Surviving Hostile Control System Environments

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Control systems are often subjected to a variety of hostile environments. For example, metalworking environments are often characterized by cutting fluids, lubricating oils and metal chips. Food processing and medical equipment typically are subjected to periodic washdowns/sterilization. Chemical production frequently generates corrosive atmospheres and dust.

Many types of commercial equipment (such as off-road equipment, boast, marine instruments, construction elevators, farm machinery, hand-held data-entry terminals and portable test equipment) must maintain their performance after exposure to dirt, dust, and moisture.

Similarly, operator controls on consumer equipment can also be exposed to harmful environments which may compromise system reliability. Rug shampooers, snowblowers, vacuum cleaners, portable power tools, motorcycles, lawn tractors, and golf carts are but a few examples of consumer products regularly subjected to rain, snow, dust, and/or dirt.

Reliable operation and survival under these conditions requires careful control system planning, design, and construction.

Enclosure Ratings

To cost-effectively satisfy this application diversity, manufacturers of electrical/electronic equipment enclosures offer a range of products which provide varying degrees of environmental protection. In the interest of "standardizing" an electrical enclosure's performance, standards-making organizations such as NEMA, UL, CSA, and IEC have established various standards (Table 1).

Use of NEMA ratings does not require independent testing. Compliance is left to the manufacturer. On the other hand, UL and CSA require independent environmental testing by qualified evaluators in their laboratories. In addition, both organizations conduct follow-up inspections to assure adherence to prescribed materials and manufacturing procedures.

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Table 1.
Selected Electrical Enclosure Standards

- **National Electrical Manufacturers Association NEMA Standards Publication No. 250, "Enclosures for Electrical Equipment"**
- **National Electrical Manufacturers Association NEMA Standards Publication No. ICS6, "Enclosures for Industrial Controls and Systems"**
- **Underwriters Laboratories Inc. UL 50, "Standard for Safety, Enclosures for Electrical Equipment"**
- **Underwriters Laboratories Inc. UL 508, "Standard for Safety, Industrial Control Equipment"**
- **Canadian Standards Association CSA Standard C22.2 No. 94 "Industrial Control Equipment for Use in Ordinary (Non-Hazardous) Locations"**
- **International Electrotechnical Commission IEC 529, "Classification of Degree of Protection Provided by Enclosures"**

These ratings provide a quantitative measure of an enclosure's ability to operate in the environment in which it will be used. Each rating defines the degree of protection against rain, snow, sleet, wind-blown dust, hosedown, corrosive agents, and occasional submersion.

While the detailed wording of ratings from standard to standard varies, each is based on similar application descriptions and performance expectations (Table 2). For example, an enclosure meeting UL Standard 50, Type 6 ratings (and similarly NEMA Standard No. 250, Type 6) is designed for indoor and outdoor use. It provides the degree of protection against hosedown, icing, dust, and the entry of water during temporary submersion at the limited depth required for this rating.

Regardless of the rating of the selected enclosure, panel cutouts made in order to mount switches, circuit breakers, panel meters, and other control/human interface components can compromise its environmental integrity. Each enclosure cutout presents a new point of potential entry for dirt, moisture, and other harmful environmental elements.

Assuring System Integrity

Design engineers have several alternative methods of assuring the environmental integrity of a control system subject to such harmful elements even after making front-panel cutouts to mount control components. These include:

- mounting the entire assembled control system in a sealed enclosure.
- use of "factory-sealed" control components which are designed to withstand the anticipated environment without degradation in performance.
- use of sealing gaskets and sealing compounds to protect against the entry of dust, moisture, etc. around the perimeter of panel-mounted component cutouts.
- use of UL-recognized environmental seals expressly designed for selected control panel-mounted components (e.g. switches, circuit breakers, potentiometers, panel meters, keypads).

Each approach offers advantages and disadvantages and each has found use in hostile environments. Plating operations, paint spray equipment, packaging machinery, woodworking machines, machine tools, material handling systems, off-road compressors, and fork lift trucks, are but a few of the applications in which the equipment is subjected to fumes, dirt, dust, oil, water, salt spray, and/or cleaning solutions.

Encapsulating the Control System

This approach involves surrounding the entire control assembled system in a sealed (sometimes transparent plexiglass) housing. This method eliminates the need to use "individually-sealed" panel-mounted control components and affords the operator an opportunity to view critical control system instruments/gauges. However it limits operator access, increases the control system's envelope dimensions, and may need to be periodically replaced due to discoloration/damage.

Factory-Sealed Components

Factory-sealed, panel-mounted components are available from a number of manufacturers. Switches and panel meters having "oiltight", "watertight", IP67, or similar ratings assure the environmental integrity of these components without the need for ancillary sealing. Such factory-sealed components, however, may be more expensive than their conventional equivalents. Depending upon their design and installation, they may not protect against the entry of environmental contaminants around the perimeter of the component's panel cutout.

In addition, their use may require testing of the entire control system if UL-recognition of the assembled system is desired.

Sealing Gaskets/Compounds

Secondary sealing gaskets and sealing compounds represent relatively inexpensive materials which can be used to seal the panel cutouts in which the control components are mounted. However, if installation is labor intensive, they may increase system cost substantially. Nor do they protect the individual panel-mounted components from the potentially degrading effects of a hostile environment.

Fitted seals protect panel mounted control components from moisture, dirt, dust and other harmful environmental elements.

Environmental Sealing Boots

These fitted, molded silicone rubber seals are designed to protect the individual panel-mounted components without compromising access or operation. Easy to install and reusable, many are designed with a perimeter sealing rib to seal the panel cutout in which the component is mounted… an important consideration for protecting internal circuitry.

UL-recognized component seals/boots, installed and tested to the stringent requirements of UL Standard 50, provided the design engineer with a cost-effective means of assuring a control system's environmental integrity. They also represent a convenient method for modifying an existing panel to include additional functions without compromising the environmental integrity of the system.

Table 2. Enclosure Types

Type	Intended Use and Description
1.	Indoor use primarily to provide a degree of protection against limited amounts of falling dirt.
2.	Indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.
3.	Outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust and damage from external ice formation.
3R.	Outdoor use primarily to provide a degree of protection against rain, sleet, and damage from external ice formation.
3S.	Outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust and to provide for operation of external mechanisms when ice laden.
4.	Indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water and damage from external ice formation.
4X	Indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water and damage from external ice formation.
5.	Indoor use primarily to provide a degree of protection against settling airborne dust, falling dirt, and dripping noncorrosive liquids.
6.	Indoor or outdoor use primarily to provide a degree of protection against hose-directed water, and the entry of water during occasional temporary submersion at a limited depth and damage from external ice formation.
6P.	Indoor or outdoor use primarily to provide a degree of protection against hose-directed water, the entry of water during prolonged submersion at a limited depth and damage from external ice formation.
12 12K	Indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids.
13.	Indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and noncorrosive coolant.

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