

■ It pays to protect against harsh environments

Electronic equipment is sensible to the environment, i.e. moisture, dust and temperature can influence the reliability of electronics. Reduced reliability causes downtime in the application with reduced earnings as a result. Therefore it is important to choose the right solution for the actual application.

This instruction informs about the possibilities to protect a frequency converter and other electronic devices against influence from an environment where aggressive gasses and moisture are present.

Basically it is important to protect the electronics from a harsh environment. The best way to do that, is to avoid the harsh environment by placing the electronics outside the harsh environment. Danfoss offers different solutions:

- Our different drives can control a motor with long motor cables. This means that the customer can place the drive far away from the critical environment.

- Our small drives are designed for placement directly in a typical industrial control cabinet. The control cabinet can be fitted with air-conditioning units ensuring that the critical environment does not get in contact with the drives and other electronics.
- Some drives are fitted with a cold plate. With this solution you can place the drive inside a closed cabinet and via the cold plate the heat is transmitted to the outside. With this solution the drive is kept away from the critical environment.
- The FCM is fitted with a tight enclosure. The enclosure protects the electronics from the outside environment.
- For selected drive series we give the customer the possibility to buy a frequency converter with coated electronics as an option. These drives have a higher reliability in environments where aggressive gasses and moisture are present.

This instruction will help you choose the right protection.

■ How critical is the environment?

You cannot directly see how critical the environment is. It depends mainly on 4 factors, the concentration of pollutants present, dirt, the relative humidity and temperature.

To find out how critical the environment is, look for some signs indicating the amount of aggressive gasses, moisture and time of wetness in the environment. This will be described in the following. In many applications typical conditions are known and for some of these we have added a table showing typical constituents.

Signs to look for

In existing plants it is possible to see if an aggressive environment is present. Take a look at a copper lead having been placed in the installation for a least some months. If a critical environment is present, the copper will turn dark.

I.e. unscrew a copperlead in a connector. The part where the screw presses is nice, but the area where screw or insulation does not protect is a good indicator for the environment. If it is black (corroded), the environment can be critical. If the copper is uncorroded, the environment is expected to be uncritical.

Examples of critical applications

The below table shows typical gasses in some selected applications which can be critical. It can give you some hints of applications that can be critical. The information in the table is not necessarily covering all actual constituents in the application.

Application	Constituent	Symbol
Sewage plants	Ammonia Hydrogen sulphide Active organic nitrogen	NH ₃ H ₂ S N ₂
Paper mills and wood pulping	Hydrogen sulphide Carbon monoxide Chlorine's Active organic nitrogen Hydrocarbons	H ₂ S CO Cl, Cl ₂ N ₂ C _n , H _n
Water treatment	Hydrocarbons	C _n , H _n
Combustion of fossil fuels/automotive emissions	Hydrogen sulphide Sulphur dioxide Nitrogen oxides Carbon monoxide	H ₂ S SO ₂ , SO ₃ NO _x CO
Sulphuric acid manufacture	Hydrogen Chloride Hydrocarbons	HCL C _n , H _n
Fertilizer manufacture	Hydrogen flouride Ammonia	HF NH ₃
Steel manufacture and ore smelting	Hydrogen flouride Hydrogen sulphide Sulphur dioxide	HF H ₂ S SO ₂ , SO ₃
Aluminium manufacture	Hydrogen flouride Chlorine's	HF Cl, Cl ₂
Foundries	Mercaptans Carbon	S _B , R-SH C
Cleaning of products	Ammonia Chlorine's	NH ₃ Cl, Cl ₂

The different constituents attack metals. I.e. sulphur dioxide attack all metals except noble metals, nitrogen dioxide, ammonia and ammonia salts attack copper and brass and hydrogen sulphide attack silver and copper.

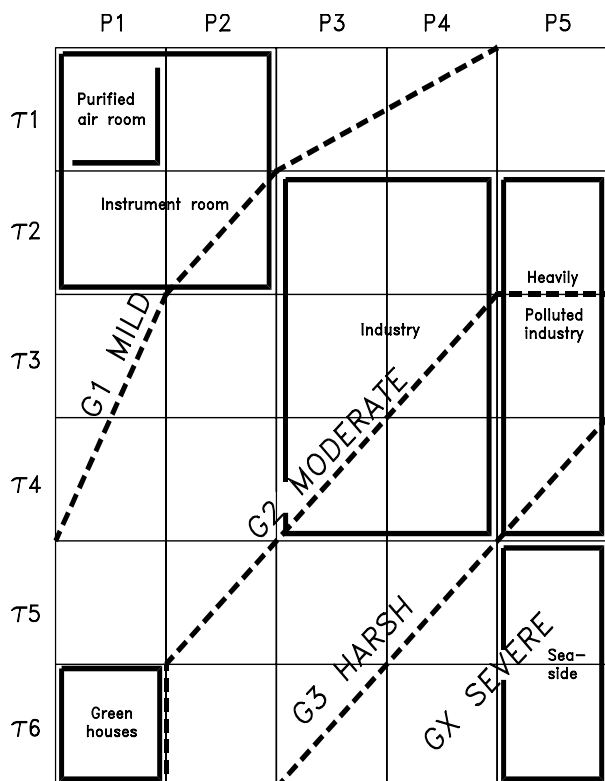
Determining the severity level

Generally the environments can be classified in groups as defined in IEC721-3-3. The classification is divided into 4 groups, 3C1 to 3C4. ANSI/ISA S71.04-1985 also divides the environment into 4 groups, G1 - Gx.

Compared with the classification in ANSI/ISA S71.04-1985, G2 is comparable to 3C2 and G3 comparable to 3C3.

From a Nordic research project the following model for classification of the environment has been developed.

Use the figure below to make a brief estimate of the actual application.



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τ_1 to τ_6 is the time of wetness and P1 to P5 is the pollution degree. P1 is a low pollution degree, P5 is a high degree.

Examples of environments have been put in the figure to give an overview.

For an exact classification it is necessary to test the environment. A way to do that is by making a standardised test.

A standard copper coupon is exposed in the actual environment for 28 days. The corrosion activity is measured as the amount of corroded copper. Based on the measured value the environment is classified in one of four classes. The coupon test is made by the Swedish Corrosion Institute:

Swedish Corrosion Institute.
Roslagsvägen 101, hus 25
S-104 05 Stockholm
Int. phone: +46 8 674 17 00
Int. fax: +46 8 16 72 70
Homepage: <http://www.corr-institute.se>

Alternatively we recommend you to contact an engineering agency to help you determining the environments.

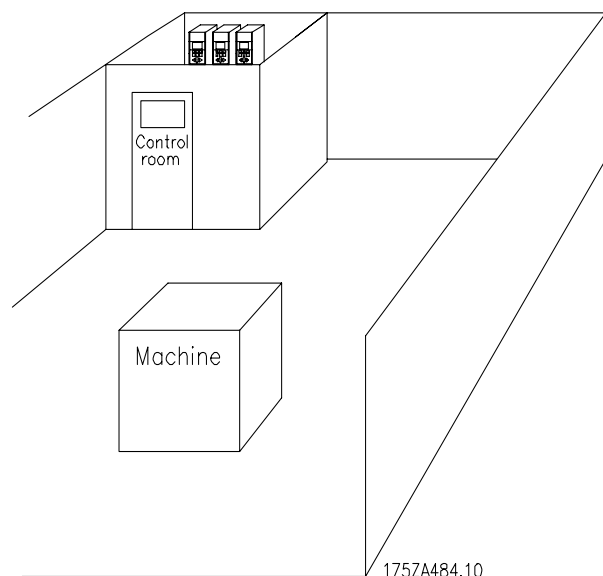
■ How to protect units against corrosion

Basically the best way to avoid problems is to keep the aggressive environment away from the electrical installations. This is possible in many applications, but in some applications not possible. In such cases other precautions must be taken to reduce the risk for problems.

Precautions during planning and installation

To avoid problems in an application we recommend to follow the general guidelines below in the order stated. If it is not possible to choose the first recommendation, then go for the second and so on. Beside the point below, You also have to choose the appropriate enclosure type (IP class) to be used in the environment, taking dust, water and objects, such as screwdrivers and fingers, into account.

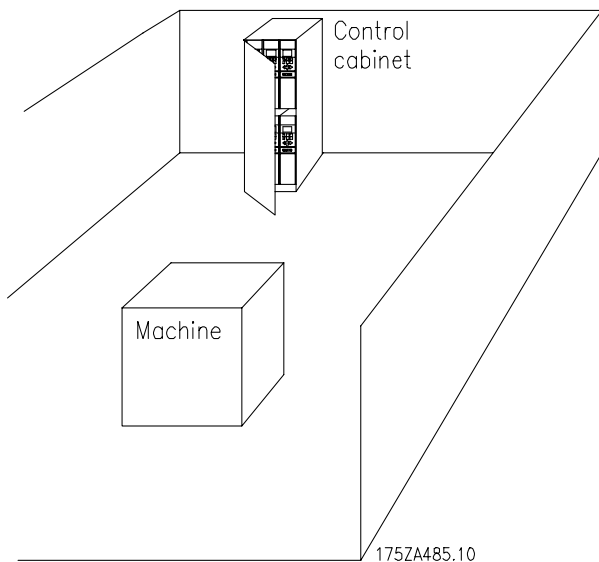
1. Plan the installation in such a way that the drives and other electronics are placed apart from the harsh environment. Doing that extra costs can be totally avoided. As the Danfoss frequency converters are capable of driving motors with long motor cables, it is possible to place the drives apart from the machinery. Examples of such solutions are control rooms in a factory where the drives are installed or complete cabinets from OEM's are placed. These rooms are sometimes also equipped with climatic control such as air conditioning.



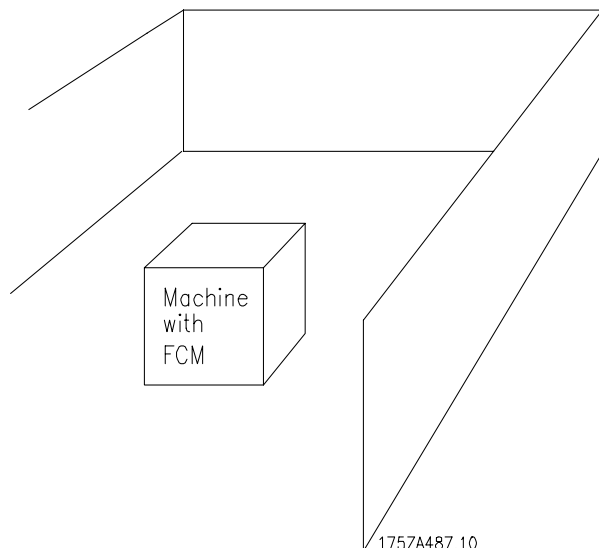
2. If it is not possible to place the drives and other electronics apart from the harsh environment, then a closed cabinet combined with a heat exchanger can be used. The harsh environment is kept away from the electronics and the solution is comparable with the first solution, except for commissioning where you have to open the cabinet.

Another possibility is to keep the harsh environment away from the electronics by supplying the control cabinet with fresh clean air.

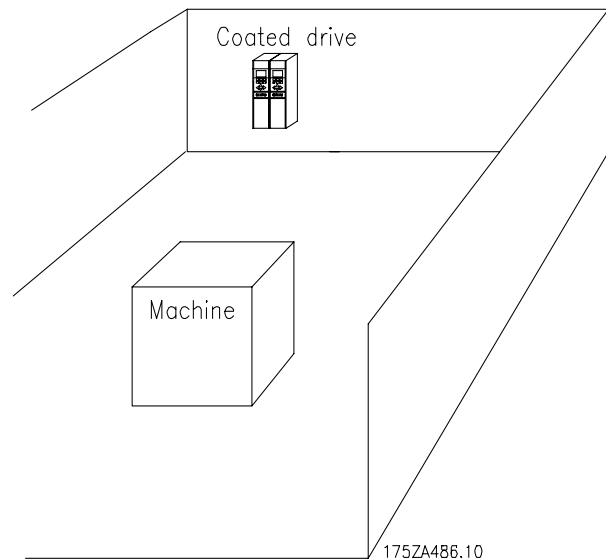
As the speed of the corrosion process is low at low relative humidity and low temperature, an air-conditioning unit can also minimize the corrosion. In this case it is important that the relative humidity and the temperature is kept on a low level.



3. Alternatively choose an integrated frequency converter and motor, FCM300, which has a tight enclosure for the electronics.



4. If it is not possible to keep the harsh environment away from the electronics, a solution can be to select a coated drive. Coating gives a better protection of the drives than an uncoated solution, but even if you choose a coated drive, precautions must be taken into account. The harsh environment can attack copper in the installation or other electronics connected to the drives, such as PLC's or other control devices which are not protected. In this case it is important to keep the relative humidity as low as possible in the environment, as a high relative humidity forces corrosion. In such a case an air-conditioning unit can help controlling the relative humidity.



General aspects

No matter which solution you choose, it is important that the solution is maintained and the installation is made according to the requirements. Filters for air-conditioning units and fans must be cleaned according to the specifications and the control cabinets and control rooms must be kept closed to keep the harsh environment outside.

Select the appropriate VLT frequency converter

The VLT® frequency converter is available in different enclosures. Additionally some of the VLT frequency converters are available with coated printed circuit boards for increased protection. See technical literature for your different possibilities to choose between the different drives and options.

■ Technical information

When referring to aggressive gases and electronics basically 2 standards are relevant, IEC721-3-3 and ANSI/ISA-S71.04.

The corrosion process is described briefly in the following.

What causes corrosion

Corrosion of electronics is determined by several factors. 4 main factors determine if corrosion occurs: concentration of aggressive gases, dirt, moisture and temperature.

- Presence (concentration) of aggressive gases
Different metals are present in electronics such as copper, tin, lead, silver and aluminum. These metals react with different aggressive gases such as sulfur compounds, chlorides, nitrogen oxides and ammonia.
- Moisture
At a relative humidity below 50% the corrosion process is very slow. At increasing relative humidity the corrosion process increases.
- Temperature
If the temperature is below 0 ° C corrosion is negligible.
- Dirt
Dust can be conductive as well as it can contain moisture.

A Nordic research project has developed a model for corrosion classification. This model is described in short form below. The model has been developed with the American ANSI/ISA S71-04 standard as reference.

The influence from the relative humidity is determined by how long the electronics is exposed to a critical humidity and temperature, called "Time Of Wetness".

The term time of wetness has been defined as: Hours per year where the temperature is above 0°C and the relative humidity is above 80%.

Time of wetness is divided into 6 categories, τ 1 to τ 6.

The critical zones are primarily the last 3 locations, as the time of wetness is minimum 10% per year.

Category	Time of wetness		Example of occurrence.
	Hours/year	% of year	
1	<10	<0.1	Indoor air with climatic control.
2	10-250	0.1-3	Indoor air in normal rooms for living or working condition.
3	250-1000	3-10	Indoor air storage rooms.
4	1000-2500	10-30	Indoor air in some production rooms. Outdoor air in cold zone, dry zone, parts of temperated zone.
5	2500-5500	30-60	Outdoor air in parts of temperated zone, parts of warm zone. Indoor air in animal houses.
6	>5500	>60	Outdoor air in tropical zone. Indoor air in greenhouse.

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The term pollution degree has been defined based on different pollutants. P1 is a very low polluted environment and P5 is a high polluted environment. See table below.

Category	Pollutants $\mu\text{g}/\text{m}^3$							Remarks
	SO ₂	NO ₂	H ₂ S	C ₁₂	NH ₃ +NH ⁺	Cl ⁻	Soot	
P1 (very low)	<10	<25	<3	<1	<10	<1	<2	Rooms purified
P2 (low)	10-30	25-250	3-10 ¹⁾ 3-20 ²⁾	1-2	10-250	1-5	2-20	
P3 (medium)	30-100	150-500	10-50 ¹⁾ 20-100 ²⁾	2-5	250-1000	5-10	20-75	
P4 (high)	100-300	500-1000	50-1001) 100-200 ²⁾	5-10	1000-10000	10-50	75-150	
P5 (very high)	>300	>1000	>1001) >2002)	>10	>10000	>50	>150	

1) Limits if silver is used. 2) Limits for other materials than silver

Reference no. 2

In ANSI/ISA S71-04-85 4 severity levels are defined. The different severity levels are described as follows:

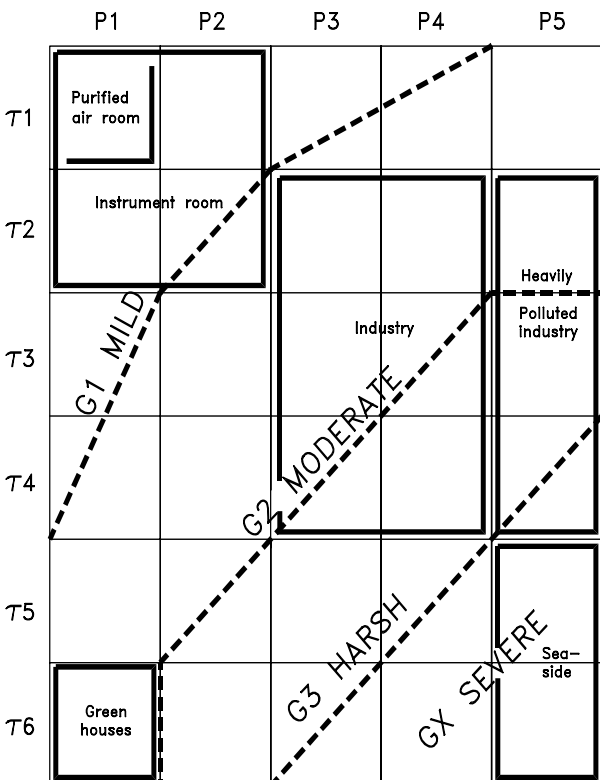
- Severity level G1- Mild
An environment sufficiently well-controlled such that corrosion is not a factor in determining equipment reliability.
- Severity level G2 - Moderate
An environment in which the effects of corrosion are measurable and may be a factor in determining equipment reliability.
- Severity level G3 - Harsh
An environment in which there is a high probability that corrosive attack will occur. These harsh levels should prompt further evaluation resulting in environmental controls or specially designed and packaged equipment.
- Severity level GX - Severe
An environment in which only specially designed and packaged equipment would be expected to survive. Specifications for equipment in this class are a matter of negotiation between user and supplier.

In the figure some examples of application categories have been identified based on the project. These categories must only be used as guiding examples. In case of doubt, you have to investigate how the actual application is classified.

References

1. IEC 721-3-3 - Classification of environmental conditions part 3: Classification of groups of environmental parameters and their severities. Stationary use at weatherprotected locations.
2. Corrosion of Electronics - A Handbook based on Experiences from a Nordic Research Project. ISBN 91-87400-02-2 by the Swedish Corrosion Institute, 1991.
3. ANSI/ISA S71.04-1985 - Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants.

Time of wetness and pollution degree have been combined with the ANSI/ISA S17-04 standard in the figure below.



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Reference no. 2