Basics for electrohydraulics in hazardous environments

1 HAZARDOUS ENVIRONMENTS

"Hazardous Environments" are areas where flammable liquids, gases, vapors or combustible dust exist in sufficient quantities to produce explosions or fire.

Oil & gas, chemical, mining and power plants are highly-sensitive environments where the presence of a potentially explosive atmosphere can accidentally or permanently occur.
In these environments an accidental failure or a wrong operation could cause the ignition of the surrounding explosive atmosphere with fatal consequences for human and goods safety, therefore all electrohydraulic equipment operating in these areas must be suitable for hazardous environments and must be certified according to international standards.

The purpose of this document is to provide general information about worldwide certifications for hazardous environments and relevant classifications

Typical hazardous environments can be found in the following sectors:

Presence of Gas and Vapors		**Presence of Combustible Dust**	
	Oil & Gas Offshore drilling		Feed industry Grain handling and storage
	Oil refineries Power plants Chemical plants LNG plants		Chemical & fertilizers Pharmaceutical
	Petroleum & LNG vessels		Wood & paper
	Aerospace industry		Metal processing
	Coal mines		Recycling operations

2 CERTIFICATIONS

Equipment with electrical parts designed for hazardous environments must be certified by third parties (notified bodies) in compliance with international standards for explosion protection.

There are several certifications concerning explosive environments and they are governed by local laws of the countries where they are applied.

In all certifications the basic principles for explosion protection are strictly regulated by severe international standards for explosion protection, as European norms EN60079 or North American NEC500 and 505.
These norms impose specific construction criteria and protection methods for the machinery and components to be used in potentially explosive areas.

ATOS CERTIFICATIONS
see section 3 for details

ATEX Europe

IECEx international

Russia

North America

PESO India

China

Canada

Brazil

Korea

WORLDWIDE CERTIFICATIONS

The following map shows the main certifications with the relative countries where they are most widely applied.
International certification IECEx is recognized worldwide even in countries where local certifications exist.

3 CERTIFICATIONS FOR ATOS EX PROOF AND INTRINSICALLY SAFE COMPONENTS

Atos ex-proof and Intrinsically safe components are certified with major international certifications, as listed in the following.

Note: see technical table of each specific Atos component to verifiy the available certifications

MULTICERTIFICATION

Multicertifications is a great plus offered by Atos, where the same component is provided with the following certifications:

ATEX Directive 2014/34/EU, equipment and protective system intended for use in potentially explosive atmosphere
It defines the manufacturing criteria and the safety requirements of the equipment used in potentially explosive environments for presence of gas or flammable dusts, within the European Union.
The Directive provides the classification and marking of components to EN 60079 harmonized norms.

IECEx International Electrotechnical Commission Explosive
International program for the safety of the equipment installed in a potentially explosive atmosphere, required to access international markets. IECEx provides certification of conformity for electrical equipment and machinery to be used in potential explosive environments and it is based on IEC 60079 standards. The objective of the IECEx is to facilitate international trade of equipment for use in explosive atmospheres.

EAC Eurasian Certification
It is applicable to the Customs Union Territory Including Russia, Kazakhstan, Belarus, Armenia and Kyrgyzstan
It indicates the compliance with the Customs Union Technical Regulation TP TC 012/2011 “safety of equipment intended for use in explosive atmospheres” and it acknowledges the whole ATEX Directive 2014/34/EU.

PESO Petroleum and Explosive Safety Organization (earlier known as CCoE)
It approves products distributed within Indian territory for suitability in usage at petroleum or in any place with potentially explosive atmosphere. It is based on harmonized norms and international standards under ATEX and IECEx.
Atos multicertified ex-proof valves for gas group II are also certified Peso.

cULus North American Certification
It is a widely recognized certification across North America (US and Canada).
It provides certification of conformity for equipment and machinery installed in locations where explosion or fire hazards exist due to the presence of flammable gases, combustible dust, or ignitable fibers. It is based on NEC standards

MA safety certificate of approval for mining products
Chinese authority for certification of components operating in chinese coal mines.
It acknowledges the harmonized norms and international standards under ATEX and IECEx.

The following sections describe the various classifications related to hazardous environments according to certifications available for Atos components.
The classification is marked on the nameplate of each certified component to state its conformity to the specific hazardous environment and explosive atmosphere.

See section 4 for classifications to **ATEX, IECEx, EAC, PESO**

See section 5 for classifications to **cULus**

4 CLASSIFICATIONS TO ATEX, IECEx, EAC, PESO

The classifications reported in the following sections are those established by the EN and IEC standards related to ATEX and IECEx.
EAC and PESO certifications acknowledge the same classification system of ATEX and IECEx.
An example of classification present on the component nameplate iso shown in the following:

environment				atmosphere		environment
II	**2 G**	**Ex**	**d**	**IIC**	**T6/T5/T4**	**Gb**
Group see sect. 4.1	**Category** see sect. 4.3	**Mark of Explosion Proof**	**Protection Method** see sect. 4.7	**Gas Group** see sect. 4.4	**Temperature Class** see sect. 4.6	**Equipment Protection Level (EPL)** see sect. 4.3

Once the user has classified the area in which the component is intended to be placed, he will be able to define the level of protection of the component.

The evaluation of the risk and consequentially the level of protection required by the equipment passes through two main classifications:

A- Environment: the classification is referred to the location in which the product is intended to be placed
Environment is further classified in **Group** and **Zone**.

B- Atmosphere: the classification is referred to the type of explosive substance present in the atmosphere
Atmosphere is further classified in **Gas Group**, **Dust Group** and **Temperature**.

A- ENVIRONMENT

4.1 Group classification

Explosive environments are classified into: **Group I** for underground mines or for surface equipments connected to mines
Group II for surface areas

4.2 Zone classification - The Zone classification is not reported on the component nameplate
Explosive environments are classified into **Zone**, identified **0, 1, 2** for **Gas**, and **20, 21, 22** for **Dust**, depending on the time and frequency the explosive substance is present: Zone 2 and 22 are less dangerous than 0, 1 or 20, 21.
Components certified for Zone 0 (or 20) may also be used in Zone 1, 2 (or 21, 22).

4.3 Safety level required: Category and EPL

The Zone is directly linked with the safety level required; a zone with higher risk requires a higher safety level. There are two different classifications: **Category** and **EPL**

Category: ATEX classifies the safety required level into **Category 1, 2, 3** accompanied with letter **G** for gas and letter **D** for Dust: Category 1G (or 1D) are safer than 2G, 3G (or 2D, 3D).
Components certified for Category 1 may also be used where Category 2 or 3 is needed.
For Group I the classification is **Category M1** or **M2** with M1 safer than M2.

EPL: IECEx classifies the safety level required into **Equipment Protection Level (EPL) a, b, c** anticipated by letter **G** for gas and **D** for dust depending on the safety level required: Category Ga (or Da) are safer than Gb, Gc (or Db, Dc).

Components certified for EPL Ga (or Da) may also be used where EPL Gb, Gc (or Db, Dc) is needed.

Environment classification

Explosive Atmosphere	**Group** see 4.1	**Zone** see 4.2	**Safety level required** see 4.3		**Atos component**	
			Category	**EPL**		
Gas / Dust (mining)	I	-	M1	-		HIGHER PROTECTION
	I	-	M2		① ③	
Gas (surface)	II	0	1G	Ga	④	HIGHER PROTECTION
		1	2G	Gb	② ⑤ ⑥	
		2	3G	Gc	② ⑤ ⑥	
Dust (surface)	II	20	1D	Da		HIGHER PROTECTION
	II	21	2D	Db	② ⑤ ⑥	
		22	3D	Dc	② ⑤ ⑥	

① Atos ex-proof (mining) ② Atos ex-proof (gas & dust) ③ Atos intrinsically safe (mining) ④ Atos intrinsically safe (gas)

⑤ Pumps and cylinders ⑥ Atos stainless steel ex-proof

4.4 Gas Group classification

The classification is based on the minimum ignition energy of the explosive atmosphere in which a component may be installed.
The **Gas Groups** are identified **IIA, IIB, IIC** depending on the dangerousness of the substances: group IIA is less dangerous than group IIB and IIC. Components certified for Gas Group IIC may also be used in less dangerous Groups IIB and IIA

4.5 Dust group classification

The classification is based on nominal dimensions and electrical resistivity of particles.
The **Dust Groups** are identified **IIIA, IIIB** and **IIIC**, depending on the dangerousness of the substances: group IIIC contains smaller and less electrically resistive substances than group IIIB and IIIA. Components certified for Dust Group IIIC may also be used in less dangerous Groups IIIB and IIIA.

4.6 Temperature class

Based on their maximum surface temperature, the components are classified into **Temperature Classes T1** to **T6** for Gas, whereas for Dust the max surface temperature is directly reported in **°C**. The maximum surface temperature of the component must be lower than the ignition temperature of the surrounding explosive atmosphere.
Components certified with Temperature Class T6 may also be used in lower Classes T5 to T1

Atmosphere and Temperature class

Gas Group	Gas type					
IIC	Hydrogen	Acetylene				Carbon disulphide
IIB	City gas Acrylic Nitrile	Ethylene	Ethyl glycol Carbon hydrogen	Ethyl ether		
IIA	Ammonia Methane Ethane Propane	Ethanol n-Butane	Petrol Diesel fuel Fuel oil n-Hexane	Acetal-dehyde		
Temperature class	**T1** < 450°C	**T2** < 300°C	**T3** < 200°C	**T4** < 135°C	**T5** < 100°C	**T6** < 85°C

HIGHER PROTECTION

HIGHER PROTECTION

Note: the Temperature class may change depending on the max ambient temperature where the component is installed. In this case two or three different T are reported on the components nameplate (i.e. T6/T5/T4). See technical table of each specific Atos component for Temperature class.

Dust Group	Dust type
IIIC	Conductive dust
IIIB	Non conductive dust
IIIA	Flammable fibers

HIGHER PROTECTION

For dust explosion proof, the max surface temperature is directly shown (e.g. T85°C)

4.7 Protection method

The ignition of the surrounding explosive atmosphere can be prevented adopting for the component a proper protection method.
The protection method is directly linked to the design and manufacturing characteristics of the component.
The table below reports the **Code** related to the protection method adopted along with the relative **Zone** of application.

HIGHER PROTECTION ← HIGHER PROTECTION

Protection principle	Protection method	Code		Zone						Atos component
				Gas			Dust			
				0	1	2	20	21	22	
Prevents transmission of the explosion outside	Flameproof enclosure	Ex	da	X	X	X	X	X	X	
			db		X	X				① ② ⑥
			dc			X				
Dust explosion proof	Protection by enclosure	Ex	ta				X	X	X	
			tb					X	X	② ⑥
			tc						X	
Low current / voltage supply	Intrinsically safe	Ex	ia	X	X	X				③ ④
			ib		X	X				
			tc			X				
Non-electrical	Construction safety Control of igniction sources Protection by liquid immersion	Ex	c b k		X	X		X	X	⑤

① Atos ex-proof (mining) ② Atos ex-proof (gas & dust) ③ Atos intrinsically safe (mining) ④ Atos intrinsically safe (gas)

⑤ Pumps and cylinders ⑥ Atos stainless steel ex-proof

4.8 Painting

According to EN60079-0 the valves can be coated with a non-metallic material (i.e. painting), observing the maximum thickness:

Group IIC < 0,2 mm max
Group IIB < 0,3 mm max
Group IIA < 0,3 mm max

5 CLASSIFICATIONS TO cULus

The classification of explosive environments in cULus certification is regulated by NEC Standards (National Electric Code) and it is based on NEC 500 and NEC 505 articles.

NEC 500 covers the requirements for the classification system in Classes I, II, II and Divisions 1 and 2.

NEC 505 covers the requirements for the classification system in Zones (Zone 0, 1, and 2) as alternative to the NEC 500.

An example of classification present on the component nameplate is shown in the following:

NEC 500

Class I	Division I	Groups C & D	T6/T5
see sect. 5.1	see sect. 5.3	**Gas Groups** see sect. 5.2	**Temperature Class** see sect. 5.5

NEC 505

Class I	Zone I	Groups IIA & IIB	T6/T5
see sect. 5.1	see sect. 5.4	**Gas Groups** see sect. 5.2	**Temperature Class** see sect. 5.5

5.1 Class classification - NEC 500 and NEC 505

Location where explosive substances are present in the atmosphere are classified as:
Class I where flammable vapors and gases may be present
Class II and **Class III** where combustible dust and easily ignitable fibers may be present

5.2 Group classification

NEC 500: based on the ignition temperatures and explosion pressure, NEC 500 classifies gases and dust into Groups, identifying **Group A, B, C, D** for **Gases** and **Group E, F, G** for **Dusts**. Group D (or G) is less dangerous than Groups A, B, C (or E, F).
Components certified with Group A (or E) may also be used in lower Group B to D (or F to G).

NEC 505: the Gas Groups have the same classifications as per IECEx, as reported in the following table for comparison with NEC 500.

Explosive atmosphere	Typical hazard material	Class	Group		Atos component
			NEC 500	NEC 505	
Gases, vapors and liquids	Acetylene	Class I	A	IIC	
	Hydrogen, Butadiene, Ethylene Oxide, Propylene Oxide	Class I	B	IIC or IIB+H2	
	Ethylene, Formaldehyde, Cyclopropane, Ethyl Ether, etc	Class I	C	IIB	①
	Methane, Butane, Petrol, Natural gas, Propane, Gasoline	Class I	D	IIA	
Dusts	Metallic dusts (conductive and explosive)	Class II	E	IIIC	
	Coal dusts (some are conductive and all are explosive)	Class II	F	IIIC	
	Grain dust	Class II	G	IIIB	
Solid combustible, fibres and particles	Textile products, wood, paper, cotton processing (easily flammable, but does not risk to be explosive)	Class III	-	IIIA	

HIGHER PROTECTION

HIGHER PROTECTION

① Atos ex-proof /UL and Atos stainless steel ex-proof /UL

5.3 Division classification – only for NEC 500 Standard

Each of the three Classes described in section 5.1 is further subdivided into two Divisions:

Division 1 includes explosive substances that are continuously, intermittently or periodically present in the atmosphere.
The ignitable concentrations of above substances exist under normal conditions or it is caused by frequent maintenance or by equipment failure.

Division 2 includes explosive substances present under "unusual" circumstances.
Above substances are normally contained into sealed containers or into closed systems from which they can only escape through accidental rupture or breakdowns of such containers.

The installation and requirements for **Division 1** are more restrictive than for **Division 2**.
Components certified with Division 1 may also be used when Division 2 is required.

5.4 Zone classification – only for NEC 505 Standard

NEC 505 Standard introduces the Zone classification:

Zone 0 defines locations in which an explosive gas is present continuously or for long periods during normal operation.

Zone 1 defines locations in which ignitable concentrations of gas exist under normal operation or it is caused by frequent maintenance or equipment failure.

Zone 2 defines the area in which an explosive gas is not likely to occur or it will exist only for a short time

Component certified with Zone 0 may be used when Zone 1 is required.

The following table reports a comparison between Division classification to NEC 500 and Zone classification to NEC 505 Standards.

	Continuous Hazard	**Intermittent hazard**	**Hazard under abnormal conditions**
NEC 500	Division 1 ①		Division 2
NEC 505	Zone 0 (Zone 20 dust)	Zone 1 (Zone 21 dust) ①	Zone 2 (Zone 22 dust)

① Atos ex-proof /UL and Atos stainless steel ex-proof /UL

5.5 Temperature classes

The temperature classes designate the maximum operating temperatures of the equipment surface which must not exceed the ignition temperature of the surrounding atmosphere.
The temperature class is marked on the component nameplate.

Products certified with temperature class T6 may also be used in lower classes T5 to T1

Code	**Max surface Temperature**		**Atos component**
	[°C]	**[°F]**	
T6	85	185	①
T5	100	212	②
T4A	120	248	
T4	135	275	③
T3C	160	320	
T3B	165	329	
T3A	180	356	
T3	200	392	④ ⑤
T2D	215	419	
T2C	230	446	
T2B	260	500	
T2A	280	536	
T2	300	572	
T1	450	842	

Note:

the Temperature class may change depending on the max ambient temperature where the component is installed. In this case two different T are reported on the components nameplate (i.e. T6/T5).
See technical table of each specific Atos component for Temperature Class.

① Atos ex-proof ON-OFF - Tamb up to +55°C
Atos stainless steel with ex-proof solenoid type OAX, OAXS

② Atos ex-proof ON-OFF - Tamb from +55°C to +70°C
Atos stainless steel with ex-proof solenoid type OAX, OAXS

③ Atos ex-proof proportionals - Tamb up to +55°C

④ Atos ex-proof proportionals - Tamb from +55°C to +70°C

⑤ Atos stainless steel with ex-proof solenoid type OAKX, OAKXS

6 ATEX vs. cULus (NEC)

The following tables report a comparison between ATEX and cULus (NEC) classification systems.

Note: due to the different nature Atex and cULus systems, the direct comparison is not fully applicable.
The comparison is just to be used as a general reference for transition from one system to the other.

6.1 Comparison concerning the classification of hazardous environments due to the presence of Gas or Dust

Gas

ATEX	Zone 0	Zone 1	Zone 2
cULus (NEC 505)	Zone 0	Zone 1	Zone 2
cULus (NEC 500)	Class I, Division I		Class I, Division 2

Dust

ATEX	Zone 20	Zone 21	Zone 22
cULus (NEC 505)	Zone 20	Zone 21	Zone 22
cULus (NEC 500)	Class II, Division I		Class II, Division 2

6.2 Comparison concerning the classification of Gas Groups

	Gas type			
	Propane	**Ethylene**	**Hydrogen**	**Acetylene**
ATEX	IIA	IIB	IIC	IIC
cULus (NEC 505)	IIA	IIB	IIC	IIC
cULus (NEC 500)	D	C	B	A

Note: the direct comparison concerning Dust Group is not possible since the classification criteria between ATEX and cULus are consistently different

6.3 Comparison concerning the Temperature Classes for Gas Group II

ATEX	**cULus (NEC 505)**	**cULus (NEC 500)**	**Max surface temperature [°C]**	**Max surface temperature [°F]**
T6	T6	T6	85	185
T5	T5	T5	100	212
		T4A	120	248
T4	T4	T4	135	275
		T3C	160	320
		T3B	165	329
		T3A	180	356
T3	T3	T3	200	392
		T2D	215	419
		T2C	230	446
		T2B	260	500
		T2A	280	536
T2	T2	T2	300	572
T1	T1	T1	450	842

7 ATOS COMPONENTS EXEMPTED FROM CERTIFICATION AND MARKING

Atos hydraulic components made only by mechanical parts and not equipped with electrical functions are exempted from certification because their functioning does not generate dangerous conditions for the explosive environment.

The safe application of these components in hazardous environments is justified by following analysis:

- All the internal parts of the components are separated and insulated from the external environment by means of pressure-proof seals. The internal volumes are filled by the hydraulic fluid, thus there are no volumes which can be saturated by the external explosive atmosphere.
- The operation of mechanical parts does not produce potential sources of ignition of the explosive gas mixture.
- The functioning of the mechanical parts does not create conditions as overheating which may cause the explosion of the surrounding atmosphere.

The following components are included in this range:

- On-off pressure control valves (without solenoid pilot) type CART-*, ARE, ARAM, AGAM, AGIR, AGIS, AGIU, REM
- Flow control valves type QV, AQFR
- Check valves type DB, DR, ADR, ADRL, AGRL, AGRLE
- Modular valves type HMP, HM, KM, HS, KS, HG, KG, JPG, HC, KC, JPC, HQ, KQ,JPQ,HR, KR, JPR (modular fast/slow valves type DHQ and pressure switch type MAP, cannot be used in potentially explosive atmosphere)
- On off Mechanical, Hydraulic, Pneumatic operated valves
- On-off ISO cartridges, type SC LI and ISO functional covers without solenoid pilot valve.

8 INGRESS PROTECTION (IP)

The “Ingress Protection” identifies the environmental protection of a device defined in IEC Standard 60529.
The IP classification system designates, by means of two digits, the degree of protection provided by a device against ingress of dust and water.

FIRST	DEGREE OF PROTECTION AGAINST SOLID OBJECTS	SECOND	DEGREE OF PROTECTION AGAINST WATER	Atos component
0	Non-protected	**0**	Non-protected	
1	Protected against a solid object with diameter greater than 50 mm	**1**	Protected against water dripping vertically, such as condensation	
2	Protected against a solid object with diameter greater than 12 mm	**2**	Protected against dripping water when tilted up to 15°	
3	Protected against a solid object with diameter greater than 2.5 mm	**3**	Protected against water spraying at an angle of up to 60°	
4	Protected against a solid object with diameter greater than 1.0 mm	**4**	Protected against water splashing from any direction	
5	Dust-protected. Prevents ingress of dust sufficient to cause harm	**5**	Protected against jets of water from any direction	
6	Dust tight. No dust ingress	**6**	Protection against heavy seas or powerful jets of water	① ② ③
		7	Protected against harmful ingress of water when immersed between a depth of 150 mm to 1 meter	① ③
		8	Protected against submersion. Suitable for continuous immersion in water	

① Atos ex-proof multicertification (mining / surface) = IP66/67 ② Atos intrinsically safe = IP66

③ Atos stainless steel ex-proof = IP66/67

The ingress protection of cULus certified components is “Raintight enclosure, UL approved”

8.1 Comparison between IEC and NEMA standards

An equivalent classification of the enclosures degrees of protection, for the USA market, is defined according to NEMA Standard.
Note: the direct comparison is not possible since the classification criteria are consistently different between IEC and NEMA.
The comparison is just to be used as a general reference for transition from one system to another.

NEMA	1	2	3	3X	3R	3RX	3S	3SX	4	4X	5	6	6P	12	12K	13
IEC (IP)	20	22	55		24		55		66		53	67	68	54		