



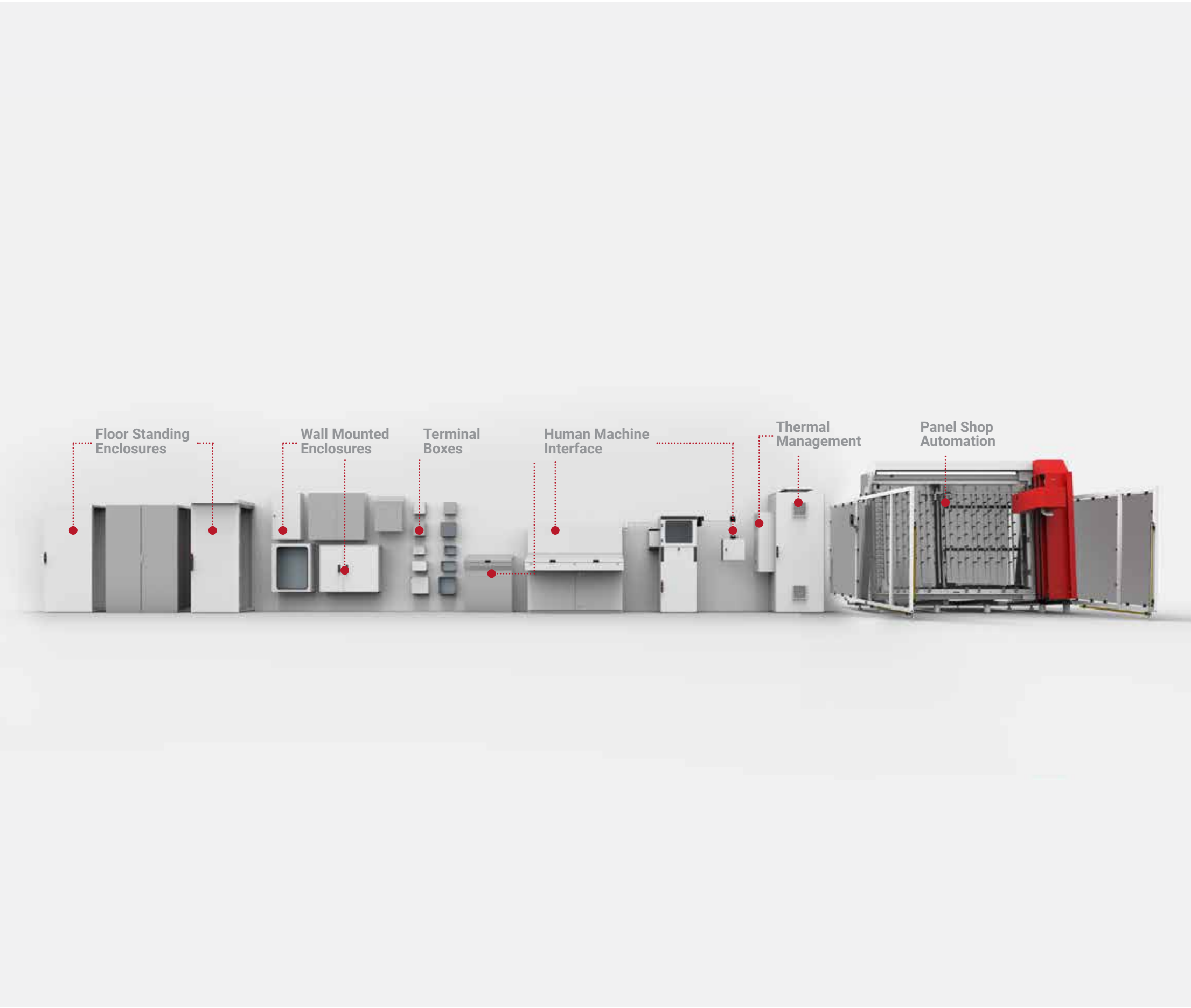
**CONNECT AND PROTECT**

# Technical information

White paper

  
nVent

**HOFFMAN**



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# Standards

## About the IEC/EN standards

All nVent HOFFMAN's enclosures are designed and developed with due regard to current, relevant international regulations, legislations and standards. Designs are developed from the many years of experience within nVent HOFFMAN to benefit customers and to provide user friendly and safe products to meet their requirements.

The International Electrotechnical Commission (IEC) is a leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

The 60000 IEC series of standards are also found preceded by EN to indicate that the IEC standards are also harmonized as European standards; for example IEC 62208 would be EN 62208. Listed below are some of the main standards that nVent HOFFMAN conforms to as an empty enclosure manufacturer:

IEC 62208	Empty enclosures for low-voltage switchgear and control gear assemblies
IEC 60529	Degrees of protection provided by enclosures. (European IP code)
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts. (IK codes)
IEC 61439	Low-voltage switchgear and control gear assemblies.
IEC 60204	Electrical equipment of machines.

## About IEC 62208

The main standard for empty enclosure manufacturers to comply with is IEC 62208, witch specifies the general definitions, classifications, characteristics and test requirements of empty enclosures, which nVent HOFFMAN is offering to the market, prior to the incorporation of switchgear and control gear components by the user. The enclosures should be used in assemblies in which the rated voltage does not exceed 1000V AC or 1500V DC, and which are suitable for general use for either indoor or outdoor applications.

## Type tests

Marking:	Marking is done by moulding, pressing, engraving or similar. Labels with a laminated plastic covering shall not need to be submitted for a test as defined by the standard. After the test the marking shall be easily legible.
Static loads:	To ensure that the enclosure can withstand the permissible load stated by the manufacturer, a static load test is conducted that is over 1. 25x above the stated load. After the test, with loads in place, the enclosure shall show no signs of cracks or permanent distortions and during the test no deflections which could impair any of its characteristics.
Lifting:	The lifting test is performed only on enclosures with provisions for lifting. The load for the lifting test is defined by the static load test. Afterwards the enclosure shall show no signs of cracks or permanent distortions and no deflections which could impair any of the enclosure's characteristics.



Axial loads of metal inserts:	The test applies to all enclosures that have threaded metal inserts to retain a mounting plate or control and switchgear supports in place. Loads applied to the inserts are dependent on the insert size. After this test the insert shall still be in its original position with no signs of movement, cracks or splits.
IK code:	Protection against mechanical impact as defined by IEC 62262. After the test, the enclosure shall continue to provide the IP code stated. Removable covers can still be removed and reinstalled as well as doors opened and closed.
IP code:	Degree of protection against access to hazardous parts, ingress of solid objects and water is defined by IEC 60529. The testing criteria and results are also defined by this standard.
Properties of insulating materials:	The thermal stability of enclosures manufactured from insulating material shall be verified by a dry heat test, which is defined by IEC 60068-2-2. Insulating materials are also tested for resistance to heat in accordance with IEC 60085. In certain applications enclosures will need to resist temperatures over and above those defined in IEC 60085, for which there is also an abnormal heat and fire test, IEC 60696.
Dielectric strength:	This test applies to enclosures where insulating material is used, even in combination with non-insulating materials. The test set-up depends on whether or not there are metal elements inside the protected space of the enclosure and after the test, the samples shall show no signs of damage which would impair the future use of the enclosure.
Continuity of the protective circuit:	It shall be verified that the different exposed conductive parts of the enclosure are effectively connected to the earthing terminal or contact of the protective circuit and that the resistance of the circuit does not exceed 0. 1Ω.
Resistance to ultra-violet (UV) radiation:	This test applies only to enclosures and external parts of enclosures intended to be installed outdoors and which are constructed of insulating materials or metals that are entirely coated by synthetic material. The UV test is defined according to ISO 4892-2. This test need not be carried out if the manufacturer can provide data from the material supplier to demonstrate that materials of the same thickness, or thinner, comply with this requirement.
Resistance to corrosion:	Ferrous metallic enclosures and external ferrous metallic parts of insulating and combined enclosures shall be tested to verify that they ensure protection against corrosion. Other local regulations and specifications concerning the siting of electrical switchgear must be observed by the user of the enclosures!  This is done by a salt spray tests: A and B. Which test is conducted depends on the enclosure's marketed environment. After the test, the enclosures are washed down or subjected to an air blast(?) to remove all water droplets. There should be no evidence of iron oxide, cracking, or deterioration of mechanical integrity, and there should be no damage to the seals of the enclosure. Doors, hinges, locks and fastenings should function without excessive effort.
Thermal power dissipation capability:	The thermal power dissipation data provided by the manufacturer shall be determined by test in accordance with IEC 61439-1, or by calculation method.



Standards

CE Mark

CE marking indicates the conformity of the product with the Union legislation applying to the product and providing for CE marking. The CE mark is affixed on products that will be placed on the EEA and Turkish market, whether they are manufactured in EED, in Turkey or in another country.

CE mark is a key indicator (but not proof) of a product’s compliance with EU legislation and enables the free movement of products within the European market.

CE marking does not indicate that a product was made in the European Union. The CE mark indicates conformity with the requirements laid down by the Union harmonization test(s) in question. Therefore, it is to be considered as essential information to Member States’ authorities as well as other relevant parties (for example distributors). CE marking does not serve commercial purposes, it is not a marketing tool.

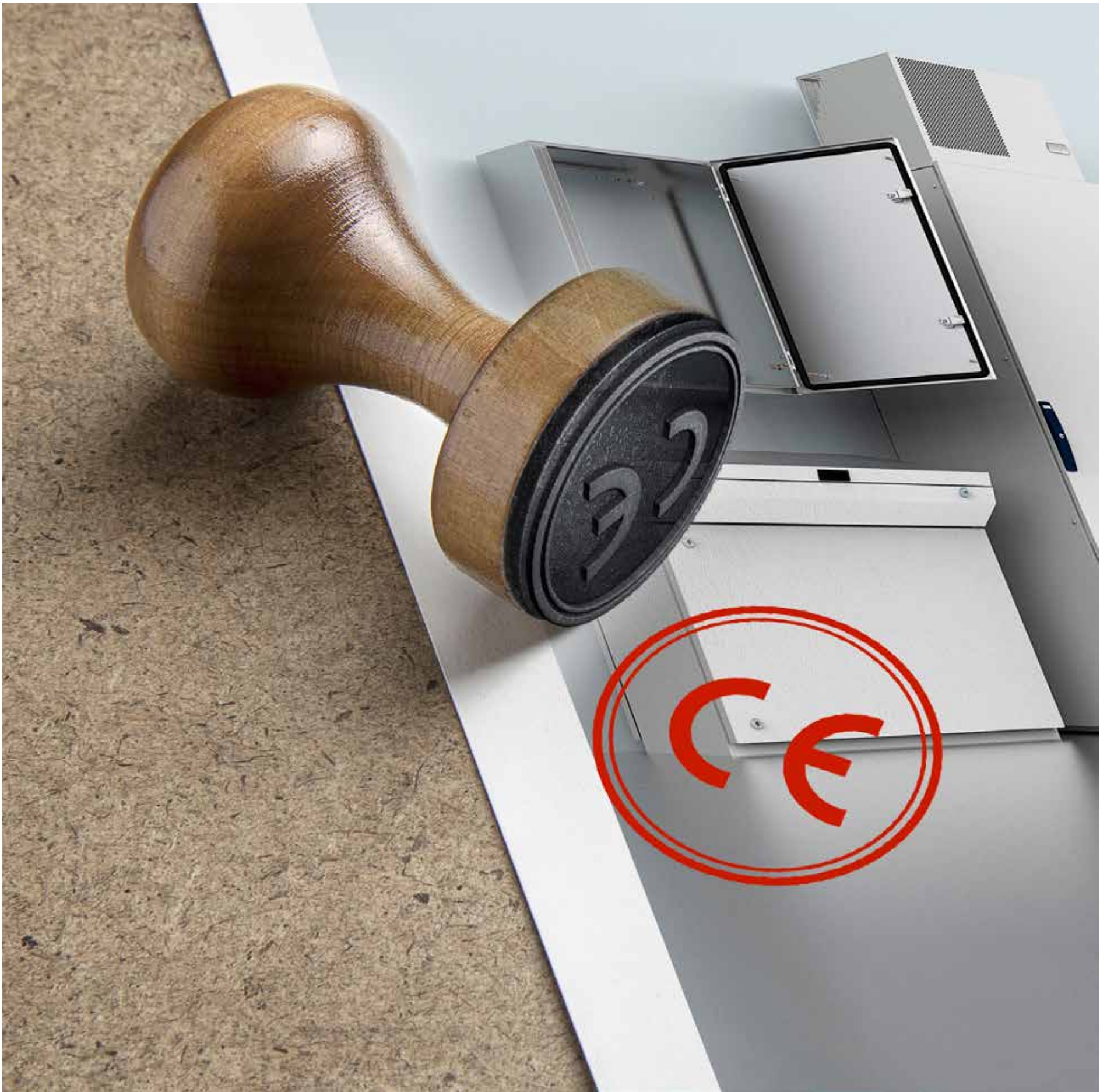
CE declaration of conformity

The CE Declaration of Conformity is a formal declaration by a manufacturer, or the manufacturer’s representative, that the product to which it applies meets all relevant requirements of all product safety directives applicable to that product. It is a sign that a product has been designed and constructed for compliance with relevant essential requirements, and has been through the appropriate conformity assessment processes. It is not a quality certificate, nor a guarantee of safety.

How is it applicable to nVent HOFFMAN?



nVent HOFFMAN as a manufacturer of empty enclosures and a supplier of peripherals and accessories is obliged to ensure that the CE mark is present on the products that are covered by EU directives and sold to the EEA market.

Most nVent HOFFMAN products have international certifications and approvals making nVent HOFFMAN a leading company in its field. Every enclosure which leaves the factory is labelled on the inside with a type label. This label carries all relevant information, including the product name, protection rate, production date and the certification marks of the institutes which have approved nVent HOFFMAN's products.













Certifications and approvals

<b>The certification and approval of products safeguards customers by ensuring that the relevant performance and quality tests are carried out and that, as a result, industry specifications and regulations are met.</b>	
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Product Certifications	
	<p><b>cULus underwriters laboratories (USA, Canada, Canada &amp; USA)</b></p> <p>UL (Underwriters Laboratories) is a global independent testing organization which provides certification on the safety of products as well as their environmental claims.</p> <p><b>UL - Listing marking</b></p> <p>There are three variations, one only valid in the United States market, one only valid for the Canadian market, and one for both the United States and Canadian market. It depends on which safety requirements are taken into consideration during the evaluation process, Canadian, U. S. or both. UL tests and verifies nVent HOFFMAN's enclosures to their own standard UL508A and also to C22. 2 for the Canadian market when applicable</p>
	<p><b>UL - Recognized component mark</b></p> <p>This mark is specifically for component parts that are part of a larger product system and that may have restrictions on their performance or may be incomplete in construction. Just as with the UL Listing mark, there are three variations, one only valid in the United States market, one only valid for the Canadian market, and one for both the United States and Canadian market. It depends on which safety requirements are taken into consideration during the evaluation process, Canadian, U. S. or both.</p> <p>Components covered by UL's Recognized component mark are intended to be installed in another device, system or end product. They are to be installed at the factory, not in the field and they may have restricted performance capabilities that limit their use. When a complete product or system containing UL Recognized Components is evaluated, the end-product evaluation process can be streamlined.</p>
	<p><b>CSA - canadian standards association (Canada, USA, Canada &amp; USA)</b></p> <p>cSA (Canadian Standards Association) is a nonprofit association serving business, industry, government and consumers in Canada and the global marketplace by developing standards that enhance public safety. There are three variations, one only valid for the Canadian market, one for the United States market and one for both the Canadian and United States markets. It depends on which safety requirements are taken into consideration during the evaluation process, Canadian, U. S or both. CSA tests and verifies nVent HOFFMAN's enclosures to their own standard C22. 2.</p>
	<p><b>KEMA - Keuring van Elektrotechnische Materialen te Arnhem, THE NETHERLANDS</b></p> <p>DEKRA is a global supplier of auditing and certification services, specializing in the fields of safety, environment and health. The KEMA-KEUR quality mark demonstrates that nVent HOFFMAN's products and production facilities are under regular surveillance by DEKRA. The KEMA-KUER mark shows that nVent HOFFMAN's enclosures have been tested and certified in accordance to IEC 62208 and that nVent HOFFMAN's production processes are audited on a regular basis.</p>



	<p><b>Lloyd's Register - Lloyd's Register of SHIPS, England</b></p> <p>Lloyd's Register is a global engineering, business and maritime organization which provides quality assurance and certification for ships that includes inspecting and approving important components and accessories. Lloyd's Register works with nVent HOFFMAN by testing their enclosures to specified standards IEC 60529 and IEC 60439 (IEC 61439) for marine, offshore and industrial use.</p>
	<p><b>DNV GL - Det Norske Veritas and Germanischer Lloyd</b></p> <p>DNV GL (Det Norske Veritas and Germanischer Lloyd) is an international certification society and recognized advisor for the maritime, oil and gas, energy, business assurance and software industry which focuses on testing, certification, technical assurance and risk management.</p> <p>DNV GL type test in accordance with IEC 62208: Enclosure protection (IP), impact and static load test. DNV GL also test the enclosures against vibration (Pt. 4, Ch. 8).</p>
	<p><b>RS - Russian Maritime Register of Shipping</b></p> <p>The RS (Russian Maritime Register of Shipping) Certificate demonstrates that the certified products, technical devices and production comply with the regulations, will not adversely affect the life, health and property of people, and will be qualitative and safe.</p> <p>RS certifies and tests nVent HOFFMAN's enclosures according to the requirements of the Russian Maritime Register of Shipping; Part XI "Electrical equipment" of rules for the classification and construction of sea-going ships, Edition 2014 "Rules for technical supervision during construction of ships and manufacture of materials and products for ships".</p>
	<p><b>GOST - Certificate of Conformity Russia</b></p> <p>GOST (Certificate of Conformity Russia) certifies the quality of supplied goods and their conformity with norms and standards in Russian Federation.</p>
	<p><b>EAC - Eurasian Conformity Mark</b></p> <p>EAC (EurAsian) is a mark of conformity for machinery exports to Russia, Kazakhstan and/or Belarus. This mark shows that the product in question conforms to the new technical regulations laid down by the above customs Union (Russia, Kazakhstan and Belarus).</p>
Materials Certifications	
	<p><b>RoHS Restriction of Hazardous Substances Directive</b></p> <p>The RoHS (Restriction of Hazardous Substances) Directive aims to restrict certain dangerous substances commonly used in electrical and electronic equipment.</p>
	<p><b>REACH Registration, Evaluation and Authorization of Chemical Substances</b></p> <p>The purpose of REACH is to limit the use of substances that may severely affect health, safety and/or the environment and to ensure that information regarding the safe use of these chemical substances is passed on to other professional users in a correct and timely manner.</p>
	<p><b>3TG - Conflict Minerals</b></p> <p>3TG (Conflict Minerals) are minerals mined in conditions of armed conflict and human right abuses, notably in the eastern provinces of the Democratic Republic of Congo: Tantalum, Tin, Tungsten and Gold. nVent HOFFMAN hereby declares that all the supplied products do not contain any of the 3TG conflict minerals</p>



Company Certifications



ISO 9001:2008 Certification

To ensure the quality of our products worldwide, nVent HOFFMAN has chosen to certify its companies in accordance with the highest level of Quality Assurance. This means a quality management system according to the ISO 9001:2008 standard.

The international acceptance of this standard will assure, that our products live up to customer expectations.

Quality management is a continuous process involving planning and, development as well as production. From the drawing board up to the release into the market and even further in our customers workshops the quality system will do its work. Products are tested and re-tested to make sure, that market demands regarding standards are met. Testing can involve corrosion resistance, level of protection, vibration resistance or customer-specific requirements. The products will receive a certificate from an independent institute to achieve the highest level of acceptance all over the world.



ISO 14001:2004 Certification

The stated purpose of ISO 14001:2004 is to support environmental protection and prevent pollution through systematic environmental management in areas and activities that have an impact on it.





Degrees of protection

To help the design engineer identify the degree of protection provided by an enclosure, IEC 60529 (IP) and IEC 62262 (IK) were introduced. These standards classify the extent to which an enclosure will resist the ingress of solid bodies, water under designated tests and against external mechanical impacts.

An enclosure which protects equipment against foreign objects will also protect a person from potential hazards within that enclosure, and this degree of protection is also defined in these standard.

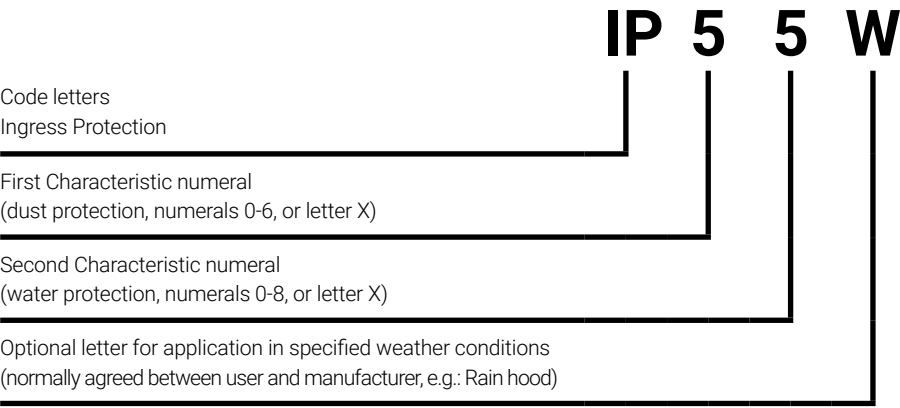
IEC STANDARDS  
IP code  
European standard IEC 60529

This standard applies to the classification of degrees of protection provided by enclosures for electrical equipment with a rated voltage not exceeding 72. 5 kV.

It is important to know that the degree of protection stated by this standard does not take into consideration the measures needed to protect the enclosure and the equipment inside the enclosure against external influences or conditions such as mechanical impacts, corrosion, fungus, solar radiation, icing, moisture and explosion.

The IP Code (International Protection Rating) classifies and rates the degree of protection provided against intrusion of solid foreign objects, dust, accidental contact, and water by mechanical casings and electrical enclosures.


All nVent HOFFMAN enclosures are designed for use in demanding environments with a stated degree of protection indicated by the IP code, in the following way:



The IP codes refer to protection against contact and the penetration of solid foreign objects and dust (marked by the first characteristic numeral of the IP code) and against the damaging ingress of water (marked by the second characteristic numeral of the IP code).

It is also possible that the IP code can contain an additional letter at the end which indicates the degree of protection of persons against access to hazardous parts. Additional letters are only used if the actual protection against access to hazardous parts is higher than that indicated by the first characteristic numeral or if only the protection against hazardous parts is indicated, the first characteristic numeral being then replaced by an X.

**The lowest type of protection is IP00; the electrical equipment is neither protected against solid foreign objects nor against the damaging penetration of water. The IP code IPXX means that the type of protection is not defined because the electrical equipment has not been subjected to testing.**

1st numeral:	2nd numeral:									
Degree of protection with respect to persons and solid objects.	Degree of protection with respect to harmful ingress of water.									
	0	1	2	3	4	5	6	7	8	9
	Non protected	Protected against dripping water	Protected against dripping water of +/- 15° angle	Protected against dripping water of +/- 60° angle	Protected against splashing water	Protected against water jets	Protected against heavy seas	Protected against immersion	Protected against submersion	Protected against high pressure and temperature water jet
	Test time 10 mins	Test time 10 mins	Test time 10 mins - max 200	Test time 10 mins	Test time 10 mins	Test time 1 min/m² minimum 3 mins	Test time 1 min/m² minimum 3 mins	Test time 30 mins	Test time 30 mins	Test time 1 min/m² minimum 3 mins
										

				10l/min 80kN.m²	10l/min 80kN.m²	12. 5l/min 30kN.m²	100l/min 100kN.m²			15l/min 1N; 80°C
Non Protect 0	IP 00	IP 01	IP 02					-	-	
Protected against solid objects greater than Dia. 50 mm. 1	IP 10	IP 11	IP 12	IP 13	-	-	-	-	-	
Protected against solid objects greater than Dia. 12 mm. 2	IP 20	IP 21	IP 22	IP 23	-	-	-	-	-	
Protected against solid objects greater than Dia. 2. 5 mm. 3	IP 30	IP 31	IP 32	IP 33	IP 34	-	-	-	-	
Protected against solid objects greater than Dia. 1. 0 mm. 4	IP 40	IP 41	IP 42	IP 43	IP 44	IP 45	IP 46	-	-	
Dust protected. 5					IP 54	IP 55	IP 56	-	-	
Dust-tight 6						IP 65	IP 66	IP 67	IP 68	IP 69

IK code  
IEC 62262

IK codes refer to the classification of the degrees of protection provided by enclosures against external mechanical impacts. The enclosures have been tested according to the standard IEC 62262 “Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)”. Each IK code, represents an impact energy value as shown in the table above.

IK grade	IK 00	IK 01	IK 02	IK 03	IK 04	IK 05	IK 06	IK 07	IK 08	IK 09	IK 10
Energy (J)	-	0,15	0,2	0,35	0,5	0,7	1	2	5	10	20
Weight and height of pendulum	-	0,20 kg 75 mm	0,20 kg 100 mm	0,20 kg 175 mm	0,20 kg 250 mm	0,20 kg 350 mm	0,50 kg 200 mm	0,50 kg 400 mm	1,70 kg 295 mm	5 kg 200 mm	5 kg 400 mm

Degrees of protection

TYPE STANDARD  
Type 250

The National Electrical Manufacturers Association is a US manufacturers’ organization which actively promotes standardized product specifications for electrical apparatus.

While TYPE does not actually test products, it establishes the performance criteria for enclosures intended for specific environments.

TYPE standards describe each type of enclosure in general and functional terms, and specifically omit reference to construction details.

TYPE performance criteria and test methods are used by Underwriters Laboratories (UL) and the Canadian Standards Association (CSA) as guidelines for investigation and listing of electrical enclosures.

TYPE has published one main standard, TYPE 250, which covers the classification and description of enclosures for electrical equipment. The primary purpose of this standard is to permit a potential user to determine:

- The type of enclosure appropriate for the application.
- The features the enclosure is expected to have.
- The tests applied to the enclosure to demonstrate its conformance to the description.

The tested enclosures are then authorized to carry a label by UL or CSA to prove they have passed the required tests. The enclosures must protect the equipment against environmental conditions and prevent the personnel having direct contact with the equipment.  
The following classifications (Type) are needed according to the required uses and descriptions:

NEMA Classification and approximate IP equivalents	
TYPE 1 / IP 30	Indoor use primarily to provide a degree of protection against limited amounts of falling dirt.
TYPE 4 / IP 66	Indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water and damage from external ice formation.
TYPE 4X / IP 66	Indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water and damage from external ice formation.
TYPE 12 / IP 55	Indoor use primarily to provide a degree of protection against circulating dust, falling dirt and dripping noncor-rosive liquids.
TYPE 13 / IP 65	Indoor use to provide a degree of protection against dust and spraying of water, oil and noncorrosive coolants.

Both standards TYPE 250 and IEC 60529 define the ratings about the protection provided by enclosures, but the definitions and tests to be carried out are not the same. IEC 60529 does not specify degrees of protection against mechanical damage of equipment, risk of explosions, or conditions such as moisture (produced for example by condensation), corrosive vapors, fungus, or vermin. On the other hand TYPE does test for environmental conditions such as corrosion, rust, icing, oil, and coolants. As there are slight differences the IEC protection degree (IP) cannot be exactly equated with the TYPE.

The table below provides an equivalent conversion from the TYPE to the IP, as the TYPE meets or exceeds the test requirements for the associated IP. The table cannot be used to convert from IP to TYPE.



IP First character	TYPE enclosure type																IP Second character		
	1		2		3, 3X, 3S, 3SX		3R, 3RX		4, 4X		5		6		6P		12, 12K, 13		
IP0_																			IP_0
IP1_																			IP_1
IP2_																			IP_2
IP3_																			IP_3
IP4_																			IP_4
IP5_																			IP_5
IP6_																			IP_6
																			IP_7
																			IP_8
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	

For example the TYPE 4 meets the IP 66, but also exceeds the IP 66 requirements because the TYPE requires an outdoor corrosion test, a gasket aging test, a dust test, and an external icing test, which are not included in the test protocol for the IP 66.

Selecting an enclosure goes beyond the IP rating; additional considerations must be taken regarding the environmental conditions in which the enclosure will be installed.

Following these guidelines will help provide an enclosure to meet your application needs.



# Environment

To make it easy to select the correct enclosure it is important to have common accepted ratings for the different solutions which take into consideration the environments in which the enclosures will be installed. It will also be important for the end-user or engineering firm to specify the degree of protection needed from the enclosure.

Indoor Installation  
The normal service conditions for INDOOR installations according to IEC 62208 are:

**Ambient air temperature:**  
It does not exceed +40 °C and its average over a period of 24h does not exceed +35 °C. The lower limit of the ambient air temperature is –5 °C.

**Atmospheric conditions:**  
The air is clean and its relative humidity does not exceed 50% at a maximum temperature of 40 °C. Higher relative humidity may be permitted at lower temperatures, for example 90% at +20 °C. Moderate condensation, which may occur occasionally due to temperature variations, should also be taken into account. Sometimes special service conditions can exist, and the enclosures must be suitable for each particular situation.

**Degree of protection required**  
The degree of protection provided by any enclosure against ingress of solid foreign bodies and liquid is indicated by the designation IP XX, according to IEC 60529 (See our section on 'The European IP-Code'). nVent HOFFMAN has developed a range of products that provide IP 55 / 66 degrees of protection providing an appropriate selection of accessories.

**Chemical agents**  
In certain installations a high degree of hygiene is needed for which chemical products are used. These products can affect the material from which the enclosure is made. In these cases nVent HOFFMAN offers a range of Stainless Steel 304L and 316L grade enclosures that have a high resistance in aggressive environments. Good examples of these installations are to be found in the chemical industry and in food processing.

Outdoor installation  
The normal service conditions for outdoor installations are:

**Ambient air temperature**  
This does not exceed +40 °C and its average over a period of 24h does not exceed +35 °C.  
The lower limit of the ambient air temperature is –25 °C.

**Atmospheric conditions**  
The relative humidity may temporarily be as high as 100% at a maximum temperature of 25 °C.  
In outside installations the enclosure won't have any protection, and it is therefore important to consider the following issues carefully when choosing an enclosure.



The conditions that will determine the type of enclosure to be used will be:

**Climate conditions**  
In outside installations the enclosure is exposed to rain, wind, etc. , and therefore it is necessary to bear these conditions in mind and choose the enclosure with the sufficient IP (See IP Codes section) that guarantees that water will not penetrate. For cases where additional protection is necessary, nVent HOFFMAN recommends the use of rainhoods, such as the ARF or ASST. This helps protect the gasket, avoiding possible deterioration. As well as considering the type of material to be used (stainless steel for example in outdoor applications) consideration should be given to temperature range and condensation.

**Geographical conditions**  
Depending on the environmental conditions and the geographical situation that the enclosure will occupy (close to or far from the coast, etc. ), it is possible that the enclosure has to be protected against corrosion as well as water. Protection against corrosion is not related to the IP but it is reflected in the salt spray (ISO 9227) and humidity (ISO 6270) tests.

In cases where the values of the previous tests for the enclosures in sheet steel are not sufficient for the proposed installation (saline environments or with high humidity), the alternative is to use stainless steel enclosures (304L or 316L grade depending on the exact conditions). Stainless steel performs significantly better against such corrosion problems, and ensures the performance of the enclosure.

**Particularly aggressive environments**  
In marine environments with a high salinity the use of Stainless Steel 304 (1. 4301) is not sufficient. Stainless Steel 316L (1. 4404), has better qualities against corrosion, and ensures the performance of the enclosure. In environments where chemical products are present it is necessary to analyze each case individually since the chemical agents affect stainless steel material in different ways. nVent HOFFMAN can supply enclosures in both Stainless Steel 304L (1. 4307) and 316L (1. 4404).

**Abrupt temperature changes**  
If the internal temperature of the enclosure is reduced rapidly (which can and does occur under 'normal' weather conditions) the pressure inside a high IP rating enclosure may be significantly lower than the ambient pressure outside, thereby inducing a suction effect through the gasket areas. This could result in moisture around the gaskets being drawn into the enclosure. Therefore consideration should be given to ventilating the enclosure.

**Condensation**  
Condensation occurs due to differences in temperature between the inner and outer surfaces of the enclosure. Therefore condensation can also occur on the inner components, which can cause the appearance of corrosion or defects. To avoid condensation, anti-condensation paint, ventilation and/or thermal management can be used.

**Note:**  
Temperatures stated in the above environments are according to the standard IEC 62208.

Special service conditions

From airborne debris and temperature variations to ultraviolet (UV) rays, environmental elements can have a significant impact on the performance of an enclosure. All electronic equipment needs to be able to withstand the physical demands of the environment in which it is to be used.

Abnormal ambient air temperature and humidity

Temperature directly affects the reliability and service life of electric and especially electronic equipment. Indeed, when devices and installations in enclosures fail or malfunction, it's almost always a thermal issue. Thus, in situations of this kind, thermal management is needed to monitor and control the temperature produced by the devices installed in the electrical enclosures.

nVent HOFFMAN offers a large range of thermal management products to meet its customers' requirements.

Presence of corrosive substances

Some applications, such as marine environments, require paint that will endure harsh conditions. For these nVent HOFFMAN applies, on request, a primer to enhance corrosion protection before painting with the standard epoxy-polyester RAL 7035 structured powder coating.

The ISO 12944 standard describes the types of paint and paint system commonly used for corrosion protection of steel structures. It also provides guidance for the selection of paint systems available for different environments and different surface preparation grades, and the durability grade that can be expected.

For corrosive environments, nVent HOFFMAN can offer, on request, harsh environment paint coatings but for environments renowned for harsh weather and the presence of chemicals, nVent HOFFMAN has a full range of stainless steel enclosures available in AISI 304L (1. 4307) and AISI 316L (1. 4404).

Presence of particular dusts

Our IP66 enclosures, rated as "dust tight", offer the highest protection against particles, and a high level of protection against water. These enclosures stringently adhere to these standards, and you can expect superior quality and craftsmanship.



Vibration

Vibration is defined as a relatively small amplitude oscillation around a rest position. It can be transverse (at right angles to the rest line), longitudinal (orientated along the rest line) or torsional (twisting around the rest line).

Transverse vibration is the most commonly encountered type, torsional is frequently present but its effects are subversive, longitudinal vibration is comparatively rare but can cause truly catastrophic problems.

Electrical enclosures can be exposed to vibrations in maritime environments, earthquake risk areas, nuclear power plants, military areas and because of that vibration tests are usually required.

The tests are carried out according to the "Rules for Ships" of Det Norske Veritas Class A by DEKRA.

Abnormal mechanical stresses

A seismic zone is a region in which the rate of seismic activity remains fairly consistent. This means that seismic activity is incredibly rare or that it is extremely common.

Most high-activity seismic zones are located along what are known as fault zones, regions of the Earth's crust which are prone to seismic activity. Fault zones often occur where continental plates meet, but they can also be found around volcanoes.

For seismic conditions nVent HOFFMAN offers a seismic kit to be installed in the Floor Standing range. This will provide a safe, secure environment for sensitive equipment in seismic areas where earthquakes can put systems at risk without notice.

The seismic bracket kit, SBK, reinforces the enclosure's frame, adding rigidity at the back with its cross bar design and on the sides, enabling the enclosure to withstand vibrations with accelerations up to 0. 9 g in all directions.

Seismic tests

The tests were done according to the standard IEEE Std. 344-1987 Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.

The seismic test was carried out with accelerations up to 0. 9 g in X, Y and Z directions using 2 swinging tables: horizontal table (X, Y directions) and vertical table (Z direction).

In all three test directions the cabinet met the demands of the earthquake test without problems. After the test no mechanical damage was found such as tears, loose screws or lasting deformations.



# Electromagnetic interferences (EMC)

## The mechanism of Electromagnetic Interference (EMI)

### The definition of EMC

The council of the European Union defines EMC in Article 4 of their "council directive on the approximation of the laws of the Member States relating to Electromagnetic Compatibility (89/ 336/EEC)" as property of an "apparatus": "The apparatus shall be so constructed that: the electromagnetic disturbance it generates does not exceed a level allowing radio and telecommunications equipment and other apparatus to operate as intended" (emission requirement) - "The apparatus has an adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended" immunity requirement. This is a very broad definition. The customary route to compliance is the application of standards. There are product standards, applicable to a specific product type (e. g. lighting) and, when not available, there are "generic standards" that can be used. When your product passes all required tests this provides the "presumption of compliance".

### What can you do?

The problem is that there is no direct relation between the tests to establish the fact of "EMC" and the measures you can take to behave satisfactorily in that respect. What you need is some basic knowledge on the mechanisms of electromagnetic interference.

### Differential and common-mode currents

All electric currents run in loops. When you measure current in a wire there must be a return current somewhere to the original source. The currents that determine the functional behavior of a design are called "differential-mode" „currents (dm-currents for short). There is another type, however: 98% of all interference problems are caused by common-mode currents (cm currents). It depicts an intended or desired current loop formed by a cable: a signal and a return line transferring some current from a source  $U_g$  to a load  $R_L$  and back. This is a differential mode current, which means that, if we were to use a current probe around the cable to measure the net cu rrent passing through the probe, we would find a zero value: all currents going from the source to the load return via the intended return conductor. Consider the circuit in figure 1.

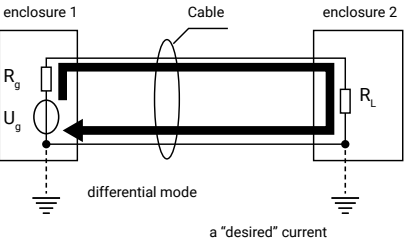


Figure 1



It depicts an intended or desired current loop formed by a cable: a signal and a turn line transferring some current from a source  $U_g$  to a load  $R_L$  and back. This is a differential-mode current, which means that, if we were to use a current probe around the cable to measure the net current passing through the probe, we would find a zero value: all currents going from the source to the load return via the intended return conductor.

Complications arise, when there are alternative return paths available, e. g. , via connections for safety grounding. In that case there is a choice for the return current: Fig 2

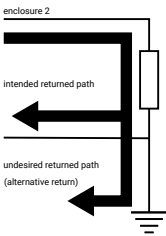


Figure 2

When a portion of the return current takes the alternative path, we will be able to measure a net amount of current with a current probe around the cable.

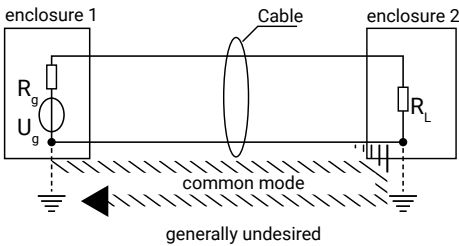


Figure 3

These undesired currents are not intended by the designer of the equipment and, worse, usually not included in his or her analyses. It is these "forgotten" currents that create most of the sometimes damaging interference in electronic systems.

Cables or, more generally, interconnections have the property to convert differential mode currents into common-mode currents and vice-versa. This property is called "transfer impedance" and is the basic phenomenon responsible for electromagnetic interference.

The rest is "related topics". For instance: all currents are accompanied by a magnetic field. The picture in figure 4 shows a two wire cable. Each wire carries the same current but their directions are opposite.

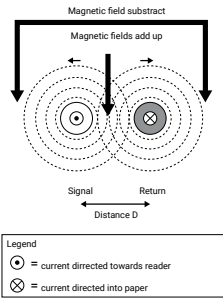


Figure 4



Electromagnetic interferences (EMC)

The magnetic field lines belonging to each of them "add up" between the two wires and "subtract" outside that area.

Assuming ideal conditions, the combined magnetic field magnitudes could be reduced to zero if it were possible to position the two wires "on top of" each other, exactly centered. The then equal but opposite fields at any position would exactly cancel ("coax" situation).

In any practical situation there will, however, be some distance between the two wires. This means that some amount of field will be measurable outside the cable. This field in turn induces currents in any conducting loop in the neighborhood. This includes the loop formed by the cable itself and any alternative return conductor (a "common-mode" or ground loop).

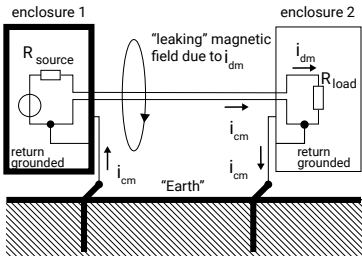


Figure 5

This alternative conductor could be the machine's structure, safety grounding provisions, the enclosure wall or other cables. This (induced) current in the usually larger loop is a common-mode (cm) current. Transfer impedance is a property of a complete interconnection: cable plus connectors, patch panels, etc. , from source to load.

The properties of a very good cable can be ruined by a lousy finishing, e. g. , the infamous "pig-tail" construction on shielded cables.

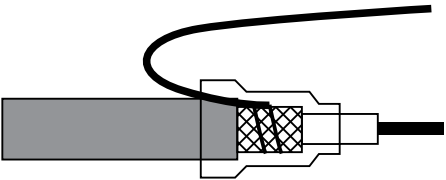


Figure 6

**Interference sources and susceptibility threats**

Thus, interconnections are our sole concern for all EMC related issues. From printed circuit board traces to system cabling. We can divide the threats to our systems into "man-made" and "natural".

**Actual interference is always a susceptibility problem: the disturbed system is unable to cope with the fields or currents that threaten it. Whether the system should be able to cope with them is determined by the prescribed levels in the EMC standards. If the system is too susceptible (civil standards call it "insufficient immunity") you will have to improve it by working on the various interconnections and improving their transfer-impedance.**

**If the system is OK, the interference source has to be located and a similar process must be carried out to reduce its "emissions".**



Interference with a continuous character

Most interference emerges from equipment, either your own system or the neighbour's. Well known sources of high frequency fields are transmitters from public services to GSM telephones.

Notably, portable telephones are a threat since they are mobile and can get very close to the susceptible equipment. Fields related to transmitters and other high frequency equipment are in the range from 1 to 100 Volts per meter (electric field value). Apart from intentional transmitters there are the unintentional transmitters formed by interconnections which generate common-mode currents and corresponding fields. A high-frequency current in a cable with inadequate transfer-impedance is the common cause.

This common-mode current can either flow directly on a sensitive cable (e. g. , from analogue sensors) or create a high frequency electromagnetic field which induces common-mode currents in sensitive cables.

Interference with an intermittent character

A special type of interference are "impulsive disturbances" caused, for example, by switching inductive loads. Examples are relays, frequency converter/motor combinations and switched mode power supplies. When inadequately "snubbed", high peak values in voltage and current are reached when the load is switched. These currents travel through the interconnecting cables and are converted into common-mode currents.

The interference mechanism is, of course, identical to the continuous case but due to the intermittent character, it can be more difficult to locate the source of the problem. Common-mode currents from these sources can be considerable: several hundred million amperes, especially when relay contacts degrade over time.

Natural sources of interference

Natural sources are lightning and electrostatic discharge (ESD). In either case a (static) electric discharge occurs. In the lightning case a large circuit is involved with dimensions covering many kilometers. In the ESD case, there is usually a person carrying the charge and discharging into a piece of equipment by touching it.

The lightning stroke is a high-energy phenomenon with a relatively low frequency character. Consequently most interference is transferred by conduction. ESD is a high frequency phenomenon with lower energy content. High frequencies, however, can travel "through air" (capacitive effect) and the corresponding damaging current in the equipment cannot easily be diverted. If there is a susceptible component in its path: too bad for the component!

Common-mode currents as a result of these natural sources can reach very high values. Amperes are not uncommon. (A direct lightning stroke typically has 50kA, i. e. , 50 000A, ESD from 5-40A).



Electromagnetic interferences (EMC)

Measures to improve compatibility

Packaging of equipment can have a major effect on the behavior in electromagnetically "hostile" environments. In the following sections several approaches are shown. Most of them are very cheap when considered at the design stage. Later in the lifecycle protective measures become scarce and more expensive.

Split up cables into categories All EMC problems (well, 98%) are common-mode problems. Try to develop an instinct for common-mode or ground-loops. Once found, they can be treated following the systematic approach given below.

A first example was given in figure 5, a slightly more complex example is shown in figure 7.

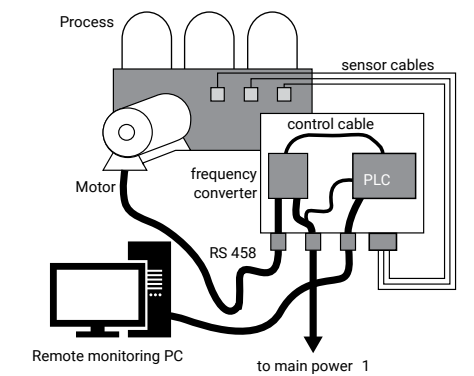


Figure 7  
Several cable types can be observed in this diagram. It is usually helpful to draw a simplified diagram showing equipment as circles with interconnecting conductors. Do not forget to include power, "ground" and machine structure as conductors! In the diagram of figure 8, several cable types can be recognized.

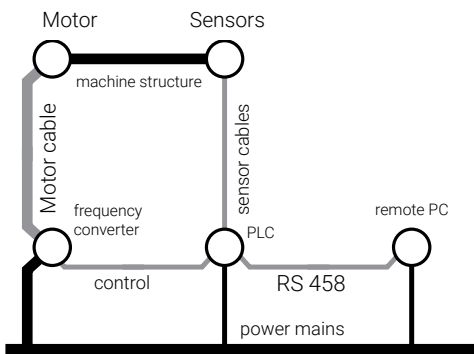
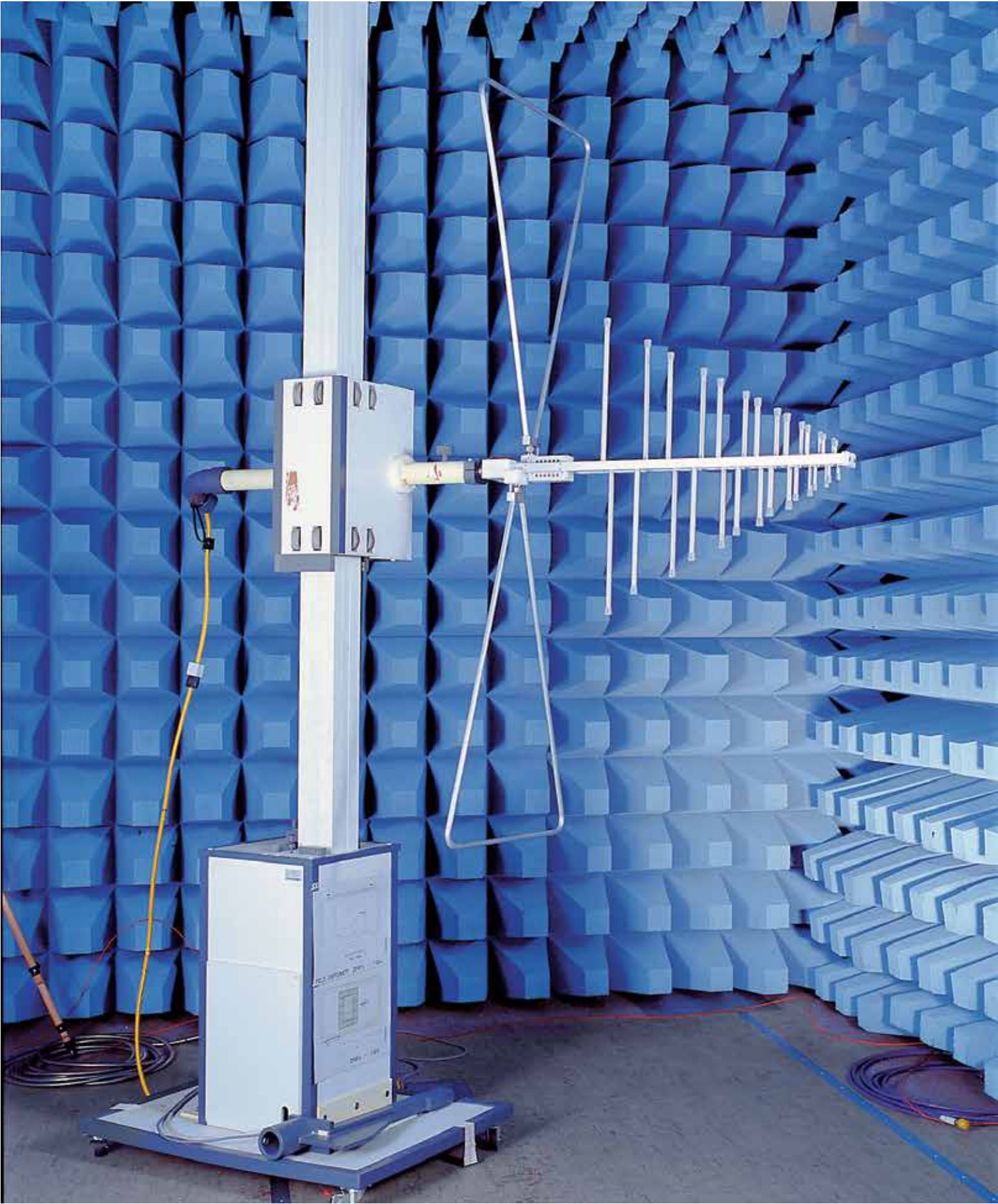


Figure 8  
Cables with large and/or high frequency currents. Indicate this type using a red color or the letter "E" for Emission: due to transfer-impedance it will generate possibly large common mode currents.

Example: the cable between frequency converter and motor.

Cables that neither generate nor are susceptible to common mode currents. Indicate them using a black color or the letter "N" for Neutral.

Example: power cables, machine or building structure, metal piping, etc.



Cables that carry small analogue signals or are otherwise sensitive to interference by common-mode currents across them. Indicate this type using a green color or the letter "S" for Susceptible.

Example: sensor cabling, RS-485 line, PLC/frequency converter control cable.

Of course, more detailed distinctions can be made. Books on EMC generally use five to seven cable categories.

The RS-485 cable in our example can be susceptible to cm currents from the motor cable but could be an interference source to sensitive analogue signals. The three categories intended here are only used to demonstrate the principle: our effort should be focused on keeping the emission sources separated from the sensitive cables!

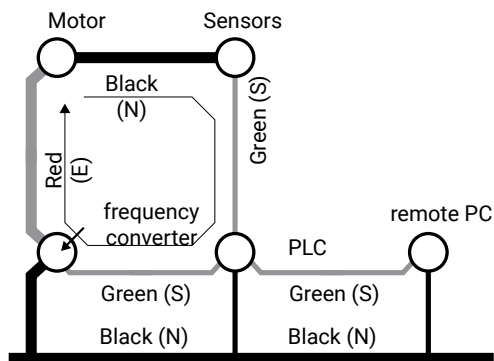


Figure 9

Keep interconnections short

The first thing we can do is keep cable lengths short. All interference is ultimately coupled through transfer-impedance, the cable property that converts common-mode currents to differential and vice versa. This effect increases with cable length. The shorter the cable, the smaller the effect. For that reason interference risks in our example in figure 8 and figure 9 would go down dramatically if we could manage to build the frequency converter right down on the motor!

No cable length to speak of, no generation of common-mode currents. Of course, external fields remain as threats to our sensitive cables.

Shield cables

The conversion of differential-mode to common-mode currents and vice-versa can be reduced considerably by shielding the cables. In other words, this reduces their transfer impedance. It is important to connect the shielding on both ends to the equipment the cable connects.

The best way to do this is to use an EMC gland (discussed later) or metal connector shell, i. e. , by providing a contact over 360° between the braid and the enclosure wall it enters. The measures described below are, nevertheless, appropriate when considerable distances have to be covered.



Electromagnetic interferences (EMC)

Reduce common-mode loop areas

As a next step it is useful to reduce the areas of (all) common mode loops detected. This does not readily remove the common-mode currents in our loops but at least the field outside the loop will be reduced by this action. Further, it makes the loop less sensitive to external fields. The reduction can be achieved by routing the category marked "black" or "N" alongside the green and red ones.

In our specific situation the black conductor between motor and sensors is the machine structure. It is cumbersome to bend it alongside the cables so a solution where the cables are routed along the structure is more appropriate here. But, as long as the enclosure containing the PLC and frequency converter cannot be built on the machine structure itself, this will remain difficult. So we will have to look for other alternatives.

EMC grounding: current boundaries

For that we will take our next step first: try to divert the threatening common-mode currents away from the sensitive cables, i. e. , provide an alternative path for them. This alternative is called a "current boundary" or reference conductor.

The situation shown in figure 10, would call for a (high frequency) connection between the bottom end of the red cable and the black conductor next to it. Of course, the closer the current boundary is to the end of the cable, the larger the effect will be.

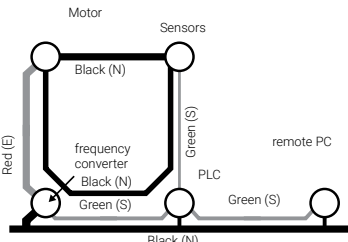


Figure 10

The construction of current boundaries

The current boundary is defined as a path for at least the high frequency part of the common-mode currents. In a case where the red cable is a shielded type cable (highly recommended, see below), the cable shield could be connected to the black conductor. If this is the machine structure, a bracket could be used to electrically connect the braid to the structure.

If it is another cable with shielding, the two shields could be bracketed together. In any case: keep this connecting device as small as possible. Whatever the construction, the obvious spot to locate it is at the interface with our equipment (the circles in figure 11).

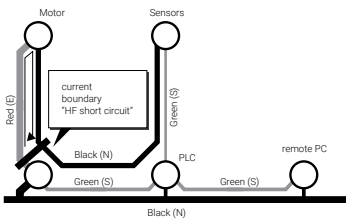


Figure 11



It is practical to always use "natural boundaries" for this purpose. A natural boundary that is obvious in figure 7 is the enclosure containing PLC and frequency converter. Assuming it is a metal case, the interconnections between the various cables could be made at their entry point. Special EMC glands are commercially available for this purpose.

They connect the cable shield electrically to the metal of the enclosure. For cables without shields, filters are the available option. Filters are insulators for mains frequencies (50 - 400 Hz) while forming a short circuit to the enclosure from, say, 100 kHz upward. Actually, what happens at the current boundary (= enclosure wall) is that an originally large common-mode loop is cut into a very small internal enclosure and a large outside version.

The small portion of the red cable remaining inside will cause only a small common-mode current. In many cases, small pigtails (figure 6) may even be acceptable inside the enclosure. To enable an excellent electrical contact between EMC glands, filters and other current boundary techniques, the enclosure entrance plate for cabling is often given a lasting conductive finish. If not, the locations for your EMC glands should be thoroughly ground or polished bare before mounting them. Afterwards a protective layer of paint can be applied.

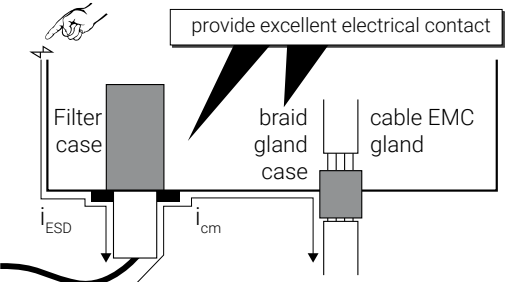


Figure 12

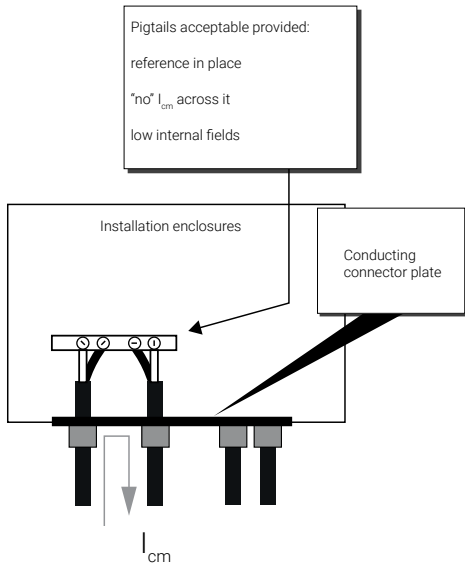


Figure 13



Electromagnetic interferences (EMC)

Use metal cable guides

Let us assume these provisions have been made on our enclosure of figure 7. Our diagram would look like the one below.

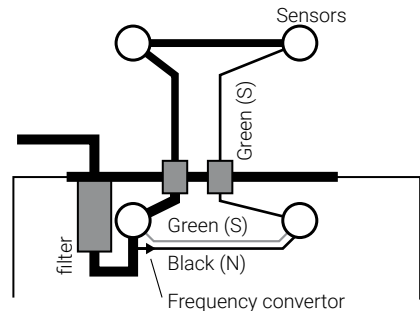


Figure 14

Objections may be raised regarding the mounting of the filter in the enclosure wall. From an EMC point of view this is, however, the best option. If mounted inside, place it as close as possible to the entry point of the power cable (no EMC gland here) and keep the wire between the entry point and the filter very close to the enclosure wall. Make sure the filter has very good electrical contact to the enclosure. It is advisable to check all current boundaries using a milli-ohm meter. Measure between the metal case and each cable braid or to the filter.

Having done all this, we are faced with a new problem: running between instrumentation enclosure and machine are two cables: the motor cable (red) and the sensor cable (taken together, green). No black conductor to protect them!

The solution is: the cable guide. To be effective, it should be made out of metal (conducting). This cable guide is connected (directly or with very short litz wire straps) to the instrumentation enclosure and to the machine structure.

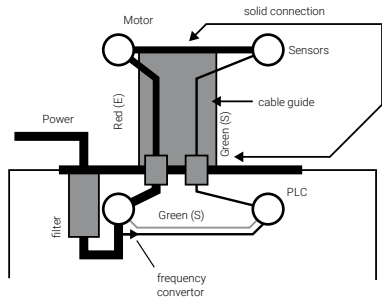


Figure 15

The red and green cabling is then placed against the metal of the cable guide with some distance between red and green.

The cable guide provides the alternative path for the common mode current. It separates the two cables by virtue of the proximity effect: a current will always take the nearest possible conductor as return conductor (provided it is connected electrically). For high frequencies, the return current (our common-mode current) will concentrate under the conductor that generates the current.



The distance between the red and green cable (-sets) should be between 5 and 10 times the diameter of the larger cable. Note: Cabling should always be routed along wide metal surfaces. A separate construction is not always needed, however. Any wide metal can be used.

The machine structure already mentioned is fine but the metal enclosure wall is also excellent for this purpose.

The final option: shielding equipment against electromagnetic fields.

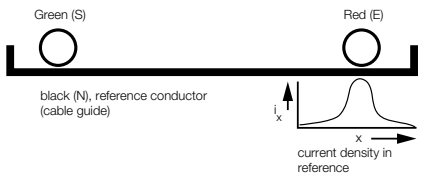


Figure 16

The effects of shielding.

Shielding is a means of keeping electromagnetic fields out of an enclosure. For that purpose the enclosure should, theoretically, be completely made out of metal and be "gas-tight". The enclosure wall can then, more or less, be considered to extend infinitely.

A model often encountered for an infinite shielding wall is the transmission line model given in figure 17. When an electromagnetic wave encounters a metal wall, some of the energy is reflected and some passed into the metal. At the other side of the wall, a similar process again reflects part of the transmitted wave and passes the rest. This final wave which emerges from the inside of the wall in relation to the original incident wave on the outside is called the shielding effectiveness (SE).

$$SE = 20 \log \text{incident wave transmitted wave (db)}$$

It is generally expressed in dbs. The absorption which reduces the intensity of the wave on its path through the wall is a phenomenon called the skin effect. Important parameters in this mechanism are wall thickness and material properties like the conductivity of the metal and its magnetic permeability property.

Treatment of apertures in shielding.

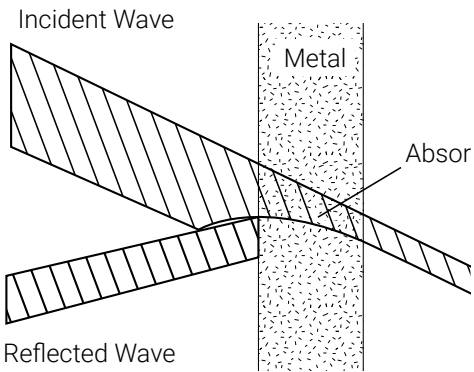


Figure 17



Electromagnetic interferences (EMC)

The effect of a hole in a shielded enclosure

In practice, enclosures are never “gas-tight”. They have apertures, slits and seams which “leak” electromagnetic energy. These apertures determine the entire shielding behavior of the enclosure. The effect can be imagined with the help of figure 18.

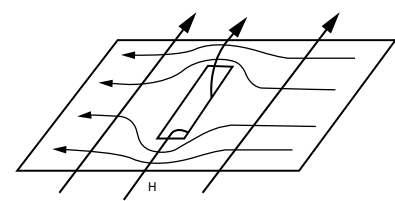


Figure 18  
The effect of the field is a current in the shielding. This current generates a field which opposes the incident field. This way even non-magnetic materials can be used as shielding.

When an aperture is encountered, the current has to flow around it. This deflects the external field into the aperture. One way to reduce this effect is to replace one large aperture with a number of small apertures.

This technique can be applied for apertures to allow light and air into an enclosure. Figure 19.

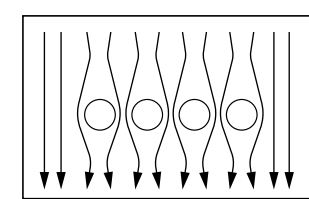


Figure 19  
The effect of slits and seams

EMC enclosures built out of sheet metal are usually spot-welded. Thus, small slits are formed which potentially leak electromagnetic energy. This leak is small when the slits are much smaller than one half wave length of the highest frequency to be shielded.

For GSM telephone fields (900 MHz), the slits would have to be considerably smaller than 16 cm (approximate half wavelength). Enclosures not originally intended for EMC can be improved by connecting the various metal panels using short litz wire straps.

The number of straps can be determined using the same rule given for seam widths (between straps) above. Overlap in seams can help to reduce higher frequencies as well (e. g. , with wavelengths shorter than the seam width). This measure works due to the effect of the capacitor thus created.



Cabling of shielded enclosures

A conductor should never be allowed to enter an enclosure unhindered: no cables or other conductors like shafts of controls or metal tubing.

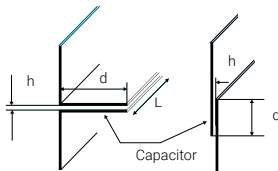


Figure 20  
There should be a direct electrical connection to the enclosure wall. If it is a cable, an EMC gland should be used (see figure 12). If you were to allow the cable to pass the hole insulated while connecting the cable braid via a (long) cable, the loop formed by it would pick up electromagnetic energy (a common mode current) and it would be conducted over the braid to the inside of the enclosure.

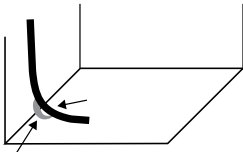


Figure 22  
There it would reradiate, forming a leak. An unshielded cable passing an enclosure wall intended for shielding should be filtered, if possible, directly on the wall. Almost as bad as an unfiltered cable through an EMC shield is a cable crossing a slit in the enclosure wall. When this is necessary, it is good practice to connect both sides of the slit electrically using a short strap of litz wire.

When is an EMC enclosure needed?

Most installations can be made to comply with the EMC directive using the measures described in section 3.

As long as the distances between cabling and protecting machine-structures or cable guides are much smaller than a half wavelength of the highest frequencies, few problems will be encountered. Field levels in an industrial environment are in the order of 10 Volts per meter (E-field) while the domestic value hardly exceeds 3 Volts per meter. Be aware, however, that external threats such as GSM telephones are everywhere and their frequency will go up to 1 800 MHz (half wavelength cm). The most sensible approach is to shield at the smallest possible scale: at the printed circuit board (PCB) level or at the PCB-rack level. The larger the enclosure (with respect to the wavelength of the field) the more difficult shielding will be.

What does nVent HOFFMAN offer?

To minimize and prevent the risk of EMI, nVent HOFFMAN offers wall and floor standing enclosures that have been tested for EMC attenuation according to VG 95 373 part 15. MASE (wall mounted enclosure) and MCSE (floor standing enclosure) are complemented with accessories that have also undergone the same testing and will provide the best enclosure solution possible.



# Material properties

Thirty years ago, materials did not play such an important role in the enclosure industry as they do today. Material choices have increased exponentially and there is a wide variety of enclosure types. Selecting the correct enclosure material is a key element in ensuring long enclosure life.

## Metals

### Mild steel

Also known as plain carbon steel is a type of metal that has an alloying element made up of a relatively low amount of carbon. A very versatile and useful material, it can be machined and worked into complex shapes, has low cost and good mechanical properties.

Mild steel enclosures are used in indoor applications in low aggressive environments, but can also be used in outdoor applications if polyester paint coating is used and in low to moderately aggressive environments if primer treatment is applied.

- Cost-effective material.
- High mechanical strength
- Moderately difficult to machine
- Density: around 7850 kg/m<sup>3</sup>
- nVent HOFFMAN uses DC01-A-m mild steel type
- Coating materials:
  - Epoxy-polyester paint – not UV resistant
  - 100% polyester paint – UV resistant (available on request).
  - Primer treatment to enhance corrosion resistance

### Stainless steel

There are several stainless steel grades; those used in the enclosure market are AISI 304L and AISI 316L which are suitable for indoor and outdoor use.

Stainless steel AISI 304L (1. 4307) is used in highly corrosive environments or environments with high demands on hygiene, such as the food & beverage and water treatment industries.

It is especially suitable in the presence of oxidizing acids (the most common one is nitric acid), such as in facilities producing fertilizers, fungicides, explosives and pharmaceuticals

- Expensive material
- Very high corrosion resistance
- Very high mechanical strength
- Difficult to machine
- Density around 7930 kg/m<sup>3</sup>

Stainless steel AISI 316L (1. 4404) grade contains 2-3% molybdenum, which prevents corrosion caused by halogen elements (fluorine, chlorine, bromine, iodine), which are found in marine environments, paper manufacturing facilities or water treatment plants where chlorine is used to disinfect water.

- Around 25-30% more expensive than AISI 304L
- Very high corrosion resistance
- Slightly lower mechanical strength compared to 304L grade
- Difficult machine
- Density around 7960 kg/m<sup>3</sup>

\* L stands for “Low carbon” and provides a better corrosion resistance in welded areas.



### Galvanized steel

Usually refers to hot-dip galvanized steel, which is the process of dipping fabricated steel into a kettle or vat containing molten zinc.

- Similar characteristics to that of steel, with an enhanced corrosion resistance
- In EMC enclosures, nVent HOFFMAN uses enclosures DX51D+Z140-M-A-C type
- Galvanized steel enclosures are usually much more expensive than mild steel ones
- Coating materials:
  - Epoxy-polyester paint – not UV resistant
  - 100% polyester paint – UV resistant

### Zamak

An alloy with a zinc base and aluminium, magnesium and copper elements, which is used in the manufacture of locks and hinges.

- It can be chrome plated, powder painted or bare Zamak
- Moderate price
- Good corrosion resistance
- High mechanical strength
- Density: around 6600 kg/m<sup>3</sup>.
- Non-magnetic

### Aluminium

Aluminium is a soft, non-magnetic and ductile metal which is remarkable for its low density and ability to resist corrosion.

Enclosures made from aluminium are frequently used in Rail & Roadways Traffic Applications, Telecommunication Systems and Internet Appliances, but also in marine and petrochemicals environments.

- Aluminium-magnesium alloy (nVent HOFFMAN alloy used: AlMg<sub>3</sub>)
- Expensive enclosures.
- Good corrosion resistance, even in marine environments
- Good mechanical strength
- Moderately difficult to machine
- Special dimensions are available
- Density: around 2660 kg/m<sup>3</sup>
- High heat dissipation rates.
- Non-magnetic
- Coating material:
  - 100% polyester paint UV resistant

Material properties

Plastics

Fiberglass reinforced polyester

Fiberglass reinforced polyester is the most used composite material system. It consists of a plastic resin matrix, glass fiber reinforcements and other additives.

Fiberglass reinforced polyesters are used in corrosive environments such as the petrochemical industry, water treatment plants, marine environments, electronics component manufacture, railways and wagon systems areas, or in the presence of organic solvents, alcohols and moderately strong alkalis or acids.

In addition to their desired mechanical properties, their resistance to corrosion is also a factor which makes it tempting to use this composite in outdoor areas.

- Polyester matrix reinforced by fibers of glass
- Moderate price
- High corrosion resistance
- Good mechanical strength
- Moderately difficult to machine
- Density: around 1800 kg/m3
- Halogen free
- Flammability: self-extinguishing, flame rating varies (nVent HOFFMAN: HB / V0)
- Wide operating temperature range (typically: around -50 °C to +150 °C)
- UV resistant, although it can be affected if highly exposed to sunlight

Polycarbonate

A particular group of thermoplastic polymers which offers very high impact strength and high modulus of elasticity. Polycarbonate enclosures are used in indoor and outdoor applications where high impact resistance is not needed, with the exception of environments that contain strong alkalis and acids.

- Cheap material
- Moderate corrosion resistance
- Moderate mechanical strength
- Easy to machine
- Special dimensions are not available
- Density: around 1200 kg/m3. Halogen free
- Flammability: self-extinguishing, high flame retardant (nVent HOFFMAN: UL 746C)
- Good operating temperature range (nVent HOFFMAN range: -50 °C to +120 °C)
- UV resistant

ABS (Acrylonitrile Butadiene Styrene)

An opaque thermoplastic polymer material made from the monomers Acrylonitrile, 1,3-Butadiene and Styrene. Strong and durable even at low temperatures, it offers good resistance to heat and chemicals and is easy to process.

ABS enclosures are used in indoor applications as a low-cost alternative to polycarbonate, especially in corrosive environments with moderate to high presence of alkalis.

- Very cheap material
- Fair corrosion resistance and mechanical strength
- Easy to machine
- Density around 1050 kg/m3
- Halogen free
- Flammability: self-extinguishing, low flame retardant (nVent HOFFMAN: UL 94 HB)
- Poor operating temperature range (nVent HOFFMAN range: -40 °C to +60 °C)
- Not UV resistant



Paint

nVent HOFFMAN enclosures are located in environments which demand resistance against corrosion, scratching and aging, and thus require a high quality painting process. nVent HOFFMAN enclosures are therefore painted with a protective epoxy-polyester type oven-dried paint.

Epoxy-polyester

Epoxy-polyester paint is used when flexibility, adhesion, toughness and corrosion resistance are required. This coating is based on epoxy resins, which gives excellent resistance to solvents and other chemicals, and provides a good corrosion protection layer.

The electrostatic powder painting process gives a tough surface and a good build-up on corners and edges. Good adhesion ensures that the paint does not crack or split when the material is drilled or punched

The paint has very good chemical characteristics: it is not flammable and contains no heavy metals like lead or cadmium.

nVent HOFFMAN applies an epoxy-polyester structured powder coating to color RAL 7035, according to the DIN 43. 656 standard.

- Intended for interior use
- Available in a range of colors
- Available in a range of finishes (textured or fine-textured)
- Good chemical resistance
- Good mechanical performance

Polyester paint

Designed for exterior environments, this is a powder coat paint that offers excellent light and weather resistance from a single coat finish on a variety of substances.

The enhanced heat resistance of polyester paint powders makes them ideal for use where color retention on surfaces exposed to continuous heat is required. They are available in a wide range of colors in textured or fine-textured effects and can be custom matched to the customer’s requirements.

- Excellent UV stability for exterior application
- Good heat resistance
- Available in a range of colors
- Available in a range of finishes (textured or fine-textured)
- TGIC free

\* Polyester paint finish can be ordered as a special request.



Material properties

Gaskets

For enclosures and connection boxes the function of a perfect seal is obvious. The interior space must be dry and clean, humidity and dust must be excluded, in this way the highest IP protection classes can be achieved.

Choosing a particular gasket material is based on the presence of certain chemicals in the application environment, the need for exceptionally high temperature resistance, or IP rating requirements.

Polyurethane

A polyurethane (PUR) gasket differs from other gasket materials as it is shaped by special foam injection in the enclosure's gasket groove (usually in the cover). In this way, the gasket sticks permanently and securely to the enclosure.

The average lifetime is up to 25 years depending on the environmental conditions. UV radiation or exposure to certain chemical agents can shorten the gasket's lifetime considerably. For outdoor applications a rain hood will protect the gasket

- Foam in place gasket (injected)
- Fair operating temperature range (-40 °C to +80 °C)
- Good compression set resistance
- Can be affected if exposed to UV radiation

Neoprene

Neoprene is self-extinguishing with excellent weather resistance properties – sunlight, oxygen and ozone do not affect the material.

Neoprene gaskets are resistant to oils, fats, hydrocarbons and alcohols, although some of these may cause limited material swelling.

- Neoprene is a trademark for CR (chloroprene rubber)
- Strip gasket, but can also be die-cut
- Typically slightly wider operating temperature range than PUR
- Waterproof
- NON halogen free

\* Enclosures with neoprene gaskets can be ordered as a special request.

Silicone

Silicone gaskets can be used at a constant temperature from -60 °C up to +200 °C and for short periods up to +350 °C while maintaining their softness and flexibility.

Due to their closed cell structure they do not absorb water and are suitable for the use in tropical or damp environment.

They are also highly resistant to other chemicals (e. g. , cleaning agents, alcohols, lubricants, hydrochloric acid, nitric acid, brake fluids, cooling agents or ammonia gases).

- Widest temperature range of all gasket materials (-60 °C to 200 °C)
- Extremely low water absorption
- Good resistance to ozone, UV and other weather-related elements
- Halogen free
- The most expensive gasket material

\* Enclosures with silicone gaskets can be ordered as a special request.



EPDM

EPDM (Ethylene propylene diene terpolymer) gaskets come either as a strip or in die-cut form. They offer very good properties in terms of resistance to water, oxidation, ultra violet, ozone, aging and weathering.

EPDM gaskets are not suitable for aromatic and aliphatic hydrocarbons, lubricating oils and petrol.

- Strip gasket but also can be die-cut
- Slightly wider operating temperature range than PUR and neoprene.
- Good resistance to water and UV radiation.
- Halogen free
- More expensive than neoprene

Material	Advantages	Disadvantages
Polyurethane	Foam can be injected in gasket	Can be affected by UV
Neoprene	Wider operating temperature range than PUR	NON halogen free
	Waterproof	
Silicone	Wide temperature range	The most expensive gasket material
	Extremely low water absorption	
	Good resistance to ozone, UV and other weather-related elements	
EPDM	Wider operating temperature range than PUR and neoprene	Usually comes as a strip gasket
	Good resistance to ozone, oxygen, water and UV radiation	More expensive than neoprene



# Enclosure selection

When the time comes to choose the appropriate enclosure material for a specific application, the following material characteristics play a critical role and need to be considered selection criteria.

## Ingress protection

One of the most vital criteria to consider when specifying an enclosure is the ingress protection rating. The IP rating of an enclosure is the measure of protection the enclosure has against solid objects, dust and water. Failing to choose the correct IP rating for the enclosure for the correct application can result in a reduction in the enclosure's life expectancy, component failure and damage, and in more extreme circumstances damage to personnel and property.

Range		Degrees of protection													
		IP						TYPE					IK		
		44	54	55	65	66	69	4	4X	12	13	06/ 07	07	08	10
Wall Mounted Enclosures	MAS					X		X		X	X				X
	MAD			X						X	X				X
	MAP					X		X		X	X				X
	ASR					X			X	X	X				X
	ADR			X						X	X				X
	AFS					X			X	X	X				X
	HDW					X	X		X	X	X			X	
Floor Standing Enclosures	MCS			X						X	X				X
	MCD			X						X	X				X
	MCI			X						X	X				X
	MCM	X													X
	MKS			X						X	X				X
	MKD			X						X	X				X
	MCSS			X						X	X				X
	MCDS			X						X	X				X
	EKSS					X			X	X	X				X
Console Systems	MPG single door					X		X		X	X				X
	MPG double door			X						X	X				X
	MPC single door					X		X		X	X				X
	MPC double door			X						X	X				X
	MPGS single door					X			X	X	X				X
	MPGS double door			X						X	X				X
	MPCS single door					X			X	X	X				X
	MPCS double door			X						X	X				X
Fiber-Glass Reinforced Polyester Enclosures	UCP					X		X	X	X	X				X
	UCPT					X		X	X	X	X		X		
	UDP				X			X	X	X	X				X
	UDPT		X					X	X	X	X		X		
Terminal Boxes	STB					X		X		X	X				X
	SSTB					X			X	X	X				X
	HALP					X	X								
	MGRP					X	X					X			
	DABP					X	X					X			
	SABP					X	X					X			
	OABP					X	X					X			
	DPCP					X	X							X	
	OPCP					X	X							X	
Swing Arms	OICP				X										
	OICE			X											X
Outdoor Enclosures	EKOM					X			X	X	X				X
	EKOM-SW					X			X	X	X				X
	ECOM					X									X
EMC Enclosures	MASE		X							X					X
	MCSE		X							X					X

\* If the surface of the enclosure has cut-outs so that further components can be installed inside, they will be tested for the IP rating



of the enclosure. If the components don't comply with the IP, the enclosure's IP will also be affected.

## Corrosion resistance

Corrosion is the gradual destruction of a material caused by chemical reaction with its environment. The EN 62208 standard establishes that empty enclosures are to be tested to prove their resistance to corrosion. Chemicals can also contribute to corrosion, please refer to the selection table as a guide to which materials can resist solvents, alkalis and acids.

## Thermal issues

Specifiers must evaluate both the temperature of the environment in which the enclosure will be located as well as the expected temperature of its enclosed electrical components.

## Operating temperature range

The operating temperature range of a material is the range in which the properties of the material are not affected. Metals have wide operating temperature ranges. In metallic enclosures the operating temperature range will be determined by the paint coating or the gasket material. In plastic enclosures, either the gasket or the enclosure material may be the one with the narrowest operating temperature range.

## UV resistance

Many natural and synthetic polymers are attacked by ultra-violet radiation and products made from these materials may crack, disintegrate or have their properties greatly affected by exposure to sunlight. The UV resistance of all materials should be taken into account before placing them into a high UV environment.

## Heat transfer rate

The capacity to dissipate or absorb heat is given by its thermal conductivity coefficient, which measures the ability of the material to transfer heat through it.

When evaluating the heat transfer rates in enclosures, heat is not only transferred through the material it is made from, but also through the air, by means of convection and radiation.

Material	Aluminium	Mild Steel	Stainless Steel	Plastic
Heat transfer rate (W/m2K)	12.5	5.5	4.5	3.5

## Flammability

Flammability refers to the ability or tendency of a material to ignite and burn when exposed to an open flame. This property only concerns plastic materials. The most important characteristic a plastic must fulfill regarding flammability is to be self-extinguishable.

	Mild Steel		Stainless Steel		Aluminum	GRP	Polycarbonate	ABS
	Epoxy paint	100% polyester paint	AISI 304L	AISI 316L				
Outdoor use	4	4	5	5	4	5	3	1
Indoor use	5	5	5	5	5	5	5	5
Light weight	1	1	1	1	1	3	5	5
High rigidity	4	4	5	5	4	4	3	1
Impact resistance	5	5	5	5	5	4	4	2
UV resistance	5	-	5	5	5	4	4	1
Temperature resistance	4	4	4	4	4	4	4	2
Ease to machine	2	2	1	1	1	1	5	5
Electrical insulation	-	-	-	-	-	4	5	5
Fire resistance	5	5	5	-	4	1	4	1
Resistance against solvents	1	1	5	5	5	5	1	1
Resistance against alkalis	1	1	5	5	1	4	2	5
Resistance against acids	1	1	4	5	1	3	3	2



Enclosure selection

Mechanical strength

Mechanical strength refers to the robustness of a material and is commonly associated with the IK rating. Even though there is a relationship between them, high mechanical strength does not necessarily imply a high IK rating.

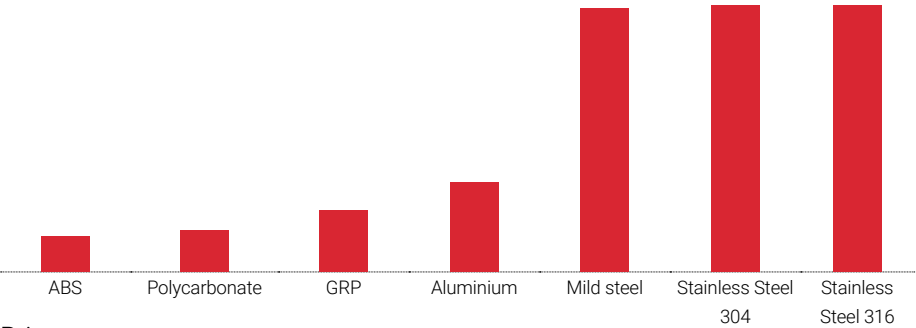
Ease of machining

Empty enclosures are very flexible and are used in many different environments and applications. To enhance flexibility it is important that customers can install components and cabling exactly where they want and in a timely manner, which is why it is very important that the material can be machined easily, resulting in money and time saved.

Weight

The weight of a material is usually measured by its density. Density gives the relation between certain weights of a material per unit of volume (kg/m<sup>3</sup>). To evaluate the weight of an enclosure, the density value must be considered together with its dimensions and thickness.

Depending on the application at hand, a lightweight enclosure may be preferable, because these materials are easier to lift and work with, especially when the enclosure will be wall or pole mounted.



Price

The price of an enclosure will not only depend on the price of the raw material it is made from, but also on the density of the material and enclosure thickness, the manufacturing process and the enclosure batch size.

There will usually be different enclosure materials that will fulfill the requirements of a specific application. In this case, the cheapest one is the most likely to be chosen.



Certifications

The certification and approval of products safeguards customers by ensuring that the relevant performance and quality tests are carried out and that, as a result, industry specifications and regulations are met. Certifications play an important role in enclosure selection; please refer to the certification table for certifications of nVent HOFFMAN's standard products.

Range	Product	CE	SP	UL	UL LISTED	KEMA	LR	UL	PG	PG	EAC
Wall Mounted Enclosures	MAS	X	X	X		X	X	X	X	X	X
	MAD	X	X	X		X	X	X	X	X	X
	MAP	X	X	X		X	X		X		X
	ASR	X	X	X		X	X	X	X	X	X
	ADR	X	X	X		X	X	X	X	X	X
	AFS	X			X	X	X	X	X	X	X
	HDW	X			X						
Floor Standing Enclosures	MCS	X	X	X		X	X	X	X	X	X
	MCD	X	X	X		X	X	X	X	X	X
	MCI	X	X	X		X	X	X	X		X
	MCM	X							X		X
	MKS	X	X	X		X	X		X		X
	MKD	X	X	X		X	X		X		X
	MCSS	X			X	X	X	X	X		X
	MCDS	X			X	X	X	X	X		X
	EKSS	X			X	X	X		X		X
Console Systems	MPG	X	X	X		X	X		X		X
	MPC	X	X	X		X	X		X		X
	MPGS	X	X	X		X	X		X		X
	MPCS	X	X	X		X	X		X		X
Fiber-Glass Reinforced Polyester Enclosures	UCP	X	X	X					X		X
	UCPT	X		X					X		X
	UDP	X	X	X					X		X
	UDPT	X	X	X					X		X
Terminal Boxes	STB	X			X	X			X		X
	SSTB	X			X	X			X		X
	HALP	X							X		X
	MGRP	X							X		X
	DABP	X							X		X
	SABP	X							X		X
	OABP	X							X		X
	DPCP	X							X		X
	OPCP	X							X		X
Swing Arms	OICP	X							X		X
	OICE	X							X		X
Outdoor Enclosures	EKOM	X			X				X		X
	EKOM-SW	X			X				X		X
	ECOM	X									
EMC Enclosures	MASE	X		X					X		X
	MCSE	X		X					X		X



Earthing

nVent HOFFMAN's enclosures are provided with various earthing points. All panels (excluding certain gland plates) are equipped with a copper-plated or stainless steel earthing stud.

The frame or body of the stainless steel enclosures and the wall mounting enclosures has two studs so one can be used as a Protected Earth (PE). nVent HOFFMAN's earthing studs have a circular base that is then welded to the surface of an enclosure, This base ensures the best contact between the earthing clamp and the enclosure. As the base is not fully painted this will also increase the earth connection when compared to an earthing stud without a circular base. The base of the earthing stud will also protect the enclosure body or door from an earthing nut being over-torqued, thus ensuring the enclosure body/door is not damaged.

To ensure that these earthing points will give you the desired protection, nVent HOFFMAN has verified the products by testing at the independent institute TNO in The Netherlands.

Technical details measured between

Panel earthing	PE - mild steel copper-plated stud M6	1,19 mΩ
	PE - mild steel copper-plated stud M8	1,06 mΩ
Frame earthing	PE - mild steel copper-plated stud M8	0,51 mΩ
General earthing	PE - mild steel zinc-plated bolt connection with contact washers M6 (Bottom plate)	1,64 mΩ
	PE - mild steel zinc-plated bolt connection with contact washers M8 (Open frame)	1,83 mΩ
	PE - mild steel zinc-plated bolt connection with contact washers M10 (Sulting frames together)	0,78 mΩ
Earthing cables	ECFA 220, 6 mm2 copper, cable eyes for M6/M8, length 220 mm	1,05 mΩ





Standard coating and finish

nVent HOFFMAN enclosures are being placed in various environments, which demand resistance against, corrosion, scratching and ageing, a high quality painting process is needed to overcome these environmental issues.

Introduction

nVent HOFFMAN's mild steel enclosures are painted with protective epoxy-polyester oven-dried paint. The electrostatic powder painting process provides a tough surface also ensuring a good build-up on corners and edges. Good adhesion ensures that the paint does not crack or split when the material is drilled or punched.

The paint has very good chemical characteristics: is not flammable and contains no heavy metals like lead or cadmium. nVent HOFFMAN applies an epoxy-polyester structured powder coating to color RAL 7035 according to the DIN 43. 656 standard.

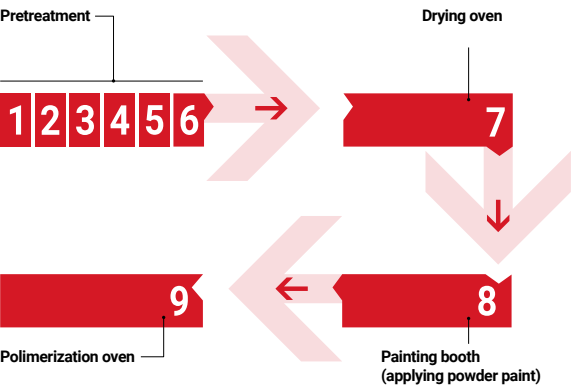
nVent HOFFMAN offers various finishes to meet different demanding environments. Epoxy-polyester paint is the standard finish nVent HOFFMAN supplies on mild steel enclosures. However polyester and harsh environment paint can also be supplied as a special request to fulfill outdoor and more extreme environments, such as those found in coastal applications.

For further information please refer to nVent HOFFMAN's powder paint coating system white paper.

Paint process

nVent HOFFMAN's paint treatment process that is applied to the surface of sheet metal is described below:

- 1. Alkaline degreasing 1
- 2. Alkaline degreasing 2
- 3. Tap water rinse
- 4. Demi water rinse
- 5. Nanoceramic
- 6. Fog demi water rinse
- 7. Drying oven
- 8. Painting booth (powder paint applied)
- 9. Polymerization oven



Repainting

nVent HOFFMAN enclosures can easily be repainted after degreasing and light abrading of the standard painted surface followed by careful cleaning to remove all traces of dirt and dust. A suitable paint is a 2-component polyurethane paint or, alternatively, ordinary alkyd paint can be applied. For example: Automobile paints, DD gloss paints, Powder coating 1-component stove enamels, 2-component gloss paints (acrylate enamels).

\*\* If drilling or machining the enclosure is required then it is standard procedure to touch up the paint around the affected area. This ensures that no bare steel is open to the environment and safeguards the enclosure's corrosion resistance.



Pretreatment

**Stage 1 and 2, Cleaning (Alkaline degreasing)** To increase the effectiveness of pretreatment, the parts must be cleaned prior to the nanoceramic stage to remove soils from the surface. Three types of cleaners are normally used: Solvent, acid and alkaline. nVent HOFFMAN uses alkaline cleaners, as these deliver optimum results on organic soils, and are versatile enough to clean the surface effectively. During the alkaline degreasing stages, the oil plus organic and inorganic contaminations, which could affect the nanoceramic process, are removed from the steel surface. The ph-value is 10, which is an aggressive alkaline solution.

**Stage 3, Rinse (tap water)** In this stage the chemicals from the previous stage are removed, preventing contamination of subsequent stages.

**Stage 4, Rinse (demi water)** During this stage all residues of salts are removed. The conductivity of the demi water is constantly monitored and controlled below a threshold value.

**Stage 5, Nanoceramic** By passing through this bath, a thin layer of nanoceramic material is deposited on the surface of the part, making it practically closed to corrosion penetration and improving the corrosion resistance of treated metal surfaces from a chemical point of view:

**Stage 6, Rinse (fog demi water)** This final stage terminates chemical reactions from previous stages.

Drying oven

**Stage 7: Drying oven** To completely dry the products coming out of the above mentioned five baths and to obtain optimal painting the products are passed through the drying oven which is set to a temperature range within 130-160 °C.

Painting booth

**Stage 8: Painting booth** The powder paint is sprayed onto the products in the automated painting booth. Where surfaces cannot be reached in this way, the powder is applied with manual guns attached to the painting booth.

**Stage 9: Polymerization oven** The final step is polymerization of the paint by passing the coated products through the polymerization oven. The process is set up so that the products stay in the oven for 20 minutes with the temperature of the metal between 185-200 °C. When the products leave the oven the painting process is complete and they are removed from the conveyor and taken to the assembly area.

Surface		Mechanical				Corrosion	
Color	Layer thickness	Impact	Adhesion (scratch)	Bend	Cupping	Salt spray	Water condensation
RAL 7035, grey	Approx. 80 µm	ISO6272	ISO 2409	ISO 1519	ISO 1520	ISO 9227	ISO 6270
		Pass 0. 5 m/0. 5 kg	G0-G1	No visible cracks	No visible cracks at 5 mm	≤ 2 mm on both sides of the cut after 480 hours for the standard coating.	After 240 hours for the standard coating:  Blistering 0(S0) to ISO 4628-2  Rusting Ri0 to ISO 4628-3

Results

nVent HOFFMAN's painted enclosures are continuously tested for corrosion resistance in the form of artificial environment tests in accordance with ISO 6270 and ISO 9227.

nVent HOFFMAN's standard enclosures are subjected to a salt spray test for a minimum of 480 hours to ensure that there is no loss of adhesion.

nVent HOFFMAN's mild steel and aluminum enclosures with a 100% polyester paint coating are subjected to a salt spray test for a minimum of 1000 hours to ensure that there is no loss of adhesion. nVent HOFFMAN's mild steel enclosures with a harsh environment coating are subjected to a salt spray test for a minimum of 1000 hours to ensure that there is no loss of adhesion.

Special applications

ATEX

ATEX, Appareils destines a etre utilisees en Atmospheres EXplosibles, refers to a possible hazardous environment where an explosive mixture of air and explosive material may be present in a room, a part of a room or a restricted indoor or outdoor space. Explosive atmospheres can be caused by flammable gases, mists or vapors or by combustible dusts. If there is enough of the substance, mixed with air, then all it needs is a source of ignition to cause an explosion.

The Equipment and Protective systems intended for use in Potentially Explosive Atmospheres (ATEX), Directive 94/9/EC, provides the technical requirements to be applied and the relevant conformity assessment procedures before placing this equipment on the European market.

Directive 94/9/EC is a "New Approach" directive laying down Essential Health and Safety Requirements and leaving it to standards, primarily European harmonized standards, to give technical expression of the relevant requirements contained in the Directive.

To ensure the safety of a product, such as a machine, it must be designed so that the use of the machine is as safe as possible.

The end-user must not be required to take their own protective measures. The end-user must follow all general instructions provided in the designer's usage instructions. Two main phases must be met to make the product as safe as possible.

Electrical installations of Ex areas must be carried out according to IEC/EN 60079-17. Electrical installations in explosive areas are specifically designed to be suitable for Ex areas and the conditions of use.

Taking the conditions of use into account, it must be ensured that the special properties designed are preserved for the entire life-cycle. This is the reason why the installations must be inspected and maintained regularly after the commissioning inspection by professional personnel.

The directive does not use Zone numbers in the classification of hazardous areas, preferring to refer to their definitions (e. g. , 'An area where an explosive atmosphere occurs frequently or continuously' for Zone 0) but it is useful to understand the classification system commonly used to describe areas where explosive atmospheres may occur.

Usually, a series of zones based on the likelihood of presence of an explosive atmosphere are defined (the following are based on BS EN 60079-10: 2003):

Equipment is selected on the basis of its suitability for use in these conditions. There is a subdivision, which separates equipment for use in mines from all other equipment.

The full list of categories is as follows:  
Basically, the ATEX Directive 94/9/EC describes what a manufacturer has to do before placing on the market a product which is intended to operate in an explosive atmosphere.

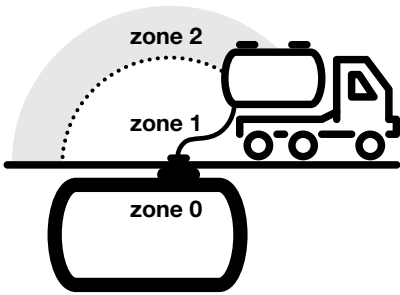
Some requisites are common to any equipment (e. g. , the obligation to put the CE marking and the ATEX logo on the equipment; the obligation to provide a Declaration/ Attestation of Conformity to the final user, the obligation to produce a Technical File, etc. )

If enclosures have holes or cutouts, then the IP can only be maintained if a component/accessory/ peripheral is fitted in the hole/cutout that meets at minimum the enclosure's standard IP rating.

All information displayed in the technical chapter is to be used as a guide.

In line with our policy of continuous development, we reserve the right to update our designs at any time. As a result, the product shown may not be identical to the one which is supplied, although it will correspond with the standards mentioned in the brochure. Whilst every care is taken to ensure that the information supplied is correct, we cannot accept any responsibility for errors or changes that may occur.

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ZONE DEFINITIONS		
Zones		Definitions
Gas	Dust	
0	20	A place in which an explosive atmosphere is continuously present
1	21	A place in which an explosive atmosphere is likely to occur in normal operation occasionally
2	22	A place in which an explosive atmosphere is not likely to occur in normal operation but if it does, only occurs for short periods

CATEGORIES	
ATEX Category	Typical Zone Suitability
1G 1D	Equipment suitable for Zone 0 Equipment suitable for Zone 20
2G 2D	Equipment suitable for Zone 1 Equipment suitable for Zone 31
3G 3D	Equipment suitable for Zone 2 Equipment suitable for Zone 22

Ex

II

2

GD

EEx

d

IIB

T6

EU Explosive atmosphere symbol	Equipment group	Equipment category	Gas /Dust		Type of protection	Cenelec Code	Gas groups		Temp code	Max Surface temperature °C
							Gas group	Sample gas		
I - Mining	M1 - Energised				Intrinsic safety	EEx ia / ib	I	Methane (mining only)	T1	450
	M2 - De-energised				Increased safety	EEx e			T2	300
	Flameproof				EEx d	T3			200	
	Pressurisation				EEx p	T4			135	
			Gas	Dust	Powder filling	EEx q			T5	100
II - Non-Mining	1 - Very high protective		0	20	Encapsulation	EEx m	IIA	Propane	T6	85
	2 - High protection		1	21	Oil immersion	EEx o	IIB	Ethylene		
	3 - Normal protection		2	22	TYPE 'n'	EEx n	IIC	Hydrogen		



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