gc
General requirements		EN 60079-0 IEC 60079-0 ANSI/ISA/ UL 60079-0	Part 0: Equipment General requirements	The general requirements for construction, testing and marking of electrical equipment and Ex Components intended for use in explosive atmospheres			
Intrinsic safety	i	EN 60079-11 IEC 60079-11 ANSI/ISA/ UL 60079-11	Explosive atmospheres Part 11: Equipment protection by intrinsic safety "i"	The construction and testing of intrinsically safe apparatus intended for use in an explosive atmosphere and for associated apparatus, which is intended for connection to intrinsically safe circuits which enter such atmospheres	■	■	■
Types of protection	n	EN 60079-15 IEC 60079-15 ANSI/ISA/ UL 60079-15	Electrical apparatus for explosive gas atmospheres - Part 15: Construction, test and marking of type of protection "n" electrical apparatus	The requirements for the construction, testing and marking for Group II electrical apparatus with type ofprotection, "n" intended for usein explosive gas atmospheres. This part is applicable to non-sparking electrical apparatus and also to electrical apparatus with parts or circuits producing arcs or sparks or having hot surfaces			■