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Industrial/Commercial Specifier's Guide

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CHAPTER 13
TECHNICAL INFORMATION

WE BELIEVE COMPLIANCE IS A COLLABORATIVE EFFORT.

Our products reflect our commitment to making a positive impact, and we select supplier partners that meet the Hoffman Supplier Code of Conduct to ensure safe and healthy working conditions, the human rights of workers, high ethical standards and environmental responsibility. We also research and understand worldwide regulations that affect our products such as REACH, RoHS and others.

In addition, we have an uncompromising policy of compliance with the export and import laws of the United States and all other countries where we do business. We can assist you with meeting your contractual and government requirements including country of origin, harmonized tariff schedule, free trade agreements, Buy American qualification and others.

We provide customers industry-leading design and are committed to quality leadership and continual improvement to our products and processes.

TO ENSURE YOUR SPECIFIC COMPLIANCE REQUIREMENTS ARE MET, PLEASE FILL OUT THE COMPLIANCE REQUEST FORM PRIOR TO PLACING A PURCHASE ORDER.

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STANDARDS ORGANIZATION SUMMARY AND DIRECTORY OVERVIEW

What's in a Rating?

As a way of standardizing enclosure performance, organizations like NEMA, UL, CSA, IEC and VDE use rating systems to identify an enclosure's ability to resist external environmental influences. Resistance to everything from dripping liquid to hose-down to total submersion is defined by the ratings systems. While these ratings are all intended to provide information to help you make a safer, more-informed product choice, there are differences among them.

North American Standards Organizations

In North America, NEMA, UL and CSA are the commonly recognized standards organizations. Their ratings are based on similar application descriptions and expected performance. UL and CSA both require enclosure testing by qualified evaluators in their certified labs. They also send site inspectors to make sure a manufacturer adheres to prescribed manufacturing methods and material specifications. NEMA, on the other hand, does not require independent testing and leaves compliance completely up to the manufacturer.

North American enclosure rating systems also include a rating that indicates corrosion resistance. This rating is based on the enclosure's ability to withstand prolonged exposure to salt water spray.

While the corrosion resistance rating is a good indicator that an enclosure can resist corrosion, it does not provide information on how a specific corrosive agent will affect a given enclosure material. It is best to conduct a full analysis of the specific application and environment to determine the best enclosure choice.

International Standards Organizations

Like NEMA, IEC does not require independent testing and leaves compliance completely up to the manufacturer. Nevertheless, there are differences in how enclosure performance is interpreted. For example, UL and CSA test requirements specify that an enclosure fails the water-tight test if even a single drop of water enters the enclosure. In the IEC standards for each level of ingress protection (IP), a certain amount of water is allowed to enter the enclosure.

IEC 60529 IP ratings do not specify construction requirements or degrees of protection against corrosive atmospheres, risk of explosion or conditions such as moisture or corrosive vapors. NEMA Type ratings, on the other hand, do specify construction and performance requirements for most environmental conditions. For this reason, and because the tests and evaluations for other characteristics are not identical, the IEC enclosure classification designations cannot be exactly equated with NEMA enclosure Type numbers.

STANDARDS ORGANIZATION DIRECTORY

National Electrical Manufacturers Association
1300 North 17th Street
Suite 1847
Rosslyn, VA 22209
www.nema.org
NEMA Standards Publication No. 250
Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA Standards Publication No. ICS6
Enclosures for Industrial Controls and Systems

Electrical Equipment Manufacturers Association of Canada
5800 Explorer Drive
Suite 200
Mississauga, Ontario
Canada L4W 5K9
www.electrofed.com

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062
www.ul.com
UL 50 Enclosures for Electrical Equipment, Non-Environmental Considerations (Type 1)
UL 50E Enclosures for Electrical Equipment, Environmental Considerations (Remaining Types)
UL 508A Industrial Control Panels
UL 870 Wireways, Auxiliary Gutters and Associated Fittings
UL 94 Flammability of Plastic Materials
UL 2279 Electrical Equipment for Use in CLI Zone 1 and 2 Hazardous Locations
UL 1863 Communication Circuit Accessories
UL 414 Meter Sockets
UL 497 Protectors for Paired Conductor Communication Circuits
UL 1773 Termination Boxes
UL 1203 Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations

Canadian Standards Association
178 Rexdale Boulevard
Rexdale (Toronto), Ontario, Canada
M9W 1R3
www.csa.ca
CSA Standard C22.2:
No. 0 General Requirements - Canadian Electrical Code, Part II
No. 0.4 Bonding and Grounding of Electrical Equipment (Protective Equipment)
No. 14 Industrial Control Equipment for Use in Ordinary (Non-Hazardous) Locations
No. 40 Cutout, Junction, and Pull Boxes
No. 26 Construction and Test of Wireways, and Auxiliary Gutters, and Associated Fittings
No. 94 Special Purpose Enclosures
No. 182.4 Plugs, Receptacles, and Connections for Communications Systems
No. 76 Splitters
No. 25 Enclosures for Use in Class 11 Groups E, F, and G Hazardous Locations

International Electrotechnical Commission
3 Rue de Varembé
CH-1211
P.O. Box 131
Geneva 20
Switzerland
www.iec.ch
IEC 60529 Classification of Degrees of Protection Provided by Enclosures
IEC 60204 Safety of Machinery - Electrical Equipment of Machines
IEC 60079 Electrical Apparatus for Explosive Gas Atmospheres
IEC 61641 Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault
IEC 62208 Empty enclosures for low-voltage switch-gear and control-gear assemblies.

STANDARDS ORGANIZATION DIRECTORY (CONTINUED)

Electronic Industries Alliance
2500 Wilson Blvd.
Arlington, VA 22201
www.eia.org
EIA RS-310-D Racks, Panels, and Associated Equipment

American National Standards Institute
1819 L Street NW
Washington, DC 20036
www.ansi.org

National Fire Protection Association
Batterymarch Park
Quincy, MA 02169-7471
www.nfpa.org
NFPA 70 National Electrical Code
NFPA 70e Standard for Electrical Safety Requirements for Employee Workplaces
NFPA 79 Electrical Standard for Industrial Machinery
NFPA 496 Purged and Pressurized Enclosures for Electrical Equipment

International Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096-0001
www.sae.org
SAE HS 1738 SAE Standard - Electrical Equipment for Automotive Industrial Machinery

Institute of Electrical and Electronics Engineers
445 Hoes Lane
Piscataway, NJ 08854-1331
www.ieee.org
C37.20.7 IEEE Guide for Testing Medium-Voltage Metal-Enclosed Switchgear for Internal Arcing Faults
IEEE 1584 Guide for Arc Flash Hazard Calculations

National Sanitation Foundation
NSF International
789 Dixboro Road
Ann Arbor, MI 48113-0140
www.nsf.org
NSF Criteria C-2 Special Equipment and/or Devices

Telcordia Technologies
8 Corporate Place
Piscataway, NJ 08854-4157
www.telcordia.com
GR 63 NEBS Requirements: Physical Protection
GR487 Generic Requirements for Electronic Equipment Cabinets

The American Society of Mechanical Engineers
Three Park Avenue
New York, NY 10016-5990
www.asme.org
ASME BPE Bioprocessing Equipment

Defense Automation and Production Service
Building 4/D
700 Robbins Avenue
Philadelphia, PA 19111-5094
http://dodssp.daps.dla.mil
MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests
MIL-S-901 Shock Tests. H.I. (High Impact) Requirements for Shipboard Machinery, Equipment, and Systems

TÜV Product Service
Segensworth Road
Fareham Hampshire
P015 5RH
United Kingdom
www.tuvps.co.uk

Institute of German Electronics Engineers (VDE)
Stresemannalle 15
60596 Frankfurt Main
Germany
www.vde.de

NEMA, UL AND CSA RATINGS

Enclosure Type Descriptions for Non-Hazardous Locations

	Type	NEMA[a]	UL[b]	CSA[c]
Indoor	Type 1	Enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment or locations where unusual service conditions do not exist.	Indoor use primarily to provide protection against contact with the enclosed equipment and against a limited amount of falling dirt.	General purpose enclosure. Protects against accidental contact with live parts.
Indoor	Type 12	Enclosures are intended for indoor use primarily to provide a degree of protection against dust, falling dirt and dripping noncorrosive liquids.	Indoor use to provide a degree of protection against dust, dirt, fiber flyings, dripping water and external condensation of noncorrosive liquids.	Indoor use; provides a degree of protection against circulating dust, lint, fibers and flyings; dripping and light splashing of non-corrosive liquids; not provided with knockouts.
Indoor	Type 12K	Enclosures with knockouts are intended for indoor use primarily to provide a degree of protection against dust, falling dirt and dripping noncorrosive liquids.	Indoor use to provide a degree of protection against dust, dirt, fiber flyings, dripping water and external condensation of noncorrosive liquids.	Indoor use; provides a degree of protection against circulating dust, lint, fibers and flyings; dripping and light splashing of noncorrosive liquids; not provided with knockouts.
Indoor	Type 13	Enclosures are intended for indoor use primarily to provide a degree of protection against dust, spraying of water, oil and noncorrosive coolant.	Indoor use to provide a degree of protection against lint, dust seepage, external condensation and spraying of water, oil and noncorrosive liquids.	Indoor use; provides a degree of protection against circulating dust, lint, fibers and flyings; seepage and spraying of non-corrosive liquids, including oils and coolants.
Outdoor	Type 3	Enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain and sleet; undamaged by the formation of ice on the enclosure.	Outdoor use to provide a degree of protection against windblown dust and windblown rain; undamaged by the formation of ice on the enclosure.	Indoor or outdoor use; provides a degree of protection against rain, snow and windblown dust; undamaged by the external formation of ice on the enclosure.
Outdoor	Type 3R	Enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain and sleet; undamaged by the formation of ice on the enclosure.	Outdoor use to provide a degree of protection against falling rain; undamaged by the formation of ice on the enclosure.	Indoor or outdoor use; provides a degree of protection against rain and snow; undamaged by the external formation of ice on the enclosure.
Outdoor	Type 3RX	Enclosures are intended for outdoor use primarily to provide a degree of protection against corrosion, falling rain and sleet; undamaged by the formation of ice on the enclosure.	Not specifically defined.	Not specifically defined.
Outdoor	Type 4	Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water and hose directed water; undamaged by the formation of ice on the enclosure.	Either indoor or outdoor use to provide a degree of protection against falling rain, splashing water and hose-directed water; undamaged by the formation of ice on the enclosure.	Indoor or outdoor use; provides a degree of protection against rain, snow, windblown dust, splashing and hose-directed water; undamaged by the external formation of ice on the enclosure.
Outdoor	Type 4X	Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water and hose-directed water; undamaged by the formation of ice on the enclosure.	Either indoor or outdoor use to provide a degree of protection against falling rain, splashing water and hose-directed water; undamaged by the formation of ice on the enclosure; resists corrosion.	Indoor or outdoor use; provides a degree of protection against rain, snow, windblown dust, splashing and hose-directed water; undamaged by the external formation of ice on the enclosure; resists corrosion.
Outdoor	Type 6	Enclosures are intended for use indoors or outdoors where occasional submersion is encountered; limited depth; undamaged by the formation of ice on the enclosure.	Indoor or outdoor use to provide a degree of protection against entry of water during temporary submersion at a limited depth; undamaged by the external formation of ice on the enclosure.	Indoor or outdoor use; provides a degree of protection against the entry of water during temporary submersion at a limited depth. Undamaged by the external formation of ice on the enclosure; resists corrosion.

[a]This material is reproduced with permission from NEMA. The preceding descriptions, however, are not intended to be complete representations of National Electrical Manufacturers Association standards for enclosures nor those of the Electrical and Electronic Manufacturers Association of Canada.

[b]This material is reproduced with permission from Underwriters Laboratories Inc. Enclosures for Electrical Equipment, UL 50, 50E and Industrial Control Panels, UL 508A.

[c]This material is reproduced with permission from the Canadian Standards Association.

Underwriters Laboratories Inc. (UL) shall not be responsible for the use of or reliance upon a UL Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon a UL Standard.

Some enclosures may have multiple ratings. For instance:

4, 12—Outdoor use; able to be used indoors with modifications

4X, 3RX—Outdoor use; able to be used indoors with modifications

4, 9—Can be used in both hazardous and non-hazardous locations

COMPARISON OF SPECIFIC NON-HAZARDOUS APPLICATIONS IN OUTDOOR LOCATIONS

Enclosure Type Rating

Provides a Degree of Protection Against the Following Environmental Conditions	3	3R[a]	3RX[a]	4	4X	6
Incidental contact with the enclosed equipment	•	•	•	•	•	•
Rain, snow and sleet[b]	•	•	•	•	•	•
Windblown dust	•			•	•	•
Hose-down				•	•	•
Corrosive agents			•		•	
Occasional temporary submersion						•

[a]These enclosures may be ventilated.

[b]External operating mechanisms are not required to be operable when the enclosure is ice covered.

The preceding table is reproduced by permission of the National Electrical Manufacturers Association from NEMA Standards Publication 250 "Enclosures for Electrical Equipment (1000 Volts Maximum)".

COMPARISON OF SPECIFIC NON-HAZARDOUS APPLICATIONS IN INDOOR LOCATIONS

Enclosure Type Rating

Provides a Degree of Protection Against the Following Environmental Conditions	1[a]	4	4X	6	12	12K	13
Incidental contact with the enclosed equipment	•	•	•	•	•	•	•
Falling dirt	•	•	•	•	•	•	•
Falling liquids and light splashing		•	•	•	•	•	•
Dust, lint, fibers and flyings[b]		•	•	•	•	•	•
Hose-down and splashing water		•	•	•			
Oil and coolant seepage					•	•	•
Oil or coolant spraying and splashing							•
Corrosive agents			•				
Occasional temporary submersion				•			

[a]These enclosures may be ventilated. However, Type 1 may not provide protection against small particles of falling dirt when ventilation is provided in the enclosure top. Consult Hoffman for more information.

[b]These fibers and flyings are non-hazardous materials and are not considered Class II type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings see the National Electrical Code Section 505.

The preceding table is reproduced by permission of the National Electrical Manufacturers Association from NEMA Standards Publication 250 "Enclosures for Electrical Equipment (1000 Volts Maximum)".

ENCLOSURE TYPE RATING VERSUS IP RATING

Electrical enclosures are rated by Type (NEMA 250 / UL 50, 50E), and/or IP rating (IEC 60529) based upon the degree of protection provided. Type ratings and IP ratings have only the following in common:

1. A degree of protection for persons from hazardous components inside the enclosure
2. A degree of protection for equipment inside the enclosure from ingress of solid foreign objects, including dust
3. A degree of protection for equipment inside the enclosure from ingress of water

NEMA 250 and UL 50, 50E Type rating documentation defines additional requirements that a Type-rated enclosure must meet. These include:

- Mechanical impact on enclosure walls
- Gasket aging and oil resistance
- Corrosion resistance
- Door and cover latching requirements
- Sheet metal gauge construction requirements (UL 50 only)

Electrical enclosures that carry only an IP rating have not been designed or tested to the additional Type-rating requirements. For this reason, and because the tests and evaluations for other characteristics are not identical, the IP ratings cannot be exactly equated with NEMA enclosure Types.

Electrical enclosures manufactured by Hoffman are tested for and carry both Type and IP ratings.

Fluid Statics and Dynamic Comparison of Ingress Water Tests

Test Type	Flow Rate (gal./min.)	Flow Rate (l/min.)	Nozzle Diameter in./mm	Nozzle Area ($in.^2$)	Nozzle Velocity (ft./sec.)	Equivalent Head (ft.)	Equivalent Pressure (psi)	Mass Flow (lb./sec.)	Power (hp)	Total Force on Vertical Plate (lb.)
Type 3	45.00	170	1.0000 25.4	0.7854	18.38	5.25	2.274	6.256	0.060	3.5716
Type 4	65.00	246	1.000 25.4	0.7854	26.55	10.85	4.744	9.037	0.180	7.4516
IPX5	3.30	12.5	0.2480 6.3	0.0483	21.93	7.46	3.235	0.459	0.006	0.3126
IPX6	26.42	100	0.4921 12.5	0.1902	44.55	30.82	13.357	3.672	0.206	5.0815

GLOSSARY TERMS SPECIFYING NON-HAZARDOUS ENVIRONMENTAL CONDITIONS

Corrosion-Resistant
Constructed to provide a degree of protection against exposure to corrosive agents such as salt spray. Type 3RX and 4X enclosures meet this requirement.

Damp Locations
Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns and some cold-storage warehouses. See the indoor enclosure types and select a type rating that fits the specific application.

Dust-tight
Constructed so that circulating or airborne dust will not enter the enclosure under specified test conditions. Type 3, 4, 4X, 12, 12K and 13 enclosures meet this requirement.

Drip-tight
Constructed so that falling moisture or dirt does not enter the enclosure under specified test conditions. Type 3, 4, 4X, 12, 12K and 13 enclosures meet this requirement.

Indoor
Not to be exposed to weather. Type 1, 12, 12K and 13 enclosures meet this requirement.

Oil-Resistant
Constructed so that oil will not interfere with successful operation of equipment. Type 12 and 13 enclosures meet this requirement.

Oil-tight
Constructed so that oil will not enter the enclosure under specified test conditions. Type 13 enclosures meet this requirement.

Outdoor
Constructed or protected so that exposure to the weather will not interfere with successful operation of equipment. Type 3, 3R, 4, 4X and 6 enclosures meet this requirement. These ratings can also be used indoors.

Rainproof
Constructed, protected or treated to prevent beating rain from interfering with the successful operation of the apparatus or result in wetting of live parts and wiring within the enclosure under specified test conditions. Type 3R and 3RX enclosures meet this requirement.

Rain-tight
Constructed or protected so that exposure to beating rain will not result in water entering the enclosure under specified test conditions. Type 3, 4, 4X and 6 enclosures meet this requirement.

Water-tight
Constructed so that moisture will not enter the enclosure when it is subjected to a stream of water under specified test conditions. Type 4, 4X and 6 enclosures meet this requirement.

Weatherproof
Constructed or protected so that exposure to the weather will not interfere with successful operation of the equipment. Rainproof, rain-tight or water-tight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust or temperature extremes, are not a factor.

Wet Locations
Installations underground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather. Use weatherproof enclosures with a type rating that fits the specific application.

IP RATING DESCRIPTIONS

Example Rating

If 1st IP number is...	and the 2nd ip number is...	Then the IP rating is
2	3	IP23
(protection against solid objects)	(protection against liquids)	An enclosure with this designation provides protection against touch with a finger, penetration of solid objects greater than 12mm, and spraying water.

First Numeral (Solid Objects and Dust)

IP	Protection of Persons	Protection of Equipment
0	No Protection	No Protection
1	Protected against contact with large areas of the body (back of hand)	Protected against objects over 50 mm in diameter
2	Protected against contact with fingers	Protected against solid objects over 12 mm in diameter
3	Protected against tools and wires over 2.5 mm in diameter	Protected against solid objects over 2.5 mm in diameter
4	Protected against tools and wires over 1 mm in diameter	Protected against solid objects over 1 mm in diameter
5	Protected against tools and wires over 1 mm in diameter	Protected against dust (limited ingress, no harmful deposit)
6	Protected against tools and wires over 1 mm in diameter	Totally protected against dust

Second Numeral (Liquid)

IP	Protection of Equipment
0	No Protection
1	Protected against vertically falling drops of water, e.g. condensation
2	Protected against direct sprays of water up to 15 degrees from vertical
3	Protected against sprays to 60 degrees from vertical
4	Protected against water sprayed from all directions (limited ingress permitted)
5	Protected against low-pressure jets of water from all directions (limited ingress permitted)
6	Protected against strong jets of water
7	Protected against the effects of immersion between 15 cm and 1 m
8	Protected against long periods of immersion under pressure
9	Protected against high pressure and temperature water jets

CE

For industrial control equipment, the CE Mark is not intended to be applied to empty enclosures because such enclosures are inactive components of a final assembly. The responsibility of ensuring compliance with all applicable EU directives and harmonized standards belongs with the final equipment manufacturer.

SHORT CIRCUIT CURRENT RATING FOR ENCLOSURES

The short circuit current rating is not required for an empty UL 508A enclosure. The majority of Hoffman's electrical accessories are generally used in the control circuit portion of a UL 508A Industrial Control Panel. Electrical accessories used in a control circuit are not included in determining the overall short circuit current rating of the industrial control panel. UL has not issued a requirement at the time of this publication to mark these accessories with a short circuit current rating.

For electrical accessories that are NOT located in a control circuit, and are not otherwise marked with a short circuit current rating, like Hoffman's power distribution units, then the default rating in Table SB4.1 of UL 508A would apply to the component being evaluated. If the power distribution unit is essentially receptacles or terminals, then the assumed short circuit current value from Table SB4.1 would be selected.

If the accessory contains both a load and controls, the controls would need to be assigned a short circuit current rating. An example of this would be an air conditioner that has a contactor included in the design. In this case, if the contactor is not marked, the SCCR could be assigned from Table SB4.1 in UL508A, or be tested per UL508, or the standard that applies to the component being evaluated, in this case the contactor.

SHORT CIRCUIT CURRENT RATING FOR AIR CONDITIONERS AND HEAT EXCHANGERS

Article 409 of the 2008 National Electric Code (NFPA 70) requires industrial control panels to be marked with a short circuit current rating. As specified in the National Electric Code, UL508A-2001 Supplement SB, the Standard of Safety for Industrial Control Equipment, provides an accepted method for determining the short-circuit current rating of the control panel.

The SCCR rating for our air conditioners and heat exchangers has a default value of 5 kA.

You may use a 5 or 10 kVA isolation transformer between the customer's panel and our air conditioner and not have an effect on the customer's 65 kA rating.

You may use a fuse or circuit breaker with a 5 kA short circuit rating on the line side of the ACU and its branch circuit protective device and not have an effect on the customer's 65 kA rating.

The current limiting fuse or circuit breaker used on the line side of the branch circuit protection for the ACU must have a SCCR => that of the panel rating. Additionally for a current limiting fuse the customer would need to verify using table SB4.2 of UL 508A, that the let through current (Ip * 10^3) of the fuse is <= 5KA. If a circuit breaker is used as feeder protection, it **must** be marked Current Limiting type from the manufacturer, and the panel builder would need to verify based on the manufacturers published curves that it will let through <= 5kA. Examples of these curves are included in UL 508A supplement SB.

You can run separate circuits for the panel and the air conditioner as long as each is labeled with their individual SCCR ratings.

(5 kA and 65 kA)

If the customer does not implement one of the options above, then the resulting SCCR rating would be the 5 kA rating of the ACU, if that is the lowest rated component in the panel.

Testing represents another option; however, if the customer does not implement these options, then the resulting short circuit rating of the panel is based on the lowest short circuit current rating of all power circuit components installed in the panel.

PAINT FINISHES ON STANDARD HOFFMAN STEEL ENCLOSURES

The National Electrical Manufacturers Association (NEMA) and Underwriters Laboratories Inc. (UL) have responded to the costly problem of corrosion by establishing a rating that guarantees an enclosure meets certain minimum conditions of corrosion resistance.

The NEMA 4X rating is applied to materials subjected to 200 hours of salt spray with no more evidence of corrosive pitting than exhibited by a concurrently run sample of Type 304 stainless steel. One drawback of the NEMA 4X rating, however, is that it only provides salt spray resistance. The task of selecting enclosures that possess satisfactory corrosion and chemical resistance in actual applications is still the responsibility of the specifying engineer. To simplify this task, Hoffman has completed extensive materials comparison testing to establish the parameters of relative material acceptability based upon total submersion of test samples. The results of this testing are summarized here.

Chemical Resistance

The Chemical Resistance chart below and on the following pages is an aid to using our product.
Each chemical and substrate has a three number rating system, 1-2-3. The order of these numbers represents 30, 60 and 120 days of total submersion of the substrate in each chemical at 72 F (22 C). Each column is also coded according to chemical class. This chart is general in nature and not intended to apply to a specific situation. The prospective user must determine the application of our product based upon an environment's individual characteristics.

Hoffman offers no guarantee or warranty as to the applicability of this chart for any particular situation as actual conditions of use are beyond our control.

Chemical Resistance Test Results

Tested Enclosure Material	#1 Fuel Oil (Kerosene)	#2 Fuel Oil	Acetic Acid (10% sol.)	Acetone	Aluminum Chloride (10% sol.)	Aluminum Sulfate (10% sol.)	Ammonium Chloride (10% sol.)	Ammonium Hydroxide (25% sol.)	Ammonium Nitrate (10% sol.)
Fiberglass, Compression Molded	1-1-1	1-1-1	2-2-2	1-2-4	1-1-1	1-1-2	1-1-1	4-4-4	1-1-4
Fiberglass, Pultruded	1-1-1	1-1-1	2-2-2	3-3-4	1-1-1	1-1-1	1-1-1	4-4-4	1-2-4
Fiberglass, Spray-Up	1-1-1	2-2-2	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	1-2-4
Acrylic Clear Sheet	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Acrylic, Molded	1-1-1	2-2-2	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
ABS	2-2-2	4-4-4	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Polycarbonate Clear Sheet	2-2-2	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	1-2-4
Polycarbonate, Silicone Coated	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	4-1-1	1-1-1	4-4-4	1-1-4
Polyester (PBT)	1-1-1	1-1-1	1-1-1	3-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Polyester (PBT Glass Reinforced)	1-2-2	1-2-2	1-1-1	2-3-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Gasket, Rubber Neoprene, Solid 51%	4-4-4	4-4-4	2-2-2	2-3-4	1-1-1	1-1-1	1-1-1	3-3-3	1-1-1
Gasket, Rubber Neoprene, Sponge	4-4-4	4-4-4	4-4-4	3-4-4	1-1-1	3-3-4	1-1-1	3-3-4	1-1-4
Gasket, Rubber Poron, Polyurethane Sponge	1-1-1	4-4-4	1-2-3	4-4-4	1-1-1	1-2-1	1-1-1	1-1-1	1-1-1
Gasket, Rubber Silicone, Sponge	4-4-4	4-4-4	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	3-3-3	1-1-1
Gasket, Rubber Viton, Sponge	1-1-1	1-1-1	2-3-4	4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	1-1-4
Gasket, foam-in-place	1-2-2	1-2-2	1-2-2	3-3-3	–	1-1-1	1-1-1	1-1-1	1-1-1
Aluminum, 5052	1-1-1	1-1-1	4-4-4	1-1-1	4-4-4	3-4-4	3-4-4	4-4-4	2-2-2
Monel	1-1-1	1-1-1	1-2-3	1-1-1	1-1-1	1-2-2	1-1-1	4-4-4	1-1-1
Steel, Cadmium Plate with Chromate	1-1-1	1-1-1	4-4-4	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4
Steel, Epoxy Powder Coat, Painted	1-1-1	1-1-1	4-4-4	2-2-2	4-4-4	1-3-4	3-4-4	4-4-4	4-4-4
Steel, Enamel, Machinery, Over Prime, Painted	1-1-1	1-1-2	4-4-4	1-1-3	4-4-4	1-4-4	3-4-4	4-4-4	3-4-4
Steel, Galvanized, G-90	1-1-1	1-1-1	4-4-4	1-1-3	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4
Steel, Grey Prime, Over Phosphate, Painted	1-1-1	1-1-1	4-4-4	1-1-2	4-4-4	3-4-4	3-4-4	4-4-4	3-4-4
Steel, Polyurethane Painted	1-1-1	1-1-1	4-4-4	4-4-4	4-4-4	3-4-4	4-4-4	4-4-4	4-4-4
Steel, Polyester Powder Painted	1-1-1	2-2-2	4-4-4	2-2-3	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4
Steel, Stainless, Type 304	1-1-1	1-1-1	1-1-1	1-1-1	1-1-2	1-1-2	1-1-1	1-1-1	1-1-1
Steel, Stainless, Type 316	1-1-1	1-1-2	1-1-1	1-1-1	1-1-2	1-1-1	1-1-1	1-1-1	1-1-1

1 Recommended — Unaffected by chemical; no deterioration
2 Satisfactory — Very little effect; reduced aesthetics probable over time
3 Limited use — Chemical attack probable with slow deterioration
4 Not recommended — Severe attack is imminent; rapid deterioration.

	SOLVENTS	ALKALIS	ACIDS
Recommended	Type 304 stainless steel Type 316 stainless steel Fiberglass (compression molded) Aluminum Polyester	ABS Polyester Type 304 stainless steel	ABS Polyester Polycarbonate Fiberglass (spray-up) Type 304 stainless steel Type 316 stainless steel
SATISFACTORY	Steel (polyester powder coat) Fiberglass (spray-up) Polycarbonate ABS	Type 316 stainless steel Polycarbonate Fiberglass (compression molded) Fiberglass (spray-up)	Fiberglass (compression molded)
LIMITED USE		Aluminum Steel (polyester powder coat)	Aluminum Steel (polyester powder coat)

Hoffman offers no guarantee or warranty as to the applicability of these charts for any particular situation as actual conditions of use are beyond our control. Call your local Hoffman distributor for assistance.

This chart provides guidance for determining the feasibility of using certain enclosure materials in environments containing solvents and organics, alkalis and oxidizers, and acids and neutral salts. Materials are rated on a scale of Recommended to Limited Use based upon their performance in resisting corrosion. However, note that the enclosure materials listed as Limited Use will perform well when exposed to certain specific corrosive agents within the three general classes.
We recommend that you refer to the detailed Chemical Resistance Charts on the bottom of this page and on the next several pages for specific performance information based upon your environmental conditions.

Chemical Resistance Test Results (continued)

Ammonium Phosphate (10% sol.)	ASTM #1 Oil	ASTM #3 Oil	Axle Grease	Boric Acid (10% sol.)	Bromine Water	Calcium Chloride (10% sol.)	Calcium Hydroxide (10% sol.)	Calcium Sulfate (10% sol.)	Calcium Hypochlorite (10% sol.)	Carbolic Acid (25% sol.)	Carbon Tetrachloride	Tested Enclosure Material
2-4-4	1-1-1	1-1-1	1-1-1	1-1-1	3-3-3	1-1-1	1-1-3	1-1-1	1-1-3	3-3-3	1-1-1	Fiberglass, Compression Molded
1-2-2	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	3-4-4	1-1-1	2-3-4	4-4-4	1-1-1	Fiberglass, Pultruded
1-1-2	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	3-3-3	1-1-1	1-3-4	4-4-4	1-1-2	Fiberglass, Spray-Up
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	3-3-3	1-1-1	1-1-1	1-1-1	1-2-2	4-4-4	4-4-4	Acrylic Clear Sheet
1-1-1	1-2-2	1-1-1	1-1-1	1-1-1	3-3-3	2-2-2	1-1-1	1-1-1	1-1-3	4-4-4	4-4-4	Acrylic, Molded
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	3-3-3	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	ABS
1-1-1	2-2-2	2-2-2	2-2-2	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	Polycarbonate Clear Sheet
1-1-1	1-2-2	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	3-4-4	1-1-1	4-4-4	4-4-4	4-4-4	Polycarbonate, Silicone Coated
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-2-2	Polyester (PBT)
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	2-2-2	1-1-1	1-1-2	1-1-1	1-2-2	4-4-4	1-1-4	Polyester (PBT Glass Reinforced)
1-1-2	3-3-3	4-4-4	1-3-3	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	3-3-3	2-2-4	Gasket, Rubber Neoprene, Solid 51%
4-4-4	1-1-2	4-4-4	1-2-3	1-1-1	4-4-4	1-1-1	4-4-4	1-1-1	4-4-4	4-4-4	4-4-4	Gasket, Rubber Neoprene, Sponge
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-4	1-1-1	4-4-4	4-4-4	4-4-4	Gasket, Rubber Poron, Polyurethane Sponge
1-1-1	1-1-1	3-3-3	1-1-1	1-1-1	4-4-4	1-1-1	1-1-2	1-1-1	1-1-1	4-4-4	4-4-4	Gasket, Rubber Silicone, Sponge
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	3-3-3	Gasket, Rubber Viton, Sponge
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	1-1-1	4-4-4	2-2-3	3-3-3	Gasket, foam-in-place
4-4-4	1-1-1	1-1-1	1-1-1	1-2-2	4-4-4	2-2-3	4-4-4	1-2-2	3-4-4	1-2-2	1-1-1	Aluminum, 5052
1-1-2	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	Monel
4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-2-2	2-4-4	2-2-3	4-4-4	3-4-4	1-1-1	Steel, Cadmium Plate with Chromate
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-2	1-1-4	2-2-4	4-4-4	4-4-4	1-1-1	Steel, Epoxy Powder Coat, Painted
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-4-4	2-2-3	2-2-4	4-4-4	4-4-4	1-1-4	Steel, Enamel, Machinery, Over Prime, Painted
4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	1-1-1	Steel, Galvanized, G-90
2-2-4	1-1-1	1-1-1	1-1-1	1-4-4	4-4-4	4-4-4	1-4-4	4-4-4	4-4-4	4-4-4	4-4-4	Steel, Grey Prime, Over Phosphate, Painted
1-2-4	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	3-4-4	1-4-4	4-4-4	4-4-4	4-4-4	1-1-1	Steel, Polyurethane Painted
1-1-1	1-1-1	1-1-1	1-1-1	1-4-4	4-4-4	1-4-4	4-4-4	2-2-4	4-4-4	4-4-4	3-4-4	Steel, Polyester Powder Painted
1-2-2	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	Steel, Stainless, Type 304
1-2-2	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	Steel, Stainless, Type 316

Each chemical is also coded according to class.
The following code is located at the top of each chemical column.

Solvents and organics
Alkalis and oxidizers
Acids and neutral salts

Chemical Resistance Test Results (continued)

Tested Enclosure Material	Chlorine Water (5-10 ppm)	Chrome Plating (sol.)	Citric Acid (10% sol.)	Cutting Fluid Castrol (980 H)	Cutting Fluid Norton (205)	Cutting Fluid Rustlick (10% sol.)	Cutting Fluid 5 Star (980 H)	Cutting Oil Dark	Distilled Water	Ethyl Alcohol	Ethylene Glycol	Ferric Chloride (10% sol.)	Formic Acid (10% sol.)	Hydraulic Brake Fluid
Fiberglass, Compression Molded	1-1-1	3-3-3	2-2-2	1-2-2	1-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	3-3-3	1-2-3	1-1-1
Fiberglass, Pultruded	1-1-1	2-3-3	1-1-1	2-2-2	3-3-3	1-1-1	1-2-2	1-1-1	1-1-1	1-1-1	1-1-1	2-2-2	1-2-2	1-1-2
Fiberglass, Spray-Up	1-1-1	2-2-2	1-1-1	2-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	4-4-4	1-1-1	2-2-2
Acrylic Clear Sheet	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-2	4-4-4
Acrylic, Molded	1-1-1	2-2-2	1-1-1	3-3-3	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-2	4-4-4
ABS	1-1-1	3-3-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4
Polycarbonate Clear Sheet	1-1-1	1-1-1	1-1-1	3-3-3	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	1-1-2	1-1-1	1-1-1	1-1-1	3-4-4
Polycarbonate, Silicone Coated	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-1-1	1-1-3	1-1-1	1-1-1	3-4-4
Polyester (PBT)	1-1-1	1-1-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Polyester (PBT Glass Reinforced)	1-1-1	3-3-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Gasket, Rubber Neoprene, Solid 51%	1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4
Gasket, Rubber Neoprene, Sponge	1-1-3	4-4-4	4-4-4	2-3-3	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	1-2-4	1-1-1	1-3-3	3-3-4	3-4-4
Gasket, Rubber Poron, Polyurethane Sponge	1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	2-3-3	1-2-4	4-4-4
Gasket, Rubber Silicone, Sponge	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-4-4	1-1-1	1-1-1	1-1-1	1-1-2	4-4-4	1-1-2
Gasket, Rubber Viton, Sponge	1-1-1	2-2-2	1-1-1	4-4-4	1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	2-2-3	4-4-4
Gasket, foam-in-place	—	—	1-1-1	1-1-1	—	—	—	—	1-1-1	2-3-3	1-1-1	1-2-2	2-2-2	2-2-3
Aluminum, 5052	2-2-2	4-4-4	2-4-4	1-1-1	3-3-4	2-2-2	1-1-1	1-1-1	1-2-4	1-1-1	1-1-1	4-4-4	2-4-4	1-1-1
Monel	1-1-1	3-3-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	3-4-4	1-1-1	1-1-1
Steel, Cadmium Plate with Chromate	2-3-3	4-4-4	4-4-4	2-2-2	3-3-4	4-4-4	2-2-3	1-1-1	3-3-3	1-1-1	1-1-1	4-4-4	4-4-4	1-1-2
Steel, Epoxy Powder Coat, Painted	1-1-1	4-4-4	4-4-4	1-1-1	1-2-2	1-1-1	1-1-1	1-1-1	1-1-2	1-1-2	1-1-1	4-4-4	4-4-4	4-4-4
Steel, Enamel, Machinery, Over Prime, Painted	1-4-4	4-4-4	1-4-4	1-4-4	1-2-3	1-1-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	2-3-3
Steel, Galvanized, G-90	4-4-4	4-4-4	4-4-4	2-3-4	4-4-4	4-4-4	2-2-4	1-1-1	4-4-4	1-1-1	2-2-4	4-4-4	4-4-4	1-1-1
Steel, Grey Prime, Over Phosphate, Painted	1-1-1	4-4-4	4-4-4	1-4-4	1-4-4	1-4-4	1-1-4	1-1-1	1-4-4	1-1-1	1-1-1	4-4-4	4-4-4	1-1-3
Steel, Polyurethane Painted	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	1-4-4	1-1-1	4-4-4	4-4-4	1-1-1	4-4-4	4-4-4	4-4-4
Steel, Polyester Powder Painted	1-1-1	4-4-4	1-4-4	1-1-1	3-4-4	1-4-4	1-4-4	1-1-1	1-1-1	2-2-2	1-1-1	4-4-4	4-4-4	4-4-4
Steel, Stainless, Type 304	1-1-1	3-3-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	3-4-4	1-1-1	1-1-1
Steel, Stainless, Type 316	1-1-1	3-3-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	3-4-4	1-1-1	1-1-1

Tested Enclosure Material	Perchlor-ethylene	Phosphoric Acid (50% sol.)	Phosphoric Acid (25% sol.)	Pickling (Solution)	Potassium Chloride (25% sol.)	Potassium Carbonate (10% sol.)	Potassium Hydroxide (25% sol.)	Potassium Nitrate (10% sol.)	Potassium Sulfate (10% sol.)	Sea Water	Soap Igepal (10% sol.)	Sodium Bicarbonate (10% sol.)	Sodium Bisulfate (10% sol.)	Sodium Chloride (25% sol.)
Fiberglass, Compression Molded	1-1-1	4-4-4	2-4-4	2-2-2	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	3-3-4	1-1-1
Fiberglass, Pultruded	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	2-3-3	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	2-2-2	2-3-3	1-1-1
Fiberglass, Spray-Up	4-4-4	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Acrylic Clear Sheet	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Acrylic, Molded	4-4-4	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
ABS	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Polycarbonate Clear Sheet	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Polycarbonate, Silicone Coated	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	2-3-3	3-3-3	1-1-1	1-1-1	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1
Polyester (PBT)	1-1-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Polyester (PBT Glass Reinforced)	1-1-3	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Gasket, Rubber Neoprene, Solid 51%	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	1-1-1
Gasket, Rubber Neoprene, Sponge	4-4-4	1-1-1	1-1-1	1-1-3	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1
Gasket, Rubber Poron, Polyurethane Sponge	4-4-4	4-4-4	4-4-4	2-2-2	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-2-4	1-1-1
Gasket, Rubber Silicone, Sponge	1-1-1	1-1-2	1-1-1	2-2-2	1-1-1	1-1-1	3-4-4	1-1-1	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	1-1-1
Gasket, Rubber Viton, Sponge	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-3	2-2-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Gasket, foam-in-place	2-2-2	2-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-2-3	1-1-1	1-1-1	1-1-1	3-3-3	1-1-1	1-1-1	1-1-1
Aluminum, 5052	1-1-1	4-4-4	4-4-4	4-4-4	2-3-3	4-4-4	4-4-4	4-4-4	3-3-3	3-3-3	2-3-3	2-2-3	4-4-4	2-2-3
Monel	1-1-1	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Steel, Cadmium Plate with Chromate	1-1-1	4-4-4	4-4-4	4-4-4	3-4-4	4-4-4	4-4-4	3-3-3	4-4-4	2-4-4	4-4-4	2-2-3	4-4-4	4-4-4
Steel, Epoxy Powder Coat, Painted	1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-2-2
Steel, Enamel, Machinery, Over Prime, Painted	1-1-3	4-4-4	4-4-4	2-4-4	4-4-4	1-1-1	4-4-4	2-4-4	4-4-4	4-4-4	1-4-4	1-1-1	4-4-4	4-4-4
Steel, Galvanized, G-90	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	1-3-3	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4
Steel, Grey Prime, Over Phosphate, Painted	1-1-1	4-4-4	4-4-4	2-4-4	4-4-4	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	1-1-4	4-4-4	4-4-4
Steel, Polyurethane Painted	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	1-1-1	4-4-4	4-4-4
Steel, Polyester Powder Painted	1-1-1	4-4-4	4-4-4	1-4-4	4-4-4	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	4-4-4
Steel, Stainless, Type 304	1-1-1	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
Steel, Stainless, Type 316	1-1-1	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	2-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1

1 Recommended — Unaffected by chemical; no deterioration
2 Satisfactory — Very little effect; reduced aesthetics probable over time
3 Limited use — Chemical attack probable with slow deterioration
4 Not recommended — Severe attack is imminent; rapid deterioration.

Chemical Resistance Test Results (continued)

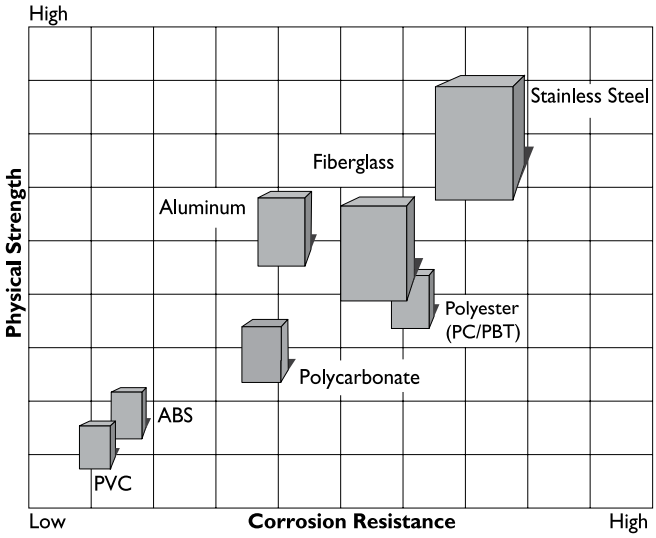
Hydraulic Oil	Hydrochloric Acid (25% sol.)	Hydrofluoric Acid (40% sol.)	Isopropyl Alcohol	Lacquer Thinner	Liquid Dish Soap (10% sol.)	Magnesium Chloride (10% sol.)	Magnesium Hydroxide (10% sol.)	Mercuric Chloride (10% sol.)	Methylene Chloride	Mineral Spirits	Motor Oil (10 wt.)	Nitric Acid (25% sol.)	Oxalic Acid (10% sol.)	Tested Enclosure Material
1-1-1	4-4-4	4-4-4	1-1-1	1-2-3	1-1-1	1-1-1	1-1-1	2-2-3	1-2-4	1-1-1	1-1-1	4-4	4-4-4	Fiberglass, Compression Molded
1-1-1	2-2-2	4-4-4	1-1-1	1-2-3	1-1-1	1-1-1	1-1-1	2-2-2	4-4-4	1-1-1	1-1-1	3-3-3	4-4-4	Fiberglass, Pultruded
1-1-1	1-2-2	2-2-2	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-2-3	1-1-2	Fiberglass, Spray-Up
1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	Acrylic Clear Sheet
1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	Acrylic, Molded
1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-2-2	1-1-1	ABS
2-2-2	1-1-1	2-2-2	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-2-2	1-1-1	3-3-3	1-1-1	Polycarbonate Clear Sheet
1-1-1	1-1-1	1-4-4	4-4-4	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	3-3-3	1-1-1	Polycarbonate, Silicone Coated
1-1-1	2-2-2	2-2-2	1-1-1	1-3-3	1-1-1	1-1-1	1-1-1	1-2-3	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	Polyester (PBT)
1-1-1	1-1-1	1-3-3	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-3	4-4-4	1-1-1	1-1-1	3-3-3	1-1-1	Polyester (PBT Glass Reinforced)
4-4-4	2-2-2	1-3-3	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-2-4	4-4-4	4-4-4	4-4-4	4-4-4	1-1-1	Gasket, Rubber Neoprene, Solid 51%
4-4-4	3-3-3	4-4-4	1-1-1	4-4-4	1-1-3	1-1-1	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	1-4-4	Gasket, Rubber Neoprene, Sponge
1-1-1	4-4-4	1-2-2	1-1-1	1-3-4	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	4-4-4	Gasket, Rubber Poron, Polyurethane Sponge
1-1-1	4-4-4	4-4-4	1-1-1	1-1-4	1-1-1	1-1-1	1-1-1	3-4-4	1-1-4	4-4-4	4-4-4	4-4-4	3-4-4	Gasket, Rubber Silicone, Sponge
1-1-1	1-1-1	1-1-1	1-1-2	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	Gasket, Rubber Viton, Sponge
1-1-1	1-1-1	2-2-2	—	4-4-4	2-2-2	1-1-1	1-1-1	1-2-3	3-3-3	1-2-2	1-1-1	4-4-4	1-1-1	Gasket, foam-in-place
1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	2-2-2	2-3-3	2-3-3	4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	Aluminum, 5052
1-1-1	2-3-4	1-2-3	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	Monel
1-1-1	4-4-4	4-4-4	1-1-1	1-1-2	1-2-3	3-4-4	3-4-4	4-4-4	1-1-3	1-1-1	1-1-1	4-4-4	4-4-4	Steel, Cadmium Plate with Chromate
1-1-1	4-4-4	4-4-4	1-1-1	1-2-3	1-1-1	1-1-1	1-1-1	4-4-4	2-2-4	1-1-1	1-1-1	4-4-4	4-4-4	Steel, Epoxy Powder Coat, Painted
1-1-1	4-4-4	4-4-4	1-1-1	4-4-4	1-1-4	3-4-4	3-4-4	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	4-4-4	Steel, Enamel, Machinery, Over Prime, Painted
1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	3-4-4	3-4-4	4-4-4	1-1-2	1-1-1	1-1-1	4-4-4	4-4-4	Steel, Galvanized, G-90
1-1-1	4-4-4	4-4-4	1-1-1	1-4-4	4-4-4	2-4-4	2-4-4	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	4-4-4	Steel, Grey Prime, Over Phosphate, Painted
1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	3-4-4	3-4-4	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	4-4-4	Steel, Polyurethane Painted
1-1-1	4-4-4	4-4-4	2-2-2	2-2-3	1-4-4	2-4-4	2-4-4	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	4-4-4	Steel, Polyester Powder Painted
1-1-1	4-4-4	2-2-2	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	Steel, Stainless, Type 304
1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	1-2-2	1-1-1	1-1-1	1-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	Steel, Stainless, Type 316

Sodium Hydroxide (25% sol.)	Sodium Hypochlorite	Sodium Nitrate (10% sol.)	Sodium Phosphate (10% sol.)	Stoddard Solvent	Sulfuric Acid (25% sol.)	Sulfuric Acid (10% sol.)	Tannic Acid (10% sol.)	Tetrahydrofuran	Toluene	Turpentine	Unleaded Gasoline	Xylene	Zinc Chloride (10% sol.)	Tested Enclosure Material
4-4-4	2-4-4	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	1-1-3	3-4-4	1-1-1	1-1-2	1-1-1	1-1-1	1-1-1	Fiberglass, Compression Molded
4-4-4	3-4-4	1-1-1	1-2-2	1-1-1	2-3-4	1-1-2	1-1-1	4-4-4	1-1-1	1-1-1	1-1-3	1-1-1	1-1-1	Fiberglass, Pultruded
4-4-4	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-2-2	1-1-2	4-4-4	4-4-4	1-1-1	3-3-3	3-4-4	1-1-1	Fiberglass, Spray-Up
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	1-1-1	Acrylic Clear Sheet
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	4-4-4	4-4-4	1-1-1	Acrylic, Molded
1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	4-4-4	4-4-4	1-1-1	ABS
3-3-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	1-1-4	4-4-4	1-2-2	Polycarbonate Clear Sheet
2-2-4	2-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	4-4-4	4-4-4	1-1-1	Polycarbonate, Silicone Coated
2-2-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	4-4-4	4-4-4	1-1-1	1-1-1	4-4-4	1-1-1	Polyester (PBT)
4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	3-4-4	4-4-4	1-1-1	1-1-1	1-1-2	1-1-1	Polyester (PBT Glass Reinforced)
1-2-3	4-4-4	1-1-1	1-1-1	4-4-4	3-4-4	2-2-2	1-1-1	4-4-4	4-4-4	4-4-4	3-4-4	4-4-4	1-1-1	Gasket, Rubber Neoprene, Solid 51%
4-4-4	4-4-4	1-1-1	1-4-4	4-4-4	1-1-1	3-4-4	1-4-4	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	1-1-2	Gasket, Rubber Neoprene, Sponge
1-2-2	4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	1-2-3	4-4-4	4-4-4	4-4-4	2-3-4	1-1-1	2-3-4	1-4-4	Gasket, Rubber Poron, Polyurethane Sponge
4-4-4	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	4-4-4	3-3-4	4-4-4	4-4-4	2-3-4	4-4-4	3-4-4	1-1-3	Gasket, Rubber Silicone, Sponge
1-2-2	1-1-1	1-1-1	1-1-1	4-4-4	1-1-1	4-4-4	3-3-4	4-4-4	4-4-4	2-3-4	4-4-4	3-4-4	1-1-3	Gasket, Rubber Viton, Sponge
1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-2	1-1-1	2-2-3	3-3-3	3-3-3	1-2-2	1-2-2	3-3-3	1-1-1	Gasket, foam-in-place
4-4-4	4-4-4	1-1-2	3-3-3	1-1-1	4-4-4	4-4-4	2-3-4	1-2-2	1-1-1	1-1-1	1-1-1	1-1-1	2-3-3	Aluminum, 5052
1-1-1	1-2-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	2-2-2	1-1-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	Monel
4-4-4	4-4-4	4-4-4	4-4-4	1-1-1	4-4-4	4-4-4	4-4-4	1-4-4	1-1-1	1-2-3	1-1-1	1-1-1	1-4-4	Steel, Cadmium Plate with Chromate
1-4-4	4-4-4	1-1-1	1-1-1	1-1-1	2-3-4	1-4-4	1-1-1	4-4-4	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	Steel, Epoxy Powder Coat, Painted
4-4-4	4-4-4	2-2-2	2-2-3	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	1-3-4	1-1-2	1-1-1	1-1-4	1-1-1	Steel, Enamel, Machinery, Over Prime, Painted
4-4-4	4-4-4	4-4-4	4-4-4	1-1-1	4-4-4	4-4-4	4-4-4	1-4-4	1-1-1	2-2-3	1-1-1	1-1-1	3-4-4	Steel, Galvanized, G-90
4-4-4	4-4-4	1-1-4	2-4-4	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	1-2-2	1-2-3	1-1-1	1-1-1	1-4-4	Steel, Grey Prime, Over Phosphate, Painted
4-4-4	4-4-4	1-4-4	2-4-4	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	4-4-4	1-4-4	1-4-4	4-4-4	1-4-4	Steel, Polyurethane Painted
4-4-4	4-4-4	3-4-4	2-4-4	1-1-1	4-4-4	4-4-4	4-4-4	4-4-4	2-2-3	1-1-2	2-2-2	2-2-3	1-1-1	Steel, Polyester Powder Painted
2-2-2	1-2-2	1-1-1	1-1-2	1-1-1	1-4-4	1-1-1	2-2-2	1-1-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	Steel, Stainless, Type 304
1-2-2	1-1-3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	2-2-2	1-1-2	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1	Steel, Stainless, Type 316

Each chemical is also coded according to class.
The following code is located at the top of each chemical column.

Solvents and organics
Alkalis and oxidizers
Acids and neutral salts

STRENGTH/CORROSION RESISTANCE OF ENCLOSURE MATERIALS



Specifying Enclosure Materials
While some enclosure materials offer exceptional corrosion resistance, they may not provide the physical strength required to support internal components. This graph plots primary enclosure materials on a grid of physical strength and corrosion resistance.

SHEET METAL THICKNESS

Steel and Stainless Steel (Less masking)

Gauge	Agency Listed Minimum (in.)	Agency Listed Minimum (mm)	Agency Listed Maximum (in.)	Agency Listed Maximum (mm)
22	.026	.66	.030	.76
20	.032	.81	.036	.91
18	.042	1.07	.046	1.17
16 Comm Steel	.053	1.35	.061	1.55
16 for Drawing	.057	1.45	.061	1.55
14	.067	1.70	.077	1.96
12	.093	2.36	.105	2.67
10	.123	3.12	.135	3.43
7	.172	4.37	.184	4.67
3/16	.187	4.75	—	—
3/8	.365	9.27	—	—

Galvanized Steel (Includes zinc coating)

Gauge	Agency Listed Minimum (in.)	Agency Listed Minimum (mm)	Agency Listed Maximum (in.)	Agency Listed Maximum (mm)
18	.045	1.14	.055	1.40
16	.056	1.42	.069	1.75
14	.070	1.78	.086	2.19
12	.097	2.46	.113	2.87
10	.126	3.20	.143	3.63

Aluminum (Less masking)

ANSI Standard Thickness (in.)	ANSI Standard Thickness (mm)	A.A. Minimum (in.)	A.A. Minimum (mm)	Agency Listed Minimum (in.)[a]	Agency Listed Minimum (mm)[a]	Agency Listed Maximum (in.)	Agency Listed Maximum (mm)
.063	1.60	.058	1.47	.058	1.47	.068	1.73
.080	2.03	.074	1.88	.075	1.90	.086	2.18
.090	2.29	.084	2.13	—	—	.096	2.44
.100	2.54	.093	2.36	.095	2.41	.107	2.72
.125	3.18	.118	3.00	.122	3.10	.132	3.35
.160	4.06	.149	3.78	.153	3.89	.171	4.34
.190	4.83	.179	4.55	—	—	.201	5.11

[a] Agency listed minimum is only required for enclosures designed to meet thickness requirements of UL508A and/or CSA C22.2 No. 14.

A.A. = Aluminum Association

Mechanical/Physical Properties Non-Metallic Materials

Property	Flexural Strength	Notched Izod Impact	Water Absorption (24 hrs.)	Tensile Strength	Specific Gravity	Flammability Rating	Heat Deflection	Service Temp Range	Thermal Conductivity	Dielectric Strength	Arc Resistance
ASTM Test Method	D-790	D-256	D-570	D-638	D-792	UL94	D-648	—	C-177	D-149	D-495
Value	PSI	Ft Lb/In	%	PSI	—	—	°F / °C 264 PSI	°F / °C	BTU In/Hr Ft2 °F	VPM	Seconds
TEST MATERIAL											
ABS (Bulletin Q41)	9,400	2.8	0.27	6,500	1.05	94HB	203/95	-4 F/-20 C 149 F/65 C	1.18	400	60-120
Acrylic, Sheet (instrumentation windows)	16,000	0.4	0.20	10,500	1.19	94HB	205/96	-31 F/-35 C 180 F/82 C	1.30	500	No Tracking
Fiberglass, Spray-up (Bulletin A17)	29,250	> 12.0	0.25	17,500	1.65 Approx.	94V-0	428/220	-31 F/-35 C 266 F/130 C	—	—	—
Fiberglass, Compression (Bulletin A17, A48, A50 and UX1)	18,000	12.0	0.30	8,000	1.77	94-5V	395/202	-31 F/-35 C 266 F/130 C	2.0	375	180
Polyamide (Nylon) (cover screws and hinges)	7,900	3.0	1.00	4,300	1.14	94HB	175/80	-22 F/-30 C 212 F/100 C	1.74	430	60-120
Polycarbonate, Glass Reinforced, Bodies (Bulletin Q41)	18,000	2.0	0.13	10,100	1.27	94V-1	275/135	-31 F/-35 C 248 F/120 C	1.60	450	<60
Polycarbonate, Opaque and Clear Covers (Bulletin Q41)	14,400	14.0	0.15	9,400	1.20	94V-0	275/135	-31 F/-35 C 248 F/120 C	1.46	430	<60
Polyester, Glass Reinforced (latches and hinges)	19,000	4.3	0.08	12,000	1.47	94HB	374/190	-31 F/-35 C 266 F/130 C	—	—	—
Polyester, Non-Glass Reinforced	11,600	2.06 @ -22 F 15.0 @ 73 F	0.10	7,690	1.30	94-5V	175/80	-31 F/-35 C 246 F/118 C	—	—	—

Hoffman offers no guarantee or warranty as to the applicability of this chart for any particular situation as actual conditions and methods of use of our product are beyond our control.
UL 746C requires enclosures either be constructed from a 5VA rated material or pass a 5-inch flame test performed on the end product. Many materials not rated 5VA will pass the end product 5-inch flame test.

The following chart is an aid to using our non-metallic products. This chart is general in nature and not intended to apply to any particular situation. The prospective user must determine the application of our product based upon an environment's individual characteristics. **Hoffman offers no guarantee or warranty as to the applicability of this chart for any particular situation as actual conditions and methods of use of our product are beyond our control.**

[To further assist in the identification of acids or alkalis the following pH values can be used: values of 0 to 7 indicate acids and values of 7 to 14 indicate alkalis.]

Environmental Conditions Non-Metallic Materials

Enclosure Material	Weak Acids	Strong Acids	Weak Alkalis	Strong Alkalis	Organic Solvents	Outdoor Weatherability	Service Temperature Range[a]
ABS (Bulletin Q41)	Good	Good	Good	Good	Not Recommended	Not Recommended	-4 F to 149 F 20 C to 65 C
Fiberglass (spray-up) (Bulletin A17)	Excellent	Good	Good	Fair	Excellent	Excellent	-31 F to 266 F 35 C to 130 C
Fiberglass (compression) (Bulletin A48, A50, and UX1)	Excellent	Good	Good	Fair	Excellent	Excellent	-31 F to 266 F 35 C to 130 C
Polycarbonate (Bulletin Q41)	Excellent	Good	Fair	Not Recommended	Not Recommended	Good	-31 F to 248 F 35 C to 120 C

a Special gasket material is required if the temperature exceeds 150 F (66 C).

Selecting and Specifying Materials and Paint Finishes Metals

Characteristics of Various Materials	Relative Cost	Suggested Application
Hot-Rolled Pickled and Oiled Steel Sheets (ASTM A569) A low-carbon, hot-finished steel produced by passing bar stock, at a temperature above the recrystalization temperature, between a set of rolls. Scale has been removed by means of a hot, weak sulfuric acid bath, after which an oil film is applied.	Low	General indoor and outdoor use after a suitable finish has been applied to protect against corrosion.
Cold-Rolled Steel (ASTM A366) A low-carbon, cold-finished steel produced by passing bar stock through a set of rolls.	Low	General indoor and outdoor use after a suitable finish has been applied to protect against corrosion.
Galvanized Steel (ASTM A653) Steel with a zinc coating to provide corrosion resistance. The most common method of applying the zinc coating is hot-dip galvanizing. Other optional methods include electrodeposition and metal spraying. Galvanizing provides protection against corrosion by serving as a sacrificial barrier and providing cathodic protection at sheared edges.	Low to Moderate	Indoor or outdoor use in neutral pH (pH is a measurement of the degree of acidity or alkalinity of a solution: pH values from 0 to 7 indicate acidity, and pH values from 7 to 14 indicate alkalinity). Resists oil, gas, glycerine, dichromates, borates and silicates. Most frequent application is outdoor including seacoast atmospheres. Additional finishes may be applied to improve corrosion resistance.
304 Stainless Steel (18-8 Stainless Steel) Containing 18 percent chromium and 8 percent nickel, it is often referred to as 18-8. It is the most commonly used nickel based austenitic alloy in the stainless family. Excellent corrosion-resistance properties and ease of fabrication contribute to its popularity. 304 stainless steel provides good corrosion resistance to many chemicals, including moderately aggressive organic acids.	Moderate	Indoor and outdoor use. Ideally suited for use in food processing areas, dairies, breweries or any wet area. Also works well in areas where caustic elements or alkalis are present.
316 and 316L Stainless Steel Contains molybdenum (2%) which provides more corrosion resistance than chromium-nickel (18-8) stainless steels in most applications. Exceptions include highly oxidizing acids, such as nitric acid which attacks the molybdenum. The 316L low-carbon version has less carbon (.03 percent vs .08 percent) than standard 316 and provides better corrosion resistance to agents that attack carbon. The superior corrosion resistance provided by molybdenum makes 316 a preferred material choice for chloride and marine environments.	Moderate to High	Indoor or outdoor use in almost any environment. These stainless steels are the most corrosion-resistant metal materials used by Hoffman. Preferred material choice for marine environments.
5052 Aluminum A lightweight metal that has a protective oxide layer which shields its surface from most corrosive elements. 5052 is the strongest non-heat-treatable aluminum alloy.	Moderate	Indoor or outdoor use, particularly in marine environments. Also an excellent choice for enclosures exposed to solvents, petrochemicals, some acids, most sulfates and nitrates.
Monel A high nickel-base alloy characterized by good strength and good resistance to heat and corrosion.	High	Frequently specified for marine and chemical plant applications, Hoffman uses monel hardware on many of its non-metallic enclosures.
Galvannealed Steel (ASTM A653) Steel with zinc on both sides specifically designed to be used in the painted condition. Typically hot-dipped to A40 and A60 designations. Features include: • Corrosion resistance • Excellent paintability • Easy weldability • The combined paint/galvannealed coating offers resistance to peeling and/or blistering with properly selected paints and primers.	Low to Moderate	Indoor or outdoor use where a painted finish is important. Used in the automotive industry.

Selecting and Specifying Materials and Paint Finishes Composite Materials

Characteristics of Various Materials	Relative Cost	Suggested Application
Polycarbonate A high-performance engineering thermoplastic resin that is processed by injection molding or sheet extrusion for Hoffman applications. Polycarbonate exhibits high impact resistance, a wide range of temperature limits, good dimensional stability, good electrical properties, and the clear polycarbonate has very good transparency. Hoffman uses grades that are fire retardant and that have been silicone coated to improve scratch resistance and UV exposure. Glass fiber reinforced grades provide increased stiffness and higher service temperature.	Low to Moderate	Hoffman uses glass fiber reinforced polycarbonate for bodies and mounting feet on the PC versions of Bulletin Q41. Unreinforced opaque and transparent is used for covers on the PC version of Bulletin Q41. Transparent polycarbonate is also used for clear covers on the AB version of Bulletin Q41, for windows in window kits and as the window in most bonded-in window enclosure applications. Polycarbonate is excellent for all indoor and outdoor applications with the exception of environments that contain strong alkalis, acids or organic solvents. Polycarbonate has a service temperature range of 31 F (-0.55 C) to 180 F (82 C).
Polyester (PBT and PBT/PC Blend) A very high-performing engineering thermoplastic and thermoplastic alloy that is processed by injection molding. Polyester exhibits high impact resistance, a wide range of temperature limits, good dimensional stability, excellent electrical properties, and chemical and moisture resistances. Hoffman uses several modified grades for enhanced material performance. Glass reinforced PBT improves stiffness and has a higher service temperature. The polyester blended with polycarbonate provides improved weatherability and impact resistance.	Moderate	Glass fiber reinforced polyester is used for latches and hinges on Bulletins A17, A48, A50 and ULTRX® enclosures. Polyester is recommended for indoor and outdoor use, although slight yellowing in color may occur in direct sunlight. A blended polyester/polycarbonate is used for POLYPRO Enclosures. This material has the highest performance of all thermoplastic materials and can be used in most environments that contain strong alkalis, acids or organic solvents. High temperature and high humidity applications are not recommended. Polyester has a service temperature range of -15 F (-27 C) to 185 F (85 C).
Fiberglass Thermoset polyester reinforced with glass fiber is our highest overall performance engineering composite resin. Fiberglass grades used by Hoffman are processed by transfer molding, injection compression, compression molding, pultrusion, RTM and open molding. This material provides the highest level of flame resistance of the composite materials used by Hoffman. It exhibits good rigidity, high impact strength, a superior temperature range capability, dimensional stability and electrical properties. Items molded using the process of transfer molding, injection compression, compression and open molding all provide exceptional moisture and chemical resistance.	Low to Moderate	Hoffman uses the compression-molding process for Bulletins F25 and F30 wireway flanges, and for the collars, bodies, covers and doors on Bulletins A48, A50, ULTRX and a portion of the A17 enclosures. All Bulletin A17 doors, backs 36 x 30 inch and smaller, and bodies 12-in. deep or less are compression molded. All Bulletin A17 bodies 12-in. deep or greater and 36 x 36 in. and larger, plus free-stands, are open molded. Doors for these enclosures are molded using the RTM process to provide greater consistency. The pultrusion process is used for bodies and covers on Bulletins F25 and F30 wireway. Fiberglass is recommended for indoor or outdoor use and is ideally suited for environments having extreme temperatures, a high salt concentration, strong alkalis, acids or organic solvents. It is also recommended for corrosive areas or environments that are continuously wet with one exception. Components molded using the pultrusion process should not be used in areas where submersion can occur. Fiberglass is frequently specified for use in petrochemical plants, sewage processing plants, food processing areas and plating facilities. Fiberglass has a service temperature range of 31 F (-0.55 C) to 266 F (130 C).
ABS and ABS/PC Blend An engineered thermoplastic and thermoplastic alloy that utilizes the process of injection molding. Hoffman uses grades that exhibit high impact resistance, a good temperature range, dimensional stability and electrical properties. Flame-retardant characteristics are somewhat less than other composite materials but meet application requirements. ABS and ABS blends have very good chemical resistance to both alkalis and acids. ABS is not recommended for use in environments where organic solvents are present.	Low	Hoffman uses ABS in the ABS version of Bulletin Q41 enclosures, DataCom racks and accessories, and many other accessories such as print pockets and fan grilles. ABS is a low-cost alternative to polycarbonate and provides a very good appearance, a high level of flexibility and corrosion resistance. ABS is recommended for indoor use in corrosive environments that have a moderate to high alkali and acid presence. ABS has a service temperature range of 0 F (-18 C) to 125 F (52 C).
Acrylic This engineered thermoplastic resin is processed by injection molding or sheet extrusion. Typical use by Hoffman is as a sheet extrusion. Clear and tinted acrylic windows provide a low-cost alternative to polycarbonate. Acrylic material has good weatherability, better scratch resistance than uncoated polycarbonate, and greater chemical resistance to alkalis, acids and organic solvents. When deciding to use an acrylic in place of a polycarbonate, consideration should be given to its lower flame retardant and impact resistance values.	Low	Acrylic material is recommended for indoor and outdoor use, although when subjected to prolonged direct sunlight, slight yellowing may occur. Hoffman uses for acrylic include clear and tinted windows, and DataCom and PROLINE cabinet window kits.
Polyamide (Nylon) A high-performance engineering thermoplastic that is processed by injection molding, Polyamide exhibits high impact resistance, wide temperature limits and excellent wear resistance. Polyamide has good chemical resistance to alkalis and organic solvents but is not recommended for use in environments where strong acids are present. Hoffman uses grades modified for low water absorption and some glass fiber reinforced grades for increased stiffness and strength.	Low to Moderate	Polyamide is used for cover screws and hinges on Bulletin Q41 enclosures. It is also used for accessories, such as hinges on ACCESSPLUS, feet on PROLINE and latch components on many models that require a material that provides good impact and wear resistance.




Paint Finishes on Standard Hoffman Steel Enclosures

Hoffman steel enclosures are painted with one of the following finishes:

- Polyester powder coating is electrostatically applied to all inside and outside surfaces. The powder coating is then baked at high temperatures to bond the coating to the enclosure surface.
- Alkyd liquid enamel coating is used on some wall-mount enclosures. The alkyd paint is baked to cure.

Hoffman polyester powder coatings and alkyd liquid enamel coatings are finish coats. *Recoating is not necessary to meet UL or NEMA rating requirements.*

Recoating powder and liquid finishes is possible using the instructions furnished on this page.

Standard Finishes

Standard colors and finishes offered on Hoffman products are suited to match those used in most installations. Frequently requested color options are available with minimal additional lead-time. We also offer more than 100 custom paint colors and textures.

Custom Finishes

Custom colors and finishes also are available on Hoffman products. Our advanced paint systems and flexible manufacturing lines enable us to deliver custom orders with minimal additional lead-time.

Repainting Hoffman Standard Finishes

Confirm with your paint manufacturer that the paint you will be applying is compatible with the factory-applied paint on the Hoffman product. Refer to the product pages in this catalog for information on the specific paint finish. Contact your local Hoffman distributor or authorized sales representative if you have questions.

Repainting alkyd enamel paints

For best adhesion results, correct surface preparation prior to repainting is essential.

- Thoroughly sand all surfaces with 240 grit sandpaper. After sanding, wipe all surfaces with a solvent containing ketone (for example, the generic solvent MIBK, or brand name solvents such as Sherwin-Williams R7K69 and PPG Industries 97-725).
- Next, apply the finish coat. Avoid heavy coats. To prevent discoloration of alkyd finishes, do not bake at temperatures exceeding 250 F.
- Finally, allow the paint to cure properly for optimum adhesion and hardness. Consult the paint manufacturer for cure rates and temperatures.

Repainting polyester powder paints:

Always consult your paint manufacturer for specific recoating and curing instructions. Test the new paint on an inconspicuous area prior to use.

All Hoffman standard polyester powder coated finishes can be repainted with air dry or baked paints.

Some types of paint adhere better than others when applied over polyester powder. The following finishes exhibit very good adhesion properties.

- Two-component epoxies
- Some two-component polyurethanes
- Alkyd baking enamels (Do not bake at temperatures exceeding 150 F.)

For best adhesion results, correct surface preparation prior to repainting is essential.

- Thoroughly sand all enclosure surfaces with 180 grit sandpaper. To minimize sanding marks, finish sanding with 220 or 240 grit sandpaper. Wet-wipe all surfaces with a solvent to remove contaminants.

If using air-dry touch-up paint supplied in aerosol cans, apply two or three medium to light coats of paint, allowing two or three minutes flash-off between coats. Allow paint to cure adequately prior to testing for adhesion.

Selecting a Non-Standard Paint for Your Enclosure

In order to select the best paint for your enclosure, you must first establish your criteria and their order of importance. Paints basically perform two functions: protection and decoration. No one paint formulation does it all.

Paint formulators frequently wish to know the exposure conditions as a first step. They subdivide into three categories:

- Severe conditions including total immersion in chemicals or salt water, coastal situations, areas of high industrial pollution and areas close to chemical processing plants.
- Moderate conditions are found in outdoor exposure to heavy rainfall and continuous humidity in light industrial and urban conditions, rural areas and inland areas more than two miles from industrial districts and coastal areas.
- Mild conditions are experienced in interiors subject to condensation, as well as interiors where there is a pollution source. Very mild conditions are found in warm, dry interiors not subject to condensation or pollution.

Besides exposure conditions pertaining to corrosion and weathering, paint formulators are also concerned with whether your enclosure will be exposed to bright sunlight and high temperatures.

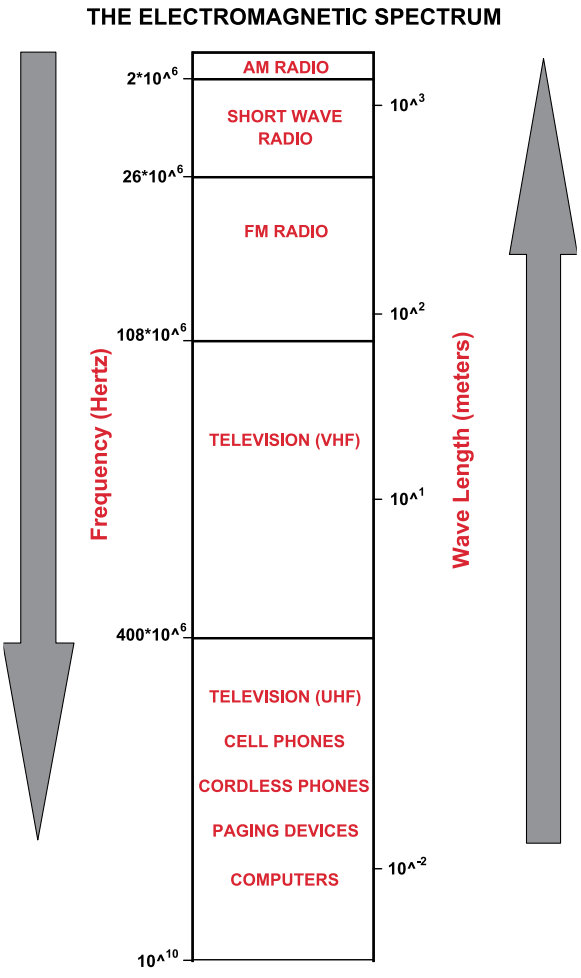
Selections Tips

Refer to Hoffman's Finish Chart for readily available finishes. The following points aid in selecting the best finish for your enclosure:

- Textured paints, such as hammertones and spatter coatings, can help reduce (but not eliminate) costly metal preparation in addition to providing an attractive finish. Polyester powder paint is standard.
- Dark-colored interiors and light (reflective) exteriors will help dissipate heat from within the enclosure.
- In general, for moderate or extreme exposure conditions, a rust-inhibiting primer followed by an epoxy or polyurethane top coat will provide superior protection.
- Epoxy paints provide excellent exposure protection but rapidly lose color and gloss through chalking.
- Silicone resin paints are superior for high heat exposure.
- Alkyd enamels are an excellent choice for mild exposure conditions when cost is a consideration.

ELECTROMAGNETIC COMPATIBILITY OVERVIEW

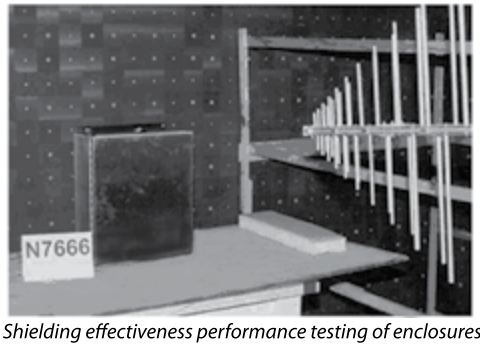
Standards governing electromagnetic compatibility commonly refer to EMI/RFI, or electromagnetic interference/radio frequency interference. Such interference is caused by stray voltages and/or currents coupling between electronic systems creating undesirable effects. These undesirable effects can vary between a brief annoyance, such as a vacuum cleaner disturbing the family television viewing, to more serious situations, such as a cellular phone interfering with the controls of a machine tool, or a noisy power supply interfering with the proper operation of an industrial robot. With the increased emphasis on electronic technology, electromagnetic interference/radio frequency interference is a growing concern.



ELECTROMAGNETIC EMISSIONS REGULATION

In the U.S. the Federal Communications Commission (FCC) regulates the amount of acceptable EMI/RFI emissions a product can produce. In Europe the EMC directives have regulations for emissions and immunity class testing of electrical products. Enclosures used to house electrical products or systems are required to comply with the above mentioned directives, although empty enclosures are not required to meet any regulatory requirements.
Enclosure EMI/RFI performance is frequently expressed as shielding effectiveness over a range of frequencies. Several standards address test methods for determining enclosure EMI/RFI performance.

STANDARDS FOR MEASURING SHIELDING EFFECTIVENESS OF ENCLOSURES



Shielding effectiveness performance testing of enclosures to MIL-STD-285, IEEE 299, and VG 95373

MIL-STD-285: Attenuation Measurements for Enclosures, Electromagnetic Shielding, for Electronic Test Purposes
IEEE-STD-299: Method of Measuring the Effectiveness of the Electromagnetic Shielding of Enclosures
ASTM E1851: Test Method for Measuring the Electromagnetic Shielding Effectiveness of Durable Rigid Wall Relocatable Structures
ASTM D4935: Test Method for Measuring the Electromagnetic Shielding Effectiveness of Planar Materials
VG 95373-15: Test Methods for Coupling and Screening

GLOSSARY

Attenuation in terms of EMC is the reduction of an electromagnetic field across a shield (usually expressed in decibels (dB) at a given frequency).

Cutoff Frequency is the maximum possible frequency beyond which the waveguide will no longer shield EMI.

Decibel (dB) in terms of EMC is a dimensionless logarithmic ratio used as a manageable value of measurement for the reduction or attenuation of electromagnetic interference.

Electromagnetic Compatibility (EMC) is the technology of shielding or preventing electromagnetic interference (EMI).

Electromagnetic Emission is the energy radiated to the environment from an electronic product.

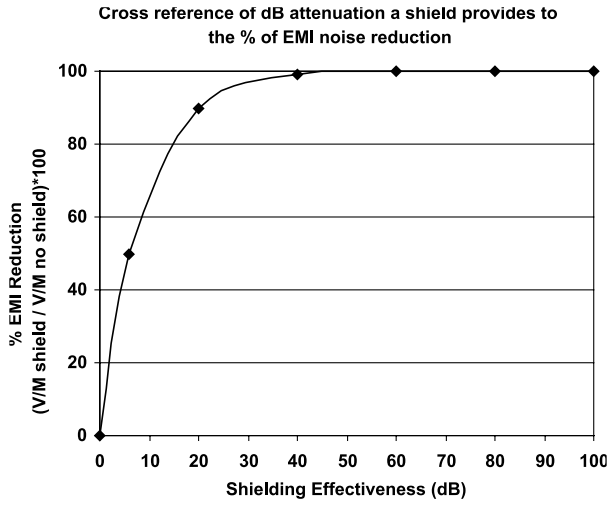
Electromagnetic Immunity is the ability of an electronic product to function in its environment in the presence of electromagnetic radiation.

Electromagnetic Interference (EMI) occurs when unintentional electromagnetic signals from a system or device cause undesired effects or malfunction in another system or device. Radio Frequency Interference (RFI) is a type of EMI that extends over the 1kHz - 10 GHz frequency band.

EO (V/m) is the measure of field strength without the shield; EI (V/m) is the field strength with the shield in place.

Shielding Effectiveness (SE) is the measure of protection provided by an enclosure against electromagnetic interference at a specific frequency. It is generally expressed in decibels (dB), where SE = 20 Log (EO/EI).

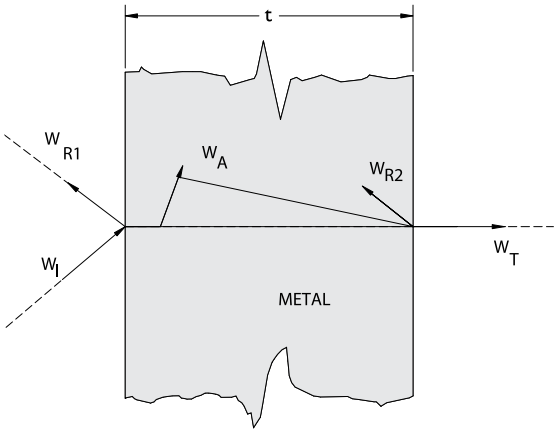
Shielding Effectiveness (dB)	EMI Blocked (%)	E (v/m no shield): E (v/m shield)
6	50	2:1
20	90	10:1
40	99	100:1
60	99.9	1000:1
80	99.99	10,000:1
100	99.999	100,000:1



Graph of shielding effectiveness to percentage of EMI noise blocked

GENERAL THEORY

RFI/EMI electromagnetic radiation is made of both electric (E) and magnetic (H) fields. High-frequency radiation tends to have a large electric field component; low-frequency radiation tends to have a large magnetic field component. High current devices produce magnetic fields that could cause interference problems.
Most high frequency wave energy is reflected off a conductive wall. In the low frequency range, however, the magnetic waves can penetrate the shield. For low frequency magnetic-dominant noise, therefore, the absorption characteristics of the shield become much more important. The absorption characteristics are related to the magnetic permeability and wall thickness of the shielding material. See drawing *Wave energy propagation through a single conductive sheet.*



Wave energy propagation through a single conductive sheet
WI = WRI + WA + WR2 + WT, where
I = Incident Electromagnetic Energy
R = Reflected Energy
A = Absorbed Energy
T = Transmitted Energy

EMC - ELECTRICAL ENCLOSURES

EMC requirements sometimes can be met with standard metal enclosures. Standard metal enclosures without EMC provisions can attenuate about 20 dB at 1 GHz, depending on the type of cover overlap. For critical EMC requirements, specially designed Hoffman EMC enclosures can provide attenuation levels of 40 dB to 100 dB and vary in ingress protection and style.
Conductive sealing around the door seams is the primary difference between a standard and an EMC enclosure. Depending on the NEMA Type rating and flange style, either a conductive gasket or finger stock is used. Because conductive gasket effectiveness relies on metal-to-metal contact, the selected gasket material must be compatible with the mating surface of the enclosure to minimize galvanic corrosion. To maintain peak performance, periodic gasket cleaning is recommended. At the same time, inspect the seams for oxidation and gasket compression.

PENETRATIONS FOR VENTILATION AND SIGNAL INPUT/OUTPUT

Unshielded conductor entry into an enclosure will act as an antenna that will carry EMI through the enclosure wall. Therefore, all openings into the enclosure, such as cable entry, device penetration, viewing windows and ventilation openings must be managed to minimize the attenuation loss they will cause.
One means of providing access through an enclosure wall while maintaining good attenuation performance is with a wave guide beyond the cutoff frequency. These are tubular openings ideal for ventilation or fiber cable entry. EMC vent kits also are available as standard products.

Electrical Resistivity and Magnetic Permeability for Enclosure Materials

Material	Electrical Resistivity	Relative Magnetic Permeability
Mild Steel	159 E-7	2.0E3
Stainless Steel (304, 316)	7.2 E-5	1.008
Aluminum	49 E-7	1.002

Notes

HEAT DISSIPATION IN SEALED ELECTRICAL ENCLOSURES

The accumulation of heat in an enclosure is potentially damaging to electrical and electronic devices. Overheating can shorten the life expectancy of costly electrical components or lead to catastrophic failure.

ENCLOSURE MATERIALS

The following discussion applies to gasketed and unventilated enclosures. Higher temperature rises can be expected with unfinished aluminum and unfinished stainless steel enclosures due to their material's less efficient radiant heat transfer. Non-metallic enclosures have similar heat transfer characteristics to painted metallic enclosures, so the graph can be used directly despite the difference in material.

ENCLOSURE SURFACE AREA

The physical size of the enclosure is the primary factor in determining its ability to dissipate heat. The larger the surface area of the enclosure, the lower the temperature rise due to the heat generated within it.
To determine the surface area of an enclosure in square feet, use the following equation:
Surface Area = 2[(A x B) + (A x C) + (B x C)] ÷ 144
where the enclosure size is A x B x C in inches.
This equation includes all six surfaces of the enclosure. If any surface is not available for transferring heat (for example, an enclosure surface mounted against a wall), that surface's area should be subtracted. *Note: Enclosure volume cannot be used in place of surface area.*

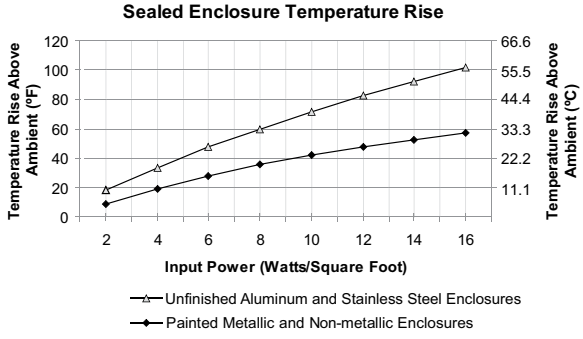
ENCLOSURE HEAT INPUT

For any temperature rise calculation, the heat generated within the enclosure must be known. This information can be obtained from the supplier of the components mounted in the enclosure.

ENCLOSURE TEMPERATURE RISE (ΔT)

Research has shown for every 18 F (10 C) rise above normal room temperature 72 - 75 F (22 - 24 C), the reliability of electronic components is cut in half.

The temperature rise illustrated by the curves in the Sealed Enclosure Temperature Rise graph is the temperature difference between the air inside a non-ventilated and non-cooled enclosure and the ambient air outside the enclosure. This value is described in the graph as a function of input power in watts per square foot. In order to predict the temperature inside the enclosure, the temperature rise indicated in the graph must be added to the ambient temperature where the enclosure is located.



DETERMINING TEMPERATURE RISE

The temperature rise inside a sealed cabinet without forced ventilation can be approximated as follows.
First calculate the surface area of the enclosure and, from the expected heat load and the surface area, determine the heat input power in watts/ft.^{2}
Then the expected temperature rise can be read from the Sealed Enclosure Temperature Rise graph. Find where the input power intersects the line for the enclosure material and read the approximate expected temperature rise at the left.
Example:
What is the temperature rise that can be expected from a 48 x 36 x 16 in. painted steel enclosure with 300 W of heat dissipated within it?
Solution:
Surface Area = 2[(48 x 36) + (48 x 16) + (36 x 16)] ÷ 144 = 42 ft.^{2}
Input Power = 300 ÷ 42= 7.1 W/ft.^{2}
From the Sealed Enclosure Temperature Rise graph:
Temperature Rise = approximately 30 F (16.7 C)

SAFETY MARGINS

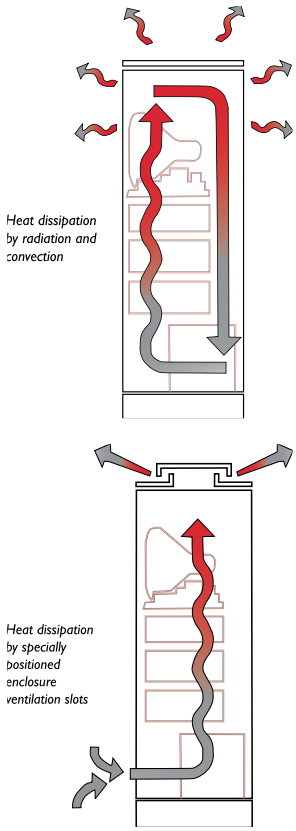
The graph provides only an approximation of temperature rise. Actual temperature rise will vary due to enclosure layout, internal fan use, air movement in the vicinity of the enclosure, and other factors. A safety margin should be used in critical applications. A safety margin of 25% is recommended.

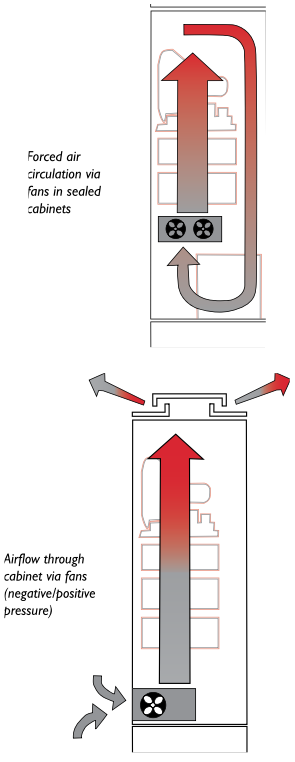
OUTDOOR APPLICATIONS

In outdoor applications where an enclosure is exposed to the sun, the temperature inside the enclosure can rise significantly above the estimates calculated. See the Solar Heat Gain section for further technical information.

CIRCULATING FANS

The use of circulating fans in an enclosure will improve heat dissipation by as much as 10 percent. Circulating fans are most commonly employed to eliminate hot spots inside an enclosure. The Sealed Enclosure Temperature Rise graph approximates the "average" temperature rise inside an enclosure. However, the temperature in the vicinity of a critical component can be much higher if it is producing a significant portion of the heat in the enclosure or if it is located near a large heat producing device. An internal circulating fan eliminates the resulting hot spots by mixing the air inside the enclosure.





COOLING OPTIONS AVAILABLE

Hoffman offers a full line of enclosure cooling products to meet the unique needs of many applications. These products include fans for circulation and ventilation as well as heat exchangers and air conditioners for closed loop cooling. Hoffman Authorized Distributors, Representatives, and factory technical applications support personnel are qualified to assist you in meeting your cooling requirements.

GLOSSARY

BTU/hr. = British Thermal Units/hour. One BTU is the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.
Watts (W) = The thermal (heat) load in the enclosure is measured in watts. One watt = 3.413 BTU/hr.
CFM = Airflow in cubic feet per minute ($ft.^3$/min.)
ΔT = Change in temperature (1.8 ΔT F = 1.0 ΔT C)
°F = Degrees Fahrenheit
°C = Degrees Celsius

SOLAR HEAT GAIN

When evaluating the thermal management needs of outdoor electrical enclosures, solar heat gain must be considered. Variables that affect the enclosure's internal temperature rise include the amount of solar exposure, enclosure color and material type, highest sustained atmospheric temperature, heat build-up from internal components and heat reflectance from the surrounding environment.

EXPOSURE TO SOLAR RADIATION

Over much of the United States, the approximate peak values of solar radiation striking the Earth's surface is 97 $W/ft.^2$ and the ambient air temperature can reach 104 F. Altitude, humidity and air pollution have an impact on these values, even more so than the location's latitude. In the high, dry climates of the southwest, solar radiation values of 111 $W/ft.^2$ and air temperatures greater than 104 F can be reached.

The extreme conditions the enclosure will be exposed to should be identified. If the internal enclosure temperature is greater than the outdoor (ambient) temperature, wind will provide greater heat transfer and thus cool the enclosure. But, because the presence of wind cannot be guaranteed, it is usually not taken into account when establishing a worst-case evaluation.

EFFECT OF SURROUNDING LOCATION

Reflection of solar energy from the foreground and surrounding surfaces can impact the total amount of radiant exposure by as much as 30 percent.

EFFECT OF ENCLOSURE COLOR AND FINISH

The percent of solar energy absorbed by the enclosure depends on surface color, finish and texture. Absorption values of the finish will increase with age.

STANDARDIZED TEST EVALUATION

Telcordia NEBS GR-487 provides a test procedure for evaluating the solar load on electrical/electronic enclosures. The test is run with the internal electronics on, in an environmentally controlled room, and three sides of the enclosure are illuminated uniformly with controlled banks of lights to a measured surface radiant value of 70 W/ft.^{2} The temperature rise inside the enclosure above ambient is added to 115 F (46 C). This temperature total must not exceed the lowest-rated component within the enclosure.

EVALUATION OF SOLAR HEAT GAIN

To evaluate the heat load on an enclosure, you must take into account:

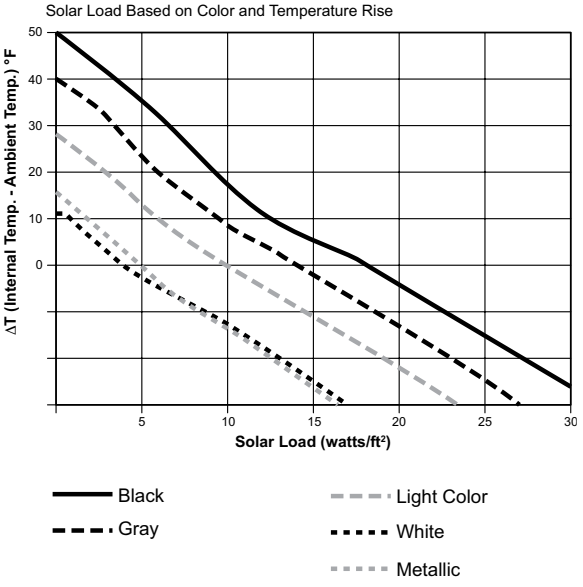
- Total surface area of the enclosure
- Color of the enclosure
- Internal heat load
- Maximum allowable internal temperature
- Maximum ambient temperature
- Solar load

Examples:

1. What amount of heat energy must be removed from a 24 x 20 x 12 (surface area = 14 ft.^{2}) ANSI 61 gray enclosure located outdoors and without any heat dissipated internally, to maintain the enclosure temperature equal to the ambient (temperature rise = 0 degrees)? From the chart below, at 0 F temperature rise we find the solar load is approximately 14 W/ft.^{2} (14 ft.^{2} x 14 W/ft.^{2} = 196 W). This is the heat energy that must be removed to maintain the enclosure temperature at ambient.

2. If the same enclosure has internal equipment dissipating 200 W of heat, what is the amount of heat energy that must be removed to maintain the enclosure at a temperature rise of 20 F above the ambient temperature? From the chart below, at 20 F temperature rise we find the solar load is approximately 6 W/ft.^{2} (14 ft.^{2} x 6 W/ft.^{2} = 84 W). All of the internally dissipated heat of 200 W must also be removed. 84 W + 200 W = 284 W. This is the total amount of heat energy that must be removed to maintain the enclosure at 20 F above the ambient temperature.

3. What is the expected temperature rise above the ambient temperature due to solar heat gain for an enclosure with ANSI 61 gray finish? From the chart below, the temperature rise due to solar heat load can be found by locating the intersection of the data curve for the given finish and the 0 Solar Generated Heat Load axis. For ANSI 61 gray, the temperature rise due to solar heat is about 40 F.

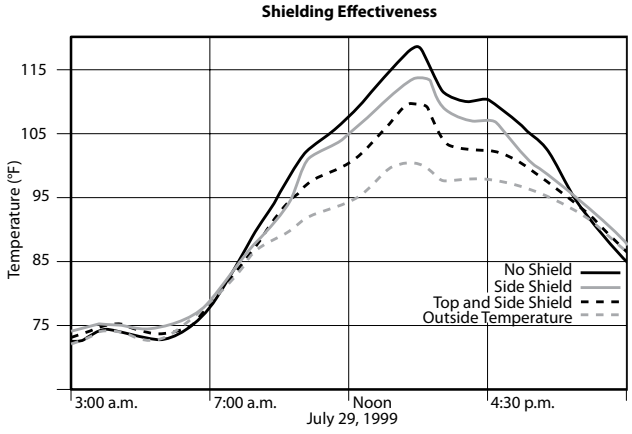


THE BENEFITS OF SHIELDING ENCLOSURES

Hoffman's research on the effects of solar radiation on enclosures has shown the positive benefits of utilizing shielding to decrease temperature rise. Shielding has been found to be an effective, low-cost method of reducing solar heat gain in outdoor electrical/electronic applications.

A test to compare the shielding effect on internal temperature rise was performed on similar enclosures exposed to the sun. The enclosures are the same color (RAL 7035 light gray) and material. The enclosure on the left is unshielded; the enclosure on the right is shielded on top and applicable sides.

The results of the test show the enclosure with top and side shields to have approximately a 46 percent reduction in temperature compared to the unshielded enclosure. The reduction in temperature is approximately 25 percent with the solar top shield only. Hoffman offers top shields as an accessory for Hoffman COMLINE Wall-Mount Enclosures. Hoffman can provide side shields as a customer-ordered modification.



Enclosure Type	Temperature (F)	Temperature (C)	Percent Temperature Reduction
Unshielded	119	48	—
Top shield only	114	46	25
Top and side shields	110	43	46

SELECTION PROCEDURE

The following selection process will help determine the size of the fan required for your application.

Application Guidelines

- Forced air systems can provide much greater heat transfer rates than those available with natural convection and radiation, therefore internal electronic packages have lower hot spot temperatures with forced air systems. The amount of cooling air flowing through an enclosure determines the temperature rise inside the enclosure due to the heat input. The more air that flows through the enclosure, the lower the temperature rise.

- Fans can be used at the exhaust to draw air through an enclosure, or at the inlet to blow air into the enclosure. Generally, a blowing fan at the air inlet is recommended for the following reasons:
  1. A fan at the inlet will raise the internal air pressure within the enclosure, which will help to keep dust and dirt out of an enclosure that is unsealed or opened frequently.
  2. A blowing fan at the inlet will produce slightly more turbulence, which improves the heat transfer characteristics within the enclosure.
  3. Fan life is prolonged since it is located in the path of the entering cooler air.

- The air inlet to the enclosure should be located as far as possible from the air outlet in order to prevent the airstream from short cycling. In a short cycling condition the air leaving the enclosure through the air outlet re-enters the enclosure through the air inlet. This condition results in a reduction in cooling efficiency. In general, it is recommended that the enclosure air inlet be on the side of the enclosure near the bottom and the air outlet be located on the opposite side and near the top.

- Fans should not be located adjacent to an area that restricts the free flow of cooling air. The use of a plenum in front of the fan is a good practice since it improves fan performance. The air velocity must be allowed to develop in order to effectively overcome the flow resistance. When the fan blades are located at the downstream end of the plenum housing, the air has a longer flow path. This improves the air velocity profile and fan performance.

- The enclosure fan system should have an air outlet area at least equal to the air inlet area.

- The system cooling efficiency changes with altitude because of reduced air density. Airflow through an enclosure should be increased when the air density decreases.

- If more than one fan is used in parallel, in the same enclosure, then both fans should be identical.

FANS AND BLOWERS

Determine the required fan/blower size (volume airflow):

Step 1
Select the product family that best fits your application:
- Compact Cooling Fans
(economical fan with no filter)
- Cooling Fan Packages
(economical fan package with low density filter)
- Type 12 Cooling Fan Package

Step 2
Determine the internal heat load in watts.
1 W = 3.413 BTU/Hr.

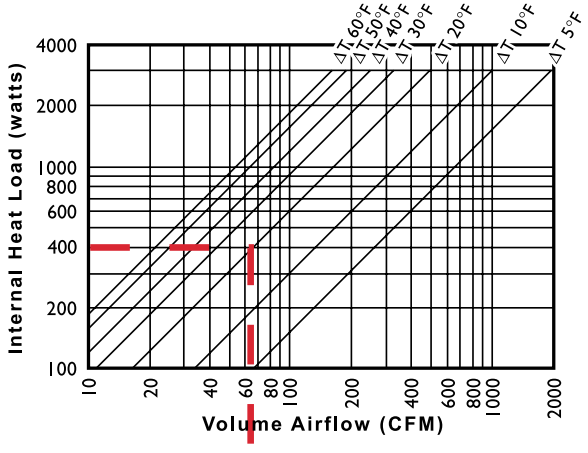
Step 3
Determine the ΔT (°F)

Step 4
Plot your application using the selection graph to the right.
- Find Watts (internal heat load) on the vertical scale
- Draw a horizontal line across to the intersection point with the diagonal line representing your ΔT
- Extend a vertical line down to the horizontal scale to determine your CFM requirement

The red line on the chart shows the airflow requirement for a 400 W heat load and a ΔT of 20°F.

Or calculate using the formula:
CFM = (3.16 x Watts) / (ΔT °F)
Where:
Watts = Internal Heat Load in watts
ΔT = Internal Temperature minus Ambient Temperature in °F
CFM = Required airflow in ft^3/min.

Example:
An internal heat load of 400 W requires airflow of about 63 CFM to maintain the enclosure at a ΔT of 20°F above the ambient temperature.
(3.16 x 400 W) / (20°F) ≈ 63 CFM



EX:
An internal heat load of 400 watts requires airflow of about 63 cfm to reduce cabinet temperature 20°F.

COOLING PRODUCT SELECTION APP

Prod. Select

Designed to assist you in determining the most suitable choices of air conditioners, heat exchangers or fans for your application. Download a free copy of our selection software by visiting **http://coolingtool.nvent.com/index.html**

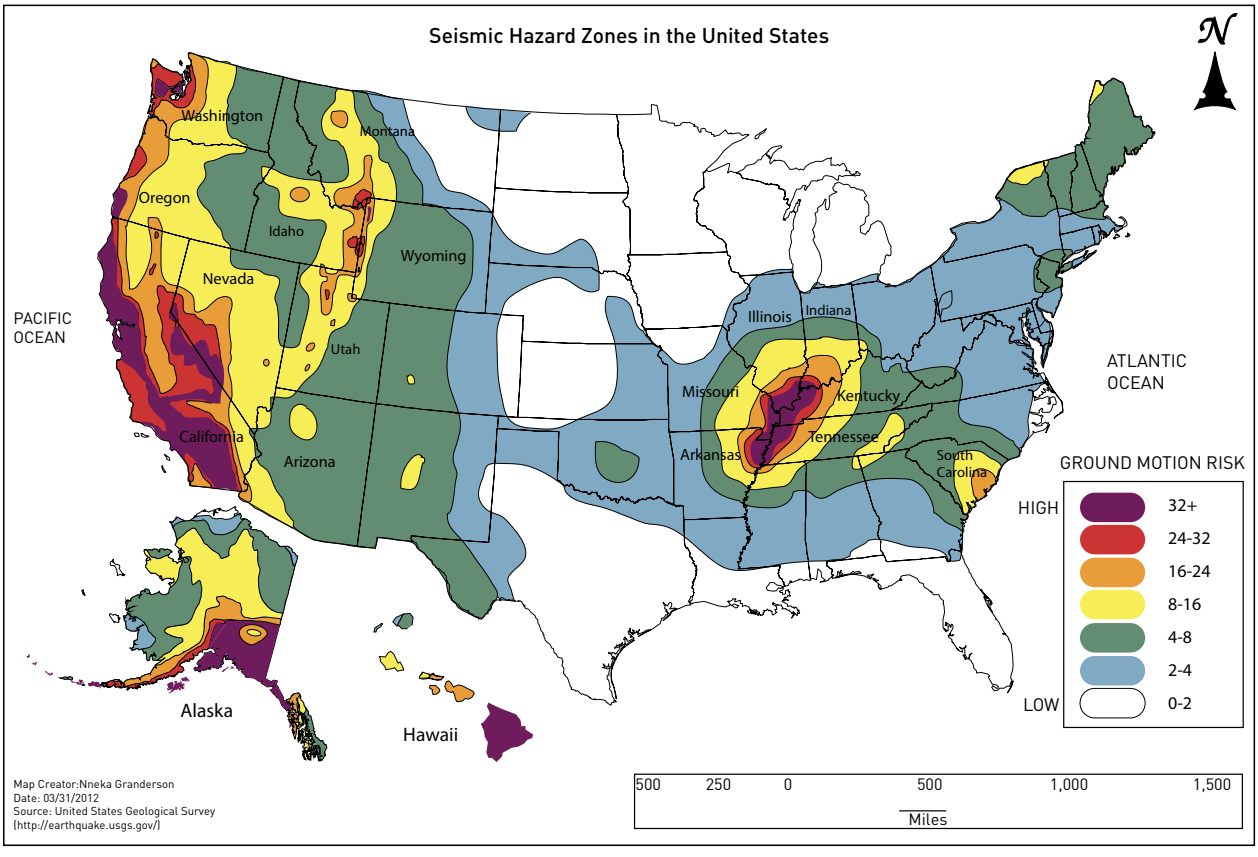
nVent | HOFFMAN

SEISMIC ENCLOSURES PROVIDE AN EXTRA MEASURE OF PROTECTION

The use of seismic-rated enclosures is recommended in areas where earthquake activity is possible. In addition, power plants, railroads, airports and other installations use rack-mounted electrical and electronic equipment that is subjected to vibration and other motion which may over-stress equipment framework, components and connections. Adequate enclosure frame strength and rigidity are necessary under these conditions.

Seismic Enclosure Standards
Industry standards define global geographical areas as earthquake-risk Zones. Referring to the seismic map below, ground motion risks are numbered from 0 to 32+ with 32+ corresponding to the highest risk areas. Geographic areas designated as 0-2 present no substantial earthquake risk.

Conditions Other Than Earthquakes
Equipment may need to withstand the effects of movement or vibration in areas close to railways, airports, power plants and other areas subject to similar conditions.



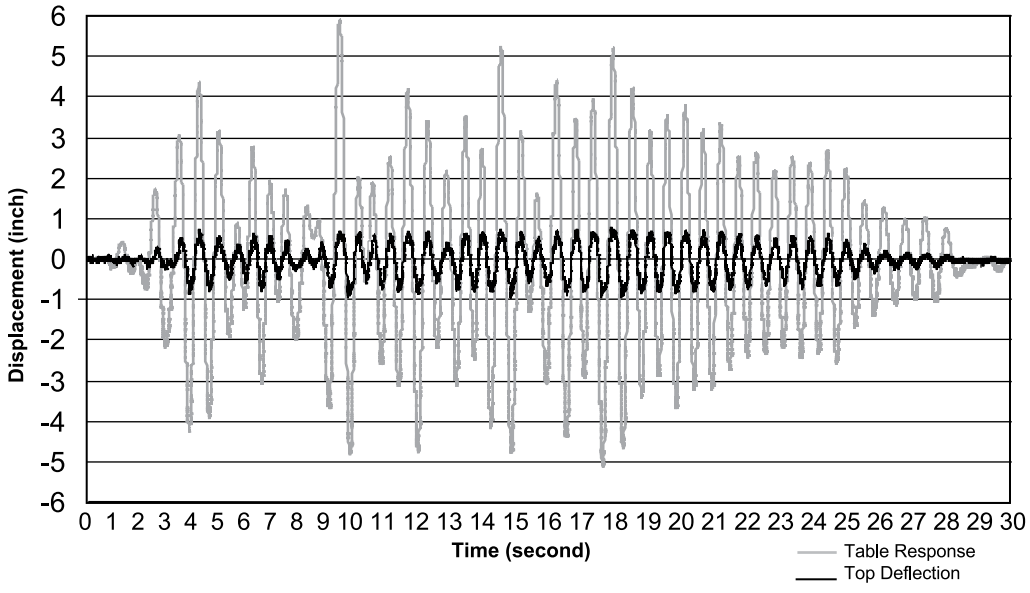
Hoffman Seismic Products
Hoffman performance-tests its seismic products according to Telcordia GR-63-CORE Network Equipment Building System (NEBS™) requirements for physical protection. These enclosures can also be manufactured to comply with all applicable national and international standards, such as the California Building Code (CBC) and International Building Code (IBC).

Seismic Compliance
A Telcordia GR-63-CORE compliant test must be conducted by a Nationally Recognized Testing Laboratory (NRTL) or other recognized independent laboratory before compliance will be issued. This test is conducted on an installation-specific basis with customer-installed equipment and cabling mounted inside the enclosure. In other cases or in addition to, a licensed structural engineer must certify the installation.

Hoffman helps facilitate the Office of Statewide Health Planning and Development (OSHPD) building approval with pre-approval of Manufacturer's Certification (OMP).

The OPM program is a voluntary program for review and pre-approval of seismic design of nonstructural components used in health facilities construction in California, per California Building Code, CBC 2013.

Enclosure mounted on shaker table



Time-motion history generated in front to back seismic enclosure test

NEBS™ IS A TRADEMARK OF TELCORDIA.

CLASSIFICATION OF HAZARDOUS LOCATIONS OVERVIEW

Protecting electrical equipment in hazardous locations requires special considerations. Options include traditional dust ignition-proof designs, Ex systems designed to avoid an explosion and enclosures that incorporate purging/pressurization solutions.

A hazardous location can be an industrial or commercial environment specifically defined in the National Electrical Code (NEC) in which flammable or explosive gases, liquids or dusts may be present. These explosive agents may be present at all times, only during abnormal operations or only when components or processes fail.

The two classification systems for hazardous locations are the NEC Division Classification system and the IEC Zone Classification system.

Enclosure Types

Type	National Electrical Manufacturers Association (NEMA Standard 250) and Electrical and Electronic Mfg. Association of Canada (EEMAC)	Underwriters Laboratories Inc. (UL698, 877, 886 and 894)	Canadian Standards Association (Standard C22.2 No. 25)
9	Enclosures constructed for indoor use in hazardous locations classified as Class II, Division 1, Groups E, F or G as defined in NFPA 70.	Class II, Division 1, Groups E, F or G – Indoor Hazardous Locations	Not specifically defined.

NEC DIVISION CLASSIFICATION SYSTEM (NEMA TYPE 9 CLASS/DIVISION)

Article 500 of the NEC classifies hazardous locations according to the properties of the flammable vapors, liquids or gases or according to the combustible dusts or fibers which may be present and the likelihood that a flammable or combustible concentration or quantity is present.

Class I Locations

Class I locations are defined by the NEC as those locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Class I locations are divided into groups determined by the specific gas or vapor involved: Group A, Group B, Group C or Group D. These locations are further classified as to whether hazardous concentrations of flammable gases or vapors are likely to occur in the course of normal operations (Division I) or only in the case of an accident or some unusual operating condition (Division 2).

Enclosures that can be used for Class I locations:

CLASS I, DIVISION 1
- NEMA Type 7 enclosures (Hoffman does not manufacture any of these enclosures)
- Purged general-purpose enclosures (subject to approval by the inspection authority having jurisdiction)

CLASS I, DIVISION 2
- Same as those listed for Class I, Division
- General-purpose enclosures [such enclosures are permitted for some applications by Article 501 of the NEC if the equipment does not constitute a source of ignition under normal operating conditions]

Class II Locations

Class II locations are defined by the NEC as those locations that are hazardous due to the presence of combustible dusts.

Class II locations are grouped according to the specific dust involved: Group E combustible metal dusts or other combustible dusts having resistivity of less than 105 ohm-centimeters; Group F combustible dusts such as carbon black, charcoal, and coal or coke dusts having resistivity greater than 102 ohm-centimeters or less than 108 ohm-centimeters; and Group G containing grain dusts or other combustible dusts having resistivity of 105 ohm-centimeters or greater. Class II locations are further classified as to whether combustible dusts may be present in the air under normal operating conditions (Division 1) or whether combustible dusts are not normally in the air but which may accumulate on or near electrical equipment (Division 2).

Enclosures that can be used for Class II locations:

CLASS II, DIVISION 1
- NEMA Type 9 enclosures
- Pressurized enclosures (subject to approval by the inspection authority having jurisdiction)

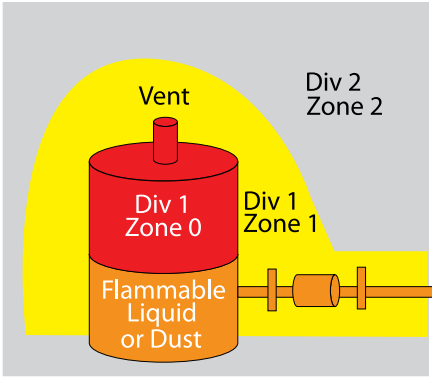
CLASS II, DIVISION 2
- Same as those listed for Class II, Division 1
- Dust-tight enclosures listed for use in hazardous locations. Tests for hazardous location dust-tight enclosures are contained in ISA 12.12.01 and UL 1604. General purpose dust-tight enclosure types as defined by UL 50 and NEMA 250 are Types 3, 4, 4X, 12, 12K and 13.
- General-purpose enclosures (such enclosures are permitted for some applications by Paragraph 502 of the National Electrical Code if the equipment does not constitute a source of ignition under normal operating conditions)

Class III Locations

Class III locations are defined by the NEC, in Article 503, as those locations that are hazardous because of the presence of easily ignitable fibers or flyings but not in quantities sufficient to produce ignitible mixtures. Class III locations are locations in which ignitable fibers or materials producing combustible flyings are handled, manufactured or used (Division 1) or locations in which ignitable fibers are stored or handled but where no manufacturing processes are performed (Division 2).

Enclosures that can be used for Class III locations:
Dust-tight Enclosures. As defined by UL 50 and NEMA 250, dust-tight enclosures are Types 3, 4, 4X, 12, 12K and 13.

CLASS I: FLAMMABLE GASES, VAPORS OR LIQUIDS



It is the user's responsibility to determine if the chosen protection method meets the requirements of the application and local standards.

Area Classification

Descriptions		
Division 1: Where ignitable concentrations of flammable gases, vapors or liquids can exist all of the time or some of the time under normal operating conditions.	**Zone 0:** Where ignitable concentrations of flammable gases, vapors or liquids are present continuously or for long periods of time under normal operating conditions.	**Zone 1:** Where ignitable concentrations of flammable gases, vapors or liquids are likely to exist under normal operating conditions.
Division 2: Where ignitable concentrations of flammable gases, vapors or liquids are not likely to exist under normal operating conditions.	**Zone 2:** Where ignitable concentrations of flammable gases, vapors or liquids are not likely to exist under normal operating conditions.	

Protection Methods

Area	Protection Methods
Division 1	- Explosion proof - Intrinsic safety (2 fault) - Purged/pressurized (Type X or Y)
Division 2	- Hermetically sealed - Nonincendive - Non-sparking - Purged/pressurized (Type Z) - Any Class 1, Division 1 method - Any Class 1, Zone 0, 1 or 2 method

Groups

Division 1 and 2	Zone 1, 1 and 2
A (acetylene)	IIC (acetylene and hydrogen)
B (hydrogen)	IIC (acetylene and hydrogen)
C (ethylene)	IIB (ethylene)
D (propane)	IIA (propane)

CLASS II: COMBUSTIBLE DUSTS

It is the user's responsibility to determine if the chosen protection method meets the requirements of the application and local standards.

Area Classification

Descriptions		
Division 1: Where ignitable concentrations of combustible dusts can exist all of the time or some of the time under normal operating conditions.	**Zone 20:** Where combustible dust or ignitable fibers and flyings are present continuously or for long periods of time in quantities sufficient to be hazardous.	**Zone 21:** Where combustible dust or ignitable fibers and flyings are likely to exist under normal operating conditions.
Division 2: Where ignitable concentrations of combustible dusts are not likely to exist under normal operating conditions.	**Zone 22:** Where dust or ignitable fibers and flyings are not likely to occur under normal operation in quantities sufficient to be hazardous.	

Groups

Division 1 and 2	Zone 20, 21 and 22
E (metals--Div. 1 only)	None
F (coal)	
G (grain)	

Protection Methods

Area	Protection Methods
Division 1	- Dust-ignition proof - Intrinsic safety - Pressurized
Division 2	- Dust-tight - Hermetically sealed - Nonincendive - Pressurized - Any Class II, Division 1 methods

NEC DIVISION CLASSIFICATION SYSTEM (NEMA TYPE 9 CLASS/DIVISION)

Article 500 of the NEC classifies hazardous locations according to the properties of the flammable vapors, liquids or gases or according to the combustible dusts or fibers which may be present and the likelihood that a flammable or combustible concentration or quantity is present.

Class I Locations

Class I locations are defined by the NEC as those locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Class I locations are divided into groups determined by the specific gas or vapor involved: Group A, Group B, Group C or Group D. These locations are further classified as to whether hazardous concentrations of flammable gases or vapors are likely to occur in the course of normal operations (Division I) or only in the case of an accident or some unusual operating condition (Division 2).

Enclosures that can be used for Class I locations:

CLASS I, DIVISION 1
- NEMA Type 7 enclosures (Hoffman does not manufacture any of these enclosures)
- Purged general-purpose enclosures (subject to approval by the inspection authority having jurisdiction)

CLASS I, DIVISION 2
- Same as those listed for Class I, Division
- General-purpose enclosures [such enclosures are permitted for some applications by Article 501 of the NEC if the equipment does not constitute a source of ignition under normal operating conditions]

Class II Locations

Class II locations are defined by the NEC as those locations that are hazardous due to the presence of combustible dusts.

Class II locations are grouped according to the specific dust involved: Group E combustible metal dusts or other combustible dusts having resistivity of less than 105 ohm-centimeters; Group F combustible dusts such as carbon black, charcoal, and coal or coke dusts having resistivity greater than 102 ohm-centimeters or less than 108 ohm-centimeters; and Group G containing grain dusts or other combustible dusts having resistivity of 105 ohm-centimeters or greater. Class II locations are further classified as to whether combustible dusts may be present in the air under normal operating conditions (Division 1) or whether combustible dusts are not normally in the air but which may accumulate on or near electrical equipment (Division 2).

Enclosures that can be used for Class II locations:

CLASS II, DIVISION 1
- NEMA Type 9 enclosures
- Pressurized enclosures (subject to approval by the inspection authority having jurisdiction)

CLASS II, DIVISION 2
- Same as those listed for Class II, Division 1
- Dust-tight enclosures listed for use in hazardous locations. Tests for hazardous location dust-tight enclosures are contained in ISA 12.12.01 and UL 1604. General purpose dust-tight enclosure types as defined by UL 50 and NEMA 250 are Types 3, 4, 4X, 12, 12K and 13.
- General-purpose enclosures (such enclosures are permitted for some applications by Paragraph 502 of the National Electrical Code if the equipment does not constitute a source of ignition under normal operating conditions)

Class III Locations

Class III locations are defined by the NEC, in Article 503, as those locations that are hazardous because of the presence of easily ignitable fibers or flyings but not in quantities sufficient to produce ignitible mixtures. Class III locations are locations in which ignitable fibers or materials producing combustible flyings are handled, manufactured or used (Division 1) or locations in which ignitable fibers are stored or handled but where no manufacturing processes are performed (Division 2).

Enclosures that can be used for Class III locations:
Dust-tight Enclosures. As defined by UL 50 and NEMA 250, dust-tight enclosures are Types 3, 4, 4X, 12, 12K and 13.

CLASS III: IGNITABLE FIBERS AND FLYINGS

It is the user's responsibility to determine if the chosen protection method meets the requirements of the application and local standards.

Area Classification

Descriptions
Division 1: Where easily ignitable fibers or materials producing combustible flyings are handled, manufactured or used
Division 2: Where easily ignitable fibers are stored or handled.

Groups

Division 1 and 2
None

Protection Methods

Area	Protection Methods
Division 1	- Dust-tight - Hermetically sealed - Intrinsic safety
Division 2	- Nonincendive - Any Class III, Division 1 method

CEC AND NEC SUMMARY

NEC

NEC	Division 1: Normally Hazardous	Division 2: Not Normally Hazardous
Class I: Flammable Gases	Purging/Pressurization (purged and pressurized general purpose enclosure*)	Purging/Pressurization (purged and pressurized enclosure) General Purpose Enclosure*
Class II: Combustible Dusts	Purging/Pressurization** (purged and pressurized general purpose enclosure*) NEMA 9 Enclosure	Purging/Pressurization (purged and pressurized general purpose enclosure*) NEMA 9 Enclosure (general purpose enclosure*)
Class III: Ignitable Fibers and Flyings	General Purpose Enclosure (dust-tight)	General Purpose Enclosure (dust-tight)

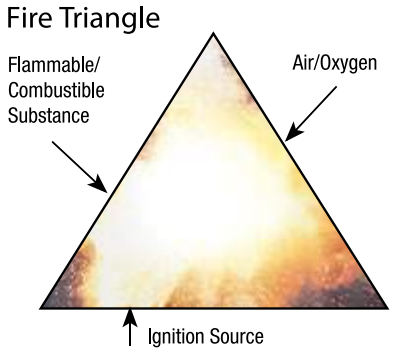
* General purpose enclosures are permitted for some applications by paragraph 500.8(B)(3) of the NE if the equipment does not constitute a source of ignition under normal operating conditions.

**Subject to AHJ (Authority Having Jurisdiction) approval.

North American Electrical Codes

Article	CEC Section	Description
500	18 - 000	General requirements
501	Appendix J	Class I, Division requirements
502	18 - 005	Class II, Division requirements
503	18 - 010	Class III, Division requirements
504	Appendix F	Class I, II and III I.S. Division requirements
505	18 - 006	Class I, Zone requirements
506	NA	Zone 20, 21 and 22 Location requirements

EUROPEAN ATEX PROTECTION METHODS



All three elements of the fire triangle must be present for ignition to occur.

Hoffman ATEX Reference Guide to European hazardous location protection methods and markings.

It is the user's responsibility to determine if the chosen protection method meets the requirements of the application and local standards.

Protection Concepts

Protection Concepts	Symbol	How It Works	Category
Increased Safety	Ex e	No arcs, sparks or hot surfaces	2 and 3
Non-sparking	Ex nA	No arcs, sparks or hot surfaces	3
Flameproof	Ex d	Contain the explosion and quench flame	2 and 3
Enclosed Break[a]	Ex nW	Contain the explosion and quench flame	3
Quartz/Sand Filled	Ex q	Contain the explosion and quench flame	2 and 3
Intrinsic Safety	Ex ia Ex ib	Limit energy of sparks; limit the temperature	1, 2 and 3 2 and 3
Energy Limitation	Ex nL	Limit energy of sparks; limit the temperature	3
Pressurized	Ex p	Keep the flammable gas away from any hot surfaces and ignition-capable equipment	2 and 3
Simplified Pressurization	Ex nP	Keep the flammable gas away from any hot surfaces and ignition-capable equipment	3
Encapsulation	Ex m	Keep the flammable gas away from any hot surfaces and ignition-capable equipment	2 and 3
Oil Immersion	Ex o	Keep the flammable gas away from any hot surfaces and ignition-capable equipment	2 and 3
Restricted Breathing	Ex nR	Keep the flammable gas away from any hot surfaces and ignition-capable equipment	3
Special	Ex s	Any proven method	1, 2 and 3

[a]Enclosed Break can also be noted as Ex nC.

Protection Methods

Protection Method	Symbol	IEC Standard
Intrinsic Safety	ia	60079-11
Intrinsic Safety	ib	60079-11
Flameproof	d	60079-1
Pressurization	p	60079-2
Increased Safety	e	60079-7
Encapsulation	m	60079-18
Oil Immersion	o	60079-6
Powder Filling	q	60079-5
Non-sparking	n	60079-15
General Requirement		60079-0
Inspection and Maintenance		60079-17

Temperature Classes

Maximum Surface Temperature	Fahrenheit	T-Class
450 C	842 F	T1
300 C	572 F	T2
200 C	392 F	T3
135 C	275 F	T4
100 C	212 F	T5
85 C	185 F	T6

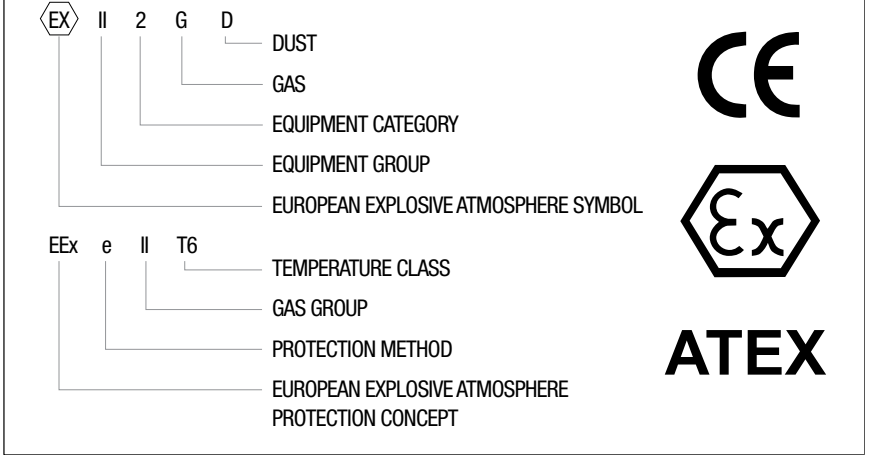
Modules ATEX (94/9/EC) ANNEX I (1) Classification of Equipment Groups into Categories

Equipment Group:	Equipment Category	Atmosphere:	Protection Level:	Required Protection Performance and Operation:
I (Mines)	M1	Methane and Dust	Very High	Two faults, remain energized and functioning
I (Mines)	M2	Methane and Dust	High	severe normal operation, de-energize in exp. atm.
II (Above Ground)	1	Gas, Vapor, Mist, Dust	Very High	Two faults
II (Above Ground)	2	Gas, Vapor, Mist, Dust	High	One fault
II (Above Ground)	3	Gas, Vapor, Mist, Dust	Low	Normal operation

Gas Groups

Typical Material	Group
Methane	I
Propane	IIA
Ethylene	IIB
Hydrogen	IIC
Acetylene	IIC
All Gases	II

ATEX MARKING DIRECTIVE (94/9/EC)



COMPARING DIVISIONS, ZONES AND CATEGORIES

Occurance

Frequency	CEC, NEC Editions Division System	Zone System CEC, NEC	Category System ATEX
Continuous		Zone 0, 20	Category 1
Intermittent	Class I, Division 1	Zone 1, 21	Category 2
Periodically	Class II, Division 1	Zone 1, 21	Category 2
Abnormal Condition	Class I, Division 2	Zone 2, 22	Category 3
Abnormal Condition	Class II, Division 2	Zone 2, 22	Category 3

International Protection Standards

Area	Protection Methods	Applicable Certification Documents: USA	Applicable Certification Documents: Canada	Applicable Certification Documents: IECEx Scheme[b]	Applicable Certification Documents: Europe
Zone 0[a]	• Intrinsic safety, "ia" (2 fault)	UL 60079-11	CSA E60079-11	IEC 60079-11	EN 50020[c]
	• Encapsulation, "ma"	–	–	IEC 60079-18	EN 60079-18[c]
	• Class 1, Division 1 intrinsic safety (2 fault) method	UL 913	CSA 157	–	–
	• Special requirements	–	–	–	EN50284[d]
Zone 1[a]	• Encapsulation, "mb" ("m" for USA and Canada)	UL 60079-18	CSA E79-18	IEC 60079-18	EN 60079-18
	• Flameproof, "d"	UL 60079-1	CSA E60079-1	IEC 60079-1	EN 50018 or EN 60079-1
	• Increased safety, "e"	UL 60079-7	CSA E79-7	IEC 60079-7	EN 50019 or EN 60079-7
	• Intrinsic safety, "ib" (1 fault)	UL 60079-11	CSA E60079-11	IEC 60079-11	EN 50020
	• Oil immersion, "o"	UL 60079-6	CSA E60079-6	IEC 60079-6	EN 50015
	• Powder filling, "q"	UL 60079-5	CSA E60079-5	IEC 60079-5	EN 50017
	• Pressurization, "px" or "py" ("p" for USA)	NFPA 496	CSA E60079-2	IEC 60079-2	EN 60079-2
	• Any Class 1, Zone 0 method	–	–	–	–
	• Any Class I, Division 1 method	–	–	–	–
Zone 2	• Energy limited, "nC" or "nL"	UL 60079-15	CSA E60079-15	IEC 60079-15	EN 60079-15
	• Hermetically sealed, "nC"	UL 60079-15	CSA E60079-15	IEC 60079-15	EN 60079-15
	• Nonincendive, "nC"	UL 60079-15	CSA E60079-15	IEC 60079-15	EN 60079-15
	• Non-sparking, "nA"	UL 60079-15	CSA E60079-15	IEC 60079-15	EN 60079-15
	• Pressurization, "nZ"	–	CSA E60079-15	–	EN 60079-15
	• Pressurization, "pz" ("p" for USA)	NFPA 496	CSA E60079-2	IEC 60079-2	EN 60079-2
	• Restricted breathing, "nR"	UL 60079-15	CSA E60079-15	IEC 60079-15	EN 60079-15
	• Any Class 1, Zone 0 or 1 method	–	–	–	–
	• Any Class 1, Division 1 or 2 method	–	–	–	–

[a]For Zone 0 and 1 protection methods, there are also general requirement documents for the USA (UL 60079-0), Canada (CSA E60079-0), IECEx Scheme (IEC 60079-0), and Europe (EN 60079-0 or EN 50014).

[b]In addition to the EIC 60079 series noted above that address Class 1 protection methods, there is also a product-specific Class 1, Zone 1 and 2 certification document for electrical resistance heat tracing, IEC 62086-1.

[c]As part of the European ATEX Directive, Category 1 (Zone 0) electrical apparatus shall also comply with EN 50284.

[d]EN 50284 contains special requirements for construction, test and marking of Category 1 (Zone 0) electrical apparatus under the European ATEX Directive.

Notes

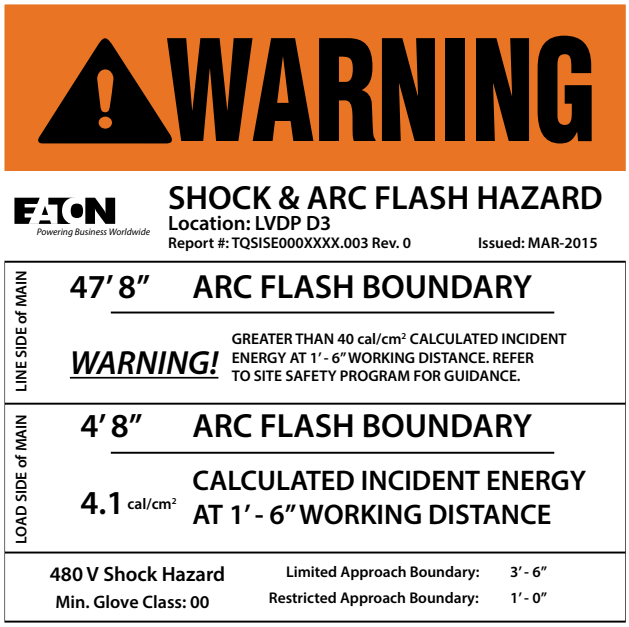
WHAT IS ARC FLASH?

An arc flash explosion is a very dangerous and often costly electrical system malfunction that occurs as a short circuit between electrified conductors. When the isolation between the conductors is breached or can't contain the applied voltage, the air immediately surrounding the short can ionize, creating an intense energy flash of 5,000 F or more.
Often, an arc flash event is triggered by operator movement or contact with the energized equipment. This is a particular threat when faults occur within an enclosure. A phase-to-ground or phase-to-phase fault that results in an explosion can cause fatal injuries and severe burns and produce considerable property damage.

STANDARDS ORGANIZATIONS AND ARC FLASH PROTECTION

To protect operators, OSHA and NFPA 70E standards require a "flash protection boundary." OSHA has adopted the National Fire Protection Association's "70E Standards for Electric Safety in the Workplace" as an acceptable means of compliance to meet this requirement.
The Occupational Safety and Health Administration (OSHA) maintains that electrical work should only take place on de-energized equipment. Access to potentially energized equipment capable of generating an arc flash must be limited to qualified personnel with extensive protective clothing and equipment, including fire-resistant suits and hoods along with non-conductive wands.
The National Electric Code requires that electrical control panels that might generate arc flash carry a permanent label applied by the panel builder.

Incident Energy
Incident energy, defined by NFPA as "the amount of energy impressed on a surface, a certain distance from a source, generated during an electrical arc event," is a key term in understanding arc-flash hazards. Incident energy is a measure of the heat created by the electrical arc and is expressed in calories per centimeter-squared.
The two most important numbers to remember are 1.2 and 40. Incident energy levels greater than 1.2 calories per centimeter-squared can produce second-degree burns. The NFPA 70E requires that workers wear personal protective equipment (PPE) when working with 50 volts or more. Arc flash levels above 40 calories per centimeter-squared can be fatal, usually resulting in a massive pressurized blast with sound pressure waves and projectiles. The PPE is available for exposures up to 100 calories per centimeter-squared; however, the force from the pressurized blast can be fatal regardless of the PPE.
Refer to the NFPA website, nfpa.org, for complete information.



HOW DOES NFPA 70E RELATE TO MY ENCLOSURE?

NFPA 70E requires protective equipment and clothing if an operator intends to open an electrical enclosure containing voltage greater than 50 VAC. NFPA 70E does not consider arc flash hazard to personnel once the enclosure is closed. Hoffman offers enclosures and accessories that comply with the equipment requirements of NFPA 70.
Please note, there are no tests specified in the NFPA 70E standard that rate an enclosure's resistance to arc flash energy. There is also nothing that can be done to the enclosure, other than keeping it closed, that would be a suitable alternative to the requirement in the NFPA 70E that states that personnel must wear protective clothing when opening an enclosure that may contain live power.

PREVENTING ARC FLASH EXPLOSIONS

Warning Label
The label is the first step. However, arc flash levels may change as routine maintenance and repair are performed.
The arc flash hazard level of any piece of equipment depends on the available fault current and the time it takes to trip the nearest upstream overcurrent protection device. In most cases, a local utility engineer can determine the fault current levels; however, these fault current values may be based on the impedance of the transformer that serves the facility, and additional impedances upstream of the transformer can lower the number. If these additional impedances are not included in the calculations, then the incident energy levels may be underestimated.
Short circuit current levels in electric utility systems are continuously changing as both electricians and maintenance workers replace overcurrent devices, fuses and panel boards or upgrades are made to the system. Any of these changes can have an effect on the arc flash energy level, but may not be noted on the warning label.

Protective Clothing
Anyone working on equipment that might generate an arc flash is required to wear protective clothing, including fire-retardant suits, gloves, face shield/goggles and other gear as stated in the Standards.

Equipment that Limits Exposure
Although no single piece of equipment can completely eliminate arc flash hazards, making it convenient to perform most routine maintenance tasks without directly accessing the equipment can significantly reduce the risk.
Providing external plug-ins to equipment inside an enclosure is one approach. Properly designed and insulated panels that are wired to the appropriate equipment inside allows operators to change settings and monitor performance without opening the enclosure. INTERSAFE Data Interface Ports by Hoffman are mounted on an enclosure to allow access to the programming devices inside the enclosure without opening the enclosure door.
Installing Infrared Windows (IR Windows) is another way to minimize exposure to live internal components. IR window is a component usually installed in the front of an enclosure to provide a view port to inspect internal equipment without the need to open the panel cover or de-energize the equipment. For example, technicians or thermographers can conduct maintenance tasks or thermal surveys using the IR windows.
Another approach to minimize exposure is to keep manuals and various worksheets outside the enclosure, but still conveniently close to the equipment. A data pocket that mounts on the outside of the enclosure protects manuals and records when closed but is easily accessed when necessary.
Finally, a power isolation enclosure, a smaller enclosure, interlocked to the main enclosure can be installed to isolate, or sequester, the fused disconnect switch or circuit breaker from the main control panel.
With a traditional disconnect switch inside the main enclosure, live power is still present on the line side of the disconnect switch. Since live power is still being fed upstream to the disconnect switch on the panel, the threat of an arc flash incident remains.
An external disconnect enclosure attaches to the side of the main control enclosure and houses only the disconnect switch or circuit breaker, physically removing it from the main enclosure. Power passes from the disconnect enclosure to the main enclosure via a terminal block mounted on the shared enclosure walls. When the disconnect switch is off, there is no power coming into the main control enclosure. The live line side of the disconnect switch is isolated in the SEQUESTR Enclosure.
Besides housing the external disconnect, the Hoffman SEQUESTR External Disconnect Enclosure System interlocks the doors of the main control cabinet when the disconnect switch is powered on. This allows users to comply with the disconnect door interlocking requirements of UL 508A, NFPA79, IEC 60204 and HS 1738, the most common electrical standards for industrial machinery. Because the disconnect switch or circuit breaker is now isolated, the SEQUESTR Enclosure enables technicians to work inside the main enclosure without the need for PPE (after verifying that power is off to the load side of the switch).

INTERSAFE Data Interface Ports

IR Window

External Data Pocket

SEQUESTR Isolation Enclosure

SANITARY WASHDOWN OVERVIEW

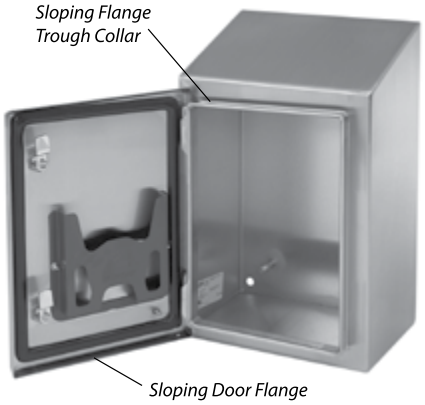
Maintaining a sanitary processing environment is crucial to food, beverage and pharmaceutical manufacturers. Removal of all waste materials and residues from processing systems and controls is essential. For these manufacturers, thorough daily washdowns are critical to ensuring cleanliness and product quality.
Incomplete washdowns can result in bacteria or mold contamination of products which can lead to delays in production, lost productivity, reduced sales, product recalls, litigation, tarnished company reputation and diminished brand equity.
Equally critical is the need for complete runoff. Flat and hidden surfaces are challenging to clean and a typical rectangular-designed enclosure has many of these surfaces. This is particularly challenging in and around tightly confined control systems and process electronics.

SANITARY ENCLOSURE DESIGN CRITERIA

The hygiene requirements, strategy and risk assessment for selecting an enclosure needs to be based on the process for which the machine is intended.
Sanitary enclosure design criteria for equipment used in storing, preparing or handling foods and beverages revolve around the ability to minimize standing and pooling of water and cleaning solutions, reduce areas that can harbor bacteria and promote easy wipe- or washdown.

SLOPED, SMOOTH SURFACES

Sloped horizontal-running surfaces, including sloped top, sloping flange trough collar and sloping door flanges, keep water from pooling on the enclosure. Sloped tops must be greater than 15 degrees to promote cleaning solution runoff. In addition, the enclosure surface must be free of imperfections such as pits, folds, cracks and crevices, with the roughness equal to or better than a number 4 mill finish, with a Roughness Average (RA) value of less than 32 µ in.



Hoffman WATERSHED® Enclosures incorporate a sloping flange trough collar and sloping door flange as well as a sloped top to ensure complete runoff.

FASTENERS, HANDLES AND HINGES

Fasteners, handles or hinges used on the enclosure must be cleanable with no exposed threads or recesses.
Piano/continuous hinges are not acceptable in most sanitary environments due to the difficulty in keeping them clean.
WATERSHED Enclosures feature easily accessible, flange-mounted, bullet-style hinges that minimize entrapment. Rounded, asymmetrical lift-off hinges provide easy access and allow complete hinge area cleaning.
Standard industrial enclosure latches are generally not suitable for washdown applications, because they typically don't include features that facilitate runoff and may not have adequate seal integrity. The latches typically specified are flush with the enclosure or smooth with a minimum of openings such as slots. They also latch forcefully enough to keep washdown solutions out of the enclosure.

SEAL/GASKET CONSIDERATIONS

A properly mounted, well-performing seal or gasket is critical to the protection of electrical equipment inside the enclosure. Holes, cutouts and viewing panels must be fully protected by a good seal.
To seal its WATERSHED Enclosures, Hoffman uses a polyurethane foam gasket that has been poured to form a continuous gasket without gaps. Periodically, gaskets should be checked for resiliency loss and gasket compression.

MOUNTING

Sanitary legs and stand off mounting brackets must be used to allow cleaning behind and underneath the enclosure. Adjustable legs can accommodate a floor's drainage slope without shimming, reducing potential entrapment areas.

STANDARDS

Several well-known organizations, including the International Electrochemical Commission (IEC), Underwriters Laboratories Inc. (UL), the National Electrical Manufacturers Association (NEMA) and the National Sanitation Foundation (NSF), have created performance standards relating to enclosures used in the washdown environment. These standards are chiefly concerned with water pressure, liquid temperature and sanitary design.

ENCLOSURE TESTING STANDARDS

IEC
IP69K is a high pressure, high temperature/jet stream washdown using a 30-degree fan nozzle at a distance of 100 mm to 150 mm (3.9 in. to 5.9 in.) from the object under test. The water temperature is 80 C +/- 5 C (176 F), and the water pressure at nozzle is 8,000 kPa to 10,000 kPa (1,160 psi to 1,450 psi) with a water flow of 14 l/min. to 16 l/min. (3.69 gal/min. to 4.22 gal/min.), approximately 4 gallons per minute.

NEMA
NEMA has ICS 5, Annex F-2002: High pressure power wash. However, this has no Type rating, 1,200 psi, 140 F, 1 gallon per minute.

UL
UL 4X washdown requirements use the cold line temperature water from a 25.4 mm (1.0 in.) inside diameter nozzle at a rate of 246 l/min. (65 gallons per min.) The water is directed at the joints of the enclosure at a distance of 3.0 m to 3.7 m (10 ft. to 12 ft.) and is to be moving at a rate of 1.6 s/cm. (4 seconds per linear inch).

NSF
The NSF/ANSI 169 standard specifies the essential sanitary design criteria for food equipment and devices, including electrical enclosures. NSF/ANSI 169 certification, as it applies to electrical enclosures, assures that all hinges, mounting devices, latches and door surfaces will protect the critical equipment while resisting exposure to environmental elements and accumulation of dirt and debris. A few of the design and construction criteria that are required for NSF/ANSI 169 include:

- lift-off hinges with removable pins (no continuous hinges are allowed)
- leg stands that provide a minimum unobstructed clearance of 6 in. beneath the enclosure
- sloped surfaces to facilitate runoff (including a sloped top and door edges)
- a sloped flange trough gutter above the enclosure door opening
- welded joints and seams that have been deburred
- easy-to-clean fasteners including slot-head quarter-turn latches
- no exposed threads or projecting screws or studs in a food or splash zone

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WIREWAY FILL TABLES

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Lay-In and Feed-Through Type 12 and Type 3R (Based on 2008 National Electric Code)

Wireway Size and Maximum Number of Conductors Allowed
(Areas shown are 20% of the full interior cross sectional area of the wireway)

Conductor Size AWG-MCM	Area of Conductor (sq. in.)	2.50 x 2.50 (1.11 sq. in.)	4.00 x 4.00 (2.98 sq. in.)	6.00 x 6.00 (6.87 sq. in.)	8.00 x 8.00 (12.4 sq. in.)	12.00 x 6.00 (13.7 sq. in.)
"RFH-2, FFH-2, RH"						
18	0.0145	76	205	473	854	945
16	0.0172	64	173	399	720	797
14	0.0209	52	1426	328	592	656
12	0.0260	42	114	264	476	527
"RHW-2, RHH, RHW"						
14	0.0293	37	101	234	422	467
12	0.0353	31	84	194	350	388
"RHW-2, RHH, RHW, RH"						
10	0.0437	25	68	157	283	313
8	0.0835	13	35	82	148	164
6	0.1041	10	28	65	118	131
4	0.1333	8	22	51	92	102
3	0.1521	7	19	45	81	90
2	0.1750	6	17	39	70	78
1	0.2660	4	11	25	46	51
1/0	0.3039	3	9	22	40	45
2/0	0.3505	3	8	19	35	39
3/0	0.4072	2	7	16	30	33
4/0	0.4754	2	6	14	26	28
250	0.6291	1	4	10	19	21
300	0.7088	1	4	9	17	19
350	0.7870	1	3	8	15	17
400	0.8626	1	3	7	14	15
500	1.0082	1	2	6	12	13
600	1.2135	0	2	5	10	11
700	1.3561	0	2	5	9	10
750	1.4272	0	2	4	8	9
800	1.4957	0	1	4	8	9
900	1.6377	0	1	4	7	8
1000	1.7719	0	1	3	6	7
1250	2.3479	0	1	2	5	5
1500	2.6938	0	1	2	4	5
1750	3.0357	0	0	2	4	4
2000	3.3719	0	0	2	3	4
"SF-2, SFF-2"						
18	0.0115	96	259	597	1077	1192
16	0.0139	79	214	494	891	986
14	0.0172	64	173	399	720	797
"SF-1, SFF-1"						
18	0.0065	169	458	1056	1905	2109
"RFH-1, AF, XF, XFF, AF, TF, TFF, TW"						
18	0.0080	138	372	858	1548	1713
16	0.0109	101	273	630	1136	1257
14	0.0139	79	214	494	891	986
12	0.0181	61	164	379	684	757
10	0.0243	45	122	282	509	564
8	0.0437	25	68	157	283	313
"RHH*, RHW*, RHW-2*, THHW, THW, AF, XF, XFF, THW-2, TW"						
14	0.0209	52	142	328	592	656
12	0.0260	42	114	264	476	527
10	0.0333	33	89	206	371	411
8	0.0556	19	53	123	222	246
6	0.0726	15	41	94	170	188
4	0.0973	11	30	70	127	140
3	0.1134	9	26	60	109	120
2	0.1333	8	22	51	92	102
1	0.1901	5	15	36	65	72
1/0	0.2223	4	13	30	55	61
2/0	0.2624	4	11	26	47	52
3/0	0.3117	3	9	22	39	43
4/0	0.3718	2	8	18	33	36
250	0.4596	2	6	14	26	29
300	0.5281	2	5	13	23	25
350	0.5958	1	5	11	20	23
400	0.6619	1	4	10	18	20
500	0.7901	1	3	8	15	17
600	0.9729	1	3	7	12	14
700	1.1010	1	2	6	11	12
750	1.1652	0	2	5	10	11
800	1.2272	0	2	5	10	11
900	1.3561	0	2	5	9	10
1000	1.4784	0	2	4	8	9
1250	1.8602	0	1	3	6	7
1500	2.1695	0	1	3	5	6
1750	2.4773	0	1	2	5	5
2000	2.7818	0	1	2	4	4
"TFN, TFFN, THHN, THWN, THWN-2"						
18	0.0055	200	541	1248	2252	2493
16	0.0072	153	413	953	1720	1904
14	0.0097	113	307	708	1277	1413
12	0.0133	83	224	516	931	1030
10	0.0211	52	141	325	587	649
8	0.0366	30	81	187	338	374
6	0.0507	21	58	135	244	270
4	0.0824	13	36	83	150	166
3	0.0973	11	30	70	127	140
2	0.1158	9	25	59	106	118
1	0.1562	7	19	43	79	87
1/0	0.1855	5	16	37	66	73

The 2008 National Electric Code limits wireway fill as follows:
1. A wireway shall not contain more than thirty current-carrying conductors except where the ampacity has been adjusted according to Table 310-15(b)(2)(a).
2. The sum of the cross-sectional areas of all conductors shall not exceed 20% of the interior cross-sectional area of the wireway.

NOTE: Section 14 of NFPA 79 allows 50% fill for industrial machine wireway.

Wireway Size and Maximum Number of Conductors Allowed
(Areas shown are 20% of the full interior cross sectional area of the wireway)

Conductor Size AWG-MCM	Area of Conductor (sq. in.) ,	2.50 x 2.50 (1.11 sq. in.)	4.00 x 4.00 (2.98 sq. in.)	6.00 x 6.00 (6.87 sq. in.)	8.00 x 8.00 (12.4 sq. in.)	12.00 x 6.00 (13.7 sq. in.)
Continued						
2/0	0.2223	4	13	30	55	61
3/0	0.2679	4	11	25	46	51
4/0	0.3237	3	9	21	38	42
250	0.3970	2	7	17	31	34
300	0.4608	2	6	14	26	29
350	0.5242	2	5	13	23	26
400	0.5863	1	5	11	21	23
500	0.7073	1	4	9	17	19
600	0.8676	1	3	7	14	15
700	0.9887	1	3	6	12	13
750	1.0496	1	2	6	11	13
800	1.1085	0	2	6	11	12
900	1.2311	0	2	5	10	11
1000	1.3478	0	2	5	9	10
"PF, PGFF, PGF, PFF, PTF, PAF, PTFF, PAFF, TFE, FEP, PFA, FEPB, PFAH"						
18	0.0058	190	513	1184	2135	2364
16	0.0075	147	397	915	1651	1828
14	0.0100	110	297	686	1238	1371
12	0.0137	80	217	501	904	1000
10	0.0191	57	156	359	648	717
8	0.0333	33	89	206	371	411
6	0.0468	23	63	146	264	292
4	0.0670	16	44	102	184	204
3	0.0804	13	37	85	154	170
2	0.0973	11	30	70	127	140
1	0.1399	7	21	49	88	98
1/0	0.1676	6	17	40	73	81
2/0	0.2027	5	14	33	61	67
3/0	0.2463	4	12	27	50	55
4/0	0.3000	3	9	22	41	45
"ZF, ZFF, Z"						
18	0.0045	245	662	1526	2752	3047
16	0.0061	181	488	1125	2030	2247
14	0.0083	133	359	827	1492	1652
12	0.0117	94	254	587	1058	1171
10	0.0191	57	156	359	648	717
8	0.0302	36	98	227	410	454
6	0.0430	25	69	159	288	318
4	0.6250	1	4	10	19	21
3	0.0855	12	34	80	144	160
2	0.1029	10	28	66	120	133
1	0.1269	8	23	54	97	108
1/0	0.1676	6	17	40	73	81
2/0	0.2027	5	14	33	61	67
3/0	0.2463	4	12	27	50	55
4/0	0.3000	3	9	22	41	45
"XHHW, ZW, XHHW-2, XHH"						
14	0.0139	79	214	494	891	986
12	0.0181	61	164	379	684	757
10	0.0243	45	122	282	509	564
8	0.0437	25	68	157	283	313
6	0.0590	18	50	116	209	232
4	0.0814	13	36	84	152	168
3	0.0962	11	30	71	128	142
2	0.1146	9	26	59	108	119
1	0.1534	7	19	44	80	89
1/0	0.1825	6	16	37	67	75
2/0	0.2190	5	13	31	56	62
3/0	0.2642	4	11	25	46	51
4/0	0.3197	3	9	21	38	42
250	0.3904	2	7	17	31	35
300	0.4536	2	6	15	27	30
350	0.5166	2	5	13	23	26
400	0.5782	1	5	11	21	23
500	0.6984	1	4	9	17	19
600	0.8709	1	3	7	14	15
700	0.9923	1	3	6	12	13
750	1.0532	1	2	6	11	13
800	1.1122	0	2	6	11	12
900	1.2351	0	2	5	10	11
1000	1.3519	0	2	5	9	10
1250	1.7180	0	1	3	7	7
1500	2.0157	0	1	3	6	6
1750	2.3127	0	1	2	5	5
2000	2.6073	0	1	2	4	5
"KF-2, KFF-2"						
18	0.0031	356	961	2215	3995	4423
16	0.0044	251	677	1560	2815	3116
14	0.0064	172	465	1073	1935	2142
12	0.0093	118	320	738	1331	1474
10	0.0139	79	214	494	891	986
"KF-1, KFF-1"						
18	0.0026	424	1146	2641	4764	5273
16	0.0037	298	805	1856	3347	3705
14	0.0055	200	541	1248	2252	2493
12	0.0083	133	359	827	1492	1652
10	0.0127	86	234	540	975	1079

The 2008 National Electric Code limits wireway fill as follows:
1. A wireway shall not contain more than thirty current-carrying conductors except where the ampacity has been adjusted according to Table 310-15(b)(2)(a).
2. The sum of the cross-sectional areas of all conductors shall not exceed 20% of the interior cross-sectional area of the wireway.

NOTE: Section 14 of NFPA 79 allows 50% fill for industrial machine wireway.

Lay-In Type 1 (Based on 2008 National Electric Code)

Wireway Size and Maximum Number of Conductors Allowed
(Areas shown are 20% of the full interior cross sectional area of the wireway)

Conductor Size AWG-MCM	Area of Conductor (sq. in.)	2.50 x 2.50 (1.25 sq. in.)	4.00 x 4.00 (3.20 sq. in.)	6.00 x 6.00 (7.20 sq. in.)	8.00 x 8.00 (12.8 sq. in.)	10.00 x 10.00 (20 sq. in.)	12.00 x 12.00 (28.8 sq. in.)
"RFH-2, FFH-2, RH"							
18	0.0145	86	220	496	882	1379	1986
16	0.0172	72	186	418	744	1162	1674
14	0.0209	59	153	344	612	956	1377
12	0.0260	48	123	276	492	769	1107
"RHW-2, RHH, RHW"							
14	0.0293	42	109	245	436	682	982
12	0.0353	35	90	203	362	566	815
"RHW-2, RHH, RHW, RH"							
10	0.0437	28	73	164	292	457	659
8	0.0835	14	38	86	153	239	344
6	0.1041	12	30	69	122	192	276
4	0.1333	9	24	54	96	150	216
3	0.1521	8	21	47	84	131	189
2	0.1750	7	18	41	73	114	164
1	0.2660	4	12	27	48	75	108
1/0	0.3039	4	10	23	42	65	94
2/0	0.3505	3	9	20	36	57	82
3/0	0.4072	3	7	17	31	49	70
4/0	0.4754	2	6	15	26	42	60
250	0.6291	1	5	11	20	31	45
300	0.7088	1	4	10	18	28	40
350	0.7870	1	4	9	16	25	36
400	0.8626	1	3	8	14	23	33
500	1.0082	1	3	7	12	19	28
600	1.2135	1	2	5	10	16	23
700	1.3561	0	2	5	9	14	21
750	1.4272	0	2	5	8	14	20
800	1.4957	0	2	4	8	13	19
900	1.6377	0	1	4	7	12	17
1000	1.7719	0	1	4	7	11	16
1250	2.3479	0	1	3	5	8	12
1500	2.6938	0	1	2	4	7	10
1750	3.0357	0	1	2	4	6	9
2000	3.3719	0	0	2	3	5	8
"SF-2, SFF-2"							
18	0.0115	108	278	626	1113	1739	2504
16	0.0139	89	230	517	920	1438	2071
14	0.0172	72	186	418	744	1162	1674
"SF-1, SFF-1"							
18	0.0065	192	492	1107	1969	3076	4430
"RFH-1, AF, XF, XFF, AF, TF, TFF, TW"							
18	0.0080	156	400	900	1600	2500	3600
16	0.0109	114	293	660	1174	1834	2642
14	0.0139	89	230	517	920	1438	2071
12	0.0181	69	176	397	707	1104	1591
10	0.0243	51	131	296	526	823	1185
8	0.0437	28	73	164	292	457	659
"RHH*, RHW*, RHW-2*, THHW, THW, AF, XF, XFF, THW-2, TW"							
14	0.0209	59	153	344	612	956	1377
12	0.0260	48	123	276	492	769	1107
10	0.0333	37	96	216	384	600	864
8	0.0556	22	57	129	230	359	517
6	0.0726	17	44	99	176	275	396
4	0.0973	12	32	73	131	205	295
3	0.1134	11	28	63	112	176	253
2	0.1333	9	24	54	96	150	216
1	0.1901	6	16	37	67	105	151
1/0	0.2223	5	14	32	57	89	129
2/0	0.2624	4	12	27	48	76	109
3/0	0.3117	4	10	23	41	64	92
4/0	0.3718	3	8	19	34	53	77
250	0.4596	2	6	15	27	43	62
300	0.5281	2	6	13	24	37	54
350	0.5958	2	5	12	21	33	48
400	0.6619	1	4	10	19	30	43
500	0.7901	1	4	9	16	25	36
600	0.9729	1	3	7	13	20	29
700	1.1010	1	2	6	11	18	26
750	1.1652	1	2	6	10	17	24
800	1.2272	1	2	5	10	16	23
900	1.3561	0	2	5	9	14	21
1000	1.4784	0	2	4	8	13	19
1250	1.8602	0	1	3	6	10	15
1500	2.1695	0	1	3	5	9	13
1750	2.4773	0	1	2	5	8	11
2000	2.7818	0	1	2	4	7	10
"TFN, TFFN, THHN, THWN, THWN-2"							
18	0.0055	227	581	1309	2327	3636	5236
16	0.0072	173	444	1000	1777	2777	4000
14	0.0097	128	329	742	1319	2061	2969
12	0.0133	93	240	541	962	1503	2165
10	0.0211	59	151	341	606	947	1364
8	0.0366	34	87	196	349	546	786
6	0.0507	24	63	142	252	394	568
4	0.0824	15	38	87	155	242	349
3	0.0973	12	32	73	131	205	295
2	0.1158	10	27	62	110	172	248
1	0.1562	8	20	46	81	128	184
1/0	0.1855	6	17	38	69	107	155

The 2008 National Electric Code limits wireway fill as follows:
1. A wireway shall not contain more than thirty current-carrying conductors except where the ampacity has been adjusted according to Table 310-15(b)(2)(a).
2. The sum of the cross-sectional areas of all conductors shall not exceed 20% of the interior cross-sectional area of the wireway.

NOTE: Section 14 of NFPA 79 allows 50% fill for industrial machine wireway.

Wireway Size and Maximum Number of Conductors Allowed
(Areas shown are 20% of the full interior cross sectional area of the wireway)

Conductor Size AWG-MCM	Area of Conductor (sq. in.)	2.50 x 2.50 (1.25 sq. in.)	4.00 x 4.00 (3.20 sq. in.)	6.00 x 6.00 (7.20 sq. in.)	8.00 x 8.00 (12.8 sq. in.)	10.00 x 10.00 (20 sq. in.)	12.00 x 12.00 (28.8 sq. in.)
Continued							
2/0	0.2223	5	14	32	57	89	129
3/0	0.2679	4	11	26	47	74	107
4/0	0.3237	3	9	22	39	61	88
250	0.3970	3	8	18	32	50	72
300	0.4608	2	6	15	27	43	62
350	0.5242	2	6	13	24	38	54
400	0.5863	2	5	12	21	34	49
500	0.7073	1	4	10	18	28	40
600	0.8676	1	3	8	14	23	33
700	0.9887	1	3	7	12	20	29
750	1.0496	1	3	6	12	19	27
800	1.1085	1	2	6	11	18	25
900	1.2311	1	2	5	10	16	23
1000	1.3478	0	2	5	9	14	21
"PF, PGFF, PGF, PFF, PTF, PAF, PTFF, PAFF, TFE, FEP, PFA, FEPB, PFAH"							
18	0.0058	215	551	1241	2206	3448	4965
16	0.0075	166	426	960	1706	2666	3840
14	0.0100	125	320	720	1280	2000	2880
12	0.0137	91	233	525	934	1459	2102
10	0.0191	65	167	376	670	1047	1507
8	0.0333	37	96	216	384	600	864
6	0.0468	26	68	153	273	427	615
4	0.0670	18	47	107	191	298	429
3	0.0804	15	39	89	159	248	358
2	0.0973	12	32	73	131	205	295
1	0.1399	8	22	51	91	142	205
1/0	0.1676	7	19	42	76	119	171
2/0	0.2027	6	15	35	63	98	142
3/0	0.2463	5	12	29	51	81	116
4/0	0.3000	4	10	24	42	66	96
"ZF, ZFF, Z"							
18	0.0045	277	711	1600	2844	4444	6400
16	0.0061	204	524	1180	2098	3278	4721
14	0.0083	150	385	867	1542	2409	3469
12	0.0117	106	273	615	1094	1709	2461
10	0.0191	65	167	376	670	1047	1507
8	0.0302	41	105	238	423	662	953
6	0.0430	29	74	167	297	465	669
4	0.6250	2	5	11	20	32	46
3	0.0855	14	37	84	149	233	336
2	0.1029	12	31	69	124	194	279
1	0.1269	9	25	56	100	157	226
1/0	0.1676	7	19	42	76	119	171
2/0	0.2027	6	15	35	63	98	142
3/0	0.2463	5	12	29	51	81	116
4/0	0.3000	4	10	24	42	66	96
"XHHW, ZW, XHHW-2, XHH"							
14	0.0139	89	230	517	920	1438	2071
12	0.0181	69	176	397	707	1104	1591
10	0.0243	51	131	296	526	823	1185
8	0.0437	28	73	164	292	457	659
6	0.0590	21	54	122	216	338	488
4	0.0814	15	39	88	157	245	353
3	0.0962	12	33	74	133	207	299
2	0.1146	10	27	62	111	174	251
1	0.1534	8	20	46	83	130	187
1/0	0.1825	6	17	39	70	109	157
2/0	0.2190	5	14	32	58	91	131
3/0	0.2642	4	12	27	48	75	109
4/0	0.3197	3	10	22	40	62	90
250	0.3904	3	8	18	32	51	73
300	0.4536	2	7	15	28	44	63
350	0.5166	2	6	13	24	38	55
400	0.5782	2	5	12	22	34	49
500	0.6984	1	4	10	18	28	41
600	0.8709	1	3	8	14	22	33
700	0.9923	1	3	7	12	20	29
750	1.0532	1	3	6	12	18	27
800	1.1122	1	2	6	11	17	25
900	1.2351	1	2	5	10	16	23
1000	1.3519	0	2	5	9	14	21
1250	1.7180	0	1	4	7	11	16
1500	2.0157	0	1	3	6	9	14
1750	2.3127	0	1	3	5	8	12
2000	2.6073	0	1	2	4	7	11
"KF-2, KFF-2"							
18	0.0031	403	1032	2322	4129	6451	9290
16	0.0044	284	727	1636	2909	4545	6545
14	0.0064	195	500	1125	2000	3125	4500
12	0.0093	134	344	774	1376	2150	3096
10	0.0139	89	230	517	920	1438	2071
"KF-1, KFF-1"							
18	0.0026	480	1230	2769	4923	7692	11076
16	0.0037	337	864	1945	3459	5405	7783
14	0.0055	227	581	1309	2327	3636	5236
12	0.0083	150	385	867	1542	2409	3469
10	0.0127	98	251	566	1007	1574	2267

The 2008 National Electric Code limits wireway fill as follows:
1. A wireway shall not contain more than thirty current-carrying conductors except where the ampacity has been adjusted according to Table 310-15(b)(2)(a).
2. The sum of the cross-sectional areas of all conductors shall not exceed 20% of the interior cross-sectional area of the wireway.

NOTE: Section 14 of NFPA 79 allows 50% fill for industrial machine wireway.

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DISCONNECT WIRE BEND SPACE TABLES

Allen-Bradley Bulletin 1494F Disconnect Switches

		Wire Bend Space Above Disconnect								
		Bulletin A22[a]				Bulletin A21		Bulletin A28, A34		
Type Number	Amp Rating	When E1=3.84 W1	When E1=6.75 W1	When E1=9.50 W1	When E1=10.5 W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
N30	30A	3.25	6.25	8.88	—	5.31	11.31	9.31	15.31	18.31
NF30	30A	3.25	6.25	8.88	—	5.31	11.31	9.31	15.31	18.31
N60	60A	2.50	5.25	8.12	—	4.62	10.62	8.62	14.62	17.62
NF60	60A	2.50	5.25	8.12	—	4.62	10.62	8.62	14.62	17.62
N100	100A	—	3.50	6.25	—	—	8.75	6.75	12.75	15.75
NF100	100A	—	3.50	6.25	—	—	8.75	6.75	12.75	15.75
N200	200A	—	—	—	7.00[a]	—	7.12	5.12	11.12	14.12
NF200	200A	—	—	—	7.00[a]	—	7.12	5.12	11.12	14.12

[a] See drawing in Disconnect Chapter to cross reference E1 dimension to enclosure depth.

Allen-Bradley Bulletin 1494D Operators for Circuit Breakers

		Wire Bend Space Above Disconnect							
		Bulletin A22[a]			Bulletin A21		Bulletin A28, A34		
Type Number	Amp Rating	When E1=3.84 W1	When E1=6.75 W1	When E1=9.50 W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
N4/N40	150A	3.25	6.12	8.88	5.25	11.25	9.25	15.25	18.25
N5/N50	250A	—	5.31	8.06	4.44	10.44	8.44	14.44	17.44
N6/N60	400A	—	5.44	8.19	—	10.50	8.50	14.50	17.50

[a] See drawing in Disconnect chapter to cross reference E1 dimension to enclosure depth.

Allen-Bradley 1494F/1494D E1 Cutout by Enclosure Height

Bulletin Number	Height A		E1 up to 100A Switch, 400A Breaker		E1, 200A Switch	
	in.	mm	in.	mm	in.	mm
A21	60.12	1527	5.88	149	na	na
	72.12	1832	11.88	302	10.56	268
A28, A34	72.12	1832	9.88	251	8.56	217
	84.12	2137	15.88	403	14.56	370
	90.12	2289	18.80	478	17.56	446

Allen-Bradley Bulletin 1494V Disconnect Switches

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CW2D, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S4, A4S2		Bulletin A28, A28S4, A34		
Type Number	Amp Rating	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[b] W1	When C=12[c] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
DS30	30A	2.78	5.13	9.66	2.78	9.65	6.66	9.66	5.85	11.85	9.85	15.85	18.85
DS60	60A	2.01	4.35	8.89	2.01	8.88	5.89	8.89	5.08	11.08	9.08	15.08	18.08
DS100	100A	—	4.17	8.67	—	8.69	5.70	8.70	4.89	10.89	8.89	14.89	17.89
DS200	200A	—	—	8.12	—	8.12	—	8.12	—	10.34	8.34	14.34	17.34
DS400a	400A	—	—	—	—	—	—	—	—	—	—	10.14[d]	13.14[d]
DS600a	600A	—	—	—	—	—	—	—	—	—	—	10.14[d]	13.14[d]

a These switches will only fit catalog number A60SA3812A24LP. Wire bend space of 12.12 in. is provided above disconnect when installed.
b C=10 applies only to Bulletin A17.
c For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.
d Does not fit Bulletin A28S enclosures.

Allen-Bradley Bulletin 1494V Operators for Circuit Breakers

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CW2D, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S4, A4S2		Bulletin A28, A28S4, A34		
Type Number	Amp Rating	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[a] W1	When C=12[b] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
M40	15A-150A	4.25	6.62	11.12	4.25	11.12	8.12	11.12	7.25	13.25	11.25	17.25	20.25
M50	70A-250A	—	—	10.62	—	10.62	—	10.62	6.81	12.81	10.81	16.81	19.81
M60	100A-400A	—	—	10.50	—	10.50	—	10.50	—	12.62	10.62	16.62	19.62

a C=10 applies only to Bulletin A17.
b For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

Allen-Bradley 1494V E1 Cutout by Enclosure Height

Bulletin Number	Height A		E1 up to 200A Switch, 400A Breaker		E1, 400A or 600A Switch	
	in.	mm	in.	mm	in.	mm
A21, A21S4, A4S2	60.12	1527	7.88	200	na	na
	72.12	1832	13.88	353	na	na
A28, A28S4, A34	72.12	1832	11.88	302	na	na
	84.12	2137	17.88	454	16.43	417
	90.12	2289	20.88	530	19.43	494

ABB Controls Disconnect Switches with Flange-Mounted Operators

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S		Bulletin A28, A28S, A34		
Type Number	Amp Rating	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[a] W1	When C=12[b] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
OETL-NF30-F	40A	6.41	8.75	13.28	6.41	13.28	10.28	13.28	9.53	15.53	13.53	19.53	22.53
OETL-NF60-F	80A	6.22	8.56	13.09	6.22	13.09	10.09	13.09	9.34	15.34	13.34	19.34	22.34
OETL-NF100-F	100A	5.66	8.00	12.53	566	12.53	9.53	12.53	8.78	14.78	12.78	18.78	21.78
OETL-NF175-F	175A	—	5.75	10.28	—	10.28	7.28	10.28	6.53	12.53	10.53	16.53	19.53
OETL-NF200-F	200A	—	5.75	10.28	—	10.28	7.28	10.28	6.53	12.53	10.53	16.53	19.53
OESA-F30J6-F	30A	4.73	7.07	11.61	4.73	11.61	8.61	11.61	7.85	13.85	11.86	17.86	20.86
OESA-F60J6-F	60A	4.73	7.07	11.61	4.73	11.61	8.61	11.61	7.85	13.85	11.86	17.86	20.86
OESA-F100J6-F	100A	4.30	6.64	11.17	4.30	11.17	8.17	11.17	7.42	13.42	11.42	17.42	20.42

[a] C=10 applies only to Bulletin A17.
[b] For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

ABB Controls Circuit Breakers with Flange-Mounted Operators

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S		Bulletin A28, A28S, A34		
Type Number	Amp Rating	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[a] W1	When C=12[b] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
K2FHD-M	100A	3.39	5.73	10.26	3.39	10.26	7.26	10.26	6.52	12.52	10.52	16.52	19.52
K3FHD-M	150A, 225A	—	—	5.56	—	5.56	—	5.56	—	7.82	5.85	11.82	14.82
K4FHD-M	250A	—	—	3.95	—	3.95	—	3.95	—	6.21	4.21	10.21	13.21
K5FHD-M	400A	—	—	—	—	—	—	—	—	6.21	—	10.21	13.21
K5FHD-M	600/800A	—	—	—	—	—	—	—	—	—	—	10.16	13.16

[a] C=10 applies only to Bulletin A17.
[b] For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

ABB Controls
E1 Cutout by Enclosure Height

Bulletin Number	Height A		E1	
	in.	mm	in.	mm
A21, A21S	60.12	1527	7.88	200
	72.12	1832	13.88	353
A28, A28S, A34	72.12	1832	11.88	302
	84.12	2137	17.88	454
	90.12	2289	20.88	530

Eaton Cutler-Hammer C361 Disconnect Switches

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S		Bulletin A28, A28S, A34		
Type Number	Amp Rating	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[b] W1	When C=12[c] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
C361NC	30A	3.44	5.75	10.31	3.44	10.31	7.31	10.31	6.50	12.50	10.50	16.50	19.50
C361SC21	30A	3.44	5.75	10.31	3.44	10.31	7.31	10.31	6.50	12.50	10.50	16.50	19.50
C361SC61	30A	3.44	5.75	10.31	3.44	10.31	7.31	10.31	6.50	12.50	10.50	16.50	19.50
C361ND	60A	3.44	5.75	10.31	3.44	10.31	7.31	10.31	6.50	12.50	10.50	16.50	19.50
C361SD22	60A	3.44	5.75	10.31	3.44	10.31	7.31	10.31	6.50	12.50	10.50	16.50	19.50
C361SD62	60A	3.44	5.75	10.31	3.44	10.31	7.31	10.31	6.50	12.50	10.50	16.50	19.50
C361NE	100A	3.00	5.38	9.91	3.00	9.91	7.47	9.91	6.06	12.06	10.06	16.06	19.06
C361SE263	100A	3.00	5.38	9.91	3.00	9.91	7.47	9.91	6.06	12.06	10.06	16.06	19.06
C361NF[a]	200A	—	—	7.94	—	7.94	4.94	7.94	4.06	10.06	8.06	14.06	17.06
C361SF264[a]	200A	—	—	7.94	—	7.94	4.94	7.94	4.06	10.06	8.06	14.06	17.06

a 200 amp switch should be installed in an enclosure with an A dimension of 30.00 in. (762 mm) or more.
b C=10 applies only to Bulletin A17.
c For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

Eaton Cutler-Hammer C371 Circuit Breaker Operators for C-H/Westinghouse Circuit Breakers

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S		Bulletin A28, A28S, A34		
Type Number	Amp Rating	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[d] W1	When C=12[e] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
C371E	225A	4.44	6.81	11.44	4.44	11.44	8.44	11.44	7.62	13.62	11.62	17.62	20.62
C371E	150A	4.44	6.81	11.44	4.44	11.44	8.44	11.44	7.62	13.62	11.62	17.62	20.62
C371F	225A	—	6.75	11.25	—	11.25	—	11.25	11.44	17.44	—	20.44	—
C371F	400A	—	—	10.75	—	10.25	—	10.75	7.00	13.00[a]	11.00	17.00	20.00
C371G	600A	—	—	9.18	—	9.18	—	9.18	—	11.38[b]	9.38	15.38	18.38
C371K	800A	—	—	—	—	—	—	—	—	—	—	11.81	14.81
C371K	1200A	—	—	—	—	—	—	—	—	—	—	11.81[c]	14.81

a Available wire bend space W1 does not allow cable sizes larger than 4/0 AWG in a 60.12-in. tall enclosure.
b Available wire bend space W1 does not allow cable sizes larger than 300 MCM.
c Available wire bend space W1 does not allow cable sizes larger than 350 MCM in a 90.12-in. tall enclosure when using 4 cable per terminal. See National Electrical Code® 2008 table 373-6(b) for more information. Available wire bend space W1 is insufficient for use with Westinghouse breakers equipped with TA1201NB1 terminals.
d C=10 applies only to Bulletin A17.
e For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

Eaton Cutler-Hammer C371 E1 Cutout by Enclosure Height

Bulletin Number	Height A		E1	
	in.	mm	in.	mm
A21, A21S	60.12	1527	7.88	200
	72.12	1832	13.88	353
A28, A28S, A34	72.12	1832	11.88	302
	84.12	2137	17.88	454
	90.12	2289	20.88	530

Eaton Cutler-Hammer Type SM Safety Handle Mechanisms for C-H/Westinghouse Circuit Breakers

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21		Bulletin A28, A34		
Handle Mechanism	Use with Circuit Breaker	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[a] W1	When C=12[b] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
SM101PR	FB Tri-Pac	—	—	—	—	—	—	—	6.50	12.50	10.50	16.50	19.50
SM150R	F Frame EHD, FDB, FD, HFD, FDC	—	—	—	—	—	—	—	6.50	12.50	10.50	16.50	19.50
SM250JR	J Frame JDB, JD, HJD, JDC	—	—	—	—	—	—	—	—	10.00	8.00	14.00	17.00
SM400KR	K Frame DK, KDB, KD, HKD	—	—	—	—	—	—	—	—	9.62	7.62	13.62	16.62
SM400PR	LA Tri-Pac	—	—	—	—	—	—	—	—	9.75	7.75	13.75	16.75
SM600R	L Frame LD, HLD, LDC	—	—	—	—	—	—	—	—	—	—	12.88	15.88
SM800R	M Frame MD, MDS, HMD	—	—	—	—	—	—	—	—	—	—	10.16	13.16
SM800PR	NB Tri-Pac	—	—	—	—	—	—	—	—	—	—	10.16	13.16

a C=10 applies only to Bulletin A17.
b For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

Eaton Cutler-Hammer Type SM E1 Cutout by Enclosure Height

Bulletin Number	Height A		E1, up to type SM200		E1, SM200 and larger	
	in.	mm	in.	mm	in.	mm
A21	60.12	1527	7.31	186	6.88	175
	72.12	1832	13.31	338	12.88	327
A28, A34	72.12	1832	11.31	287	10.88	276
	84.12	2137	17.31	440	16.88	429
	90.12	2289	20.31	516	19.88	505

General Electric Type STDA Disconnect Switch Operators

		Wire Bend Space Above Disconnect										
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S		Bulletin A28, A28S, A34		
Type Number	Amp Rating	When C=8 [a] W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[a] W1	When C=12[b] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
TDOM1A	30A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	8.38	14.38	12.38	18.38	21.38
TDOM1B	30A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	8.38	14.38	12.38	18.38	21.38
TDOM1A	60A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	8.38	14.38	12.38	18.38	21.38
TDOM1B	60A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	8.38	14.38	12.38	18.38	21.38
TDOM1A	100A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	8.38	14.38	12.38	18.38	21.38
TDOM1B	100A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	8.38	14.38	12.38	18.38	21.38
TDOM2	200A	—	—	9.50	—	9.50	6.50	9.50	5.69	11.69	9.69	15.69	18.69

a C=10 applies only to Bulletin A17.
b For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

General Electric Type STDA Circuit Breaker Operators

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S		Bulletin A28, A28S, A34		
Type Number	Amp Rating	When C=8 [a] W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[b] W1	When C=12[c] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
SDOM1A	150A	6.06	7.50	12.06	5.19	12.06	9.06	12.06	7.24	13.24	11.24	17.24	20.24
SDOM3	250A	—	6.06	10.62	—	10.62	7.06	10.06	6.81	12.81	10.81	16.81	19.81
SDOM4	600A	—	—	7.93	—	7.93	—	7.93	—	9.18	—	13.18	16.18
TDOM1A-C	150A	6.06	7.50	12.06	5.19	12.06	9.06	12.06	7.24	13.24	11.24	17.24	0.24
TDOM1D	150A	—	5.12	9.62	—	9.62	6.62	9.62	5.87	11.87	9.87	15.87	18.87
TDOM3	225A	—	6.06	10.62	—	10.62	7.62	10.62	6.81	12.81	10.81	16.81	19.81
TDOM4	400A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	—	11.91	9.91	15.91	18.91
TDOM4	600A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	—	11.91	9.91	15.91	18.91
TDOM5	400A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	—	11.91	9.91	15.91	18.91
TDOM6	225A	6.18	7.62	12.12	5.30	12.12	9.12	12.12	—	11.35	—	15.35	18.35
TDOM6	400A	—	5.12	9.69	—	9.69	6.69	9.69	—	9.97	—	13.97	16.97
TDOM6	800A-1200A	—	—	—	—	—	—	—	—	—	—	—	18.38
TDOM6	1200A	—	—	—	—	—	—	—	—	—	—	—	18.38
TDOM7	600A	—	—	—	—	—	—	—	—	—	—	12.25	15.25
TDOM7	800A	—	—	—	—	—	—	—	—	—	—	12.25	15.25
TDOM7	1200A	—	—	—	—	—	—	—	—	—	—	—	15.25

a Disconnect moved down .88 inch to fit on panel.
b C=10 applies only to Bulletin A17.
c For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

General Electric Type STDA E1 Cutout by Enclosure Height

Bulletin Number	Height A in.	mm	E1 in.	mm
A21, A21S	60.12	1527	7.88	200
	72.12	1832	13.88	353
A28, A28S, A34	72.12	1832	11.88	302
	84.12	2137	17.88	454
	90.12	2289	20.88	530

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S		Bulletin A28, A28S, A34		
Type Number	Amp Rating	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[a] W1	When C=12[b] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
TCN-30	30A	3.69	6.03	10.56	3.69	10.56	7.56	10.56	6.75	12.75	10.75	16.75	19.75
TCF-30	30A	3.69	6.03	10.56	3.69	10.56	7.56	10.56	6.75	12.75	10.75	16.75	19.75
TCF-33	30A	3.69	6.03	10.56	3.69	10.56	7.56	10.56	6.75	12.75	10.75	16.75	19.75
TDN-60	60A	3.69	6.03	10.56	3.69	10.56	7.56	10.56	6.75	12.75	10.75	16.75	19.75
TDF-60	60A	3.69	6.03	10.56	3.69	10.56	7.56	10.56	6.75	12.75	10.75	16.75	19.75
TDF-63	60A	3.69	6.03	10.56	3.69	10.56	7.56	10.56	6.75	12.75	10.75	16.75	19.75
TEN-10	100A	—	5.91	10.44	—	10.44	7.44	10.44	6.62	12.62	10.62	16.62	19.62
TEF-10	100A	—	5.91	10.44	—	10.44	7.44	10.44	6.62	12.62	10.62	16.62	19.62
TEF-13	100A	—	5.91	10.44	—	10.44	7.44	10.44	6.62	12.62	10.62	16.62	19.62
TC-1	30A	3.12	5.12	9.62	3.12	9.62	6.62	9.62	5.88	11.88	9.88	15.88	18.88
TC-2	30A	3.12	5.12	9.62	3.12	9.62	6.62	9.62	5.88	11.88	9.88	15.88	18.88
TC-3	30A	3.12	5.12	9.62	3.12	9.62	6.62	9.62	5.88	11.88	9.88	15.88	18.88
TD-1	60A	3.62	6.00	10.50	3.62	10.50	7.50	10.50	6.75	12.75	10.75	16.75	19.75
TD-2	60A	3.62	6.00	10.50	3.62	10.50	7.50	10.50	6.75	12.75	10.75	16.75	19.75
TD-3	60A	3.62	6.00	10.50	3.62	10.50	7.50	10.50	6.75	12.75	10.75	16.75	19.75
TE-1	100A	—	5.75	10.25	—	10.25	—	10.25	6.50	12.50	10.50	16.50	19.50
TE-2	100A	—	5.75	10.25	—	10.25	—	10.25	6.50	12.50	10.50	16.50	19.50
TE-3	100A	—	5.75	10.25	—	10.25	—	10.25	6.50	12.50	10.50	16.50	19.50
TF-1	200A	—	—	8.88	—	8.88	—	8.88	5.12	11.12	9.12	15.12	18.12
TF-2	200A	—	—	8.88	—	8.88	—	8.88	5.12	11.12	9.12	15.12	18.12
TF-3	200A	—	—	8.88	—	8.88	—	8.88	5.12	11.12	9.12	15.12	18.12

a C=10 applies only to Bulletin A17.
b For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

Schneider Square D Class 9422 Variable Depth Operators-Circuit Breakers

		Wire Bend Space Above Disconnect											
		Bulletin A25, A26			Bulletin CWD, CWSD		Bulletin A17, A19, A19S		Bulletin A21, A21S		Bulletin A28, A28S, A34		
Type Number	Amp Rating	When C=8 W1	When C=10 W1	When C=12 or 16 W1	When C=8 W1	When C=12 W1	When C=8 or 10[a] W1	When C=12[b] W1	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
RG-1	75A	3.59	5.93	10.47	3.59	10.47	7.47	10.47	6.69	12.69	10.69	16.69	19.69
RG-1	100A	3.59	5.93	10.47	3.59	10.47	7.47	10.47	6.69	12.69	10.69	16.69	19.69
RN-1	100A	3.75	6.12	10.62	3.75	10.62	7.62	10.62	6.88	12.88	10.88	16.88	19.88
RP-1	250A	4.25	6.88	11.38	—	11.38	8.38	11.38	7.56	13.56	11.56	17.56	20.56
RR-1	400A	—	—	7.00	—	7.00	—	7.00	—	9.25	—	13.25	16.25
RT-1	800A	—	—	—	—	—	—	—	—	—	—	13.25	16.12
RT-1	1000A	—	—	—	—	—	—	—	—	—	—	13.25	16.12

a C=10 applies only to Bulletin A17.
b For A24HS2412GQRLP use the C=8 or 10 column for W1 wire bend space.

Schneider Square D Class 9422 E1 Cutout by Enclosure Height

Bulletin Number	Height A in.	Height A mm	E1 in.	E1 mm
A21, A21S	60.12	1527	7.88	200
	72.12	1832	13.88	353
A28, A28S, A34	72.12	1832	11.88	302
	84.12	2137	17.88	454
	90.12	2289	20.88	530

Westinghouse Type AMT Below-Handle Mechanisms with Variable or Fixed Pivot Assemblies for Disconnect Switches

		Wire Bend Space Above Disconnect				
		Bulletin A21		Bulletin A28, A34		
Type Number	Amp Rating	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
DS16U	30A	9.28	14.78	13.28	18.78	21.78
DS121R	30A	9.28	14.78	13.28	18.78	21.78
DS161R	30A	9.28	14.78	13.28	18.78	21.78
DS122	30A	9.28	14.78	13.28	18.78	21.78
DS162	30A	9.28	14.78	13.28	18.78	21.78
DS26U	60A	9.28	14.78	13.28	18.78	21.78
DS222R	60A	9.28	14.78	13.28	18.78	21.78
DS262R	60A	9.28	14.78	13.28	18.78	21.78
DS263	60A	9.28	14.78	13.28	18.78	21.78
DS36U	100A	9.28	14.78	13.28	18.78	21.78
DS363R	100A	9.28	14.78	13.28	18.78	21.78
DS364	100A	9.28	14.78	13.28	18.78	21.78
DS46U	200A	7.00	12.50	11.00	16.50	19.50
DS464R	200A	7.00	12.50	11.00	16.50	19.50
DS465	200A	7.00	12.50	11.00	16.50	19.50

Westinghouse Type AMT Below-Handle Mechanisms with Variable or Fixed Pivot Assemblies for Circuit Breakers

		Wire Bend Space Above Disconnect				
		Bulletin A21		Bulletin A28, A34		
Type Number	Amp Rating	When A=60.12 W1	When A=72.12 W1	When A=72.12 W1	When A=84.12 W1	When A=90.12 W1
EB	100A	9.28	14.78	13.28	18.78	21.78
FB Tri-Pac	100A	9.28	14.78	13.28	18.78	21.78
MCP (0-4), Current Limiter	150A	9.28	14.78	13.28	18.78	21.78
F Frame/Series C	150A	9.28	14.78	13.28	18.78	21.78
J Frame/Series C	250A	9.28	14.78	13.28	18.78	21.78
K Frame/Series C	400A	9.28	14.78	13.28	18.78	21.78
LA, LAB, HLA, LC, HLC	600A	9.28	14.78	13.28	18.78	21.78
LA Tri-Pac	400A	9.28	14.78	13.28	18.78	21.78
MC, HMC, MA HMA	800A	9.28	14.78	13.28	18.78	21.78
NC, HNC, NB, HNB	1200A	9.28	14.78	13.28	18.78	21.78
NB Tri-Pac	800A	9.28	14.78	13.28	18.78	21.78

Westinghouse AMT Below Handle Mechanisms E1 Cutout by Enclosure Height

	Height			
Bulletin Number	A in.	mm	E1 in.	mm
A21	60.12	1527	9.12	278
	72.12	1832	14.62	446
A28, A34	72.12	1832	13.12	400
	84.12	2137	18.62	568
	90.12	2289	21.62	659

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