CORTEM®
GROUP

To be sure to be safe.

THE MATERIALS SUITABLE FOR HAZARDOUS AREAS

The materials suitable for hazardous areas

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INDEX

1. The compatibility/incompatibility of the materials used in the production of Ex equipment and some chemical substances

In chemical, petrochemical, oil plants and, generally, in all types of industrial facilities which present a danger of explosion due to the presence of gas in the form of cloud or flammable dust, there are also harsh chemical substances that can be harmful and source of deterioration of electric and non-electric equipment.

However, we’d give few examples of compatibility or incompatibility of the ferrous and non-ferrous metals that can be installed in all types of industrial facilities that present hazardous atmosphere due to the presence of gas, in the form of cloud or flammable dust, and, at the same time, the presence of aggressive chemical substances. In Table 1 are listed some chemical substances and the compatibility/incompatibility to these substances of some ferrous and non-ferrous metals, some plastics materials and the borosilicate glass.

The Table 1 must be considered as a basic guideline, it will not and cannot be exhaustive for all the possible cases.

It’s virtually impossible to state all of them, pointing out that the levels of compatibility/incompatibility must always be validated by the designer, in collaboration with the responsible for process plant or the project designer. However, in order to a better understanding of the above, we give examples of "behavioral variable" with chemical substances not used in their natural state (100%).

1. The compatibility/incompatibility of the materials and some chemical substances

Table 1 Compatibility / incompatibility of certain chemicals with ferrous, non-ferrous, plastic materials and borosilicate glass

- 🟢 Nessuna aggressione, ottimo comportamento (eccellente)
- 🟡 Aggressione leggera, buon comportamento (accettabile)
- 🟠 Aggressione moderata, poco adatto (sconsigliabile)
- 🔴 Aggressione forte, non adatto (non utilizzare)
- ⚫ *Dato non disponibile*

- 🟢 *No aggression, excellent behavior (excellent)*
- 🟡 *Aggression light, good behavior (acceptable)*
- 🟠 *Moderate aggression, unsuitable (not advisable)*
- 🔴 *Aggression strong, not suitable (not used)*
- ⚫ *Not available data*

Elenco di alcuni elementi chimici

	Elenco di alcuni metalli ferrosi e non ferrosi *List of some ferrous and non-ferrous metals*								Elenco di alcune materie plastiche e vetro borosilicato *List of some plastics materials and borosilicate glass*								
	Alluminio (EN AB 44100 GAlSi 13) *Aluminium (EN AB 44100 GAlSi 13)*	Acciaio inox AISI 304 (EN 1088 X5CrNi 18-10) *Stainless steel AISI 304 (EN 1088 X5CrNi 18-10)*	Acciaio inox AISI 316L (EN 1088 X2CrNiMo 17-12-2) *Stainless steel AISI 316L (EN 1088 X2CrNiMo 17-12-2)*	Lega di ottone *Brass alloy*	Bronzo *Bronze*	Ghisa grigia (EN GJL 25) *Grey cast iron (EN GJL 25)*	Ghisa sferoidale (EN GJS 40) *Spheroidal cast iron (EN GJS 40)*	Acciaio al carbonio *Carbon steel*	Policarbonato (PC) *Polycarbonate (PC)*	Poliestere UP (SMC) *Polyester UP (SMC)*	Vetro borosilicato *Borosilicate glass*	Teflon (PTFE) *Teflon (PTFE)*	Gomma etilenpropilene (EPDM) *Ethylene propylene rubber (EPDM)*	Gomma nitrilica (NBR) *Nitrile rubber (NBR)*	Neoprene (CR) *Neoprene (CR)*	Silicone (VMQ) o (MVQ) *Silicone (VMQ) or (MVQ)*	
Acetilene	🟢	🟢	🟢	🟡	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟡	*Acetylene*
Acetone	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🟡	🟢	🟢	🟢	🔴	🔴	🔴	*Acetone*
Acidi grassi	🟢	🟠	🟢	🟠	🟠	🔴	🔴	🟠	⚫	⚫	⚫	🟢	🟠	🟡	🟡	🟡	*Fatty acids*
Acido acetico	🟢	🟠	🟡	🟢	🟠	🔴	🔴	🔴	🟢	🟢	🟢	🟢	🟡	🟡	🔴	🟡	*Acetic acid*
Acido borico	🟢	⚫	🟢	🟡	🟠	⚫	⚫	⚫	🟢	⚫	⚫	🟢	🟢	🟢	🟢	🟢	*Boric acid*
Acido carbonico	🟢	🟢	🟡	⚫	🟠	🔴	🔴	🔴	⚫	⚫	⚫	🟢	🟢	🟡	🟢	🟢	*Carbonic acid*
Acido cianidrico	🟢	🟡	🟢	🔴	⚫	🟠	⚫	⚫	🟢	🟢	🟢	🟢	🔴	🔴	⚫	⚫	*Hydrocyanic acid*
Acido citrico	🟠	🟢	🟢	🟠	🟠	🔴	🔴	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	*Citric acid*
Acido cloridrico	🔴	⚫	🟡	🔴	🔴	🔴	🔴	🔴	🟡	🟠	🟡	🟢	🟠	🔴	🔴	🔴	*Hydrochloric acid*
Acido fluoridrico (anidro)	🔴	🔴	🔴	🔴	🟠	🔴	🔴	🔴	🟡	🔴	🔴	🟢	🟢	🔴	🔴	🔴	*Hydrofluoric acid (anhydrous)*
Acido fosforico	🔴	🟡	🟢	🔴	🟠	🔴	🔴	🟠	🟢	🟡	🟡	🟢	🟡	🔴	🔴	🟠	*Phosphoric acid*
Acido formico	🟢	🟢	🟡	🟡	🟡	🔴	🔴	🟡	🟢	⚫	⚫	🟢	🟢	🔴	🔴	🟡	*Formic acid*
Acido lattico	🟡	🟢	🟢	🔴	🟠	🔴	🔴	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	*Lactic acid*
Acido nitrico (dal 10 al 30%)	🔴	🔴	🟡	🔴	🟠	🔴	🔴	🟠	🟢	⚫	⚫	🟢	🔴	🔴	🔴	🔴	*Nitric acid (10-30%)*
Acido solfidrico	🟢	⚫	🟢	🟠	⚫	⚫	⚫	⚫	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	*Hydrogen sulfide*
Acido solforico	🟡	🟡	🟡	🔴	🔴	🔴	🔴	🟠	🟡	🟡	🟡	🟢	🟢	🔴	🟠	🔴	*Sulphuric acid*
Acqua di mare	🟠	🟢	🟢	🟠	🟡	🔴	🔴	🔴	🟡	🟡	🟢	🟢	🟢	🟢	🟢	🟢	*Sea water*
Acqua dolce (potabile)	🟡	🟢	🟢	🟢	🟢	🔴	🔴	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	*Fresh water (drinking)*
Alcool etilico	🟢	🟢	🟢	🟡	🟢	🟡	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	*Ethyl alcohol*
Alcool metilico	🟢	🟢	🟢	🟡	🟢	🟡	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	*Methyl alcohol*
Alcool propilico	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	*Propil alcohol*
Ammoniaca anidra (liquida)	🟢	🟢	🟢	🔴	🟢	🟡	🔴	🟠	🟡	🟡	🟡	🟢	🟢	🟡	🟢	🟡	*Anhydrous ammonia (liquid)*
Ammoniaca umida (10%)	🟢	🟢	🟢	🔴	🟠	🟢	🟢	🟢	🟡	🟡	🟡	🟢	🟢	🟡	🟢	🟡	*Moist ammonia (10%)*
Ammonio nitrato	🟡	🟢	🟢	🔴	⚫	⚫	⚫	⚫	🟡	🟡	🟡	🟢	🟢	🟢	🟡	⚫	*Ammonium nitrate*
Ammonio solfato	🟢	🟢	🟢	🔴	⚫	⚫	⚫	⚫	🟢	🟡	🟡	🟢	🟢	🟢	🟢	⚫	*Ammonium sulfate*
Anidride carbonica (secca)	🟢	🟢	🟢	🟢	🟢	⚫	⚫	⚫	🟡	🟠	🟢	🟢	🟡	🟠	🟢	🔴	*Carbon dioxide (dry)*
Anidride solforica (secca)	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟠	🟢	🟢	🟡	🔴	🔴	🟡	*Sulphur trioxide dry*
Anidride solforosa (secca)	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🟠	🟢	🟢	🟢	🔴	🟢	🔴	*Sulphur dioxide (dry)*
Benzina	🟢	🟢	🟢	🟢	🟢	🟡	🟢	🟡	🟡	⚫	⚫	🟢	🟠	🟡	🟠	🟠	*Gasoline*
Benzene	🟡	🟢	🟢	🟡	🟢	🟡	🟡	🟢	🔴	⚫	⚫	⚫	🔴	🔴	🔴	🔴	*Benzene*
Butano	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🟢	🟢	*Butane*
Cherosene	🟢	🟢	🟢	🟢	🟡	🟡	🟢	🟡	🟢	🟢	🟢	🟢	🔴	🟢	🔴	🔴	*Kerosene*
Cloro gassoso secco	🟢	🟢	🟢	🔴	🟢	⚫	⚫	⚫	⚫	⚫	⚫	🟢	🔴	🔴	🔴	🔴	*Chlorine dry gas*
Cloro liquido (anidro)	🔴	🔴	🔴	🔴	🟠	🟠	🔴	🟠	⚫	⚫	⚫	🟢	🟡	🔴	🔴	🔴	*Liquid chlorine (anhydrous)*
Colofonia (liquefatta)	🟢	🟢	🟢	🟢	🟠	🟠	🟠	🔴	🟢	🟢	🟢	🟢	⚫	⚫	⚫	⚫	*Colophony (liquefied)*
Esano	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🟢	🔴	⚫	⚫	🟢	🔴	🟢	🟡	🟡	*Exane*
Etano	🟢	🟡	🟢	🟡	🟢	🟡	🟡	🟢	⚫	⚫	⚫	🟢	🔴	🟢	🟡	🟡	*Ethane*
Formaldeide	🟢	🟡	🟢	🟡	🟠	🟠	⚫	🟠	🟡	🟡	🟢	🟢	🟡	🟠	🔴	🟡	*Formaldehyde*
Freon 12 (soluzione acquosa)	🟡	🟢	🔴	🟡	🟢	🟠	⚫	🟢	⚫	⚫	⚫	🟢	🟡	🟢	🟡	🔴	*Freon 12 (water solution)*
Glicerina	🟢	🟢	🟢	🟡	🟢	🟡	🟡	🟡	🟢	⚫	⚫	🟢	🟢	🟢	🟢	🟢	*Glycerine*
Idrocarburi aromatici	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🔴	🔴	🔴	*Aromatic hydrocarbons*
Idrogeno (gas)	🟢	🟢	🟢	🟢	🟢	⚫	🟡	🔴	🟢	🟢	🟢	🟢	🟡	🟢	🟢	🟠	*Hydrogen*
Idrossido di sodio (soda caustica al 20%)	⚫	🟢	🟢	🟢	🟡	🟡	🟢	🟡	🔴	⚫	⚫	🟢	🟢	🟢	🟡	🟢	*Sodium hydroxide (caustic soda at 20%)*
Metano	🟢	🟡	🟢	🟡	🟢	🟡	🟡	🟢	⚫	⚫	⚫	🟢	🔴	🟢	🟡	🟡	*Methane*
Metil Etil Chetone	🟢	🟢	🟢	🟢	🟢	⚫	⚫	⚫	🔴	⚫	⚫	🟢	🟢	🔴	🔴	🔴	*Methyl Ethyl Ketone*
Nafta	🟢	🟢	🟢	🟡	🟡	🟡	🟡	🟡	⚫	⚫	⚫	🟢	🔴	🟡	🔴	🔴	*Naphtha*
Ossigeno	🟢	🟢	🟢	🟢	🟢	⚫	⚫	⚫	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🟢	*Oxygen*
Ossigeno gassoso (freddo)	🟡	🟡	🟡	🟢	🟡	⚫	⚫	🟡	⚫	⚫	⚫	🟢	🟢	🟢	🟢	🟠	*Oxygen gas (cold)*
Ossigeno gassoso (caldo)	🟡	🟡	🟡	🟢	🟡	⚫	⚫	🟡	⚫	⚫	⚫	🟢	🟢	🟢	🟢	🟠	*Oxygen gas (hot)*
Pentano	🔴	🟠	🟠	🟢	🟢	🟡	🟡	🟢	⚫	⚫	⚫	🟢	🔴	🟢	🟡	🟠	*Pentane*
Trementina	🟢	🟢	🟢	🟡	🟢	🟡	🟡	🟡	🔴	⚫	⚫	🟢	🔴	🔴	🔴	🔴	*Turpentine*
Urea	🟡	🟢	🟢	🟢	🟢	🔴	🟠	🟢	🔴	⚫	⚫	🟢	🟢	🟢	🔴	🟢	*Urea*

List of some chemical elements

1. The compatibility/incompatibility of the materials and some chemical substances

The borosilicate glass

From the technical point of view, the most important chemical properties of the borosilicate glass **(Table 2)**, is the chemical inertness towards acidic or alkaline solutions. From the available literature can be stated that the only chemical compounds which may give rise to corrosion phenomena are hydrofluoric acid, concentrated solutions of sulfuric acid and combinations of caustic solutions with high pH and high temperatures.

Another characteristic of the borosilicate glass, while having a lower transparency compared to soda-lime glass, is that it is more resistant to corrosion and thermal shock, due to the low coefficient of expansion.

Table 2 Corrosion levels of some chemicals on borosilicate glass

Elenco di alcuni elementi chimici	Nessuna aggressione, ottimo comportamento (eccellente) *No aggression, excellent behavior (excellent)*	Aggressione leggera, buon comportamento (accettabile) *Aggression light, good behavior (acceptable)*	Aggressione forte, non adatto (non utilizzare) Aggression strong, not suitable (not used)	Dato non disponibile Not available data	*List of some chemical elements*
Acetilene	🟩				*Acetylene*
Acetone	🟩				*Acetone*
Acidi grassi				⬛	*Fatty acids*
Acido acetico	🟩				*Acetic acid*
Acido borico				⬛	*Boric acid*
Acido carbonico				⬛	*Carbonic acid*
Acido cianidrico	🟩				*Hydrocyanic acid*
Acido citrico	🟩				*Citric acid*
Acido cloridrico		🟨			*Hydrochloric acid*
Acido fluoridrico (anidro)			🟥		*Hydrofluoric acid (anhydrous)*
Acido fosforico		🟨			*Phosphoric acid*
Acido formico				⬛	*Formic acid*
Acido lattico	🟩				*Lactic acid*
Acido nitrico (dal 10 al 30%)				⬛	*Nitric acid (10-30%)*
Acido solfidrico	🟩				*Hydrogen sulfide*
Acido solforico		🟨			*Sulphuric acid*
Acqua di mare	🟩				*Sea water*
Acqua dolce (potabile)	🟩				*Fresh water (drinking)*
Alcool etilico	🟩				*Ethyl alcohol*
Alcool metilico	🟩				*Methyl alcohol*
Alcool propilico	🟩				*Propil alcohol*
Ammoniaca anidra (liquida)		🟨			*Anhydrous ammonia (liquid)*
Ammoniaca umida (10%)		🟨			*Moist ammonia (10%)*
Ammonio nitrato		🟨			*Ammonium nitrate*
Ammonio solfato		🟨			*Ammonium sulfate*
Anidride carbonica (secca)	🟩				*Carbon dioxide (dry)*
Anidride solforica (secca)	🟩				*Sulphur trioxide dry*
Anidride solforosa (secca)	🟩				*Sulphur dioxide (dry)*
Benzina				⬛	*Gasoline*
Benzene				⬛	*Benzene*
Butano	🟩				*Butane*
Cherosene	🟩				*Kerosene*
Cloro gassoso secco				⬛	*Chlorine dry gas*
Cloro liquido (anidro)				⬛	*Liquid chlorine (anhydrous)*
Colofonia (liquefatta)	🟩				*Colophony (liquefied)*
Esano				⬛	*Exane*
Etano				⬛	*Ethane*
Formaldeide	🟩				*Formaldehyde*
Freon 12 (soluzione acquosa)				⬛	*Freon 12 (water solution)*
Glicerina				⬛	*Glycerine*
Idrocarburi aromatici	🟩				*Aromatic hydrocarbons*
Idrogeno (gas)	🟩				*Hydrogen*
Idrossido di sodio (soda caustica al 20%)				⬛	*Sodium hydroxide (caustic soda at 20%)*
Metano				⬛	*Methane*
Metil Etil Chetone				⬛	*Methyl Ethyl Ketone*
Nafta				⬛	*Naphtha*
Ossigeno	🟩				*Oxygen*
Ossigeno gassoso (freddo)				⬛	*Oxygen gas (cold)*
Ossigeno gassoso (caldo)				⬛	*Oxygen gas (hot)*
Pentano				⬛	*Pentane*
Trementina				⬛	*Turpentine*
Urea				⬛	*Urea*

1. The compatibility/incompatibility of the materials and some chemical substances

The aluminum

Let’s see in the **Table 3**, the technical behavior of aluminum and aluminum alloy (Al-Cu alloys excluded) in the presence of hydrocarbons and halogenated compounds (source *Alluminio Manuale degli impieghi*). For technical aluminum, we mean aluminum falling within the categories defined by the international classification as series 1000, 2000, 3000, 5000, 6000 and 7000, whereas the Aluminum Alloy used by Cortem Group for its castings, belongs to the 4000 series of the same classification.

The international classification provides a four-digit system, the first of which indicates the main alloying element according to this index:

1…	Aluminum with minimum purity 99.00%
2…	Al-Cu alloys
3…	Al-Mn alloys
4…	Al-Si alloys (used by Cortem Group for its castings)
5…	Al-Mg alloys
6…	Al-Mg-Si alloys
7…	Al-Zn alloys

Table 3 Aluminum and aluminum alloys behavior with hydrocarbons and halogenated chemical compounds

Composto	Corrodibilità alluminio tecnico *Susceptibility to corrosion technical aluminium*							Corrodibilità leghe (escluse Al-Cu) *Susceptibility to corrosion alloys (excluding Al-Cu)*					Elements
	Ottima resistenza *Excellent resistance*	Buona resistenza *Good resistance*	Buona resistenza (purchè anidro) *Good resistance (as long as anhydrous)*	Buona resistenza con T < 100°C *Good resistance with T< 100°C*	Buona resistenza con T < 175°C (purchè anidro) *Good resistance with T< 175°C (as long as anhydrous)*	Scarsa resistenza *Poor resistance*	Pessima resistenza *Slack resistance*	Buona resistenza *Good resistance*	Buona resistenza con T < 100°C *Good resistance with T< 100°C*	Buona resistenza con T < 175°C (purchè anidro) *Good resistance with T< 175°C (as long as anhydrous)*	Scarsa resistenza *Poor resistance*	Pessima resistenza *Slack resistance*	
Acetilendicloruro		●						●					*Ethylene chloride*
Benzilcloruro			●					●					*Benzyl chloride*
Cloroamine							●					●	*Chloramines*
Clorobenzene	●							●					*Chlorobenzene*
Cloroformio			●					●					*Chloroform*
Cloronitrobenzene				●					●				*Chloronitrobenzene*
Clorotoluene		●							●				*Chlorotoluene*
Etilen dicloruro		●							●				*Ethylene dichloride*
Esacloroetano				●					●				*Hexachloroethane*
Isobutilcloruro		●						●					*Isobutyl chloride*
Diclorodifluorometano					●					●			*Dichlorodifluoromethane*
Vinil cloruro						●					●		*Vinyl chloride*

1. The compatibility/incompatibility of the materials and some chemical substances

Halogenated hydrocarbons, in presence of water, can decompose giving rise to the corresponding acids (eg hydrochloric acid), which attack the natural oxide film destroying it. It is also possible the development of complex reactions starting from aluminum halides.
The trend to reactivity is related to the stability of the organic halogen-radical bond. In each case, the corrosion problems occur at elevated temperatures, such as those boiling of chemical compounds. Some phenomena may occur in the presence of moisture, also in phase of storage, if the pieces subjected to degreasing with halogenated hydrocarbons are not well dried.

Let's see the behavior of the technical aluminium and the aluminium alloy (Al-Cu alloys excluded) (**Table 4)**, in the presence of compounds with aromatic rings (source *Alluminio Manuale degli impieghi*). The non-chlorinated aromatic compounds do not present serious problems of susceptibility to corrosion towards aluminium and its alloys. The aromatic acids are an exception to this rule, in particular salicylic acid, in the presence of moisture.

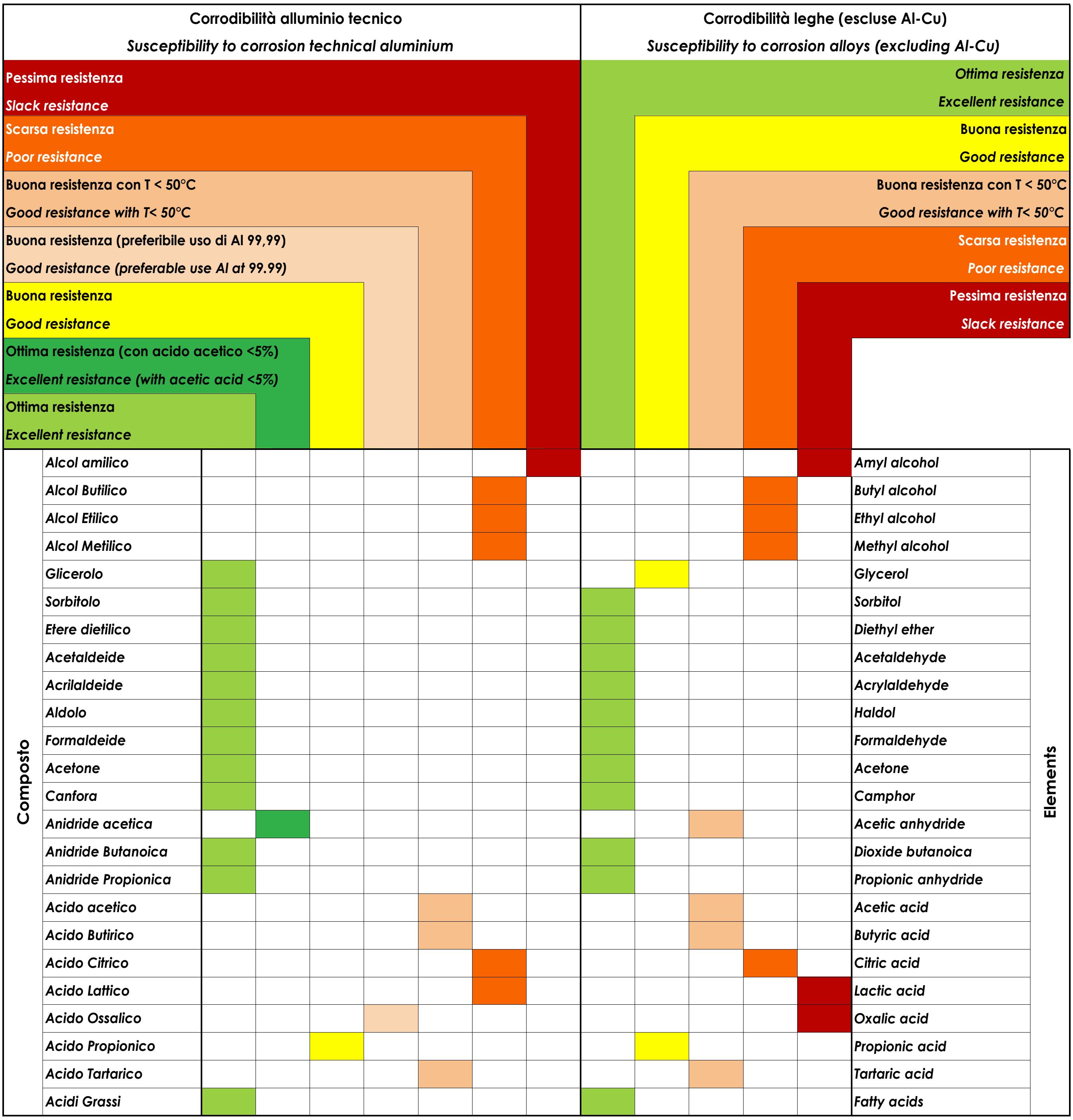
Table 4 The behavior of aluminum and alloy aluminum alloy in the presence of compounds with aromatic rings

	Corrodibilità alluminio tecnico *Susceptibility to corrosion technical aluminium*				Corrodibilità leghe (escluse Al-Cu) *Susceptibility to corrosion alloys (excluding Al-Cu)*				
Composto	Ottima resistenza *Excellent resistance*	Ottima resistenza (purchè esente da clorurati) *Excellent resistance (but free of chlorinated)*	Buona resistenza *Good resistance*	Buona resistenza (purchè anidro % acqua <1) *Good resistance (but anhydrous % water <1)*	Ottima resistenza *Excellent resistance*	Ottima resistenza (purchè esente da clorurati) *Excellent resistance (but free of chlorinated)*	Buona resistenza *Good resistance*	Buona resistenza (purchè anidro % acqua <1) *Good resistance (but anhydrous % water <1)*	**Elements**
Acetofenone	🟩				🟩				*Acetophenone*
Acido benzoico			🟨				🟨		*Benzoic acid*
Acido fenilacetico	🟩				🟩				*Phenylacetic acid*
Anidride italica				🟧				🟧	*Anhydride Italic*
Antracene	🟩				🟩				*Anthracene*
Benzaldeide	🟩				🟩				*Benzaldehyde*
Benzene		🟩				🟩			*Benzene*
Chinone	🟩				🟩				*Quinone*
Cresoli			🟨				🟨		*Cresols*
Dibutil Ftalato	🟩				🟩				*Dibutyl phthalate*
Difenile	🟩				🟩				*Diphenyl*
Diossano	🟩				🟩				*Dioxane*
Etilbenzene	🟩				🟩				*Ethyl benzene*
Fenoli	🟩				🟩				*Phenols*
Idrochinone	🟩				🟩				*Hydroquinone*
Naftolo		🟩				🟩			*Naphthol*
Salicilato	🟩				🟩				*Salicylate*
Stirene	🟩				🟩				*Styrene*
Toluene	🟩				🟩				*Toluene (Toluol)*

1. The compatibility/incompatibility of the materials and some chemical substances

Let's see the behavior of the technical aluminum and the aluminium alloy (Al-Cu alloys excluded) **(Table 5)**, in the presence of compounds with oxygen in the functional group (source *Alluminio-Manuale degli impieghi)*. The alcohols and organic acids can attack the light alloys and their aggressiveness depends on water content. Ethers, ketones, esters and anhydrides are classes of products virtually inert.

Table 5 The behavior of aluminum and aluminum alloys in the presence of compounds with oxygen



Composto	Corrodibilità alluminio tecnico / *Susceptibility to corrosion technical aluminium*: Ottima resistenza / *Excellent resistance*	Ottima resistenza (con acido acetico <5%) / *Excellent resistance (with acetic acid <5%)*	Buona resistenza / *Good resistance*	Buona resistenza (preferibile uso di Al 99,99) / *Good resistance (preferable use Al at 99.99)*	Buona resistenza con T < 50°C / *Good resistance with T< 50°C*	Scarsa resistenza / *Poor resistance*	Pessima resistenza / *Slack resistance*	Corrodibilità leghe (escluse Al-Cu) / *Susceptibility to corrosion alloys (excluding Al-Cu)*: Ottima resistenza / *Excellent resistance*	Buona resistenza / *Good resistance*	Buona resistenza con T < 50°C / *Good resistance with T< 50°C*	Scarsa resistenza / *Poor resistance*	Pessima resistenza / *Slack resistance*	Elements
Alcol amilico							■					■	*Amyl alcohol*
Alcol Butilico						■					■		*Butyl alcohol*
Alcol Etilico						■					■		*Ethyl alcohol*
Alcol Metilico						■					■		*Methyl alcohol*
Glicerolo	■								■				*Glycerol*
Sorbitolo	■							■					*Sorbitol*
Etere dietilico	■							■					*Diethyl ether*
Acetaldeide	■							■					*Acetaldehyde*
Acrilaldeide	■							■					*Acrylaldehyde*
Aldolo	■							■					*Haldol*
Formaldeide	■							■					*Formaldehyde*
Acetone	■							■					*Acetone*
Canfora	■							■					*Camphor*
Anidride acetica		■								■			*Acetic anhydride*
Anidride Butanoica	■							■					*Dioxide butanoica*
Anidride Propionica	■							■					*Propionic anhydride*
Acido acetico					■					■			*Acetic acid*
Acido Butirico					■					■			*Butyric acid*
Acido Citrico						■					■		*Citric acid*
Acido Lattico						■						■	*Lactic acid*
Acido Ossalico				■								■	*Oxalic acid*
Acido Propionico			■						■				*Propionic acid*
Acido Tartarico					■					■			*Tartaric acid*
Acidi Grassi	■							■					*Fatty acids*

1. The compatibility/incompatibility of the materials and some chemical substances

The stainless steel

Let's see the behavior of stainless steels **(Table 6)**, used in the chemical, petrochemical and oil plants, those non-magnetic, resistant to most chemicals organic and inorganic, with Cr content> 11%.
Stainless steel AISI 304 and AISI 316L are the most frequently used for such purposes.

Table 6 The behavior of non-magnetic stainless steels

Composto		Acciaio inox AISI 304 *Stainless steel AISI 304*				Acciaio inox AISI 316L *Stainless steel AISI 316L*					Elements
		🟩 Ottima resistenza *Excellent resistance*	🟨 Buona resistenza *Good resistance*	🟧 Bassa resistenza *Low resistance*	🟥 Bassissima resistenza *Very Low resistance*	🟩 Ottima resistenza *Excellent resistance*	🟨 Buona resistenza *Good resistance*	🟧 *Bassa resistenza* *Low resistance*	🟥 *Bassissima resistenza* *Very Low resistance*		
	Acetato di Amile		🟨			🟩				*Amyl acetate*	
	Acido Benzoico				🟥		🟨			*Benzoic acid*	
	Acido Bromidrico				🟥				🟥	*Hydrobromic acid*	
	Acido Butirico			🟧			🟨			*Butyric acid*	
	Acido Cloroacetico				🟥				🟥	*Chloroacetic acid*	
	Acido Fluorosilicico		🟨				🟨			*Fluorosilicic acid*	
	Acido Tricloroacetico				🟥				🟥	*Trichloroacetic Acid*	
	Acqua Ragia	🟩				🟩				*Turpentine*	
	Anidride Acetica				🟥		🟨			*Acetic anhydride*	
	Anidride Ftalica	🟩				🟩				*Phthalic anhydride*	
	Bauxite		🟨			🟩				*Bauxite*	
	Benzedrina		🟨				🟨			*Benzedrine*	
	Biossido di Zolfo		🟨				🟨			*Sulfur Dioxide*	
	Bromobenzene		🟨				🟨			*Bromobenzene*	
	Cianuro di Sodio	🟩				🟩				*Sodium cyanide*	
	Clorobenzene		🟨				🟨			*Chlorobenzene*	
	Cloroformio secco		🟨				🟨			*Dry chloroform*	
	Cloruro di Alluminio				🟥				🟥	*Aluminium chloride*	
	Cloruro di Etile (secco)			🟧		🟩				*Ethyl chloride (dry)*	
	Cloruro di Idrogeno			🟧				🟧		*Hydrogen chloride*	
	Cloruro di Magnesio				🟥			🟧		*Magnesium Chloride*	
	Fenolo		🟨			🟩				*Phenol*	
	Fosfato di sodio (tribasico)	🟩				🟩				*Sodium phosphate (tribasic)*	
	Idrossido di Alluminio		🟨				🟨			*Aluminium hydroxide*	
	Mercurio	🟩				🟩				*Mercury*	
	Nitrato di Ammonio			🟧			🟨			*Ammonium nitrate*	
	Ossido di Etilene	🟩					🟨			*Ethylene Oxide*	
	Perossido di Idrogeno			🟧			🟨			*Hydrogen peroxide*	
	Propano	🟩				🟩				*Propane*	
	Soda Caustica			🟧				🟧		*Sodium hydroxide*	
	Solfuro di Carbonio		🟨			🟩				*Carbon disulphide*	
	Toluene	🟩				🟩				*Toluene*	

2. The materials used in the construction of explosion-proof electrical equipment

Many different materials are used for producing enclosures, equipment, fittings and components designed for areas with a potentially explosive atmosphere.

They can be basically classified as follows:

Metal materials	***Plastic materials***	***Transparent materials***
Alluminium	*Polyesters*	*Polycarbonates*
Cast Iron	*Polycarbonates*	*Borosilicate glass*
Stainless steel		
Brass		

Choosing the best materials to be transformed into finished products, it is important to consider the limiting factors of nature.
All materials in general, and ours are no exception, are facing enemies such as:

- The environment
- The temperature
- The time
- The corrosion resistance
- Effect of hypo normal temperatures on metals
- Effect of temperature on thermoplastic resins

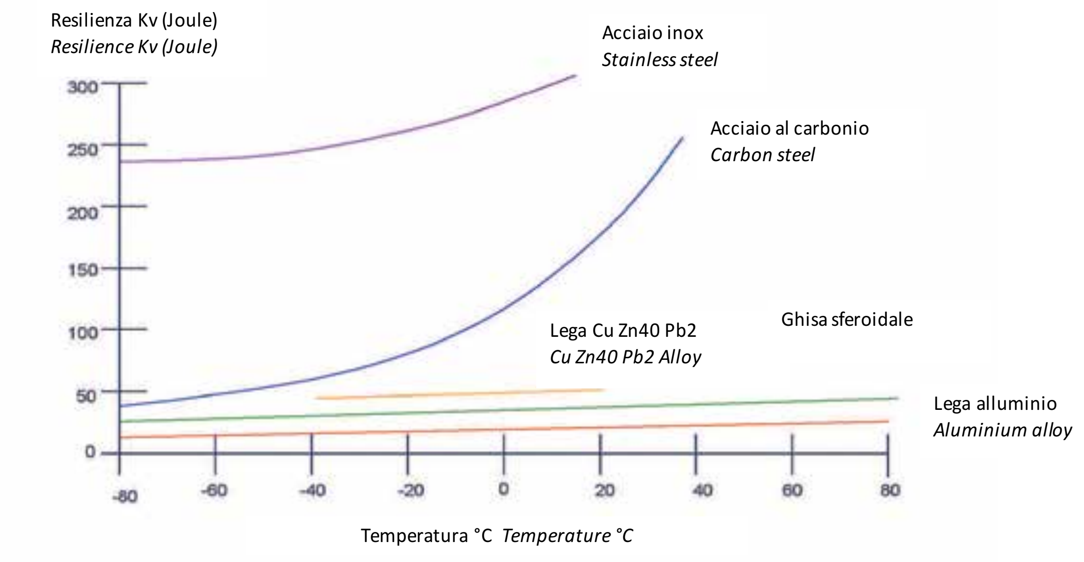
The environment, where our products are used, is not easy to control. We are not referring to the potential hazards due to the explosive atmosphere that we all well know and which are controlled by laboratory tests and guaranteed by the certifications. We're referring to the deterioration caused by the highly aggressive environment normally found in chemical and petrochemical plants.

The temperature is one of the factors which has variables dependent on the installation site and it is specific for each orographic lease of the plants.

Time is another factor which has variables dependent on the expectation of the end of life of the product or by the request of the client to ensure the functionality in a defined period of time.

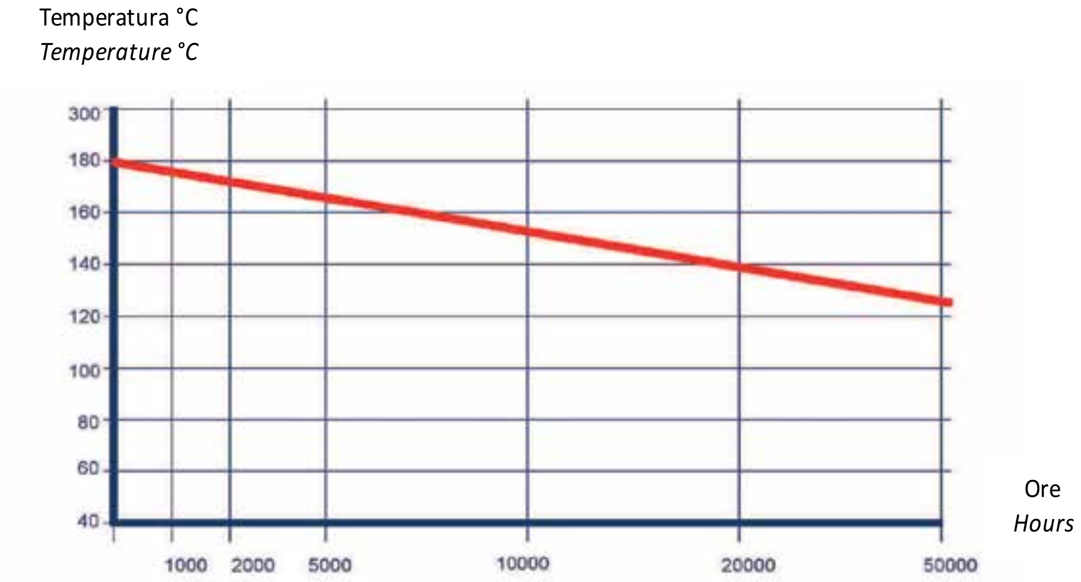
The corrosion resistance of the materials is a basic factor to ensure that the equipment is not degraded by the weather conditions and by the presence in the plant of aggressive and corrosive products. It's therefore essential the choice of the material and its surface treatment, in order to ensure its integrity over time.

The *Graph 1* below, highlights the behavior of the various materials at different temperatures. It is interesting to note that the aluminum alloy, brass alloy and the ductile iron, with decreasing temperature, retain almost unaltered their mechanical characteristics.



Graph 1 The effect of temperature on thermoplastic resins

Another problem regards the ageing of thermoplastic materials.
With the help of the DUPONT Information Centre, we have identified what type of thermoplastic resinsconforms to the ageing parameters required by Standard IEC 60216-2, which specifies that a thermoplastic material brought to its specific temperature of use and maintained for 20.000 hours must not lose more than 50% of its initial properties.
The *Graph 2* below shows the behavior of material used by Cortem Group.



For this purpose, Cortem Group constantly carries out tests on the materials used and in-depth studies on their resistance to external environments, in order to make some weigh up choices based on objective experience and thus ensuring the Customer safety of its products over the years.

The next chapter examines the aluminium alloys used by Cortem Group, the most commonly used material.

2.1 The aluminium alloy

The aluminum alloy is today one of the most widely used worldwide materials for the construction of a flameproof enclosure.
Its excellent corrosion resistance characteristics, make this material universally recognized as the most versatile and it applies for the majority of applications.

Compared to cast iron has the advantage of being much lighter and thus facilitate both assembly and maintenance of the system. It has excellent corrosion resistance without the need to be galvanized or varnished protected on the surface, as cast iron.

Compared to stainless steels, it has a cost very most lower. The mechanical characteristics, see Table below, of aluminum alloys castings are highly satisfactory for uses in the field of explosion-proof electrical protection.

Casting technologies	Ultimate tensile stress R(Kg/mm^2)	Yield point limit S(Kg/mm^2)	Elongation A5 (%)	Brinell hardness Hd(Kg/mm^2)
Sand	17 ÷ 20	8 ÷10	4 ÷ 8	50 ÷ 60
Shell	18 ÷ 22	9 ÷ 11	5 ÷ 7	50 ÷ 70
Die casting	23 ÷ 27	13 ÷ 17	1,5 ÷ 2,5	75 ÷ 95
Low pressure	23 ÷ 27	13 ÷ 17	5 ÷ 7	50 ÷ 70

Twenty-five or thirty years ago, it was commonly believed that aluminium was not suitable for applications in areas with highly corrosive atmospheres, like coastal and offshore plants or chemical plants using strong acids.

This was not entirely untrue, as there were signs of corrosion in these kinds of environments. However, this was because some aluminium alloys were used incorrectly.

We often refer to the improper term “aluminium”, but it is more correct to speak of aluminium alloys, as the aluminium used for casting is always alloyed with other compounds that enhance certain properties.

The Aluminium-Copper alloys are normally used in the car industry for producing engine parts. Corrosion protection is not important in this case, as the engine is always coated with oils. Aluminium-Copper alloys are therefore ideal due to their mechanical properties and good malleability.

The first explosion-proof enclosures were merged precisely with these alloys, which, however, have the disadvantage of not being absolutely corrosion resistant.
Today, after extensive studies, we have seen that it's the copper content in the alloy that, in the presence of an electrolyte, starts the corrosion.

Magnesium-aluminium alloys offer the best corrosion resistance. This is why they are most commonly used for producing ship parts. However, they cannot be used for making explosion-proof enclosures or any other parts designed for use in potentially explosive atmospheres.

In fact, the aluminum magnesium alloys have the characteristic of causing sparks when rubbed with metal utensils.
It is known that magnesium is a metal highly flammable and its presence in the alloy creates this drawback, not acceptable in an explosion-proof installation.

The 60079-0 standard, for the Group II, admits aluminum alloys with a content in magnesium, titanium and zirconium (for EPL Gb) up to 7.5% in total. However, Cortem believes that this limit is too high, since, as we said before, a percentage of this kind can cause sparks if the surface of the enclosure is rubbed. This belief comes from direct experience with such alloys and laboratory tests.

The aluminum alloys currently used by most manufacturers are Aluminum Silicon alloys, with a percentage of alloy which varies, depending on the formation technology, from 5% to 13%.

The copper is present only as an impurity and the main alloys may contain copper alloys for a maximum of 0.05% in the ingots and 0.1% in the castings.
Such alloys provide the perfect protection against corrosion in any environment.

In the past, manufacturers normally used alloys with a copper content of 0.3% or more, so in the best conditions, the copper content was six times higher than today.

■ The resistance of corrosion

The aluminium and its alloys are generally characterized by excellent corrosion resistance in many different environments.

Despite being a chemically active metal, aluminium is made stable by the formation of a protective oxide film on the surface. If this film breaks, it is able to reproduce itself immediately, and has a thickness of 50 to 100 Å if it forms in the air.

In case of exposure to more aggressive atmospheres, or when enhanced with artificial growth processes (anodizing), the film becomes thicker. »

This oxide film is transparent, hard, adherent to the surface and not laminated. Accidental abrasions on the surface of the film are automatically repaired. The corrosion of the aluminium and its alloys is therefore caused by conditions that mechanically abrade the protective film or lead to chemical conditions that damage a certain area of the film and reduce the amount of oxygen required for the film to repair itself.

This protective oxide film is generally stable in aqueous solutions with a pH of 4.5 to 8.5 and is not corroded by acids and alkaline solutions like nitric acid, acetic acid, sodium silicate or ammonium hydroxide, for example.

As per other metals, corrosion is related to the flow of cur- rent between anodic and cathodic areas, and therefore the potential difference between the areas. The entity and morphology of corrosive phenomena depend on various factors, such as the composition of the microconstituents, their localization and their quantity

Pure aluminium offers the best corrosion resistance, but all its alloys are still highly resistant to corrosion in many different environments. Like most materials, the presence of impurities on the surface or inside the metal can significantly reduce corrosion resistance.

■ Silicon Aluminium alloys

As previously stated, the alloys normally used for the production of aluminium castings are of three types:

- Aluminium – Copper
- Aluminium – Magnesium
- Aluminium – Silicon

Excluding the first two for the reasons outlined above, let's focus on silicon aluminum alloys.

This class of materials (aluminum - silicon) included aluminum alloys for widespread castings for a wide range of applications. These alloys are characterized by a silicon content from 5% up to 13% and they are used without copper to guarantee good castability, average mechanical resistance and corrosion resistance.
Small amounts of magnesium can be added to make these alloys heat-treatable and, therefore, ideal for semi-structural and structural uses.

In summary, the Si alloys are one of the most prestigious families in the field of aluminum smelter. They have some of the properties most valued by manufacturers and users of castings:

- Fairly high mechanical resistance
- Adequate ductility
- Good denseness
- Corrosion resistance.

Some of these properties are only potentially contained in Al-Si alloys. To make these properties effective, you need a special type of treatment: the modifying.

■ The modifying of Aluminium – Silicon alloy

There is no concise, effective or universally accepted term for defining this kind of modification.

This is because of the ambiguity surrounding the actual mechanisms of the so-called “modifying agents”, both on a chemical and metallurgical level.
The term “modification” is a very vague and generic term. The german term "Veredelung" is more accurate and descriptive, as it literally means “nobilization”.

In order to understand the physical and mechanical implications of this modification, you just need to analyze the differences on a micrograph of the structure before and after the treatment.

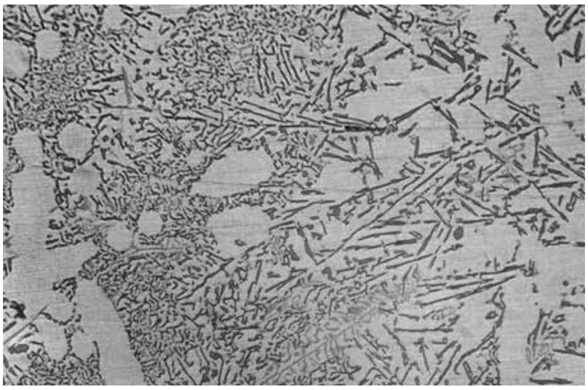


Figure 1

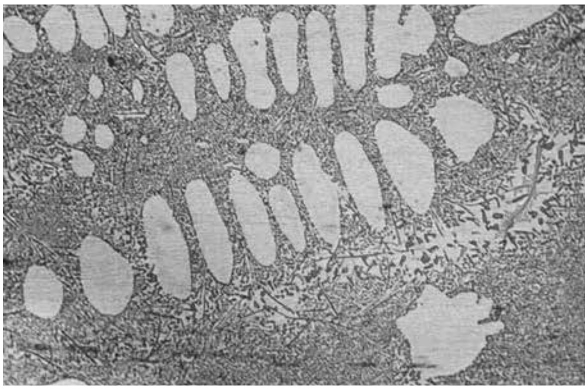


Figure 2

If you look at the microphotographs shown in figure 1 and figure 2, you can see the refined, “more noble” quality of the modified alloy structure in figure 2, compared to the coarser structure of the unmodified alloy in figure 1.

In the unmodified structure, you can see large polyhedral primary silicon crystals surrounded by much finer but many smaller acicular and needlelike formations of Al-Si eutectic. The background is a coarse matrix of phase ⍰ (solid solution of Silicon in Aluminium).

The appearance of the structure is very heterogeneous, all its constituents are distributed and combined in a random manner, and it is intuitive as the large size and the angularity of the contours of the various formations lead to unpredictable mechanical performance, anisotropic and poor anyway.

In the modified structure, however, the big Silicon crystals are totally absent, while the solid structure α is presented in the form of dendrites, immersed in a compact mass of tiny eutectic formations, which by means of a higher magnification appear globular.

Summarizing the above, one might conclude that the modification treatment acts on the structure of the alloy Al-Si eutectic formations attributing a fine globular morphology.

Choosing the type of modification is still one the most controversial issues in aluminium casting.

It depends on a series of reasons - from the technology that the type of modification requires, to its impact on the characteristics of the casting as well as economic and environmental implications.

Hypoeutectic alloys, which have a silicon content of less than 13%, can be modified by adding controlled quantities of sodium or strontium, which both refine the eutectic. The addition of calcium and antimony can also be useful in some cases.

In hypoeutectic alloys, the structure of the castings is refined by modifying non-eutectic silicon crystals and adding phosphorous.

The structure of Al-Si alloy is obtained through a modification treatment which improves its mechanical properties and corrosion resistance, as shown in tests carried out on samples produced with a piece of modified Al-Si alloy.

■ Determining of corrosion resistance

Purpose of tests

A series of testing procedures demonstrate and measure the susceptibility of modified Al-Si casting alloy to generalized, localized and structural corrosion when it’s combined with bronze components and subjected to specifically corrosive environmental conditions, in order to simulate the effect of an accelerated industrial situation.

These procedures include the tests and methods standardized by ASTM as described in following paragraphs.

Methods and reference documents

The laboratory equipment, the procedures used, the calculation of corrosion rates and the methods for evaluating the results have been planned in accordance with or in relation to the ASTM standards.

Pratiche standard per la rilevazione di suscettibilità all'attacco intergranulare nell’acciaio inossidabile austenitico.	**ASTM A262-15**	*Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels*
Pratica standard per la preparazione, la pulizia, e la valutazione di corrosione su campioni di prova	**ASTM G1 - 03**	*Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens*
Guida standard per eseguire le prove di corrosione su applicazioni in impianti	**ASTM G4 - 01**	*Standard Guide for Conducting Corrosion Tests in Field Applications*
Terminologia standard e acronimi relativi alla corrosione	**ASTM NACE / ASTMG193 - 12d**	*Standard Terminology and Acronyms Relating to Corrosion*
Guida standard per l'applicazione di statistiche di analisi dei dati di corrosione	**ASTM G16 - 13**	*Standard Guide for Applying Statistics to Analysis of Corrosion Data*
Guida standard per prove di corrosione dei metalli per immersione in laboratorio	**ASTM NACE / ASTMG31 - 12a**	*Standard Guide for Laboratory Immersion Corrosion Testing of Metals*
Metodo di prova standard per suscettibilità all'esfoliazionee corrosione delle leghe d'alluminio secondo serie 2XXX e 7XXX (EXCO Test)	**ASTM G34 - 01**	*Standard Test Method for Exfoliation Corrosion Susceptibility in 2XXX and 7XXX Series Aluminum Alloys (EXCO Test)*
Terminologia standard relativa all'usura ed erosione	**ASTM G40 - 15**	*Standard Terminology Relating to Wear and Erosion*
Guida standard per l'esame e la valutazione di corrosione puntiforme (vaiolata)	**ASTM G46 - 94**	*Standard Guide for Examination and Evaluation of Pitting Corrosion*
Pratica standard per eseguire le prove di corrosione atmosferica sui metalli	**ASTM G50 - 10**	*Standard Practice for Conducting Atmospheric Corrosion Tests on Metals*
Metodo di prova standard per la misurazione della corrosione potenziale di leghe di alluminio	**ASTM G69 - 12**	*Standard Test Method for Measurement of Corrosion Potentials of Aluminum Alloys*
Guida standard per la conduzione e valutazione della corrosione galvanica in soluzione elettrolitica.	**ASTM G71 - 81**	*Standard Guide for Conducting and Evaluating Galvanic Corrosion Tests in Electrolytes*
Guida standard per lo sviluppo ed uso di una serie galvanica per predire risultati di corrosione galvanica	**ASTM G82 - 98**	*Standard Guide for Development and Use of a Galvanic Series for Predicting Galvanic Corrosion Performance*
Pratica standard per prove degli apparati in nebbia salina (Fog)	**ASTM B117**	*Standard Practice for Operating Salt Spray (Fog) Apparatus*
Metodo di prova standard per prova accelerata con acido acetico in nebbia salina (Fog) prova (CASS Test)	**ASTM B368-09**	*Standard Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)*
Guida standard per il monitoraggio online di corrosione su apparecchiature in impianto (metodo elettrico ed elettrochimico)	**ASTM G96 - 90**	*Standard Guide for Online Monitoring of Corrosion in Plant Equipment (Electrical and Electrochemical Methods)*

Testing procedure

In accordance with the above aims and considering the assembled combination of aluminium alloy and bronze components **Figure 3,** a series of tests have been planned in order to recreate industrial environmental conditions in an accelerated way. These tests were carried out combining pairs of specimens in contact, with average surface ratios similar to real use.

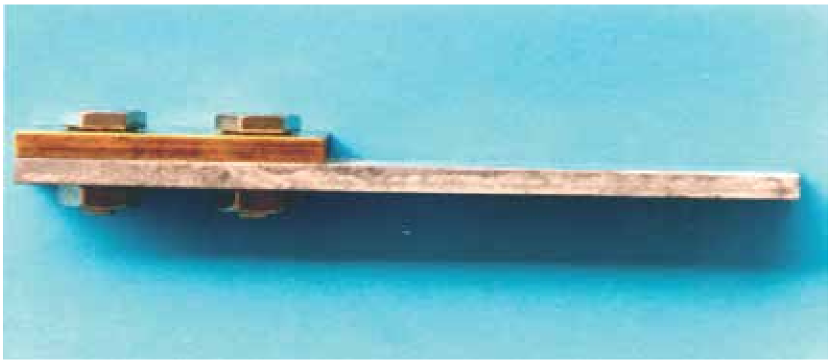


Figure 3 - Test Sample

The testing plan included the following tests:

Salt spray corrosion test- duration 48 / 96 h (ASTM B117)

- Instrument used: Salt spray chamber HERAEUS VOTSCH VSN 500
- Salt concentration, density and pH: 5 % ± 0.5 %; mass 1033 Kg/m3; pH 6.9
- Volume collected in pluviometer: 1.6 cc/hour
- Temperature of chamber and air pressure: 35°C ± 1°C; 0.7 atm
- Testing times: Duration 48 hours and 96 hours - 24-hour observation
- Washing of test piece after test: running water
- Test pieces: silicon aluminium alloy plate, bronze plate, stainless steel screws
- Surface finishing of test pieces: 600 grain carborundum paper

Test results

Test specimen	***Testing time (hours)***	***Weight loss (grams)***	***Comments***
Al-Si / Bronzo alloy	*24*	*0*	*Formation of black spots on both alloy plates*
	48	*0*	*Worsening of black spots that appear extended, appearance of white corrosion products*
	96	*0*	*Progressive worsening of defects previously*

Corrosion test in hydrogen sulphide current - duration 96 h ASTM NACE / ASTMG31-12a

- Instrument used: ERLENMYER 1000 cc containers and METTLER analytical balance div. 0.0001 g.
- Test solution, pH: aqueous solution of NaCl (5 % in weight); pH 7.4
- Chamber temperature: 25°C ± 1°C
- Exposure time: 96 hours
- Test pieces:

1. al-Si alloy plate:20.7 x 5.0 x 100.5 mm - Weight: 26.856 g
2. Bronze plate: 39.9 x 20.1 x 4.9 mm - Weight: 30.709 g
3. Surface finishing of test pieces: 600 grain carborundum paper

Gas flows:

- saturation of testing chamber with nitrogen released at 100 cc/min per litre of solution for 1 hour;
- saturation with hydrogen sulphide released at 200 cc/min per litre of solution for 1 hour;
- saturation with hydrogen sulphide released and maintained at a ratio of 10 cc/min per litre of solution for 96 hours.

Test results

Test specimen	***Testing time (hours)***	***Weight loss (grams)***	***Comments***
Al-Si / Bronzo alloy	*96*	*0*	*The specimens do not lose weight after 96 hours. Localized black marks appear on the surface of both plates and the dendritic structure of aluminium is more evident. No sign on either surface of corrosive phenomena like pitting.*

Corrosion test in hydrogen chloride solution 20 ppm - 600 h (for immersion) ASTM NACE / ASTMG31-12a

This test was carried out using a solution of 20 ppm hydrogen chloride.
The calculations only refer to the silicon-aluminium specimen, as the bronze piece did not lose weight and therefore demonstrated excellent corrosion resistance.

- Instrument used: 250 cc flask and METTLER analytical balance div. 0.0001 g.
- Test solution: aqueous solution of 20 ppm hydrogen chloride
- Chamber temperature: 25°C ± 1°C
- Exposure time: 600 hours

- Test pieces: Al-Si alloy plate: 20.6 x 5.0 x 100.7mm, Weight: 26.856 g, Density: 2.66 g/cm3
- Surface finishing of test pieces: 600 grain carborundum paper

Test results

Exposion time (hours)	**Weight loss (grams)**	**Corrosion index* (mm/year)**	**Remarks**
600	*0,0011*	*0,012*	*The tested specimen demonstrated good resistance to hydrogen chloride in the percentage of 20 ppm.*

** Corrosion index (mm/year) = (K x W) / (A x T x D)*
where:
- K = constant equal to 87,600
- W = loss in weight (grams)
-A = surface exposed (in cm^2);
- T = exposure time (hours)
- D = density (g/ cm^3).

Galvanic corrosion test in electrolytic solution (NaCl 5%) ASTM G71 - 81

- Instrument used: 1000 cc flask and METTLER analytical balance div. 0.0001 g.
- Test solution: aqueous solution of NaCl at 5% in weight
- Chamber temperature: 25°C ± 1°C
- Exposure time: 48 hours
- Voltage applied: 2V
- Current applied: 1.4A
- Test pieces: Al-Si alloy plate:20.4 x 5.1 x 100.9mm, Weight: 26.928 g
  Bronze plate 39.9 x 20.1 x 4.9 mm, Weight: 30.709 g
- Surface finishing of test pieces: 600 grain carborundum paper

Test results

Sample on test	**Exposition time (ore)**	**Voltage applied (Volt)**	**Current applied (Amper)**	**Weight loss (grammi)**
Al-Si Bronze alloy	*48*	*2*	*1,4*	*0*

Remarks:

The behavior of the bronze sample confirms the good corrosion resistance of this material presenting only slight hints of formation of white products on the exposed surface.
On the sample of Al-Si alloy white corrosion products are more evident in particular on the area of contact between the two materials.
On the aluminum surface in a manner not uniform, we notice the formation of slight corrosion (pitting), and localized in particular evident in the area of contact between the two samples and on the edges.

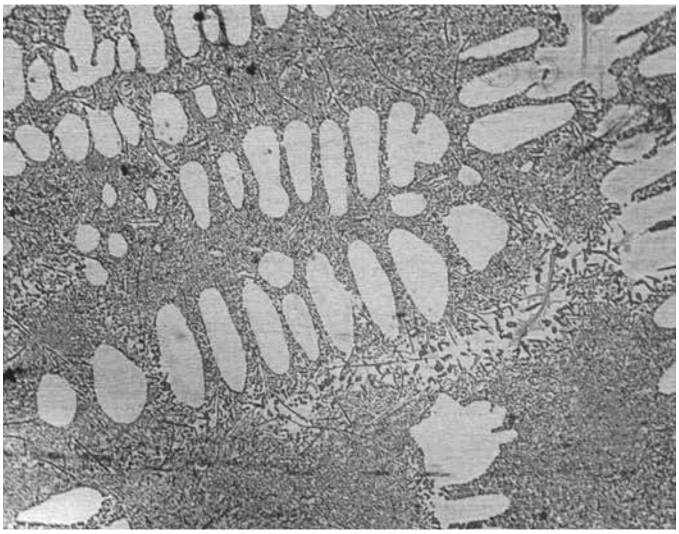
- Pitting corrosion evaluation ASTM G46 - 94

The pitted corrosion (pitting), present on only one sample subjected to corrosion test for galvanic currents, assumes a modest appearance with the presence of pitting read modest (maximum depth 0.15mm).
The preferential distribution is in correspondence with the edges.

- Evaluation of intergranular corrosion by micrographic examination, according to ASTM A262-15

The micrographic structures of the samples tested in the course of different corrosion tests, were verified in order to identify corrosion of intergranular type.
After metallographic preparation of the samples (cutting, polishing and chemical etching), the structures have the typical characteristics of alloys in question. In particular, we can see the typical structural differences arising from the different rate of solidification; Microphotograph n ° 1 (Figure 1): aluminum dendrites in solid solution with the matrix formed by the eutectic Al-Si; Microphotograph No. 2 (Figure 2): inter dendritic eutectic silicon particles in the aluminum matrix. These two types of structures are present on all tested samples and pass with continuity from one to another; Microphotograph n° 3 (Figure 4). All the observed structures highlight the absence of intergranular corrosion phenomena.

Figure 4 Micrograph of the sample after testing



■ The surface treatment of ferrous and non-ferrous metals

The materials that are usually used in plants described above, except for the steels, which do not need further protective treatments, if properly selected for their installation, need of surface treatment suitable to the type of possible corrosion present at the place of installation.

Aluminium, for example, may require anodizing or other surface treatments to be protected against aggressive agents or painting treatments, always for the same reasons, choosing such treatments according to the system design specifications.

Furthermore, the carbon steel, commonly indicated as "Iron", requires protective surface treatment such as: a system of electrolytic galvanizing, if the aggressiveness is slight and if the material will be installed in confined areas (Indoor); hot-dip galvanized if installed in highly aggressive and outside areas (Outdoor); coating systems like "wet on wet" or electro-static (powder), with defined cycles of preparation and treatment for the types of aggressive agents.
Cortem Group, always focused on these issues and constantly looking for new technologies for the treatment of materials, for several years uses a system for surface treatment, depending on the specific system requirements. It is able to apply a protection to materials usually used to manufacture its equipment: lighting fixtures, sockets, distribution boxes (junction box), switching boxes (Marshaling box) or panel boards for starter, control and distribution that, if left in their natural state and in the presence of not compatible harsh chemicals, they can be attacked even irreversibly.

■ Conclusions

As you can see, the variables that could occur in the various cycles of the production process are many and not always predictable, if not in the phase of the plant engineering.

Therefore, the aim of this discussion was to highlight how many and which may be the factors of the degradation of materials that can be used in industrial plants, leaving to the designer the choice of the correct type of material.

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