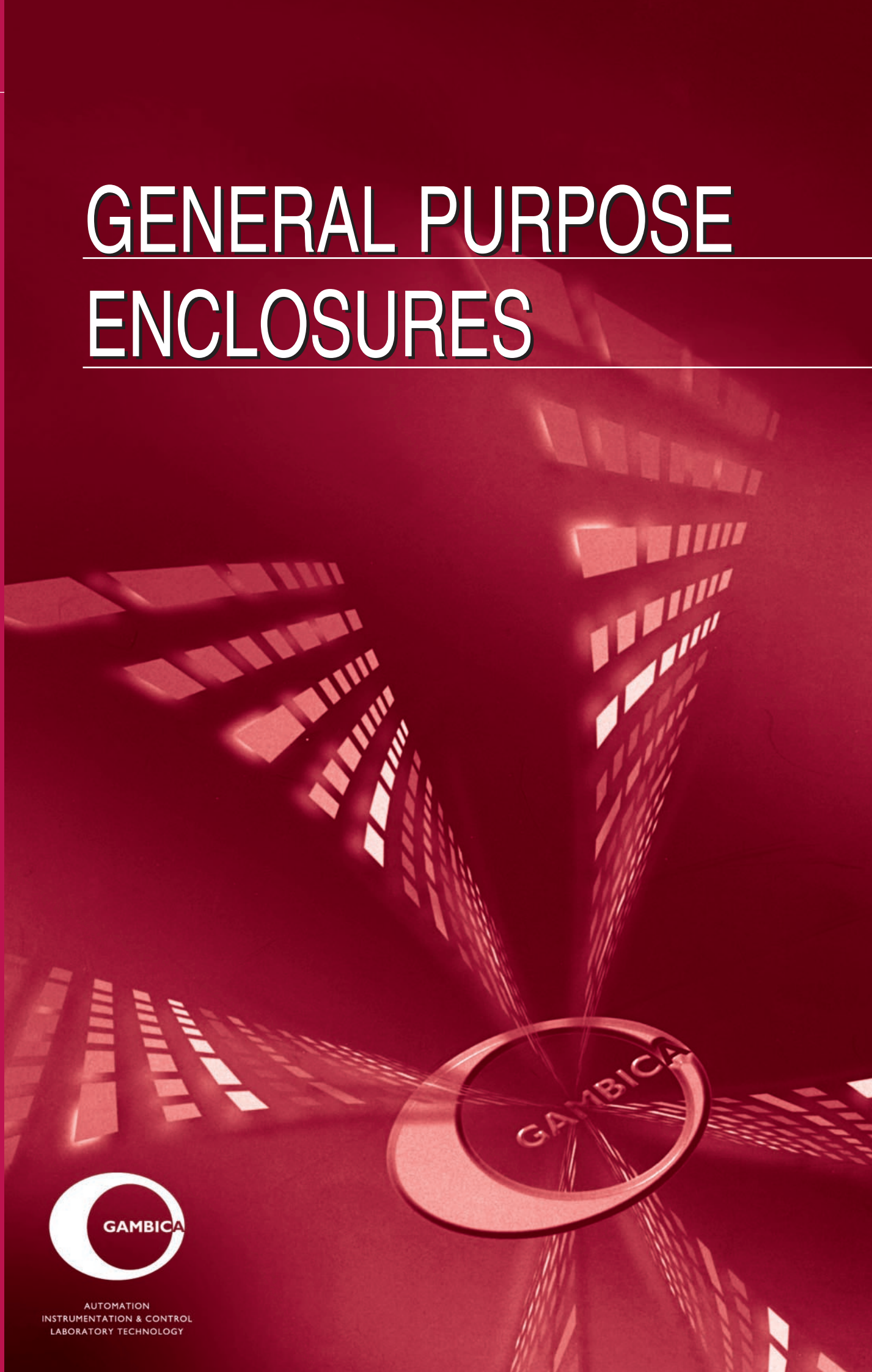
THIRD EDITION

A GAMBICA TECHNICAL GUIDE

GENERAL PURPOSE ENCLOSURES



GAMBICA

AUTOMATION
INSTRUMENTATION & CONTROL
LABORATORY TECHNOLOGY

INDEX

INTRODUCTION

This GAMBICA handbook is intended as a guide to specifiers and users of Enclosures for electrical and electronics applications. It has been produced recognizing that the Enclosure can form the most important part of any system. It protects the equipment within from the effects of the environment and the environment itself, including people, from the effects of the equipment.

This handbook has been produced by members of the Enclosures Group of GAMBICA, Association for Instrumentation, Control, Automation and Laboratory Technology. GAMBICA's Enclosures Group is the UK's professional organisation for manufacturers and suppliers of Enclosure products. Members aim to apply the most up to date industry standards in design, quality and production, to promote the professional use of Enclosures throughout industry and to support development of international standards for Enclosures through participation in Standards Committees.

In addition to Enclosures, GAMBICA covers Industrial Control Components and Systems, Power Electronics, Programmable Controllers and Systems Integrators, Hazardous Area Equipment, Laboratory Analytical and Nucleonic Instruments, Electronic Test and Measurement and Automatic Test Equipment, Process Measurement and Control Instruments and Systems, Environmental Pollution Monitoring and Control, Fluid Measurement and Control Valves. Guides to member's products in some of these areas are available on request.

A list of members of GAMBICA'S Enclosures Group, together with a product guide to suppliers of various types of enclosures, can be found on the web at www.gambica.org.uk together with hot links, to member's web sites. Contact the members directly for details of their products and applications.

THE RIGHT ENCLOSURE FOR YOUR APPLICATION

Consider:

- Where it will be installed
- What it will be used for
- How it will be mounted
- The type of environment
- The degree of ingress protection required
- The weight of internal equipment
- Aesthetics
- The risk of physical damage
- Internal accessibility
- Which standards apply
- The maintenance requirements
- EMC or protection
- Controlling the operating temperature
- Accessories
- Security requirements
- Safety requirements

Standard general-purpose enclosures normally range in size from around 50 mm square up to a maximum height of around 2400 mm. It should not be difficult to find an enclosure to fit even the most awkward site, or to house the required equipment with maximum economy of space, avoiding the expense of unnecessarily large enclosures.

IP RATINGS - INGRESS PROTECTION

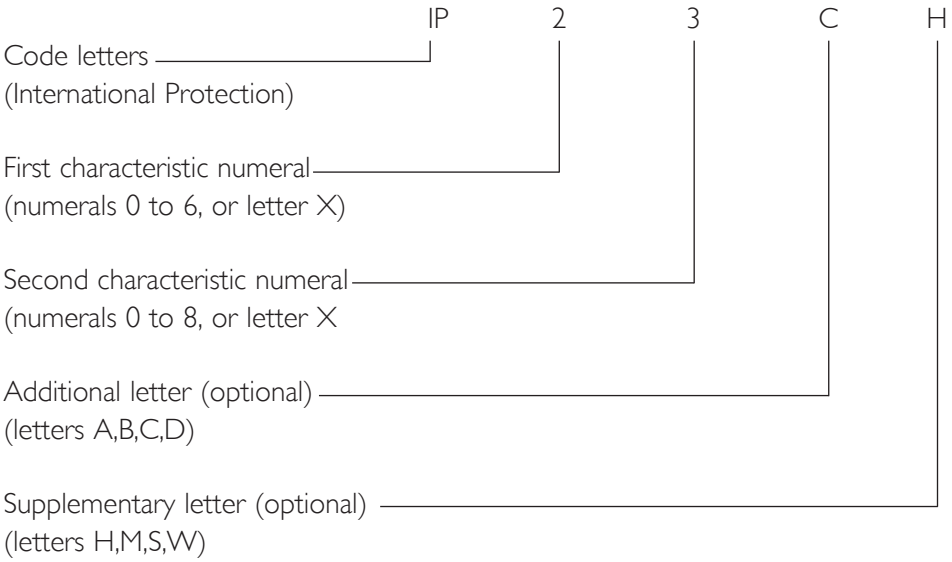
The IP code defined in the standards BS EN 60529: 1992, EN 60529: 1991, IEC 60529: 1989 Specification for degrees of protection provided by enclosures (IP code) provides a means of specifying the ability of an enclosure to protect its contents from external objects. The standard applies to enclosures for electrical equipment with a rated voltage not exceeding 72.5 kV.

The standard provides Definitions, Designation and Requirements for degrees of protection provided by enclosures for electrical equipment for:

protection of equipment inside the enclosure against ingress of solid foreign objects;
protection of persons against access to hazardous parts inside the enclosure;
protection of equipment inside the enclosure against the ingress of water.

The following extract from BS EN 60529: 1992 is reproduced with the permission of BSI and explains the arrangement of the Code, which consists of 2 numerals and optional letters. Complete editions of the standard can be obtained by post from BSI Customer Services, 389 Chiswick High Road, London W4 4AL.

4.1 *Arrangement of the IP Code*



Where a characteristic numeral is not required to be specified, it shall be replaced by the letter "X" ("XX") if both numerals are omitted).
Additional letters and/or supplementary letters may be omitted without replacement.
Where more than one supplementary letter is used, the alphabetic sequence shall apply.
If an enclosure provides different degrees of protection for different intended mounting arrangements, the relevant degrees of protection shall be indicated by the manufacturer in the instructions related to the respective mounting arrangements.
Details for the marking of an enclosure are given in Clause 10.

4.2 *Elements of the IP Code and their meanings*

- A brief description of the IP Code elements is given in the following chart. Full details are specified in the clauses indicated in the last column.

Code letters	IP	—	—	
First characteristic numeral	0 1 2 3 4 5 6	Against ingress of solid foreign objects (non-protected) ≥ 50 mm diameter ≥ 12.5 mm diameter ≥ 2.5 mm diameter ≥ 1.0 mm diameter dust-protected dust-tight	Against access to hazardous parts with (non-protected) back of hand finger tool wire wire wire	Cl.5
Second characteristic numeral	0 1 2 3 4 5 6 7 8	Against ingress of water with harmful effects (non-protected) vertically dripping dripping (15° tilted) spraying splashing jetting powerful jetting temporary immersion continuous immersion	—	Cl.6
Additional letter (optional)	A B C D	—	Against access to hazardous parts with back of hand finger tool wire	Cl.7
Supplementary Letter (optional)	H M S W	Supplementary information specific to: High voltage apparatus Motion during water test Stationary during water test Weather conditions	—	Cl.8

4.3 *Examples for the use of letters in the IP Code*

The following examples are to explain the use and arrangements of letters in the IP Code.

For more comprehensive examples see Clause 9.

IP44 - no letters, no options;

IPX5 - omitting first characteristic numeral;

IP2X - omitting second characteristic numeral;

IP20C - using additional letter;

IPXXC - omitting both characteristic numerals, using additional letter;

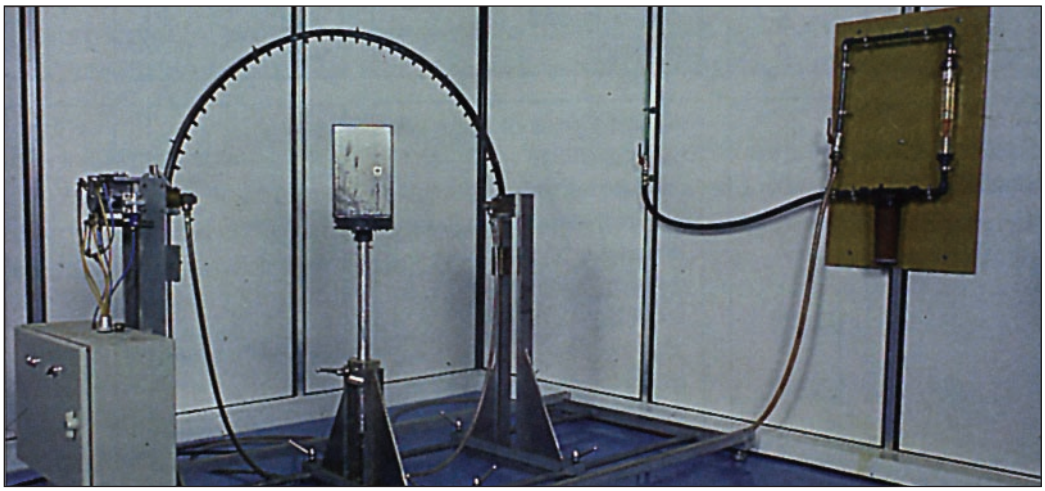
IPXIC - omitting first characteristic numeral, using additional letter;

IP3XD - omitting second characteristic numeral, using additional letter;

IP23S - using supplementary letter;

IP21CM - using additional letter and supplementary letter;

IPX5/IPX7 - giving two different degrees of protection by an enclosure against both water jets and temporary immersion for "versatile" application.



When deciding which IP rating to specify for a particular application, care should be taken not to over specify as the cost of an enclosure often increases with the rise in IP rating.

MECHANICAL IMPACTS (IK CODE)

The IK code defined in the standard BS EN 50102: 1995 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code) provides a means of specifying the capacity of an enclosure to protect its contents from external impacts.

Before the advent of EN 50102 a third numeral was added to the IP code to indicate the level of impact protection - e.g. IP66(9). Non standard use of this system was one of the factors leading to the development of the standard, which uses a separate two numeral code to distinguish it from the old differing systems. The standard came into effect in October 1995 and conflicting national standards had to be withdrawn by April 1997.

EN 50102 specifies the way enclosures should be mounted when tests are carried out, the atmospheric conditions that should prevail, the number of impacts (5) and their (even) distribution, and the size, style, material, dimensions etc. of the various types of hammer, designed to produce the energy levels required.

IK code and impact energy (Values changed in Amd 1: 1998)

IKcode	IK00	IK01	IK02	IK03	IK04	IK05	IK06	IK07	IK08	IK09	IK10
Impact energy (joules)	*	0.14	0.2	0.35	0.5	0.7	1	2	5	10	20

To test for resistance to higher impacts an energy of 50 joules is recommended

Impact test characteristics

IK code	IK00	IK01 to IK05	IK06	IK07	IK08	IK09	IK10
Impact energy (joules)	*	<1	1	2	5	10	20
R mm (radius of striking element)	*	10	10	25	25	50	50
Material	*	polyamide [1]	polamide [2]	steel [2]	steel [2]	steel [2]	steel [2]
Mass kg	*	0.2	0.5	0.5	1.7	5	5
Pendulum hammer	*	YES	YES	YES	YES	YES	YES
Spring hammer	*	YES	YES	YES	NO	NO	NO
Free fall hammer	*	NO	NO	YES	YES	YES	YES

* not protected according to the standard

1) R100 Rockwell hardness according to ISO 2039/2

2) Fc 490-2, Rockwell hardness according to ISO 1052

MATERIALS FOR ENCLOSURES

A variety of different materials are used in the manufacture of enclosures. Those in common use are listed below, together with their advantages and limitations. Choice of material clearly has a major bearing on the degree of protection afforded by the enclosure.

Mild Steel

Mild steel is the most widely used material for general-purpose indoor or outdoor applications. Standard enclosures are manufactured from steel up to 2 mm thick.

Mild steel sheet is an ideal medium for fabrication, hole punching and forming into shape. It is easily welded to form a permanent bond and component parts are easily joined together. The two most common grades of steel used in the enclosure industry are CR4 and CR2.

CR4 is easy to form into angles and commonly used in the construction of wall mounted and floor standing enclosures. CR2 is a ductile material, which lends itself to be pressed into shape reducing the need for welding. Pressed enclosures are limited to smaller sizes.

Different gauges (thickness) are available from 0.75 mm. However, it is not always the thickness of the material that determines the strength of the enclosure but rather the construction and how the material is formed. For example, the position and number of return folds makes a significant difference. Good design may allow for a reduction in enclosure cost and weight.

Stainless Steel

Stainless steel is commonly used in areas where hygiene, cleanliness or corrosion resistance are important. Grades 304 and 316 are the most common and a thickness of 0.75 mm to 2 mm is suitable for most enclosure applications. Stainless steel enclosures are an effective protection against more aggressive environments. Care should be taken to ensure the correct grade of material is selected.

Grade 304 is used for standard stock enclosures covering the majority of industrial applications, in particular for the food, beverage and dairy industries. Grade 316 is a more expensive option, covering those applications where the enclosure is to be sited in a highly corrosive environment, in particular, salt laden atmospheres.

Advantages

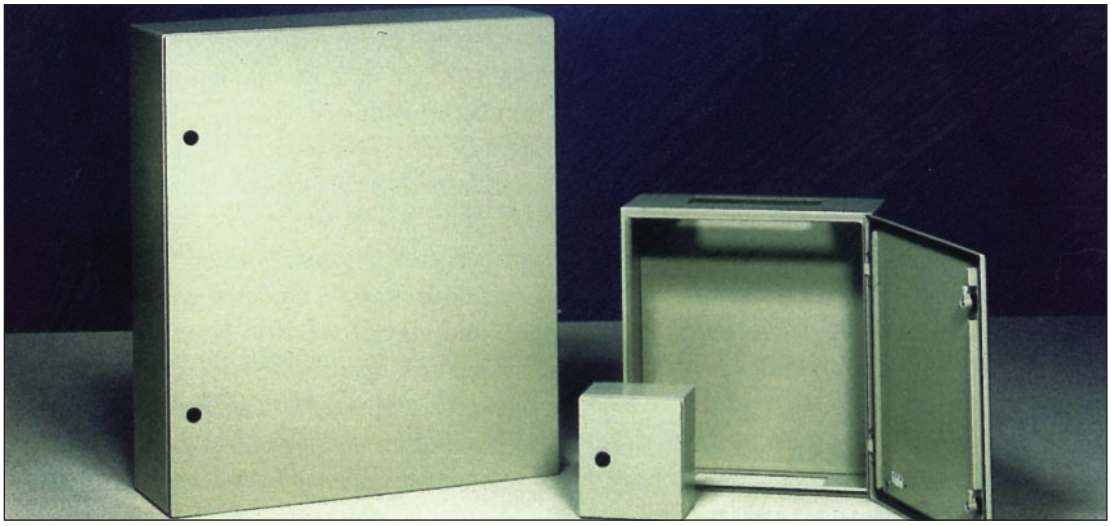
- May be used in many aggressive environments
- Provides excellent corrosion resistance
- May be less expensive than surface treated mild steel
- Does not deteriorate when subject to exposure to sun light (ultra-violet radiation)
- Alternative grades and finishes available to enhance appearance and corrosion resistance
- Low maintenance

Disadvantages

- More expensive than mild steel
- More difficult to work

Pre-Plated Steel

Zinc is the most common pre-plated steel for enclosures and is usually available in the same thickness and size as mild steel.



It is often used in the manufacture of EMC enclosures.

Pre-Coated

There are many plastic coated steels which are typically used in the production of electronic housings and racks.

Aluminium

Aluminium is used in either sheet, extruded, sand or die cast forms. A thickness of 1 mm to 4 mm is typical.

Die casting is the most common method used in the production of enclosures. Molten aluminium is forced into a steel die at high pressure by the action of hydraulic rams. The process produces components with good mechanical properties and close tolerances.

LM6 (Al Si 12) is a medium strength casting alloy with excellent foundry characteristics, high ductility, impact strength and shock resistance, together with high resistance to corrosion. The alloy can be used to produce castings of intricate shape and with thin varying wall thicknesses. It is however difficult to machine and results in rapid tool wear caused by its high silicon content.

Corrosion Resistance

The corrosion resistance of aluminium and its alloys is due to their ability to form a thin but protective coating in the presence of oxygen or water. This oxide, unlike rust on steel, is continuous and adherent. Should the surface be damaged, the oxide film is immediately reformed. In aggressive environments localised corrosion may occur but structural integrity is unlikely to be affected.

Where two dissimilar metals are in electrical contact with each other in the presence of an electrolyte, they adopt a potential and a current flows in the electrolyte from the metal having the negative potential to the positive. This results in increased corrosion of the former metal; an important factor when components such as fixings or cable glands made of other unprotected metals are used with aluminium enclosures.

Aluminium Enclosures in Hazardous Areas
The use of aluminium alloys for some applications of equipment is controlled by legislation derived from the concern of incentive sparking achievable from the impact between aluminium and rusty steel. *BS5501: Parts 1-9 Atmospheres.* General requirements restrict the use of aluminium in enclosures for mining applications to alloys containing not more than 6% magnesium and titanium. For potentially explosive atmospheres other than mines, the alloy must not contain more than 6% by weight of magnesium but with no limit on aluminium content.

Use in Marine Environments
The correct choice of aluminium alloy is essential and it is recommended that one with a higher silicon content is selected. Avoid possible corrosion caused by electrolytic action from dissimilar metals. Insulation materials should be used for separation purposes when installing the boxes on steel structures. Metal parts lying outside the enclosure, such as fixing screws, should be manufactured from austenitic stainless steel. Cable glands made of brass with chrome or nickel finish give no cause for concern.

Cast Iron

The use of this material for enclosures is mostly restricted to outside use, where high strength and protection from vandalism are required. It is also used for enclosures in hazardous areas where there is a risk of explosion.

Cast iron is not a single material but a term applied to a large family of materials. Cast irons have many attributes, some of which are of particular value for the production of enclosures for electrical and electronic equipment. Foremost is their high strength and fire resistance when compared with materials such as mild steel or GRP. This enables them to be used in severe service conditions, such as in process plants and mines. Ductile irons are particularly valuable when the enclosures have to be flame-proof or explosion proof. Of all the cast metals, cast iron has the best founding characteristics, which means that it is well suited for making components, which must be pressure-tight.

A wide range of cast irons is available for use in both benign and aggressive environments. Further protection may readily be given through the applications of coatings, such as hot dipped galvanising or electro-plating. Alloying allows good low and high temperature performance to be achieved, whilst maintaining all the advantages of a cast product.

The casting process is a most energy efficient and cost effective way of making complex-shaped components, including enclosures. It offers the designer almost limitless freedom to place metal where it is required and is suitable for producing both one-offs and long production runs, and both small and large components.

Plastic Materials

Plastics are capable of providing a tough durable product of excellent appearance. The properties of a number of materials may be varied by means of additives. The following descriptions relate to standard materials and for further information on performances in a particular situation, the manufacturer should be consulted.

Polycarbonate

Many different types are used for producing enclosures and with the correct choice, it may be used in a variety of locations.

This material has good impact resistance which varies only marginally over the temperature range - 50°C to + 120°C. In the long term it should not be exposed to temperatures higher than 80°C. Outdoor exposure may cause some loss of mechanical strength and yellowing in appearance. An agent to combat the effects of ultraviolet light can be added in the manufacture of the raw material. Exposed to flame it is self-extinguishing. Polycarbonate releases no toxic gases on burning. Contact with methyl alcohol, alkaline solutions, amines, gaseous ammonia and its solution should be avoided.

ABS (Acrylonitrile Butadiene Styrene)

Usually produced in the same designs as polycarbonate enclosures, ABS is a cheaper material with characteristics similar to polycarbonate but not suitable for such extremes of temperature and having a lower impact strength. ABS and polycarbonate may be combined offering an enclosure with an ABS base and a polycarbonate lid. When exposed to flame, it is not necessarily self-extinguishing.

GRP (Glass Reinforced Polyester)

The good mechanical properties of this material include insulation, strength, hardness and stability over the temperature range - 50°C to + 150°C. Its self-finishing quality and durability have widened its range of applications.

The electrical advantage of GRP is that it is an excellent insulator and can offer double insulation properties. Its use reduces the risk of electric shock in the event of impact. Where busbars are being fitted, use of GRP enclosures may allow reduction of the clearance between the bars and the enclosure, offering benefits of size reduction.

It should be noted that when any work is carried out on the enclosure, cut or exposed surfaces, holes or edges should be treated to avoid moisture ingress. Damage to the surface may also result in moisture ingress into the material through the exposed glass fibres.

GRPs with a range of properties are available. Manufacturers can supply more detailed information on the grades of materials used in the construction of individual enclosures and the results of tests to which they have been subjected. Engineering specifications, details of mechanical, electrical and physical properties, as well as flame and chemical resistance are normally available.

In its unfilled state - without its glass fibres, polyester is brittle but offers crystal clear transparency, making it suitable for windows or clear fronted enclosures. It may be wiped clean with soap and water. If a detergent is used, it should be rinsed well with clean water: Solvents and abrasives should not be used. Deep scratches are not easily removed and should be filled.

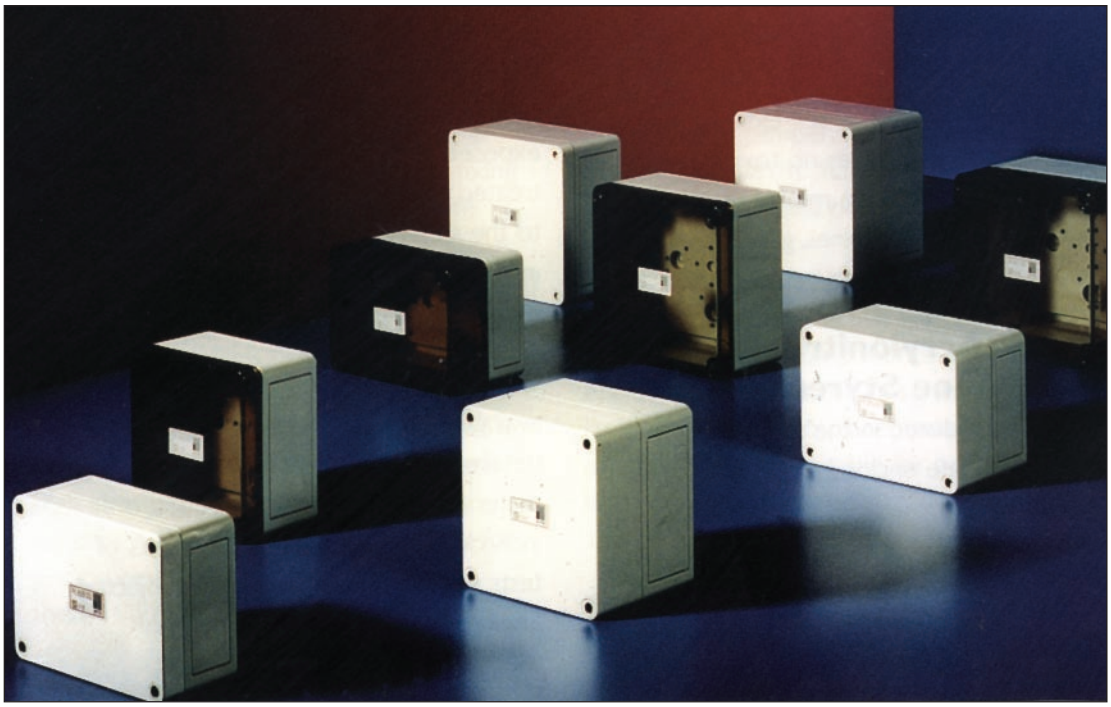
GRP is resistant to mineral acids, many organic acids, oxidants and reducing agents, neural and acid salt solutions, greases and oils, and some alcohols. Resistant, does not mean that it is entirely impervious - over a period of time, for example, some machine tool oils can affect its integrity.

PVC (Poly Vinyl Chloride)

PVC is used for moulding small plastic boxes. It has excellent resistance to mineral acids (both dilute and concentrated), alkalis and detergents. Resistance to alcohol-based solvents is good but poor to ketones, aromatic bases and hydrocarbons. Although it is a self-extinguishing material, PVC does give off toxic and corrosive gases when burned. PVC has a low UV resistance and can be brittle.

Nylon

Nylon is used for moulding small boxes and can become brittle in dry atmospheres. It can be affected by moisture and has poor resistance to acids although good resistance to alkalis.



SURFACE FINISHES

The type and quality of finish required on an enclosure depends very much on its ultimate environment and application. Other considerations are appearance and life expectancy.

Is the enclosure to be used indoors or outside? Within these two areas there are still many variations. Indoors may mean a farm building, a dairy, a chemical plant, a power station. Outdoors can mean anything from the North Sea to tropical Africa, with many other climates and environments between.

How important is appearance, not just on installation but over the longer term? Where the enclosure is strictly functional, the fading of colour may not be a cause for concern. Scratches can easily be retouched with standard paint. In another application scratch resistance may be vital to avoid a shabby appearance or prevent corrosion.

Manufacturers offer a variety of treatments, some as standard, others as specials.

No Additional Finish

Where the material of the enclosure has its own, suitable "natural" finish, no further treatment is necessary. This eliminates maintenance costs. An obvious example is stainless steel, brush polished for a grained finish or shot-blasted for a satin finish, both of which are intended not to show finger marks, or electro-polished for a higher shine. Because of its natural corrosion resistance, glass reinforced polyester needs no additional finish.

It is important that enclosures supplied primed or otherwise in need of further treatment are properly finished before they are taken into service. Not to do so is false economy.

Aluminium

For industrial use aluminium enclosures are normally painted. They may be anodised or 'alochromed' but these finishes are not very hard and scratch easily. Anodised finish is non-conductive whereas alochrome is conductive. Other forms of treatment are available.

Pre-Treatment for Painting
Paints suitable for protecting steel are generally suitable for aluminium, the requirements being that the paint be lead-free to avoid galvanic attack of aluminium.

The presence of air-formed aluminium oxide on the surface can result in poor paint adhesion. One method of addressing this is to use an etch primer containing phosphoric acid and zinc chromate. An alternative to etch-primers is a conversion coating. This is produced from solutions containing chromates and either fluorides or phosphates applied by dipping the component in hot solutions.

Paint with special properties such as stoved factory-applied polyurethane paint provides increased wear and scuff resistance. Plastic coating of either thermo-setting or thermo-plastic type can be used but good pre-treatment to ensure adhesion is necessary.

Metal spraying provides a high quality finish and protection of welded joints. Tin and zinc coatings are used to improve the electromagnetic shielding effectiveness of the enclosure.

Anodizing
The anodizing process consists of converting the surface layers to a hard oxide coating by electrolytic means. For maximum protection, the thickness applied should be 25 microns. Anodizing is of benefit where appearance is required to be maintained and weathering prevented.

Stainless Steel

A wide range of finishes are available:

Mechanical Polishing
The products are available in grained (brushed) or glass bead (satin) finish.

Electropolishing
Produces an exceptionally bright lustre and improved evenness of the surface by immersion in an electrolytic bath.

Coatings
Stainless steels are durable and resistant to corrosion. They will however, accept chemically produced coatings, vitreous enamels and conventional paint.

Steel

Various methods are used, depending upon the location and duty of the enclosure.

Some manufacturers still prefer traditional wet paint. Acrylic, polyurethane, and some unspecified types are all offered. Their durability depends upon a number of factors such as the preparation procedure, type of paint, and number of coats applied.

In recent years many manufacturers have switched from wet paint to thermosetting powders (powder coating) which offer protection against a variety of environments. Typically, powder coating film thickness is 60-80 microns and does not normally require a primer or undercoat. The powder is applied to the chemically prepared surface electrostatically and the object passes directly into the curing oven. It then liquefies to give a continuous uniform bonded finish.

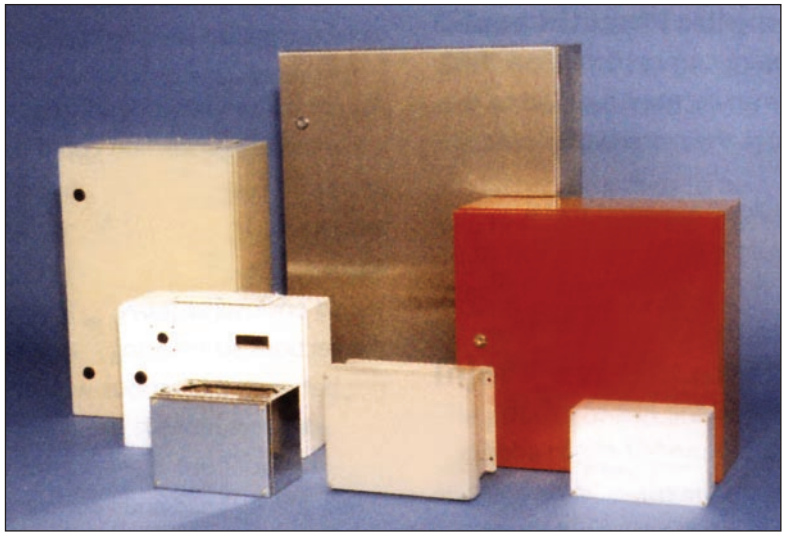
Powder can be divided into three categories; polyester, epoxy and epoxy/pol. Polyester powder should be specified where protection against ultra-violet light is required. Epoxy powder should be specified where protection against mechanical damage or chemicals is required although it should be noted that this surface will quickly lose its gloss and deteriorate to leave a dusty residue. Where resistance to all of the above is required a hybrid referred to as Epoxy/Pol is available which offers good general protection in the majority of applications.

Off the shelf, powder coated enclosures are usually finished in grey (RAL 7032) but they can be overpainted using two pack air drying finishes.

For more severe, wet or corrosive environments, zinc coating by spray or dip can be used but this is dependent on the thickness of the material as process deformation can often occur.

Iron or phosphate can be applied in a number of film thicknesses with zinc generally giving the best protection.

The economic moulding of plastic enclosures in non-standard colours demands long runs. Typically this is based on a minimum quantity of moulding material.



The majority of enclosure manufacturers do not recommend the use of a hot-dip galvanising process because distortion can occur.

Colours

Producers of steel enclosures tend to offer the same basic colours. This has an advantage to users in that they can mix equipment from different manufacturers and still preserve a colour scheme. However, care must be taken as shades and textures may vary slightly. Special colours are generally available, but may incur a surcharge and a delay in supply.

Most manufacturers have highly automated painting lines geared to standard finishes. Leaving an enclosure unfinished may cause an interruption in the normal process and takes time. Hence the anomaly that a primed enclosure may cost more than a standard paint finish.

If an alternative to the self-colour injection moulded plastic enclosure is required, or a textured finish, then paint can be used in accordance with the manufacturer's recommendations. Compression moulded GRP can be painted with two-pack polyurethane paints but surface preparation to form an adequate key can be expensive.

Colour finishes can be provided to either BS or RAL colour standards, with additional quantities of the appropriate paint (e.g. RAL 7032 grey) available in an aerosol or tin. Colour charts are produced by paint manufacturers.

Note that BS and RAL colour standards are not fully cross-referenced.

CONSTRUCTION

There are many differing types of enclosure construction. The list below gives some indication of the construction techniques.

Design

As with car design the strength of the modern enclosure comes more from the attention the manufacturer has paid to the design than from the material thickness.

Most wall and floor mounted metal enclosures available today are produced from sheet of 0.75 mm to 2 mm thickness with the folding and welding techniques used providing rigidity and strength. The thicker the material the higher the potential cost of the enclosure. In addition the difficulty of making cut-outs or holes for components increases with thickness.

Mounting plates are thicker to allow for drilling and tapping holes for components. These are also available with various mounting systems to overcome the need for drilling.

Other design features allow for the environment in which the enclosure is to be installed, for example, gutters to ensure any water runs away from the gasketed areas.

Enclosures are often manufactured using more than one technique, for example a floor standing enclosure could have a rolled frame, folder and welded doors and panels, die cast hinges and fixing parts. Plastic top and bottom covers could be added to extruded aluminium side walls to give an aesthetically pleasing enclosure.

Welding

One of the most common methods of construction is to cut the basic components from sheet steel and form into shapes prior to welding. Dependent on the specification of the enclosure various types of welding can be used.

An enclosure with a need to achieve only a low ingress protection could be produced using simple spot welding techniques. The most common approach today as the demand for more tightly sealed enclosures grows is to seam weld all the sections so ensuring no penetration risk between the various welded elements of the enclosure.

Self Assembly and Bolted Construction

Modular self assembly systems transfer the assembly process from the manufacturer to the customer and offer speedy delivery of enclosures and busbar systems. The equipment is delivered in kit form with resultant savings in delivery and storage costs. The customer should confirm that adequate training and back-up are available from the manufacturer to ensure that the system is assembled correctly and efficiently. By its nature, this type of construction will allow modifications to panel layouts to be accommodated after delivery/assembly, whilst keeping associated costs and delays to a minimum.

Casting

Various materials are suitable for casting or die-casting. Die-casting is used for high volume production runs. Sand casting can be used for one offs. Casting can introduce design features into the enclosure such as internal fittings.

Vacuum Forming

This system is used for plastic materials or thin metals. The material is drawn over a moulding form to give the finished shape.

Extruding

Plastics and metals such as aluminium can be extruded to shape. The raw material in molten or semi-molten state is pushed through a die to give the desired shape of the component. Large production quantities are required to compensate for the cost of the die.

Glass Fibre Moulding

GRP enclosures can be manufactured on a one off basis by hand 'lay-up' of the fibre mats. However, it is more usual for production quantities to be manufactured by a hot press method with heated materials and a form of punch and die or a vacuum forming technique.

Injection Moulding

The process of injection moulding enclosures involves the conversion of plastics granules into a moulded form. The material is heated to its molten state and injected, under pressure, into the forming tool. This process is suitable for both thermo-plastic and thermo-setting plastic materials.

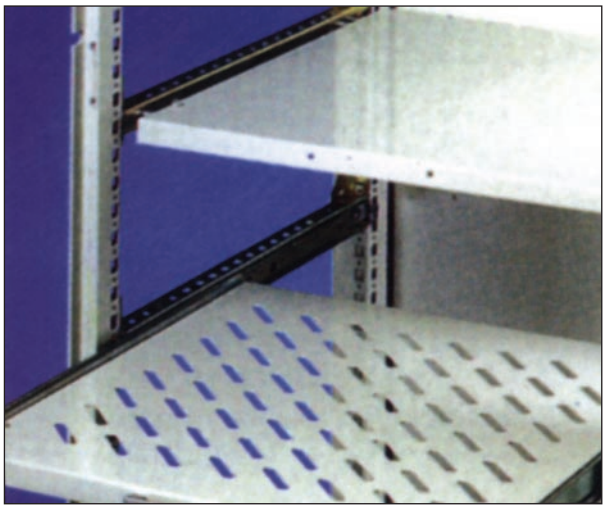
INTERNAL FITTINGS

An enclosure provides a housing for equipment, generally for reasons of safety, security, environmental protection or combinations of all three. A variety of fittings may be incorporated within the enclosure to assist in the mounting of this equipment, including:

Mounting Plates

These are usually in the form of plated or painted sheet steel, sometimes folded along two or more edges to give extra rigidity and attached to the enclosure with nuts and bolts, studs or fixing rails. The fixing rail method normally allows the mounting plate position to be adjusted between the front and rear of the enclosure.

Mounting plates are available in other materials such as aluminium, fibreboard, and stainless steel dependent on the supplier and application. Also available are pre-punched mounting plates that allow captive nuts to be fitted to hold equipment so obviating the need to drill and/or tap the plate. On larger enclosures partial height mounting plates are now available.



Mounting Studs/Inserts

This method of fixing equipment is normally reserved for wall mounting enclosures or non-metallic products. The studs and inserts are traditionally positioned to accommodate the manufacturer's standard accessories.

Mounting Rails

More common in mainland Europe, these systems are readily available and take the form of various standard lengths of 'DIN' rail or top hat shaped profiles and bracket systems that allow them to be fitted anywhere in the enclosures. These systems are fitted as accessories and therefore tend to pick up their main fixing positions from the mounting plate fixing studs, bolts or rails.

The rails may also be fitted to the doors of the enclosures.

Racking Techniques

19 inch rack enclosures have been designed especially for the electronics industry to allow 'prepacked' modules such as modems, video equipment etc., to be fitted easily and quickly. A standard width between front fixing holes has been established at 482.6 mm (19 inch - hence the name) although other dimensions such as 515 mm - IEC 60917 Series and 600 mm are used. New standards such as ETSI and metric modular are becoming more popular.

These racks have many fixing options including drawers, sliding rails and fixed or sliding trays. The normal 'racks' are often designed without ingress protection in mind due to the benign environment in which they are installed. In order to offer an IP facility, enclosure manufacturers have designed accessories to allow rack mounting systems to be installed in an ingress protected product.

In its simplest form this could be two vertical rails that when fitted to a 600 mm wide enclosure offers the 482.6 mm (19 inch) front fixing option. Variants on these include variable depth versions, partial height rails and swing frames.

Swing frames are in essence a simple frame with the two vertical rails to provide the 482.6 mm (19 inch) punchings. These frames may be full or partial height and are fitted with hinges and brackets that allow them to act as an inner door and hinge out to offer access to the rear for servicing.

Special Brackets

Many manufacturers offer accessory brackets to assist users with the installation of equipment. These may range from simple angled brackets to allow the fitting of a profile rail for terminals to a full system to support monitors or other equipment. Full details can be found in manufacturers literature.

Accessories

Many other useful accessories are available, including drawing pockets, earthing bars and cables, internal lighting, power distribution panels, door switches, door stays and cable retaining rails.

LOCKS & HINGES

Enclosures are fitted with locks and hinges for two main reasons - to enable easy access to the interior and to prevent unauthorised access.

However, with tampering, vandalism and unauthorised use of equipment on the increase, there is a need for more sophisticated security measures to be built into products and systems. Enclosure manufacturers offer a number of options.

The simplest form is probably the insert lock, when operated by a key rotates a simple cam or tab to engage behind the enclosure body.

Various lock inserts can be fitted for increased security.

With larger enclosures, the locking mechanism has to perform other functions apart from just securing the door. Depending upon the IP rating of the enclosure, a gasket may be fitted to provide a seal. It may be necessary to have a design of lock that will secure the door at more than one place. This can give rise to a whole range of rod-latch systems. Any lock fitted must not degrade the designed sealing capability of the enclosure. If the enclosure is sealed to IP65 it is important that the lock is no less in specification, or water and dirt may enter the enclosure.

The need to secure against unauthorised access is not the only reason for fitting sophisticated locking systems. Many enclosures contain high voltage electrical equipment and it may be essential that this is isolated prior to opening the access doors, a need that leads to interlocking systems which isolate the supply to the internal equipment before the door can be opened. In considering this, it is also important to respect any other safety needs of the apparatus. Can the supply simply be turned off without any hazards arising from the effects of the disconnection of associated equipment? Is there a sequence to the shut down procedure, which must be followed?

Much of the above relates to the larger enclosure, but particularly in the Electronics industry there is a need for smaller, but none the less secure, locking systems. In this sector a range of quarter turn fasteners, pawl latches, push and slide action fasteners and similar devices have been developed.

Just as it is important that any lock ensures that doors locate correctly on to their gaskets, so it is necessary to ensure that the hinge design is such that the lid or door fits properly at that edge. A simple 'piano hinge' type of approach can result in leaks. A hinge design that in itself pulls the appropriate edge of the door tightly into the gasket needs to be used. When considering larger, sheet metal cabinets, care must be taken to ensure that the hinge does not allow or cause distortion.

Locks and hinges are essential parts of the enclosure system and it is important that they are given proper consideration when selecting the enclosure, if the design integrity of the completed installation is to be preserved.

LIFTING ARRANGEMENTS

An important feature of any large enclosure is the facility to allow it to be lifted and transported.

Eyebolts

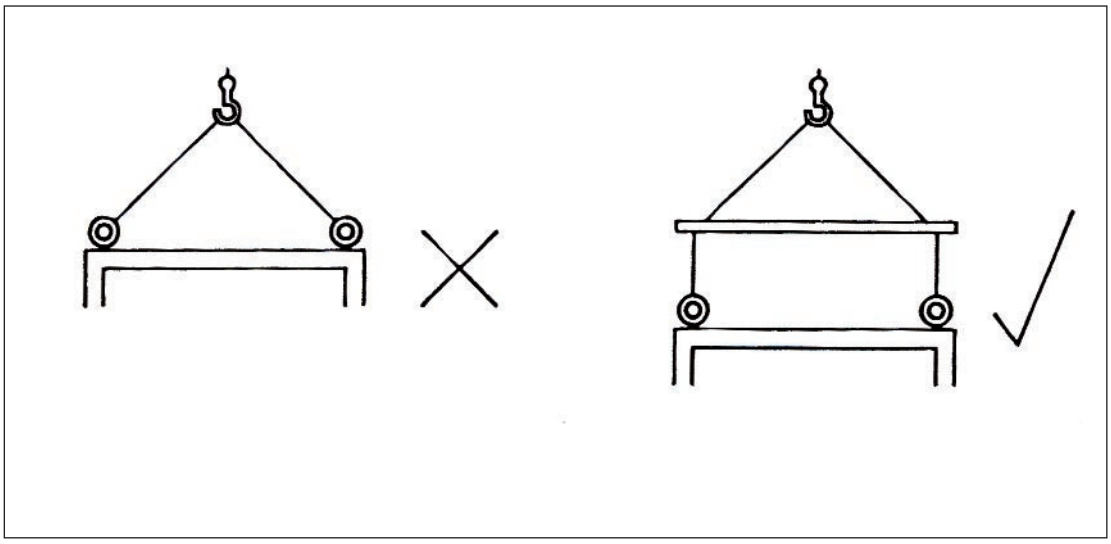
The most common method of lifting large or heavy enclosures is by eyebolts screwed to the top surface of the enclosure. Various methods of fixing the eyebolts are employed. The most common is a collar/nut in a strengthened section on the underside of the top of the enclosure.

Eyebolts manufactured in accordance with the relevant national or international standard and certified accordingly should be used, the thread diameter dictating the safe work load (SWL) from tables in the standard.

An eyebolt should not be surface finished after it has been tested and stamped as the process could anneal the metal, affecting its strength.

Safe working loads are given assuming a vertical lift on the eyebolt, although by the use of slings with links (shackles) attached to the fixed eyebolts it is possible to lift from a single hook. The angle of sling reduces the safe working load of the eyebolt by as much as 75%.

A preferred method is to use a parallel lifting beam as shown below:



Practical Advice

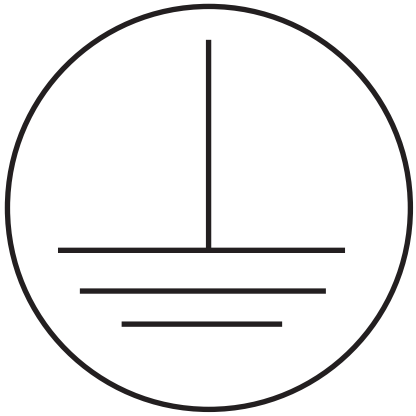
- Personnel performing lifting operations should be suitably qualified, trained and familiar with the relevant standards. They should also be aware of their responsibilities under health and safety legislation.
- Reduce the risk of the enclosure becoming unstable while being lifted by designing to ensure, where practicably possible, the weight distribution is evenly dispersed. Maintain a low centre of gravity by positioning heavy items towards the bottom of the enclosure.
- For a suite of enclosures intended to be bolted together, try to design the joints within the suite to reduce the size and weight of each lifted section to help transportation.
- Where possible, before lifting, remove heavy items such as large transformers from the enclosure and transport separately.
- Use dedicated lifting points as indicated in manufacturer's literature.
- Consult manufacturer for purpose designed lifting aids.
- Always check that the thread size on the eyebolt corresponds to the thread size at the lifting point on the enclosure.

EARTHING & BONDING

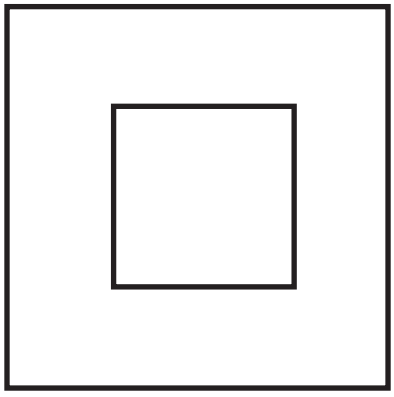
In the interests of electrical safety, all metal parts should be bonded and then earthed. Traditionally, this has applied to doors, panels, mounting plates and gland plates. Facilities for the connection of an earth conductor are usually provided on these components and the main body of the enclosure.

The manufacturer's dedicated earth points should be positioned such that bonding to the main body can be achieved by short conductors, which reduce the probability of damage to the conductor by snagging. If a dedicated earth point is not provided and a fixing is made through a hole in a panel or gland plate, then a suitable means must be used to ensure that adequate metal-to-metal contact is achieved.

Dedicated earth points on enclosures can be identified by the use of Symbol 417 - IEC 5019-a:

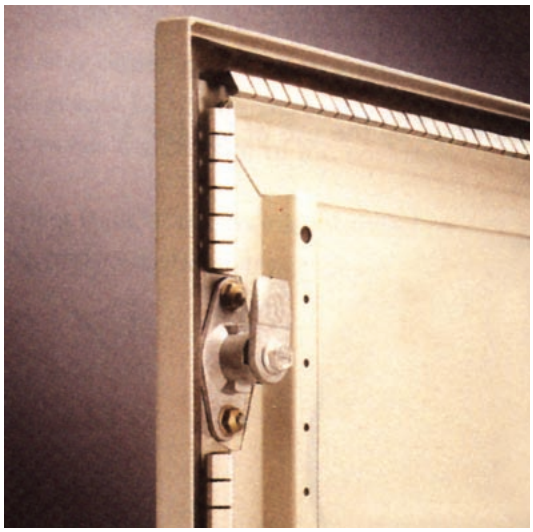


Protection against electric shock can also be achieved by total insulation against indirect contact. The enclosure should be made of insulating material eg. GRP and carry the Symbol 417 - IEC 5172-a visible from the outside to indicate 'Double Insulation'.



GASKETS

Gaskets are fitted to enclosures to provide a seal against ingress of solid objects or moisture to conform to a chosen protection rating. Some enclosures have no gaskets because the conditions in which they are required to perform do not demand the fitting of one.



Gaskets are usually applied by four different methods:

- Use of an adhesive strip on the rear face of the gasket which is then placed on the enclosure.
- Use of a gasket material which foams and sets, as part of the manufacturing process.
- Use of gaskets moulded and designed to fit a particular location in the enclosure, fitted by the customer and mechanically sandwiched in place between the gland plate and the enclosure.
- Use of an extruded shaped gasket, which is fitted to an edge or flat surface and has particular physical properties.

Electromagnetic Compatibility (EMC)

Special electrically conductive gaskets are available to provide protection against radio frequency interference (RFI). These gaskets may or may not protect against the ingress of particles and moisture. They may take the form of:

- carbon filled silicon elastomers,
- silver filled silicon elastomers,
- carbon composite gaskets,
- conductive wires in a silicon material,
- wire meshes over elastomer cores,
- copper beryllium finger strips,
- wire mesh strips.

The choice of EMC gaskets should be discussed with the manufacturer with regard to the application.

COMPARTMENTED ENCLOSURES

The majority of compartmented enclosures are produced in mild-steel but stainless steel and aluminium options are also available.

Various methods may be employed to achieve the division of enclosure sections (columns) into sub-sections or compartments:-

a) Enclosures bolted together to form sections sub-divided by horizontal barriers, individual doors being provided for the sub-sections or compartments formed within each section.

b) Enclosures welded together to form the individual sections, the sub-division of the sections being achieved by the inclusion of horizontal insert plates.

c) Enclosures of fully welded construction with all sub-divisions formed at the fabrication stage.

In the switchgear and controlgear industry in particular, further divisions within a suite of enclosures are often required in order, for example, to segregate busbars, individual incoming or outgoing circuits, and the terminals for external conductors.

In Type-tested assemblies to *BS EN 60439-1: 1994 Specification for type-tested and partially type-tested and partially type-tested assemblies* these separation arrangements are classified in terms of various "Forms of internal separation".

Increasingly, attention is given to the manner in which cables enter or leave this type of enclosure since users may require that external cables can be connected or replaced without the need to shut down the entire enclosure assembly. *BS EN 604439-1: 1994* includes an informative annex (Annex NC): Guide to the internal separation of assemblies which gives additional information about the typical methods of construction which may be empolyed to achieve varying levels of segregation. However, it emphasises that the form of separation is still subject to agreement between the manufacturer.

More information on this subject is contained in the GAMBICA technical guide, *A Guide to the Specification for Low Voltage Switchgear and Controlgear Assemblies - BS EN 60439-1: 1999* which is available from GAMBICA.

ENVIRONMENTAL CONSIDERATIONS

Outdoors

When an enclosure is used outdoors consideration must be given to the prevailing weather conditions and extremes of temperature.

These conditions will determine choice of material e.g. GRP, stainless steel, aluminium; the design of the enclosure e.g. requirements for improved sealing, venting, rainhoods; the addition of extra equipment e.g. heaters, vents, thermal management systems; and special finishes e.g. anti-condensation paint.

Standard steel enclosures generally are designed to meet the demands of industrial environments. Failure to take account of other conditions can result in damage to the enclosure and contents.

The Cooling Effect

A standard enclosure will probably allow rainfall to run around the outside of various gasketed areas. If the internal temperature is reduced rapidly the pressure inside a high IP rating enclosure may be significantly lower than the ambient pressure outside, thereby inducing a suction effect through the gasketed areas. This could result in moisture around the gaskets being drawn into the enclosure.

This effect may be avoided by reducing the number of gasketed areas in contact with the rain by choosing an enclosure with gutters and/or fitting a rainhood. Alternatively it may be possible for the pressure to equalise quickly by allowing the enclosure to breath (through controlled ventilation) although this may reduce the IP rating.

Condensation

Condensation is often mistaken for water ingress. It is caused by a difference in temperature between the inner and outer surfaces of an enclosure and normally forms on the same side as the prevailing wind. The most common solutions are to fit anti-condensation heaters, controlled ventilation or use of anti-condensation paint.

Apart from water lying in the bottom of the enclosure, moisture may condense on the components causing electrical 'leakage' and 'tracking' as well as component corrosion and degradation of insulation.

Remember the temperature effect. Water vapour is always present in the air and when air is cooled the 'dew point' is reached, the air is then saturated and further cooling results in condensation. Looking for the cause of moisture in an enclosure on a 'warm' day may mean that the obvious is missed and the condensation has evaporated, only to return when the temperature drops again.

Corrosive Environments

In certain applications enclosures will need protection from chemicals and selection of the right material is determined by the chemicals involved. The most likely choice is stainless steel but even then care must be taken to ensure the correct grade is selected.

Some non-metallic materials have excellent resistance to certain chemicals and poor resistance to others. Advice should be obtained when selecting a suitable material and construction as, for example, the components within the enclosure may need protecting from harmful gases.

Marine, Coastal and Off-shore

Coastal, external applications can usually be covered by referring to the previous 'Outdoors' element of this section and then paying particular attention to the treatments or materials chosen to address the extra corrosion likely from the salt laden atmosphere.

Off-shore specifications depend on the intended location of the enclosure e.g. a relatively low IP rating enclosure in an accommodation area through to a very high rating on a ship's deck.

Some users have very clear specifications for such equipment but if in doubt contact a GAMBICA Enclosure Group member.

Hosedown Areas

Enclosures in these areas are usually in processing plants when the environment is subject to special regulations. The enclosures chosen are usually free of surface treatment to avoid contamination, for example by paint flakes entering the production process.

In practice most users choose stainless steel designs which have few external features, for ease of cleaning. Various non-metallic products offer the same benefits but a stainless steel enclosure will maintain the best appearance.

Care must be taken when using a hose to clean the enclosure and surrounding area. Often very high-pressure hoses exceed the IP rating of the enclosure, resulting in unexpected ingress. Condensation can also be a problem in cool areas (see below).

HAZARDOUS AREAS

Hazardous Areas are those locations where a potentially explosive atmosphere may exist. This is an atmosphere in which dangerous quantities of flammable substances may occur in the form of gas, vapour, haze, dust or fibre capable of combining with air to form potentially explosive mixtures.

Use of equipment (including enclosures) in Hazardous Areas is highly regulated, with equipment generally requiring third part certification, whether mandatory or not. Selection of equipment must take into account the regulations of the country in which it is to be used and the acceptability of the third party certificate to that country.

Prior to selecting equipment (including enclosures) for Hazardous Area use, the Gas Grouping, Zone Classification and Temperature Classification assessments must be made.

Gas Grouping

In Europe hazards are classified and grouped as follows:

Group I	-	Those found in Mining Only (underground firedamp methane)
Group II	-	Those found in Surface industry and "Off-shore" installations
IIA	-	Typically butane
IIB	-	Typically formaldehyde
IIC	-	Typically hydrogen or acetylene

Zone Classification

Having established the hazardous substances, the likelihood of the explosion risk also needs to be considered. This is simplified by a zoning method in International and European standards as follows:

Zone 0	-	Hazard continuously present or present for long periods
Zone 1	-	Hazard likely to be present
Zone 2	-	Hazard unlikely to be present or only present for short periods of time, for example under fault conditions

Temperature Classification

In order to establish the suitability of apparatus for use in a hazardous area from the view point of hot surfaces, apparatus is awarded a T-rating, corresponding to its maximum surface temperature under certain conditions: EN50014 or IEC 60079-0. The T-rating or T-class, can then easily be compared to the Auto Ignition Temperature or Spontaneous Ignition Temperature of the hazard in which it is to be used, thus establishing safety from ignition from hot surfaces. For example T6 = 85°C which is the highest temperature the apparatus will reach when operated under the most onerous conditions.

Protection Concept

Various concepts of Hazardous Area protection are available to suit a particular application. The "Enclosure Specification" chart shows suitability of each concept and the type of enclosure that is applicable.

European Regulations

In the European Economic Area (EEA*), applicable regulations are in the form of Directives. These are not applied directly but implemented by national regulations in each country.

For electrical equipment in hazardous areas the Directives currently in force are:

- 76/117/EEC (as last amended by 97/53/EC) and 79/196/EEC (also at last amended by 97/53/EC): Electrical Equipment for use in Potentially Explosive Atmospheres, with the latter relating to 'Equipment Employing Certain Types of Protection'.

- 82/130/EEC (as last amended by 98/65/EC): Electrical Equipment for Use in Potentially Explosive Atmospheres in Mines Susceptible to Firedamp

These 'old approach' Directives remain in force until 30 June 2003 and refer to specific technical standards (the EN 50014 series) and their issues and amendments. They require specific information to be present on the product's certification labels, for example:

EEx ... de…II…C…T6

EEx = Equipment conforms to types of protection standardised by CENELEC (European Standards EN 50014)

de = Type of protection used:

d = flameproof enclosure

e = increased safety

II = Gas grouping:
II = surface industry an "Off-shore"

C = Gas subdivision, most critical category, including hydrogen, acetylene and carbon disulphide

T6 = Temperature class:
T6 = maximum 85°C

A 'new approach' Directive becomes mandatory from 1 July 2003 but became available for use as an alternative to the 'old approach' Directives from 1 March 1996. Called the ATEX Directive, 94/9/EEC, it covers both mine and surface industries and introduces, for the first time in Europe, requirements for mechanical hazards and potentially explosive atmospheres arising from dusts. The Directive gives the essential safety requirements that must be met by equipment, including enclosures and protective systems, for use in hazardous areas. European Harmonised standards (EN's) may then be used for demonstration of compliance with the essential requirements of the Directive.

The ATEX Directive introduces the following changes:

Equipment is classified by group and category according to its intended use:

Apparatus group I (mines)….
Equipment category M1 and M2

Apparatus group II (surface) …..
Equipment category 1,2 and 3

* EEA comprises the 15 countries of the European Union (EU), Iceland, Liechenstein and Norway. Switzerland is not part of the EEA but because of its membership of the European Standards Organisations, uses the same technical standards.

Under this Directive apparatus is marked as follows:

CE … Ex …11…2…G and D

CE = CE marking, which has to be in a specific format

Ex = Use of equipment in potentially explosive atmospheres, again in a specific format

11 = Equipment group:
11 = surface industry

2 = Equipment category

G = Gas

D = Dust

In Great Britain the ATEX Directive is Implemented by Statutory Instrument 1996 No. 192, The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996. Northern Ireland has its own regulations, but both will use the BS EN's, the UK harmonised standards, as a way of demonstrating compliance.

Both the 'old approach' and 'new approach' Directives require the use of a specific explosion protection mark, the 'Epsilon x' symbol. CE marking may not necessarily be an indication of compliance with the ATEX Directive, since it can also mean compliance with other applicable 'new approach' Directives.

ENCLOSURE SPECIFICATION

Protection Concept	Code	Principle of Concept	Zone Suitability			Type of Enclosure		Application
				IP Rating	Impact Resistance	Material Limitations	Examples of Special Requirements	
Non Incendive	EX N EXn	Non sparkling in normal use	Zone 2	IP54 (min)	7 Nm		Portable equipment 1m drop test	Luminaries, motors, junction boxes
Increased Safety	EEx e	Non sparkling and non incendive	Zone 1 & 2	IP54 (min)	7 Nm			Luminaries, motors, junction boxes
Intrinsic Safety	EEx i	Electrical energy is limited below that which could cause an explosion	'ia' Zone 0,1,2 'ib' Zone 1,2	IP 54 (min)	None			Instrumentation, control, low power devices
Pressurized	EEx p	Pressurization prevents entry of the external gas and purging is necessary before power is switched on	Zone 1 & 2	IP40	7 Nm	Normally metal construction	To withstand 1.5x max operating pressure with min 200 Pa	Control panels, Motors, Computers and instruments
Flameproof	EEx d	Must be capable of containing an explosion	Zone 1 & 2	Suggest IP54	7 Nm	Generally cast alloys/iron	Special consideration of flame paths at flange joints	Motors, junction boxes, luminaries and control devices
Oil Immersion	EEx o	Immersing incendive devices in oil. BSEN 50015 does not allow sparkling devices	Zone 1 & 2 (see note 1 below)	Sealed and open reservoir enclosures are permitted	7 Nm	Normally metal construction	Requires pressure relief value to IP23, over pressure test of 0.5 bar for 1 min	Heavy current apparatus, Transformers and instrumentation
Sand/Powder	EEx q	Covering devices with sand/powder quenches explosions caused by sparks or hot surfaces	Zone 1 & 2 (see note 1 below)	Factory Sealed	7 Nm	Normally metal construction		Electronic assemblies, power supplies
Encapsulation	EEx m	Encapsulating devices in insulating material	Zone 1 & 2	N/A	2 Nm		Plastic enclosures must have min. 1 mm wall thickness	Electronic components

Note 1 IEC 79-14 Zone1
BS 5345 Part 1- Zone 2

THERMAL MANAGEMENT

The management of the operating temperature of the enclosure can be a very complex matter. Equipment may need to be heated to protect it from frost or maintain a working temperature when the system is shut down to prevent condensation. Alternatively equipment may need to be cooled to prevent malfunction.

Below are given some types of thermal management devices and their typical usage.

Thermostats

Used to switch thermal management devices at predefined temperature limits.

Heaters

These can be installed in enclosures to maintain working temperature or prevent condensation. A fan may be used to increase the thermal power output and assist the flow of warmed air.

Louvres

Raised covers, louvres, louvre plates or bolt on grilles are used to give a natural air flow. The IP rating of the enclosure may be affected by the method used. Any cooling will only be to the level of the ambient temperature and there could be heat pockets formed within the enclosure due to the absence of a forced air system.

Fans

Fans used with louvres, louvre plates or grilles give an air throughput for the enclosure. Unless filters are used, contaminated air may be brought into the enclosure.

Fans may vary in size, power, design and air flow characteristics. Some high air flow fans may have a low pressure stall limit. Fans can be used to draw air in or out of the enclosure and should be used with an inlet/exhaust louvre or grille. If any intake fan is used without an exhaust or with an undersized or restricted exhaust a positive pressure will result. In special circumstances this can be used to help prevent ingress of particles. Fans will only cool to around ambient temperature and are therefore of limited use in high temperatures. An advantage of fans and units containing more than one fan is that they can be used for the cooling of hot spots.

Heat Exchangers

Air to air heat exchangers work on the principle of two separate air circuits passing each other in opposite directions and separated by a thin (usually aluminium) dividing wall.

Heat exchangers allow a higher degree of IP protection due to the use of separated air circuits. The enclosure temperature will be cooled to just above the ambient temperature.

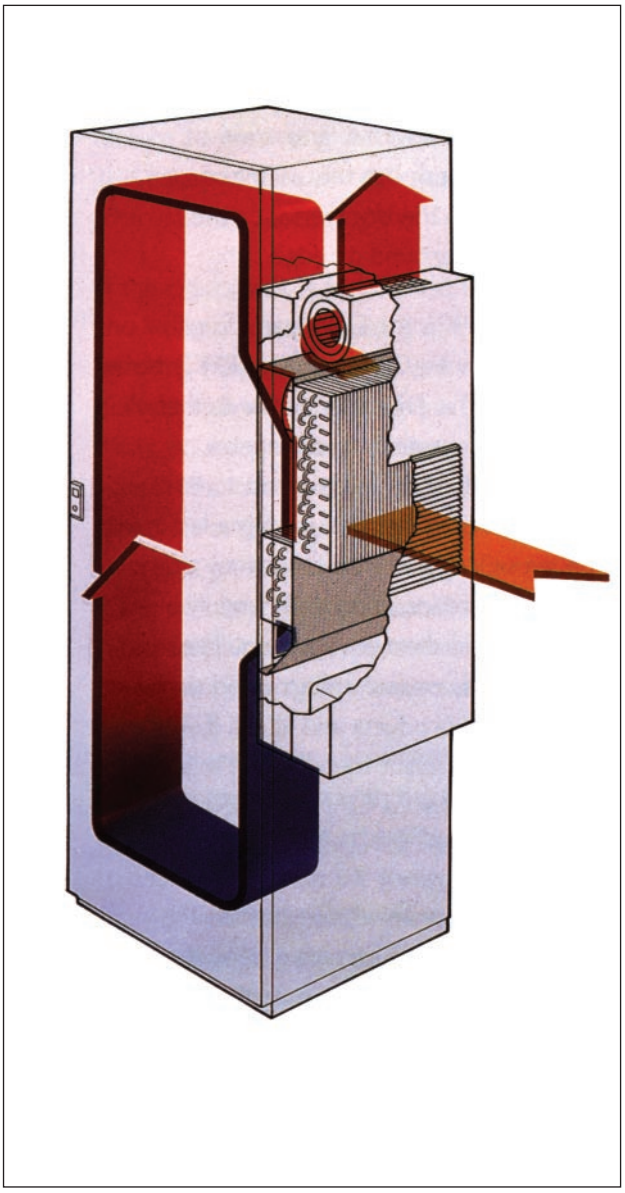
Where the ambient temperature is high an air/water heat exchanger may be used with the water being used as the cooling medium. However, a prerequisite of this system is the availability of a continuous water supply.

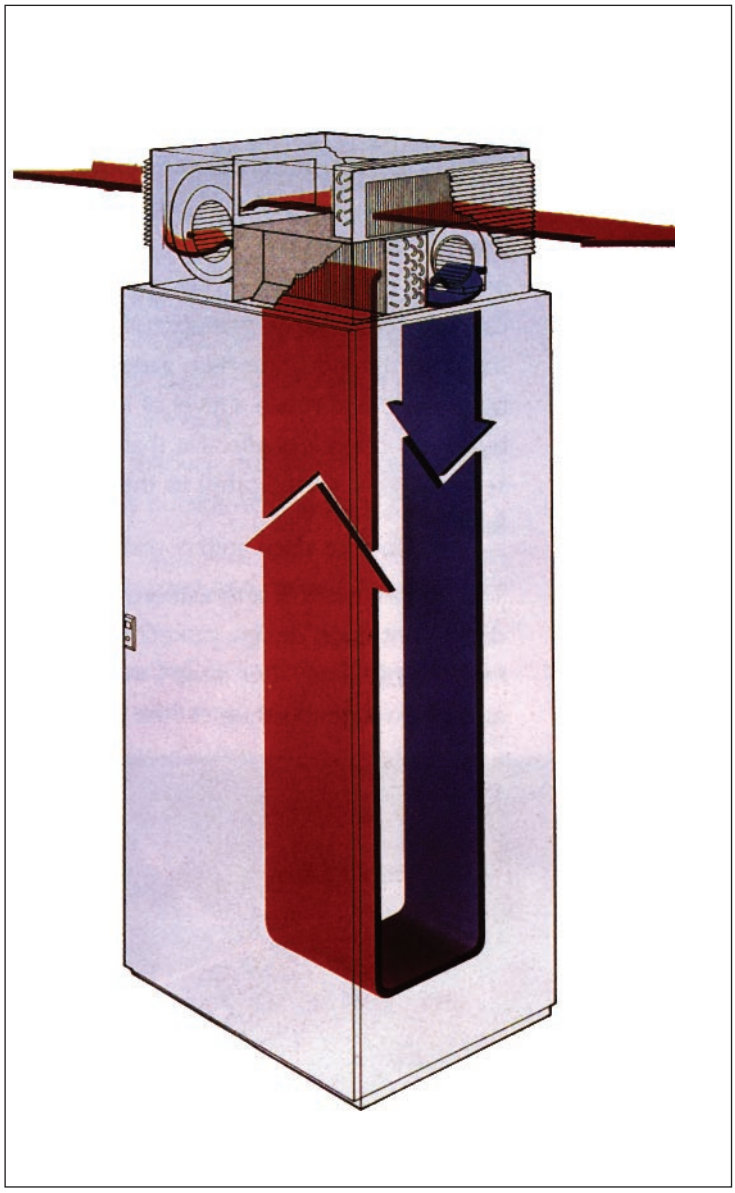
Coolers

These are based on the principle of a refrigerator. The internal air of the enclosure is kept to a sealed air circuit, which passes through the cooler. Coolers can be roof mounted, 19 inch rack mounted, door or side panel mounted and may incorporate a microprocessor for function indication and control as well as be linked to a central process computer.

The cost of coolers is high when compared with other forms of thermal management but may be the only solution to problems in high ambient temperatures. The IP rating is generally unaffected.

Many manufacturers offer expert guidance and information in the field of thermal management control.





RFI/EMI SHIELDING FOR ENCLOSURES

Radio frequency interference (RFI) and Electromagnetic interference (EMI) can be prevented from penetrating or escaping from an enclosure by ensuring it acts as a Faraday Cage. This means providing a electrically conductive shield over all the surfaces. Doors and ports have to be electrically sealed to their apertures. In practice this need not be continuous provided the frequencies being shielded cannot escape. Some manufacturers offer solutions using dual function gaskets that both shield and retain a level of IP rating but this is often less effective than two separate gaskets dedicated to their own function.

The overall levels of attenuation vary dependent upon design, gasketing used and maintenance. The latter is very important as contaminants build up on the conductive surfaces over a period of time so reducing the conductive effect. This is more common in designs with "butt" joints. Gaskets sealing with a wiping action offer a level of self cleaning and so retain their shielding levels without maintenance for longer.

Shielding windows can be provided by using a material with a lamination of conductive mesh but this will need connecting to the door or aperture continuously around its edge.

In January 1996 the European Directive on Electromagnetic Compatibility (EMC) came into force. This Directive demands that all products susceptible to or capable of emitting EMI must be designed so that their function is not unduly degraded in the presence of EMI and that they do not emit interference that would unduly affect equipment in their environment. The Directive has caused an increased demand for shielding products and filters. If you are in any doubt about the effect of this Directive contact a GAMBICA Enclosure Group member for clarification.

Enclosures themselves are outside the scope of the EMC Directive since they neither produce nor are susceptible to EMI. They do not have to carry the CE mark as far as

INSTALLATION & MAINTENANCE

It is important that users of electrical equipment, including enclosures, ensure that the equipment is given proper care and attention by competent personnel. The following notes are intended to provide guidance on a general level only. Any regulations or manufacturer's instructions concerning installation, safety or specific hazardous area applications must be strictly adhered to.

Installation

Before commencing the work of installing the equipment, study the installation instructions supplied by the manufacturer.

If the equipment is to be lifted, use all of the lifting points supplied, ensuring that the securing bolts or eye bolts are of the correct size and thread. Check that the lifting equipment used is adequate to handle the load and do not lift in any other direction or from any other point other than that intended in the design. During lifting do not induce additional stress by rapid acceleration or deceleration. Set down gently to avoid mechanical shock.

Heavy or awkward equipment should be moved into position with the aid of skates, such that the weight is distributed evenly to avoid deformation. It should not be dragged into position or moved on rollers as such handling can result in damage to the surface finish or the structure itself.

The following are common sense tips which can help to ensure a successful installation:

- Inspect outer packaging on delivery as damaged wrapping may mean the enclosure itself has been damaged in transit.
- Do not insert a knife into the packaging to cut tape or other wrapping material as you risk scoring the paint finish and creating a potential rust site.
- Do not drag enclosures - use approved lifting methods.
- Clear swarf from work and make sure work surfaces are free from debris before working on enclosures.
- Empty the enclosure of any debris before installation as it may form a focus for condensation which may cause corrosion.
- When marking out do not score paint surfaces outside drilling sites.
- Use sharp cutting tools to avoid cracking paint and repaint bared hole edges.
- Use punches in preference to drills on steel enclosures.
- Seek manufacturers advice on care of seal and paint selection before removing seals or over-spraying.
- Remember that all work on the enclosure should seek to maintain the IP integrity. For example, cable entries should have glands with similar or higher IP rating.
- Check the loading of equipment to be fitted as distortion of mountings or doors may affect the sealing.
- Check wall mounting brackets are sufficiently robust for the purpose.
- Final inspection should be conducted before transportation from the workshop.

Site Installation

- Ensure adequate site access is available for the size and weight of the enclosure.
- Ensure walls/floors are plumb, level and in good condition. On external locations, site on the lee (out of the wind) side of building where possible.
- Canopies are recommended to deflect direct rainfall, as are pedestals to raise enclosures from wet floors.
- Floor standing enclosures which are not designed to be free standing should be bolted back to a wall or stanchion for stability.
- Cable entries must be supported outside the box, so that no stress is caused to the enclosure, as deformation may degrade the sealing.
- Earthing continuity should conform to local standards.
- Check loads on doors and swing frames as opening them may cause the enclosure to become unbalanced and tip over.

Mounting

It is essential that the equipment is mounted on a level surface. If the enclosure is bolted to an uneven surface, the doors or covers may not fit correctly and the integrity of the enclosure will be degraded.

For wall mounting enclosures, ensure that the designed fixing method i.e. internal holes or external fixing brackets are used. The size of fixing should fit comfortably into the hole or bracket provided.

For floor fixing enclosures, it is essential that adjacent sections of an assembly are bolted together and aligned prior to final tightening on the floor fixings. Any swarf or dust that has accumulated within the enclosure must be removed and any doors or covers that were taken off must now be reassembled.

Cabling

All external cabling associated with the enclosure should be firmly supported so as not to increase stress on either the enclosure fixings or the enclosure itself. Any damage caused to the surface finished by the cutting of gland holes must be rectified prior to the fitting of the gland.

Inspection

Before putting the equipment into service, ensure that the enclosure has been fully reassembled and all gaskets are in place. All external surfaces should be inspected for scratches and damage with the purpose of repairing such damage.

The installation should comply with the relevant standards as specified by the user. Selection of the enclosure should conform to the required BS or equivalent.

Maintenance

A planned maintenance programme is advisable, checking gaskets, paintwork, hinges, locks, etc, for signs of physical damage, tampering and corrosion.