



ALUVENTA

Aluventa Selection Guideline

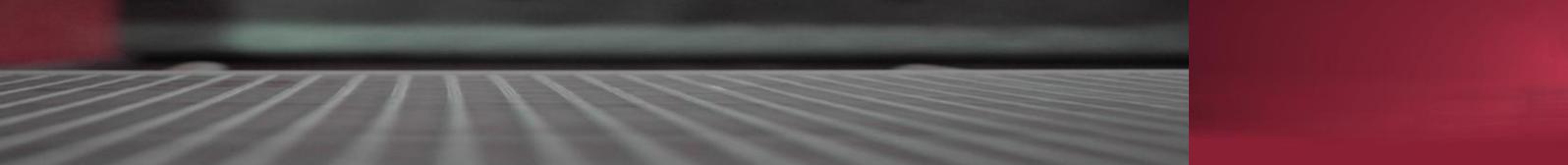
High performance

ALUMINIUM CONDENSERS



Selection Guidelines

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The purpose of this document is to guide our customers when selecting a product for a given operation environment. To do this the attention needs to be drawn to towards classification of different environments in respect to pollution and corrosion of metal.

The awareness of and knowledge about environmental pollution, corrosion of metal and corrosion protection is of great importance during the entire lifetime of HVAC units and systems (design, construction, assembly, storage, transport, installation, commissioning, operation, maintenance and repair). This includes also when choosing the appropriate Heat Exchanger.

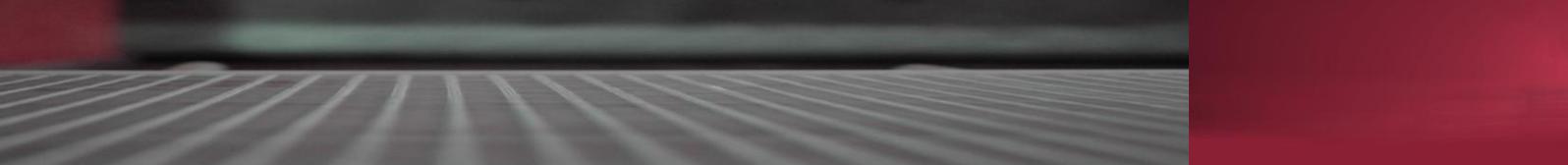
At Aluventa we take pride in helping and guiding our customers in choosing the best Heat Exchanger product. We are aware of the limitations of materials in corrosive environments and do our utmost to guide our customer on this subject. We do it because we feel it is a sustainable and fair way to do business.

At Aluventa we don't have control over the choice of field environment for the Heat Exchangers. So we rely on our customers to have a proactive approach towards preventing corrosion of the heat exchangers by thorough and professional evaluation and analysis of the field environment. It is the responsibility of our customers to choose the right product for a given environment, but we are always at the disposal of our customers during this phase.

The information we have compiled in this document has been selected to give a relevant introduction to the subject of pollution and corrosive environments in order to guide in the product selection phase. We ask you as our customer to seek additional and more detailed information and guidance elsewhere, as the information in this document cannot be considered complete on these subjects.

Apart from this information please also be sure to consult the Aluventa Installation and maintenance manual as well as the Aluventa design guidelines.

These recommendations and guidelines reflect our experience. They can neither replace the assessment of the installation location, conditions and environment by experts nor the assessment of possible corrosion attack. The recommendations and guidelines are merely intended for technical information purposes. We assume no liability for the completeness and correctness of the information. The information is intended to support the technical assessment of the installation location conditions.



Introduction

Everywhere we go we may expect the environment to be polluted. We often think and see pollution as for instance health or environment threatening smoke emissions from large factories or plants. However sources of pollution can be much more subtle and less obvious. Pollution can consist of chemical substances but can also be in the form of for instance noise or heat. Our perception of pollution is closely linked to the effects pollution has on our environment. Of the many effects that can be caused, corrosion of metal is an important one. Apart from corrosion caused by pollution, corrosion of metal is a natural phenomenon that can easily be observed and is experienced everywhere in the world. Corrosion of metal is normally considered a negative effect that needs to be dealt with and preferably prevented. In the HVAC industry corrosion protection by clever choice of materials and coatings is an integral part of the system design and has been for many years.

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Corrosion

Any metal exposed to the atmosphere/environment will react with the contents of this environment. These reactions are normally referred to as oxidation, corrosion and similar. The extent and nature of the specific reactions that take place depends on the type of metal and on the specific contents of the surrounding environment (temperature, humidity, "pollution", oxygen). There are several types of corrosion.

Uniform corrosion is a corrosion type where the corrosion attack is evenly distributed over the entire metal surface like for instance atmospheric corrosion of iron. Galvanic corrosion is a more localized corrosion attack on a less noble metal in contact with a more noble metal for instance when iron is in contact with copper. Other corrosion types are pitting corrosion, Inter-crystalline corrosion etc. These types of corrosion can arise if the conditions allow it. Generally an electrolyte is needed for the corrosion reactions to occur. Often water or humidity in general is acting as electrolyte.

The corrosion wear of a metal Heat Exchanger can be significantly influenced by the HVAC application using it. Some applications and installation sites can challenge the materials system more than others. Special attention must be paid to the corrosion severity of the environment at the installation site. An environment in a high corrosion category (See for instance ISO 9223-9226 standards) will have a much higher and negative impact on the Heat Exchanger than a low corrosion category. Similarly the time of wetness which depends on the operating pattern and the cleanliness of the coil will also have a significant influence on the coils corrosion resistance. The local climate and the immediate surroundings play a similar role. A nearby industry or local exhausts or emissions can alter an otherwise favorable and clean environment to a corrosive one. Similarly attention must be paid to installations in busses, trucks or trains that pass through many different regions, climates, environments etc.

Inappropriate Installation and handling can similarly influence corrosion wear of the heat exchanger. When metals of different types are in contact, appropriate corrosion protective measures must be taken. When sheet metal or metal piping is being cut or grinded in or near the unit, sprays of metal dust and sparks can reach the Heat Exchanger and be the source of a local corrosion attack. Similarly if for instance rain water can drip onto the Heat Exchanger from bare metal piping or sheet metal etc. There are unfortunately many ways in which corrosion attacks can be initiated or stimulated.

To identify the possible corrosive initiators and conditions for the heat exchangers the environment is divided in three areas: The General Environment, the Specific Environment and the Direct Environment.

General environment

The general environment is the environment that intuitively is characteristic for the geographic region. General environments are normally referred to as: Industrial, Urban, Rural and Coastal/marine.

The corrosion effects in these environments are also highly influenced by weather conditions. The wind direction and speed, the humidity of the atmosphere, as well as rain and temperature during the year. In some areas and in some parts of the year the weather conditions are favorable towards limiting corrosion in other areas and times the weather conditions can accelerate corrosion considerably.

Coastal and marine environments

Coastal and marine environments are characterized by the effects from the nearby sea. The environment is corrosive mainly because of the saline sea water and possibly high humidity. Salt from sea water can be spread by the wind in forms of droplets, mist or fog and cause corrosion attack due to the presence of chlorine many kilometers from the coast line. Marine environments are of course extremely exposed to corrosion caused by chlorine.



Industrial environments

An industrial environment is the environment generated in areas with a high density of industry. Industrial environments can be very different depending of which industry is present and depending on what emission levels are allowed in that particular area. A very large variety of chemical substances and combinations of such can be present. Industrial areas typically have increased amounts of sulphur, ammonia, chlorides, NOx compounds and metals in air and dust. These are known to cause corrosion attack on metal.



Urban environments

An urban environment is an environment with a high population density. These environments are typically polluted with the emissions from traffic and from heating of buildings. The degree of pollution of the urban environments depends very much on the size of the area and traffic load, as well as of the combination of build structures and climate. Many urban areas in the world are to be considered industrial environments due to the nature and amount of emissions.



Rural environments

Rural environments are normally not corrosive environments. However certain types of local emissions are common in rural areas. For instance ammonia from animal feces and urine, fertilizers and diesel exhausts. In these areas the environment must be considered industrial.



The specific environment

The specific environment is the environment in the close proximity of the installation for instance within a few 100 m. The specific environment is the environment generated by emissions from nearby factories, traffic, power plants or similar. The corrosive effects can often be estimated from the knowledge of the emissions from the specific sources. The specific environment can be anywhere inside a General Environment and may be very different from the general environment. For instance a pig production unit in a rural area may create a different environment due to the emissions of ammonia from the stables.

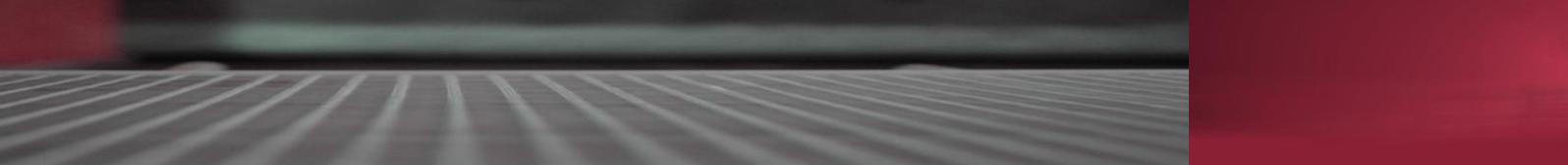


Specific environments can be: Airports, food processing factories, chemical factories, power plants, fuel stations, power plants, biofuel plants, wastewater treatment plants, Animal production units, waste dumps etc.

The direct environment

The direct environment is the environment generated by emissions directly at the installation site or towards the unit. This environment may only exist adjacent to the installation. Direct environment is the environment generated by for instance: Exhausts vents, cleaning fluids, combustion exhausts, spills of fuel or chemicals, de-icing agents, weed control using chemicals, slurry tanks and manure etc. The corrosive effects of the direct environment can be dramatic and are often overlooked. For instance ventilation exhausts from food factories containing fumes of chlorine or acids from cleaning processes.





Corrosion testing and Field experience

To evaluate the ability of a materials system to resist corrosion attack accelerated corrosion test can be used. Several tests exist to accelerate corrosion on metals. The ASTM G85 and ASTM B117 are considered by the Automotive and HVAC industry to be the most severe and wide spread standardized tests available. These tests differ in severity by having different acidity (pH) and other test parameters. The tests probe the relative corrosion resistance of the metal. The most severe corrosion test is severe enough for all metals to be affected over time (days).

The Corrosion tests are relative test and must always be used with some sort of reference for comparison. The accuracy of the ASTM specification for the test conditions means that the same material will behave differently in different tests. Additionally the tests does not probe the effects of atmospheric substances like, SO_x, NO_x, NH₃ as well as the effects of time of wetness and biological fouling that can be present in the field.

These test results cannot be used to predict the behavior of Heat Exchangers in the field. To do this, indirect methods and experience must be used. Knowledge about the field environment and observations from the field is one of the best methods to evaluate the risk of corrosion and one of the best tools for initiating preventive actions against corrosion.

The ISO 9223-9226 standards on corrosion classify quantitatively different environments according their corrosion severity and effects on common metals. These standards can be consulted for further guidance and detailed information regarding corrosive environments.

Corrosion protection

The natural oxide layer of Aluminium is very strong/dense and acts as a corrosion protection to the underlying metal. This does not mean that Aluminium is sufficiently protected by its inherent oxide layer for all applications and conditions. That will depend on the specific Aluminium alloy and the corrosivity of the environment.

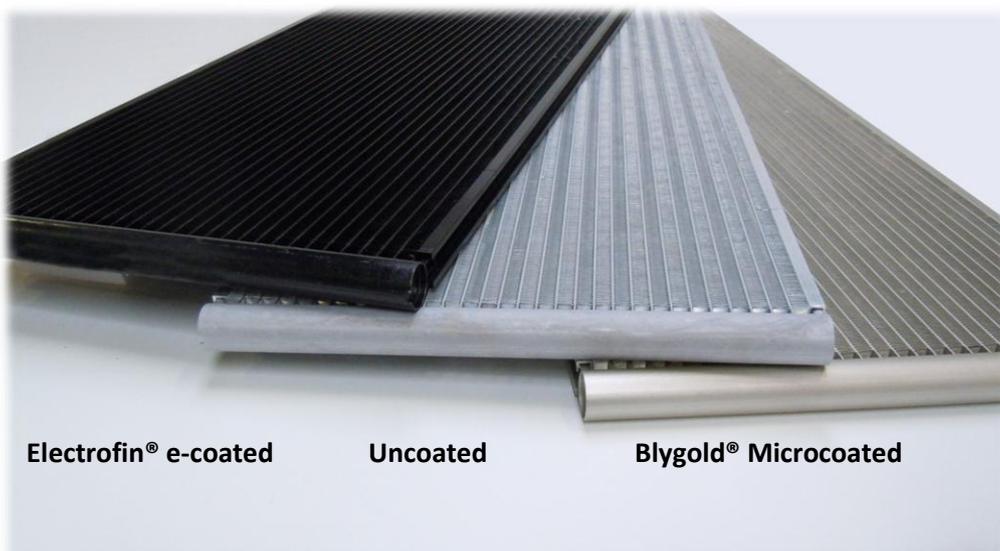
Materials system

The Aluminium alloys used in the Aluventa Heat Exchangers are constantly undergoing evaluation in order for the Aluventa products always to meet the customer requirements and obtain the best performance in the field. As the knowledge about the performance of Aluminium heat exchangers in various field applications increases, new alloys are being developed and used for MCHX. This is an ongoing activity where Aluventa is working together with leading Aluminium suppliers and international experts and scientists in the task of constant improving the Aluventa materials system. However Aluminium has its limitations and even the best possible alloy will need additional corrosion protection in sufficiently corrosive environments.

Coating

One method of protecting the Heat Exchanger against corrosion is coating. There are several corrosion protective coatings available on the market suitable for HVAC components. Some of which have proven reliable in the field over several years. However for the Micro Channel Heat exchanger only a few coating solutions are acceptable.

Aluventa is offering coating solutions of the Heat Exchanges that will prevent otherwise fast corrosion mechanisms to occur. Due to the Aluventa coil design and the coating properties these coating solutions only have a very low impact on the coil performance.



Electrofin® E-coating

The e-coat is a water based flexible, epoxy polymer coating. The e-coat formulation is a PPG Powercron® designed to provide excellent edge coverage of fins. The Electrofin® e-Coating is a UV resistant proven technology and process for corrosion protection of Aluminium MCHX with 100% coverage without bridging. The coating layer thickness is 15-30 micron resulting in very small performance loss. Our coating supplier guaranties the following specifications:

Technical performance of coating

Dry Film Thickness: 15-30 micron (ASTM D7091-05)
Gloss -60°: 65-95% (ASTM D523-89)
Pencil Hardness: 2H minimum (ASTM D3363-00)
Water Immersion: >1000 hours @ 38°C (ASTM)
Cross Hatch Adhesion: 4B-5B (ASTM D3359-97)
Impact Resistance: 160 in./lbs. Direct (ASTM D2794-
Salt Spray: 6048+ hours (ASTM B117-97)
Humidity Resistance: 1000 hours minimum (ASTM)
Durability: Very Flexible, Consistent film
Heat transfer reduction: <1% (ARI 410)
Bridging: No bridging guaranteed
Coating of enhanced fins: Up to 30 Fins per inch
pH Range: 3-12
Temperature limits: -40 – 163°C

Standards met

MIL-C-46168 Chemical agent resistance – DS2, HCl
CID-A-A-52474A (GSA)
MIL-STD 810F, Method 509.4 (Sand and Dust)
MIL-P-53084 (ME)-TACOM Approval
MIL-DTL-12468 Decontamination Agent (STB)
DPG (Dugway Proving Grounds) Soil & Water
GM9540P-97 Accelerated Corrosion Test (120
ASTM B117-G85 Modified Salt Spray (Fog) Testing-

Blygold® Microcoat

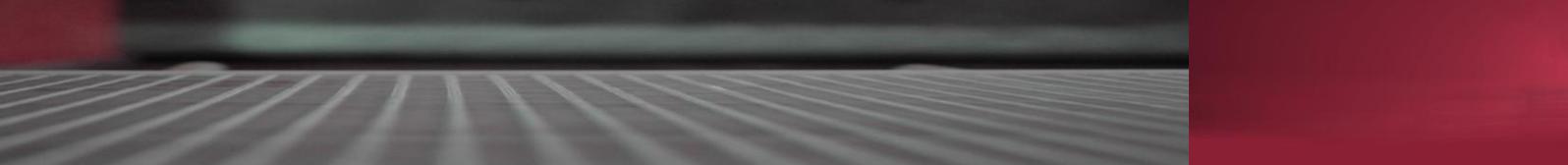
The Blygold® Microcoat is a polyurethane based UV resistant coating filled with aluminium pigmentation to ensure good heat conductivity. The Microcoat process includes a zirconium based treatment of the heat exchanger for additional protection and adhesion of the top layer. The top layer is applied in a spray process specially developed to penetrate into the center of the Heat exchanger and ensure coverage of the entire surface. The Microcoat is specially adapted to the microchannel technology and is derived from the years of experience with corrosion protection of heat exchangers in the field. Our coating supplier guaranties the following specifications:

Technical performance of coating

Gloss - 60°: 11
Pencil Hardness: H (ASTM D3363)
Cross Hatch Adhesion: 5B (ASTM D3359-83,
Impact Resistance: No visual defects at 5 mm (ISO 1520)
Mechanical hardness (Falling sand abrasion): 38.0litres
Salt Spray: 4,000+ hours (ASTM B117)
Acid Salt Spray: +4000+ hours (ASTM G85 A1)
SO2 Spray: 80 cycles (Din 50018-SFW Kesternich 2.0l
UV test: Very small discoloration (ASTM G23-81 method

Coating characteristics

Dry Film Thickness: 0,025 mm average.
Durability: Very flexible coating
Heat Transfer Reduction: 0,5%
Bridging: No Bridging Guaranteed
pH Range: 3-11 (long term)
Temperature Limits: -30°C to 150°C



Guideline for evaluating the environment

A proper evaluation of the environment of the installation site is important for the selection of a suitable heat exchanger solution.

General environment

Check if the installation site is marine or near the coastline and if the prevailing wind is from the coast towards the unit. Is the installation site inside a large city or highly populated area. Is the installation site in the country side or in an area with a lot of industry?

Specific environment

Check if the installation site is near or at a factory or industry ground. Check for nearby sewage treatment facilities or power plants, chemical industry, Food industry Bio fuel processing, petro industry, plastic industry etc

Direct environment

Check if the unit is adjacent to exhaust pipes, ventilation ducts, fueling areas, Combustion exhausts, flue pipes, building grounds. Check for risk of sprays or vapour of cleaning fluids, sparks and metal dust from grinding or welding processes.

Selection recommendations

In the following recommendations when and not to choose coated heat exchangers are made based on the evaluation of the field environment. It is important that the most severe corrosive parameter dominates the others. If one parameter is severe enough to require a coated coil 1 or more parameters with low severity cannot neutralize this requirement.

General Environment

Table1: COASTAL / MARINE						
	Distance from Coast					
	20 km inland			Coastline		
	→					
	Predominant wind direction					
	From unit to coast			From coast to unit		
	→					
	Corrosion present on other equipment					
	None			Clearly present		
	→					
Blank Heat Exchanger	OK	NOK	NOK	NOK	NOK	NOK
Coated Heat Exchanger	OK	OK	OK	OK	OK	OK

Table2 : INDUSTRIAL						
	Contaminant Concentration					
	Low			High		
	→					
	Corrosion present on other equipment					
	None			Clearly present		
	→					
Blank Heat Exchanger	OK	NOK	NOK	NOK	NOK	NOK
Coated Heat Exchanger	OK	OK	OK	OK	OK	OK

Table 3: URBAN						
	Pollution level / Population density					
	Low			High		
	→					
	Corrosion present on other equipment					
	None			Clearly present		
	→					
Blank Heat Exchanger	OK	NOK	NOK	NOK	NOK	NOK
Coated Heat Exchanger	OK	OK	OK	OK	OK	OK

Table 4: RURAL						
	Corrosion present on other equipment					
	None			Clearly present		
	→					
Blank Heat Exchanger	OK	NOK	NOK	NOK	NOK	NOK
Coated Heat Exchanger	OK	OK	OK	OK	OK	OK

Specific environment

Specific environments emitting corrosive substances must be treated as Industrial environments (see table 2). Below is a table of installation sites that constitutes a specific environment.

Installation site	Properties	Aggressive substances
Power plants	Combustion products	SO _x , NO _x , Chlorides, Fluorides
Chemical industry	Process emissions	Ammonia, Chlorides, NO _x , SO _x
Bio fuel plants and processing	Process emissions	Ammonia, SO _x , NO _x
Petro industry	Oils, Fuel, process emissions	Ammonia, Chlorides, NO _x , SO _x
Fuel stations	Fuels, combustion products	Fuel spill, Chlorides, NO _x , SO _x
Airports	Combustion products	NO _x , SO _x , Chlorides,
Agricultural	fertilizer, organic compounds	SO _x , NO _x , Ammonia
Sea air, ships, offshore	Salt water spray	Chlorides, Sulphur
Heavy industry	Carbon dust	Sulphur, SO _x , NO _x
Steel industry	Carbon, dust	Sulphur, SO _x , NO _x
Food industry	Fat, air humidity, Cleaning agents	Chlorine, acid, SO _x , NO _x
Waste disposal industry	Particles, organic airborne particles	Ammonia
Sewage treatment plants	Organic airborne particles	Sulphur, ammonia
Deserts	Low air humidity	

Direct Environments

If sources for corrosive substances in the direct environment are identified, the direct environment must be treated as industrial (See table 2). These sources are in the form of exhaust vents for process gas, sewage, steam and general ventilation. Fuel or chemical spills, chimneys etc.

Chemicals resistance list

Electrofin E-coating Chemical Resistance guide

ElectroFin® polymeric e-coat is chemically resistant to the following chemicals at ambient temperatures. The ElectroFin® e-coat is not intended for liquid (immersion) applications. Elevated temperatures can have an adverse effect on the corrosion durability of ElectroFin® e-coat, depending on the specific environment. This table is to be used as a guide for general reference. For specific corrosion resistance durability, please contact Aluventa A/S for technical support.

Acetone	Fructose	Ozone
Acetic Acid	Gasoline	Perchloric Acid
Acetates (ALL)	Glucose	Phenol 85%
Amines (ALL)	Glycol	Phosgene
Ammonia	Glycol Ether	Phenolphthalein
Annonium Hydroxide	Hydrochloric Acis <10%	Phosphoric Acid
Amino Acids	Hydrofluoric Acid (NR)	Potassium Chloride
Benzene	Hydrogen Peroxide 5%	Potassium Hydroxide
Borax	Hydrgen Sulfide	Propyl Alcohol
Boric Acid	Hydrazine	Propylene Glycol
Butyl Alcohol	Hydroxylamine	Salicylic Acid
Butyl Cellosolve	Iodine	Salt Water
Butyric Acid	Isobutyl Alcohol	Sodium Bisulfite
Calcium Chloride	Isopropyl Alcohol	Sodium Chloride
Calcium Hypochlorite	Kerosene	Sodium Hypochlorite 5%
Carbon Tetrachloride	Lactic Acid	Sodium Hydroxide <10%
Cetyl Alcohol	Lactose	Sodium Hydroxide >10% (NR)
Chlorides (ALL)	Lauryl Acid	Sodium Sulfate
Chlorine Gas	Magnesium	Stearic Acid
Chrome Acid (NR)	Maleic Acid	Sucrose
Citric Acid	Menthol	Sulfuric Acid 25-28%
Creosol	Methanol	Sulfates (ALL)
Diesel Fuel	Methylene Chloride	Sulfides (ALL)
Diethanolamine	Methyl Ethyl Ketone	Sulfites (ALL)
Ethyl Acetate	Methyl Isobutyl Ketone	Starch
Ethyl Alcohol	Mustard Gas	Toliene
Ethyl Ether	Naphthol	Triethanolarmine
Fatty Acid	Nitric Acid (NR)	Urea
Fluorine Gas	Oleic Acid	Vinegar
Formaldehyde 27%	Oxalic Acid	Xylene

NR = Not Recommended

Blygold® Microcoat Chemical resistance guideline

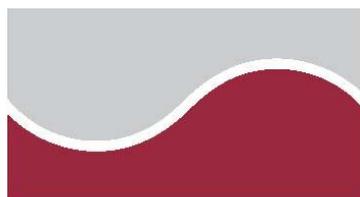
Blygold® Microcoat resistance to various agents and particles has been tested in lab conditions. The issue of a warranty to a heat exchanger by the Blygold® Microcoat corrosion protection system will be subject to the exposure conditions simulated in this test. Values are based on average concentrations, at any doubt the R&D department of Blygold® International should be consulted. Attention !! Resistance is expressed in terms of vapors, not fluids. Concerning exposure to fluids, cleaning agents, chemicals, process fluids or others, Aluventa A/S should be consulted. Resistance is based on exposure temperature of 20°C or 68°F.

Inorganic acids	Max ppm	Ethers	Max ppm
Arsenic acid	641	Diethylether	20
Boric acid	641	Acetic ether	20
Hydrogen carbonate	641	Aromatic hydrocarbons	
Chromic acid	641	Xylene	640
Bromic acid	320	Toluene	640
Hydrochloric acid	320	Asphalt	640
Hydrogen fluoride	320	Anthracene	640
Hydrogen sulphide	320	Benzapherene	640
Nitric acid	320	Benzene	640
Sulphuric acid	320	Solventnaphta	640
Phosphoric acid	320	Naphtalene	640
Perchloric acid	320	Terpenes	640
Selenic acid	320	Aliphatic hydrocarbons	
sulfonic acid	641	White spirit	640
Organic acids		Max ppm	
Acetic acid	320	White spirit	640
Benzoic acid	320	Shellsol TD	640
Lactic acid	320	Bitumen	640
Phenols	320	Isopar G	640
Citric acid	320	Paraffine	640
Fatty acids	320	Paraffineoil	640
		Alcohols	
Formic acid	80	Methanol	320
Hydrocyanic acid	320	Ethanol	320
Malic acid	320	Isopropanol	320
Margaric acid	320	n-Butanol	320
Picric acid	320	Amylalcohol	320
Oleic acid	320	Benzylalcohol	320
Oxalic acid	320	Diacetonalcohol DAA	320
Sulphamic acid	320	Glycerine	320
Wine stone acid	320	n-Propanol	320
Barn stone acid	320	Pentanol	320
		Fuels and Oils	
Palmitic acid	320	Diesel	640
Tannin	320	Fuel oil	640
Phthalic acid	320	Petrol	640
Propionic acid	80	Superpetrol	640
Salicylic acid	320	Kerosene	640
Stearic acid	320	Sferic oils	640
Valeric acid	320	LPG	640
Alkalines		Max ppm	
Ammonia	160	Mineral Oils	640
Caustic soda	80	Breakliquide	640
Sodiumhydroxyde	20	Skydrol	640
Caustic potassium	80	Aninal oils	640
Potassium hydroxyde solution	20	Ethric oils	640
Lithium hydroxyde	20	Vegetable oils	640
Calciumhydroxyde	20	Butagas	640
Magnesium hydroxyde	20	Acetylene	640

Esters	Max ppm	Salts and watersolutions	Max ppm
Ethylacetate	160	Sodiumsalts	640
Amylacetate	160	Potassiumsalts	640
Propylacetate	160	Calciumsalts	640
Ethyloxalate	160	Aluminiumsalts	640
Butylacetate	160	Ammoniumsalts	640
Butylpropionate	160	Bariumsalts	640
Ethylformiate	160	Coppersalts	640
Ethylbenzoate	160	Leadsalts	640
Ketones and Aldehydes	Max ppm	Lithiumsalts	640
Acetone	320	Magnesiumsalts	640
Acetaldehyde	320	Mercurysalts	640
Benzaldehyde	320	Lithopone	640
Formaldehyde	320	Hydroquinone	640
Salicylaldehyde	320	Ironsalts	640
Diisobutylketone	320	Others	Max ppm
Methylisobutylketone	320	Carbondisulphide	160
Methylethylketone	320	Hydrogenperoxyde	320
Butanal	320	hydrogensulphide	20
Crotonaldehyde	320	Chlorine	64
Halogenated Hydrocarbons	Max ppm		
1.1.1.Trichloorethane	20		
Methyleenchloride	20		
Methylbromide	20		
Tetrachloormethane	20		
Dichloorethene	20		
Trichloorethylene	20		
Perchloorethylene	20		
Tetraiodicmethane	20		
PCB	20		



These recommendations and guidelines reflect our experience. They can neither replace the assessment of the installation location, conditions and environment by experts nor the assessment of possible corrosion attack. The recommendations and guidelines are merely intended for technical information purposes. We assume no liability for the completeness and correctness of the information. The information is intended to support the technical assessment of the installation location conditions.



A L U V E N T A

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