Technical Article

Designing the Human Machine Interface.
Front panel materials, finishes and marking.

The Human Machine Interface (HMI) encompasses all the elements a person will touch, see, hear, or use to interact with a machine. The task of the HMI developer is to build innovative, intuitive and reliable interfaces which make every interaction easy, comfortable, safe and enjoyable.

A successful build requires an expert understanding of a complex design process. Human factors, technical and commercial considerations must be addressed. One important aspect is the design of the front panel – the face of the HMI. Damage here could leave the entire system more vulnerable, and adversely affect the brand's reputation. This article provides an expert viewpoint on front panel materials and surface finishes used in HMI construction and reveals some of the key considerations to make the proper selection.

The HMI is a particularly vulnerable element and may be exposed to impact, spillage, chemical cleaning, bacterial attack and harsh use by operators. Direct damage to the front panel – the operator interface – can leave the entire system more vulnerable. This may result in equipment downtime, production stoppages, additional maintenance, redundant labour, and other negative cost implications of having the equipment out of service.

Front panel damage also looks bad on the brand. As the direct link to the user, the operator interface directly represents the core system's quality and value. Using the proper materials and finishes helps create an optimal user experience and will ultimately influence a customer's satisfaction of the product. There's a wide range of metals, plastics and composites available for front panels. Ruggedness and environmental resistance are among the most important considerations, however the increasing strength of modern composites means the final choice is sometimes a matter of aesthetics and appearance.

Aluminium

One of the most popular materials is aluminium alloy. The high strength-to-weight ratio, excellent corrosion resistance, easy machining and good conductivity are unique properties among metals.

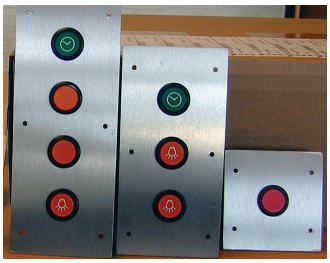
There are two categories: Wrought (plates, bars) and cast alloys. According to the International Alloy Designation System, alloys are given class numbers to identify their properties – 1xxx, 2xxx, etc. For example, 6061 is a widely used precipitation hardening aluminium alloy, containing

“Non-magnetic properties make aluminium suitable for medical equipment where interference may be present.”

“Aluminium is rarely selected for thin plates below 1.5 mm.”

“Die cast aluminium is popular for explosion proof enclosures.”

The metal photo etching technique is used for decorating front panels.



Stainless steel front panels are widely used in public areas which are prone to vandalism.

Anodised aluminium panels will provide enough strength and durability for most industrial equipment.

magnesium and silicon as its major alloying elements. The type of aluminium selected depends upon the application and environment.

Corrosion resistance is one of its key advantages. Aluminium reacts naturally with oxygen in the air to form an extremely thin, dense oxide which provides excellent corrosion resistance. Anodising increases the thickness of this layer and thus improves the level of protection.

Several other advantages exist including:
- Machinability at roughly twice the speed of stainless steel, which yields savings in material costs and production
- Ease of engraving

Surface-treated, anodised aluminium front panels will satisfy the strength and durability needs of most industrial equipment used in process control and automation, except those used in food processing. Due to its non-magnetic properties, it may be used in medical applications where there is a risk of interference with magnetic fields. At roughly three times lighter than steel (2700 kg/m^3 compared to 7850 kg/m^3 depending on alloying constituents), it is ideal for weight-sensitive applications within aeronautics and transportation.

Aluminium is rarely selected for thin plates below 1.5 mm. The stiffness – how much a material bends when a load is applied – being only about $^1/_3$ of steel. Welding is possible, but more challenging due to the higher thermal conductivity and the natural oxide which must first be removed. The linear expansion coefficient is higher than that for steel and the risk of cracking is greater. It is more difficult to bend so less accommodating for curved, ergonomic surfaces. Therefore EAO usually recommends steel over aluminium for curved, welded panels.

Die cast aluminium is popular for explosion proof enclosures. The die casting process involves forcing molten metal under high pressure into a mould cavity. A hot chamber casting process is used for aluminium. Die castings are monolithic: The strength is that of the material, not that of threads or welds, and the overall strength is substantially higher.

Steel

Steels are alloys produced by combining iron with carbon and other elements. Plain steels – carbon steels – are categorised as mild/low, medium or high according to the percentage of carbon. Alloy steels, including stainless steel, are created by adding metals such as nickel, chromium and tungsten. The properties of steel including strength, hardness, brittleness, resilience and

Stainless remains popular for front panels due to the very high "ultimate strength". *It is widely deployed in public use equipment which might be prone to vandalism.*

"Stainless steel 1.4401 is typically used for HMI front panels due to the excellent corrosion resistance and toughness at cryogenic temperatures (–150 °C)."

"Marine grade 1.4432 is a molybdenum-bearing variant with a high resistance to pitting and crevice corrosion in chloride environments."

malleability are affected by the composition, tempering and rolling processes.

There are various grading systems, but among the most widely used are SAE (formerly Society of Automotive Engineers) and EN European standards. EN 10027-2 specifies a numbering system for the designation of grades, e.g. 1. xx xx, where 1 = steel; first xx = group number; second xx = sequential number. Among the groups are 00 (non-alloy steel) and 4x (stainless steel and heat-resistant versions). For example, 1.0037 (sometimes called ST37) is a general purpose carbon steel, whereas 1.4401 (also known as 316 grade) is a commonly used stainless.

HMI front panels are typically built from 1.0037 mild steel, which offers:
- High strength in a relatively thin plate (>1 mm)
- Guaranteed minimum tensile strength
- High hardness but without excessive brittleness
- Good welding and handling properties (i.e. easy to mill)

EAO typically uses 1.0037 steel for machine control panels, train interior controls (driver desk and door controls).

Steel is porous and subject to moisture ingress and corrosion – the main weakness of this material. Galvanization (the process of applying a protective zinc coating) or chrome plating (electroplating a thin layer of chromium onto steel) is used to inhibit corrosion. For some environments, painting can provide sufficient protection without the need for plating or galvanizing (see *Surface Treatments*).

Where weight reduction is important (e.g. automotive, aeronautics), an alternative alloy may be preferable to steel.

Stainless steel

Stainless steels contain a minimum of about 10.5 % chromium. Generally, they offer a number of benefits over carbon steels:
- Higher strength and hardness even at thin panel thickness
- Higher corrosion resistance
- Higher cryogenic toughness
- Higher ductility

Many grades of stainless steel exist, but 1.4401 is widely used for HMI front panels due to the excellent corrosion resistance and toughness even at cryogenic temperatures (below –150 °C). The overall resistance is further increased with added titanium.

There are some drawbacks – not least of all the higher material cost compared to steel or anodized aluminium:
- Weight is roughly triple that of aluminium alloys so it's unsuitable for the aircraft industry, and for very large panels
- Machining takes longer so typical production costs are higher, and engraving is more difficult and expensive
- Difficult to bond an overlay like a membrane keypad to the surface

Stainless remains popular for front panels due to very high "ultimate strength", particularly for public use equipment which might be prone to vandalism, or where the front plate is under 1 mm and cannot be fabricated from aluminium.

Highly-polished 1.4301 stainless steel is widely used for front panels in the food processing industries. These environments are rigorously cleaned using very hot, high-pressure water sprays and caustic, acid-based detergents. "Marine grade" 1.4432 is a molybdenum-bearing variant with high resistance to pitting and crevice corrosion in chloride environments – hence the name.

Composites

There are several composites with similar properties – Dibond by 3A is very popular. Two 0.012" aluminium sheets are thermo-bonded to a solid polyethylene (PE) core. It is light, yet retains flatness and a relative sense of rigidity. The special aluminium resists corrosion and can be anodised. The super-polyester lacquer can be printed using both silk screen and digital processes. It comes in a wide range of colours and

Deep drawing creates cup-like containers without seams or joins. *No bacteria can grow in the crevices and water and chemical cleaning agents cannot penetrate.*

"Carbon fibre offers an incredibly high strength to weight ratio – around five times that of steel but 70 % lighter."

"Glass fibre is not as strong and stiff as carbon fibre but typically far less brittle, and the raw materials are cheaper."

Carbon fibre is a lightweight high-strength panel material often used in performance cars.

The "deep drawing" process creates cup-like metal containers without seams or joins.

Plastic enclosures with IP65 sealing offer sufficient protection for interior use.

finishes. Even the surface colour and core material can have different colours, making it easy to engrave. Dibond is stable within a –50 °C to +80 °C temperature range and has B1 and B2 flammability rating.

Overall it's a highly usable material for flat front panels, particularly within machine controls, but it's difficult to bend and cannot be welded. More rigid materials may be preferred for rigorous, high use applications (always refer to manufacturer's specifications).

Carbon fibre

Carbon fibre offers an incredibly high strength to weight ratio – commonly quoted as five times the strength of steel but only a third of the weight. It's made of thin strands of carbon: a filament is around 5 µm, about a third of a hair's thickness. Strands are woven together, then embedded within a plastic resin – typically epoxy or polyester – and cured by heat or pressure to form a composite.

There's a multitude of applications as it can be formed at various densities in limitless shapes and sizes. Typically used in high performance automobiles, aeronautics and aerospace industries for curved, ergonomic, lightweight but strong front panels. High material and tooling costs prevent it from being used widely.

Glass fibre

Fibreglass (glass fibre / glass-reinforced plastic / GRP) is a fibre-reinforced polymer composed of a plastic matrix reinforced by fine fibres of glass – lightweight, extremely strong and robust. Not as strong and stiff as carbon fibre but typically far less brittle, and the raw materials are also cheaper. Fibreglass is highly resistant to corrosion, petrochemical products and fats, combined with high impact strength and lightweight. Its bulk strength and weight properties compare well with metals.

There's a multitude of applications as it can be formed at various densities in limitless shapes and sizes. The standard "shoe box" enclosure is typically used for housing electrical and electronic equipment of high value. High tooling cost often precludes fibreglass from being used for low volume production.

Metal shaping techniques

Deep drawing is a metal fabrication technique that involves using very high pressures to press a 3D shape into a metal sheet; aluminium cans are produced in this way. The process creates cup-like containers without seams or joins. No bacteria can grow in the crevices and water and chemical cleaning agents cannot penetrate. It is especially well suited for designing small HMI enclosures into which two or three switches can be mounted.

EAO is a recognised global leader for supplying various moulded control panels and switching interfaces – *as they have done for the automotive industry.*

"Moulded plastics are widely used within HMI design for front panels, enclosures, ergonomic control surfaces, buttons and handles."

"Thermosetting plastics undergo an irreversible chemical reaction: After solidifying, they remain solid, e.g. vulcanised rubber."

The deep drawing process is executed in stages. Each one requires additional tooling costs; the art is to reduce them to a minimum. The process is used for high-volume production, typically more than 5000 pieces.

Plastics

Plastics are generally categorised as thermoplastics or thermosetting polymers. The former undergoes chemical change in their composition when heated and can be remoulded, e.g. Polyethylene, Polypropylene, Polystyrene and Polyvinyl Chloride. Thermosetting materials undergo an irreversible chemical reaction: After solidifying, they remain solid, e.g. vulcanised rubber.

Within each category are various types, each with different properties for strength, impact and temperature resistance, lifespan and production costs. For example, ABS Acrylanitrile Butadiene Styrene is a commonly used amorphous polymer plastic which offers good impact strength and appearance, but poor chemical resistance.

The selection of plastic materials can dramatically affect the HMI's overall strength, temperature resistance, appearance, life-span and production cost. Below is a general materials description overview of a few, common plastics.

Moulded plastics are widely used within HMI design for front panels, enclosures, ergonomic control surfaces, buttons, handles, etc. For example, EAO manufactures and supplies various, moulded control panels and switching interfaces to the automotive industry, and is a recognised expert in this field.

While plastics are ubiquitous, the high tooling costs makes it economic only with larger quantities – typically more than 1000 pieces. Environmental considerations such as exposure to impact and harsh use, cleaning agents, UV rays, etc, can limit the applications of plastics within HMI design. However a plastic enclosure with resistant front panel provides sufficient protection for light use control panels, especially those used inside.

Surface treatments

A wide range of surface treatments are possible to decorate, extend the lifespan, and protect the front panel material. This enables manufacturers to customise according to the OEM, and display and differentiate "their brand".

Liquid paint

Most paints contain resins, pigments, reducers and additives. Resins form a film and hold the pigment in place. Paint types are defined in terms of resin – Polyvinylidene Fluoride (PVDF),

Plastic	Characteristics
ABS (Acrylanitrile Butadiene Styrene).	Easy to work. Good impact strength and appearance. Poor chemical resistance. Commonly used in: Computer shells, medical parts, hand-held appliances, auto trim parts. Flame retardant and medical grade availability.
Acetal (POM)	Acetal Polymers that are semi-crystalline and have excellent fatigue resistance, lubricity, and chemical resistance. Can omit gasses at higher temperatures. Brittle at lower temperatures.
PMMA, Acrylic	Amorphous polymers offering superb clarity. Excellent weather durability for outdoor applications.
PC, Polycarbonate	Amorphous material with superb clarity, impact strength and mechanical properties. Medium weather durability.
The above general information is intended for preliminary material identification only.	

E-coating is a process to deposit paint onto the surfaces. *It's now widely used as an alternative to powder coating.*

"Paint types are defined in terms of resin – Polyvinylidene Fluoride (PVDF), Polyester, Acrylic, Polyurethane or Epoxy is common."

"Powder coating is not as easy to apply in smooth thin films. As the film thickness is reduced, the surface becomes more and more 'orange peeled' in texture."

Brushing creates an attractive, distinctive look for aluminium and stainless steel.

High-definition images can be printed on aluminium using Alugraphics and "metal photo" processes.

Example of a laser engraved, anodized aluminium panel.

Polyester, Acrylic, Polyurethane or Epoxy is common. Some paints contain multiple resins, which help the coating perform to specific requirements. Pigments are selected for their properties – durability, gloss, colour fastness and chemical exposure. Reducers including solvents and dilutents are used to control viscosity and volume. Additives are used for more gloss, hardness and other characteristics. Those with a PVDF resin compound are typically used for HMI front panels, which perform well against industrial pollution, chemicals, marine attack and degradation by UV light.

Despite the wide use of powder coating, liquids may be preferred due to:

- Suitability for any front panel material, including plastics; heat not required to achieve curing
- Available in limitless colours and specialised metallic and high-gloss finishes
- Thinner coats, which are desirable when working to very tight tolerances during product assembly
- After painting, front panels can be engraved or silk-screened with graphics

Powder coating

Powder coat is a pigment encapsulated in a powdered resin without the need for a solvent. The coating is typically applied electrostatically and is then cured and hardened with heat.

The advantages of powder coating for industrial applications include:

- Harder, impact resistant finish that is tough and weatherable
- Gloss levels above 15 % are possible
- Thicker coatings than conventional liquid coatings without running or sagging
- Several powder colours can be applied before curing them all together, allowing colour blending and bleed special effects in a single layer
- No differences between horizontally and vertically coated surfaces

However, it is not as easy to apply smooth thin films. As the film thickness is reduced, the surface becomes more and more "orange peeled" in texture due to the particle size and glass transition temperature (Tg) of the powder. For small batches, powder coating can be significantly more expensive; always calculate based on minimum order quantities.

Electro-deposition

Commonly called electro-coating or e-coating, it is the process by which a metal object is submerged in a tank and electric cur-

“Grinding and polishing uses abrasives to create finishes like satin, dull-, bright- or mirror-polish.”

“A satin polish, where surface deviations are typical less than 0.5 (Ra) micro-metres, offers a fine, clean cut with minimal micro-crevices. This helps optimise the corrosion resistance and minimising dirt retention of the surface.”

rent is used to deposit paint onto the surfaces. Both inside and outside cavities can be coated. Parts are removed from the tank and heat cured. It’s now widely used as an alternative to powder coating because of its ability to cover even the most complex parts and assembled products according to specific performance requirements. Coatings generally have a very uniform thickness without porosity. It’s also considered a very environmentally friendly solution, involving no heavy metals or HAPS, and low VOCs.

Anodising (aluminium)

Anodising harnesses the natural oxidising process by increasing the layer’s thickness and thus the level of corrosion resistance. An electrical current is passed from the anode (positive) to the cathode (negative). The object being anodised becomes the anode part of the electric circuit. It is placed with cathodes in an anodising tank which contains dissolved chemicals. A hard layer of aluminium oxide forms on the object’s surface. Thickness is determined by the time spent in the tank.

Single colour anodising is the most economical way to colour aluminium, but also with the most limited colour spectrum. It’s suitable for colouring a complete panel – front, back and edges. The process can produce mild but visible variations in colour between batches due to variations in the aluminium substrate.

Mechanical finishing (for metals)

Mechanical finishing commonly involves grinding, polishing and brushing. These techniques can be used on any metal, but mainly aluminium and stainless steel.

Grinding and polishing uses abrasives to remove surface metal. It creates finishes like satin, dull-, bright- or mirror-polish finishes. Successively finer abrasives are used to obtain the desired look. A buffing step can be included to remove any emery marks. The final finish is affected by other factors such as abrasive pressure, contact time, material feed rate and wet or dry techniques.

A satin polish, where surface deviations are typical less than 0.5 (Ra) micro-metres, offers a fine, clean cut with minimal micro-crevices. This helps optimise the corrosion resistance and minimising dirt retention of the surface. These finishes are more suitable for external HMI applications. Dull and brushed finishes (0.5-1.5 Ra) are more suitable for interior use.

Brushing creates an attractive, distinctive look for aluminium and stainless steel. The surface retains most of its lustre and is given a pattern of very fine lines parallel to the brushing direction. It‘s typically produced by brushing the metal with a gritted belt or wheel, then softening with a finer compound. While it looks attractive, it can have a detrimental effect on corrosion resistance by allowing moisture to collect in the grooves.

Brushed finishes do not fingerprint easily and therefore can be used successfully in areas of high contact, particularly public use and interactive applications. Environmental deposits and other forms of surface soiling are generally washed away when uni-directional polishing or grinding marks are oriented vertically, in the direction of water run-off.

Electro-polishing is popular for stainless steel, an electrochemical process that removes material and evens out any surface flaws, resulting in a uniquely flat, mirror-like finish. This makes it scratch-resistant and more difficult for unwanted substances to stick to the surface. This improves the anti-microbial properties too.

Highly-polished stainless steel is widely used for front panels in the food processing industries, but is also useful for medical applications. These environments can be subject to strict hygiene processes – hot, high-pressure water sprays and caustic, acid-based detergents.

Printing and marking

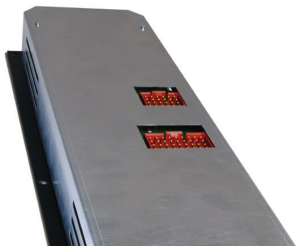
Several printing and engraving techniques are available depending on the front panel surface material.

“With metal photo printing, the end result almost appears as though the image has been photocopied onto the metal surface.”

“Photo etching – chemical etching – is an alternative to stamping and can be used for creating intricate graphics like company logos on metal.”

Printed polyester provides a durable front panel overlay for membrane touch switches.

Enclosures may combine different materials for weight and strength advantages.



The enclosure material is as important as that of the front panel.

Digital printing on aluminium

For high-definition printing, the Alugraphics technique is a newer digital printing and finishing technique that’s capable of “tattooing” high-resolution, photo-realistic graphics on anodised aluminium. The images will not fade, wear or scratch off. Specially-formulated inks are embedded within the surface prior to being sealed with a crystal-clear coating. The finished surface is as hard as sapphire and highly resistant to high temperatures, UV exposure, chemicals, salt spray, erosion, abrasion, and de-lamination. In practice there’s a similar level of resistance as with stainless steel, but in a lighter weight package.

Another process called metal photo printing creates a similar high-definition result but with a different technique that utilizes photosensitive anodized aluminium. Images are sealed beneath a sapphire-hard anodic layer for maximum durability. The end result almost appears as though the image has been photocopied on to the metal surface – including colour graphics.

Digital processes can print almost anything on natural aluminium, including symbols, bar codes, photos – even a stainless steel effect to achieve that tough, industrial look.

Screen printing

Screen printing is a widely used, cost-effective printing technique for transferring images onto any type of material-metal (excluding stainless steel), plastic or composite. Ink is forced through a screen mesh, typically made from polyester or nylon, onto a substrate. Areas of the screen are blocked off like in a stencil. Different colours are added in layers. It’s still widely used for printing on front panels due to the low set-up costs, sharp quality image and versatility.

There are some disadvantages that limit the application:

- Graphics are not scratch proof
- Low resistance to cleaning liquids
- Not recommended for frequent, high contact areas
- Unsuitable for outdoor applications

Photo etching on metal

Photo etching, or chemical etching, can be used for creating concave images on metal plates as an alternative to stamping or punching. It’s ideal for creating intricate graphics or characters like company logos or part numbers on metal. An acid-resistant image is printed on the substrate and then an etchant acid removes the unprotected areas. Photo etching does not affect the properties of the metal with regard to hardness, grain structure, or ductility.

“Laser engraving is often used in conjunction with paint. Markings can be left as natural etchings or filled with coloured paint.”

“Graphic overlays provide a simple and effective solution for adding decoration, functionality and an extra protective layer to fascias and front panels.”

Laser engraving

Lasers are now commonly used for marking all materials – aluminium, steels, plastics and fibres. Various types of lasers are used according to the material – they either burn or alter the surface. The precise, permanent, repeatable nature of the technique allows very intricate etching.

EAO uses lasers to engrave front panels and individual HMI components, particularly within machinery and instrumentation controls and especially where keypads are present. As heat from the laser is minimal, the fine, delicate control allows even fully-assembled keypads to be marked without damaging the electronics.

The technique is often used in conjunction with paint. Markings can be left as natural etchings or filled with coloured paint. The trend for control panels with sleek, modern appearances feature all black pushbuttons with white translucent legends that illuminate using an innovative back-lighting technique. These pushbuttons are created by first painting them white, then black, and then removing the black with a laser. This technique is popular for automotive displays.

Overlays

Graphic overlays provide a simple and effective solution for adding decoration, functionality and an extra protective layer to fascias and front panels. The graphics are printed on the reverse side of a transparent plastic overlay, which is then bonded to the front panel. The graphics often include keypads and button functions which overlay tactile membrane switches.

Overlays are popular for their ruggedness and versatility, particularly:

- Resistance to low impact, spills, moisture, weathering and UV, abrasions and chemical washing
- Multiple colours and complex graphics can be printed as well as transparent, tinted or “secret-till-lit” windows for displays and LEDs
- Embossing can be incorporated on keys to create a more tactile feel, as well as on borders and graphics to enhance the appearance of the overlay
- Mounting cut-outs can be die-cut after printing to allow for fitting switches and dials
- Easy to customise – using text inserts instead of fixed markings allows a standard front plate to be adapted for different applications
- Suitable for interior or exterior use, depending on type of material

EAO would typically use a combination of Series 70 membrane switches and a polyester film designed for membrane touch switch overlays, such as the Autotex® V200 – a high quality, flexible, textured polyester film that will last for more than five million actuations. Graphic overlays can be designed on eloxal anodised aluminium for more demanding applications. The graphics are printed on the top, not on the reverse side like in plastic overlays, but once coated they have a hardness similar to knife steel or hard chrome. The edges cannot be printed.

Additional protection

Enclosures, internal construction, fastenings and overall environmental protection must all be taken into account.

Enclosures

Front panels are typically fastened within a protective enclosure and then connected to the host system (in smaller devices, they are often mounted directly in the equipment). They must provide full protection and a controlled internal environment for the electronic assemblies. In nearly all cases it’s essential to develop a custom-made housing that perfectly encloses the assembly.

Factors which affect the choice of enclosure material and design include:

- Environmental: Exposure to water/solids ingress, pollution, cleaning agents
- Robustness: Resistance to shock, impact and vibration
- Regulatory: Material behaviour when exposed to flames, smoke and high temperatures

Depending on the environment, the enclosure may also need to protect against electromagnetic interference, electrostatic discharge and radio frequency interference.

Consider a static machine compared to an off-road vehicle, or military equipment in the vicinity of an explosion. *Shock and vibration can vary enormously depending on the situation.*

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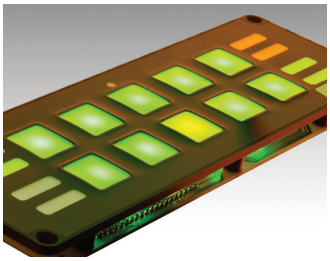
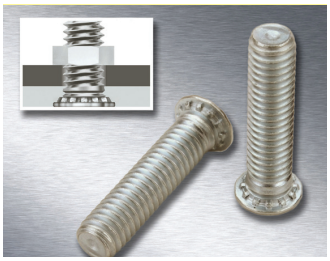
"PEM® studs are 'self-clinching', i.e. the fastener cannot rotate in the material once it has been properly inserted."



EAO's Series 70 is a popular tactile switch for use under a printed membrane.



PEM® studs are widely used for mounting the front control panel assembly.

IP69K protection class is required for public transport passenger access controls.

Shock and vibration can vary enormously depending on the situation. Consider a static machine compared to an off-road vehicle, or military equipment in the vicinity of an explosion. Environment-specific testing is therefore critical before selecting an enclosure. Vibration mounts and shock isolators are commonly used in HMI construction. Vibration mounts such as rubber washers dampen high-frequency, low-magnitude vibration, whereas shock isolators like cable mounts counteract high-magnitude, low-frequency motion. Many applications also demand internal isolators to provide shock absorption for equipment on the interior of an enclosure.

For protection against adverse interference or radiation, measures often include:

- Sprays: Acrylic based paints are used to create conductive, static free surfaces with excellent characteristics.
- Coated surfaces reduce electromagnetic or radio frequency interference (EMI / RFI)
- Foils: Copper foil to protect against electromagnetic pulses

Whilst most enclosures are more than adequately strong, fatigue failure may be an issue with elements such as fastenings, hinges, and other elements which create an integrated structure from a set of components.

Fasteners

Constant shock and vibration can loosen fasteners and cause them to fail, with potentially serious consequences for people and equipment. The failure of one small fastener could result in a major problem that could have been prevented through proper fastening component selection. PEM® studs are widely used for mounting the front control panel assembly and custom-mounting hardware. They are "self-clinching", i.e. the fastener cannot rotate in the material once it has been properly inserted. Once locked into place they become non-movable and thus a permanent part of the host material. PEM® studs are capable of strong, load bearing threads in relatively thin sheets of metal.

Environmental protection standards

A system is only as strong as the weakest link. Therefore it's important the complete HMI construction is tested for environmental protection, not just the individual components.

The International/Ingress Protection, or IP rating system, is widely used throughout Europe to indicate the level of protection against the intrusion of solids and liquids. The standard is laid down by the International Electrical Commission (IEC) directive 60529. In

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Therefore it's important that the complete HMI construction is tested for environmental protection, not just the individual components.

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an IP number, the first digit represents protection against solids, the second against liquids at various pressures.

Where water, fuel, cleaning solutions, fine dust, and other materials may come in contact with HMI control panels the following, IP numbers apply:

- IP 40 – protected from objects greater than 1 mm diameter (wires, tools, etc) but not protected from water
- IP 60 – dust tight but not protected from water
- IP 65 – dust tight and protected against water and liquid jets
- IP 67 – dust tight and protected against temporary water and liquid immersion

In the United States of America and in Canada, the National Electrical Manufacturers Association sets the NEMA standard for environmental sealing. NEMA standards meet or exceed IP ratings listed, but the reverse cannot be assumed. IP code only addresses requirements for protection of people, ingress of solids and ingress of water. The NEMA types consider these and numerous others including:

- Corrosion resistance
- Effects of icing
- Gasket aging and oil resistance

For this reason, it is possible to say that a NEMA type is equivalent to an IP rating but an IP rating is not equivalent to a NEMA type.

IK codes – impact protection
The European standard EN 62262 (the equivalent of international standard IEC 62262, 2002) classifies degrees of protection provided by enclosures against external mechanical impacts. Any enclosure rated IK7 or above should be capable of resisting a free-fall hammer striking the enclosure between 2-20 joules.

IP69K
German standard DIN 40050-9 created an additional rating for environmental sealing – IP69K, for high-pressure, high-temperature wash-down applications. Devices must not only be dust tight (IP6X), but also able to withstand high-pressure and steam cleaning. The test is very strict: 80 °C water is sprayed through a nozzle at pressures of 8-10 MPa (80-100 bar) and a flow rate of 14-16 litres/min. The nozzle must be held 10-15 cm from the tested device at angles of 0°, 30°, 60° and 90° for 30 seconds each. The test device sits on a turntable that rotates once every 12 seconds (5 rpm). The IP69K test specification was initially developed for road vehicles, especially construction vehicles and those that need intensive cleaning, but now also finds use in other intensely hygienic environments like food processing.

Conclusion
The choice of front panel materials and finishes will significantly affect the strength, durability and suitability of the overall Human Machine Interface. Direct damage to the front panel can leave the entire system more vulnerable. This may result in equipment down-time, production stoppages, additional maintenance, redundant labour, and other negative cost implications of having the equipment out of service.

It's important to work with an HMI expert who can address all the human-factors, technical, and commercial considerations of a complex HMI development project.

EAO is a global partner and manufacturer of HMI Systems and HMI Components to a range of markets including machinery and automation, public transport, automotive design, special purpose and heavy duty vehicles, as well as many others that involve an interaction between humans and machines. EAO is here to make this interaction innovative, intuitive and reliable.