

Engineering Data

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Industry Standards

Enclosure Ratings

Third party certifiers, such as UL & CSA, have adopted most of the enclosure ratings from the ANSI /NEMA 250 standard for electrical enclosures. Such ratings identify the environmental capabilities of enclosures based on specified performance criteria. Thus, the type of enclosure can be selected as deemed appropriate for the application.

These enclosures are intended to house electrical equipment rated at no more than 1000 volts for use in nonhazardous locations. Such enclosures do not protect devices against conditions such as condensation, icing, corrosion or contamination which may occur within the enclosure or may enter via the conduit or unsealed openings, and are not intended to prevent entry or operation by unauthorized personnel.

Sources of Standards



NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

1300 North 17th Street

Suite 1847

Rosslyn, VA 22209

- NEMA Standards Publication No. 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
- NEMA Standards Publication No. ICS6, Enclosures for Industrial Controls and Systems



ELECTRICAL/ELECTRONIC MANUFACTURERS ASSOCIATION OF CANADA

10 Carlson Court, Suite 500

Rexdale (Toronto), Ontario

Canada, M9W 6L2



UNDERWRITERS LABORATORIES INC.

333 Pfingsten Road

Northbrook, IL 60062

- UL 50, Enclosures for Electrical Equipment
- UL 508, Industrial Control Equipment
- UL 870, Wireway, Auxiliary Gutters and Associated Fittings
- UL 414, Meter Sockets



JOINT INDUSTRY COUNCIL

7901 Westpark Drive

McLean, VA 22101

- EMP-1, Electrical Standards for Mass Production Equipment
- EGP-1, Electrical Standards for General Purpose Machine Tools



CANADIAN STANDARDS ASSOCIATION

178 Rexdale Boulevard

Rexdale (Toronto), Ontario

Canada, M9W 1R3

- CSA Standard C22.2 No. 94-M91, Industrial Control Equipment for use in Ordinary (Nonhazardous) locations.
- CSA Standard C22.2 No. 40 M1989, Cutout, Junction & Pull Boxes
- CSA Standard C22.2 No. 26 1952, Wireways, Auxiliary Gutters & Associated Fittings
- CSA Standard C22.1, 1990, Canadian Electrical Code

NFPA

NATIONAL FIRE PROTECTION ASSOCIATION




Batterymarch Park

Quincy, MA 02269

- NFPA 70 National Electrical Code (1999)

An enclosure is a surrounding case constructed to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

A brief description of the more common types of enclosures used by the electrical industry relating to their environmental capabilities follows:

|  NEMA |  UL (UL 50) |  CSA 22.2 No. 94-M91 |
|---|---|--|
| Type 1 Enclosures are intended for indoor use primarily to provide a degree of protection against limited amounts of falling dirt. | Type 1 Indoor use primarily to provide a degree of protection against limited amounts of falling dirt. | Type 1 General purpose enclosure. Protects against accidental contact with live parts. |
| Type 3 Enclosures are intended for outdoor use primarily to provide a degree of protection against rain, sleet, wind blown dust and damage from external ice formation. | Type 3 Outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust and damage from external ice formation. | Type 3 An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, snow, and windblown dust; undamaged by the external formation of ice on the enclosure. |
| Type 3R Enclosures are intended for outdoor use primarily to provide a degree of protection against rain, sleet and damage from external ice formation. | Type 3R Outdoor use primarily to provide a degree of protection against rain, sleet, and damage from external ice formation. | Type 3R An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, and snow, undamaged by the external formation of ice on the enclosure. |
| Type 4 Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water and damage from external ice formation. | Type 4 Indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water and damage from external ice formation. | Type 4 An enclosure for either indoor or outdoor use, constructed so as to provide a degree of protection against rain, snow, windblown dust, splashing and hose-directed water; undamaged by the external formation of ice on the enclosure. |
| 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, hose-directed water and damage from external ice formation. | Type 4X Indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water and damage from external ice formation. | Type 4X An enclosure for either indoor or outdoor use, constructed so as to provide 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. |
| Type 12 Enclosures are intended for indoor use primarily to provide a degree of protection against circulating dust, falling dirt and dripping noncorrosive liquids. | Type 12/12K Indoor use primarily to provide a degree of protection against circulating dust, falling dirt and dripping noncorrosive liquids. | Type 12 An enclosure for indoor use, constructed so as to provide a degree of protection against circulating dust, lint, fibres, and flyings; dripping and light splashing of noncorrosive liquids; not provided with knockouts. |
| Type 12K Enclosures with knockouts are intended for indoor use primarily to provide a degree of protection against circulating dust, falling dirt and dripping non-corrosive liquids. | | Type 12K An enclosure for indoor use, constructed so as to provide a degree of protection against circulating dust, lint, fibres, and flyings; dripping and light splashing of noncorrosive liquids; and provided with knockouts. |
| Type 13 Enclosures are intended for indoor use primarily to provide a degree of protection against dust, spraying of water, oil and noncorrosive coolant. | Type 13 Indoor use primarily to provide a degree of protection against dust, spraying of water, oil and noncorrosive coolant. | Type 13 An enclosure for indoor use, constructed so as to provide a degree of protection against circulating dust, lint, fibres, and flyings; seepage and spraying of noncorrosive liquids including oils and coolants. |

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Comparison of Specific Applications of Enclosures for Indoor Nonhazardous Locations

| Provides a degree of protection against the following environmental conditions | Enclosure Type | | | | | |
|--|----------------|---|----|----|-----|----|
| | 1* | 4 | 4X | 12 | 12K | 13 |
| Incidental contact with the enclosed equipment | X | X | X | X | X | X |
| Falling Dirt | X | X | X | X | X | X |
| Falling liquids and light splashing | | X | X | X | X | X |
| Circulating dust, lint, fibers and flyings** | | X | X | X | X | X |
| Settling airborne dust, lint, fibers and flyings** | | X | X | X | X | X |
| Hosedown and splashing water | | X | X | | | |
| Oil and coolant seepage | | | | X | X | X |
| Oil or coolant spraying and splashing | | | | | | X |
| Corrosive agents | | | X | | | |
| Occasional temporary submersion | | | | | | |
| Occasional prolonged submersion | | | | | | |

* These enclosures may be ventilated.

** These fibers and flying are nonhazardous materials and are not considered the Class III type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings see the National Electrical Code, Article 500.

Comparison of Specific Applications of Enclosures for Outdoor Nonhazardous Locations

| Provides a degree of protection against the following environmental conditions: | Enclosure Type | | | |
|---|----------------|-------|---|----|
| | 3 | 3R*** | 4 | 4X |
| Incidental contact with the enclosed equipment | X | X | X | X |
| Rain, snow and sleet* | X | X | X | X |
| Sleet** | | | | |
| Windblown dust | X | | X | X |
| Hosedown | | | X | X |
| Corrosive agents | | | | X |
| Occasional temporary submersion | | | | |
| Occasional prolonged submersion | | | | |

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

** External operating mechanisms are operable when the enclosure is ice covered.

*** These enclosures may be ventilated.

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Comparison Between NEMA Enclosure Type Numbers and IEC Enclosure Classification Designations*

IEC Publication 529 *Classification of Degrees of Protection Provided by Enclosures* provides a system for specifying the enclosures of electrical equipment on the basis of degree of protection provided by the enclosure. IEC 529 does not specify degrees of protection against mechanical damage of equipment, risk of explosions, or conditions such as moisture (produced for example by condensation), corrosive vapors, fungus or vermin. NEMA Standards Publication 250 does test for environmental conditions such as corrosion, rust, icing, oil and coolants. 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.

The IEC designation consists of the letters IP followed by two numerals. The first characteristic numeral indicates the degree of protection provided by the enclosure with respect to persons and solid foreign objects entering the enclosure. The second characteristic numeral indicates the degree of protection provided by the enclosure with respect to the harmful ingress of water.

Table A-1 provides an equivalent conversion from NEMA Enclosure Type Numbers to IEC Enclosure Classification Designations. The NEMA Types meet or exceed the test requirements for the associated IEC Classifications; for this reason Table A-1 cannot be used to convert from IEC Classifications to NEMA Types.

Table A-1 Conversion of NEMA Type Numbers to IEC Classification Designations
(Cannot be used to convert IEC Classification Designations to NEMA Type Numbers)

| NEMA ENCLOSURE TYPE NUMBER | IEC ENCLOSURE CLASSIFICATION DESIGNATION |
|----------------------------|--|
| 1 | IP20 |
| 2 | IP22 |
| 3 | IP55 |
| 3R | IP24 |
| 3S | IP55 |
| 4 and 4X | IP66 |
| 5 | IP53 |
| 6 and 6P | IP67 |
| 12 and 12K | IP54 |
| 13 | IP54 |

Note: This comparison is based on tests specified in IEC Publication 529.

Components Suitable for Closing Openings in Enclosures

| Enclosure Type | Openings shall be closed by equipment rated for enclosure types |
|----------------|---|
| 3 | 3, 3S, 4, 4X |
| 3R | 3, 3R, 3S, 4, 4X |
| 4 | 4, 4X |
| 4X | 4X |
| 12,12K | 12, 12K, 13, 4, 4X |
| 13 | 13 |

Materials and Finishes

Caution: Environmental capabilities of enclosures, including materials and finishes, are limited to the degree of protection provided by the “type” rating of the selected enclosure. See industry standards for more information.

METALS

Characteristics of Various Metals

Hot Rolled Pickled and Oiled Steel Sheets (ASTM A1011)

A low-carbon, hot-finished steel that has had the normal mill oxide removed by means of an acid bath. After de-scaling, an oil film is applied to protect the surface. Removal of the mill oxide improves the surface appearance, uniformity, and finishing quality.

Cold Rolled Steel (ASTM A1008)

A low-carbon, cold-finished steel having commercial quality, close thickness tolerance and better surface than hot rolled pickled and oiled.

Galvanized Steel (ASTM A653)

Steel with a zinc coating applied by the hot dip galvanizing process. The zinc coating provides a degree of corrosion protection, and also provides some protection at the sheared edges.

Stainless Steel Type 302/304 (ASTM-A240)

An excellent corrosion resistant material with excellent mechanical properties. It has many of the same chemical resistance attributes of fiberglass materials.

5052-H32 Aluminum (ASTM B209)

An excellent alloy for enclosure manufacturing. It exhibits good resistance to corrosion in a marine atmosphere.

Gasket Material

Poron 4701-40

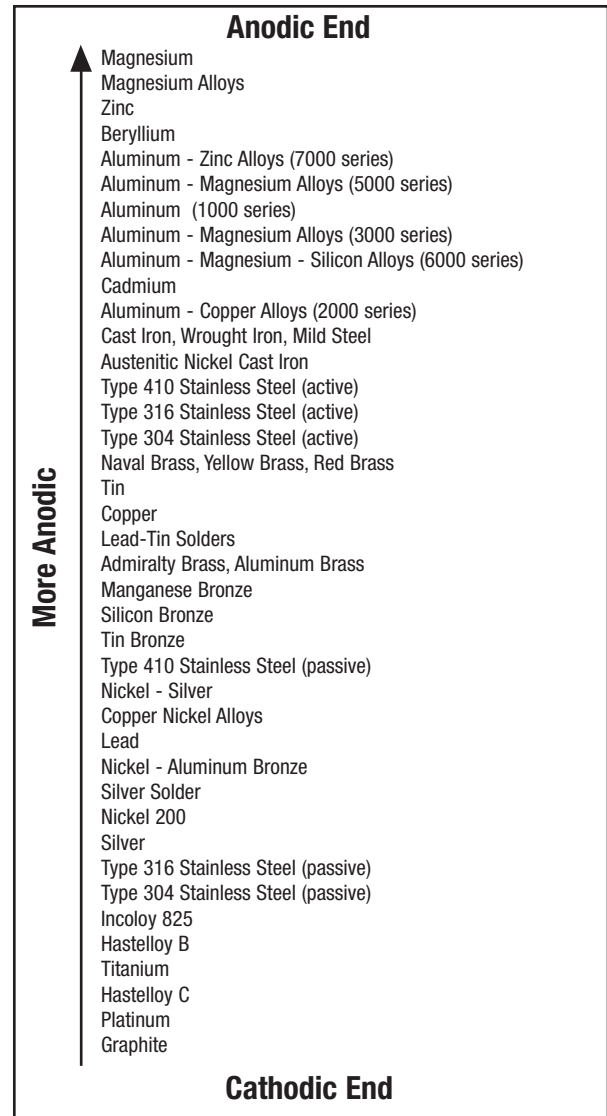
High density polyurethane with excellent compression set, resistance and good oil resistance.

Finishes

Polyester Urethane - Powder: A durable and smooth coating with good adhesion and corrosion resistance suitable for outdoor use. Provides good impact protection against heat or chemicals.

Electrocoat (E-Coat) - Liquid: A rugged cathodic acrylic coating that results in a unique combination of durability and corrosion resistance.

Epoxy - Powder: A tough, durable finish which is corrosion resistant and resistant to many solvent oils. Gloss may be affected by prolonged exposure to UV light.



B-Line Manufactures enclosures from a wide range of materials, offering varying degrees of resistance against chemical corrosion. All materials are affected by corrosion in some manner. Depending on the physical properties of the material and the environment to which it is exposed, chemical or electromechanical corrosion may occur. In order to select the appropriate material for your application, refer to the corrosion resistance table on the following pages.

Atmospheric Corrosion

Atmospheric corrosion occurs when a material is exposed to airborne liquids, solids, or gases. Some sources of atmospheric corrosion are moisture, salt, dirt, and sulfuric acid. This form of corrosion is typically worse outdoors, and especially near marine environments.

To combat the effects of atmospheric corrosion, the National Electrical Manufacturers Association (NEMA) has developed the NEMA 4X rating. An enclosure carrying the NEMA 4X rating meets certain minimum conditions of corrosion resistance. Specifically, the materials from which NEMA 4X rated enclosures are formed must withstand two hundred hours of salt spray with no more evidence of corrosive pitting than is exhibited by a concurrently tested sample of Type 304 stainless steel.

B-Line offers metallic NEMA 4X rated enclosures in aluminum, and stainless steel Type 304 and Type 316L as well as a full line of NEMA 4X rated non-metallic enclosures.

Chemical Corrosion

Chemical corrosion takes place when a material comes into direct contact with a corrosive agent. The severity of chemical corrosion is affected by chemical concentration level, frequency of washing, and operating temperature. Refer to the chart below for a general overview of how different enclosures might perform when in contact with chemicals of varying pH. The chart is provided as a quick guide to how different materials might perform in your environment. We recommend consulting the detailed corrosion resistance table provided on the following pages to be sure that the appropriate material is selected.

Storage Corrosion

Wet storage stain (White rust) is caused by the entrapment of moisture between the surfaces of closely packed and poorly ventilated material for an extended period. Wet storage stain is usually superficial, having little affect on the properties of the material.

Proper handling and storage will help to assure stain free material. If a product arrives wet, it should be unpacked and allowed to dry before storage. Dry material should be stored in a well-ventilated, low-moisture environment to avoid the formation of condensation. Outdoor storage is undesirable and should be avoided whenever possible.

Galvanic Corrosion

Galvanic corrosion occurs when two or more dissimilar metals are in contact in the presence of seawater or another electrolyte. In this situation, an electrolytic cell is created and the metals become either an anode or a cathode. The anodic material will corrode and the cathodic material will be protected.

Whether a material is anodic depends on the relative positions of the interacting materials in the Galvanic Series Table (shown at left). For example: If zinc and steel are in contact, the zinc acts as the anode and will corrode while protecting the steel. If steel and copper are in contact, the steel is now the anode and will corrode while protecting the copper.

The rate at which galvanic corrosion occurs depends on several factors:

1. The amount and concentration of electrolyte present. An indoor, dry environment will support little or no galvanic corrosion relative to a wet atmosphere.
2. The relative amount of the materials. A small amount of anodic material in contact with a large amount of cathodic material will result in accelerated corrosion of the anodic material. Inversely, a large amount of anodic material in contact with a small amount of cathodic material will decrease the rate of corrosion.
3. The relative position of the materials in the Galvanic Series. The further apart the interacting materials are in the Galvanic Series, the greater the potential for corrosion of the anodic material.

| | Solvent | Caustic | Acid |
|--------------|--|--|--|
| Preferred | Stainless Steel Type 316 Stainless Steel Type 304 Non-Metallic Aluminum Steel, Epoxy Powder Coated | Non-Metallic Stainless Steel Type 316 Stainless Steel Type 304 | Non-Metallic Stainless Steel Type 316 Stainless Steel Type 304 |
| Satisfactory | Non-Metallic | Non-Metallic | Non-Metallic Steel, Epoxy Powder Coated |
| Limited | | Steel, Epoxy Powder Coated Aluminum | Aluminum |

Note: The corrosion data given in the table on the following pages is for general comparison only. (Reference Corrosion Resistance Tables, Second Edition)
The presence of contaminants in chemical environments can greatly affect the corrosion rate of any material. B-Line strongly suggests that field service tests or simulated laboratory tests using actual environmental conditions be conducted in order to determine the proper materials and finishes to be selected. B-Line offers no guarantee or warranty as to the suitability of a particular material for use in any specific environment which is beyond our control.

Corrosion Resistance Table

| Chemical | Unpainted Metal Enclosures | | | | | | | | | Painted Steel Enclosures | | | | | |
|--|----------------------------|------|-----|--------------------------|------|-----|--------------------------|------|-----|-----------------------------------|------|-----|------------------------------------|------|-----|
| | Aluminum | | | Stainless Steel Type 304 | | | Stainless Steel Type 316 | | | Acrylic Electrocoat, ANSI 61 Gray | | | Polyester Powdercoat, ANSI 61 Gray | | |
| | Cold | Warm | Hot | Cold | Warm | Hot | Cold | Warm | Hot | Cold | Warm | Hot | Cold | Warm | Hot |
| Acetic Acid, 50% | R | L | U | R | R | L | R | R | R | U | U | U | R | R | U |
| Acetic Acid, 10% | R | L | U | R | R | R | R | R | R | U | U | U | R | R | R |
| Acetone | R | R | R | R | R | R | R | R | R | U | U | U | U | U | U |
| Aluminum Chloride | U | U | U | R | R | R | R | R | R | R | -- | -- | R | R | R |
| Aluminum Sulfate ,Saturated | R | R | R | R | R | R | R | R | R | R | -- | -- | R | R | R |
| Ammonia Gas | -- | -- | -- | R | -- | -- | R | -- | -- | R | -- | -- | R | R | L |
| Ammonium Hydroxide, 10% | L | L | L | R | R | R | R | R | R | R | -- | -- | L | L | L |
| Amyl Acetate | R | R | R | R | R | R | R | R | R | U | U | U | L | U | U |
| Amyl Alcohol | R | R | R | R | -- | -- | R | R | R | R | -- | -- | R | R | R |
| Aniline | R | R | R | R | R | R | R | R | R | U | U | U | U | U | U |
| Aqua Regia | U | U | U | U | U | U | U | U | U | -- | -- | -- | U | U | U |
| Benzene, Benzol | R | R | R | R | R | R | R | R | R | U | U | U | U | U | U |
| Benzoic Acid | L | L | U | R | R | R | R | R | R | U | U | U | R | R | -- |
| Boric Acid | R | R | L | R | R | R | R | R | R | R | -- | -- | R | R | -- |
| Bromine Water | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| Butyl Acetate | R | R | R | R | -- | -- | R | R | R | U | U | U | L | U | U |
| Butyl Alcohol, Tertiary | R | R | R | R | R | R | R | R | R | R | -- | -- | R | -- | -- |
| Butyric Acid | L | L | L | R | R | R | R | R | R | U | U | U | R | R | -- |
| Calcium Chloride | L | L | U | R | R | R | R | R | R | R | -- | -- | R | R | R |
| Calcium Hydroxide | U | -- | -- | R | R | R | R | R | R | R | -- | - | R | R | -- |
| Calcium Nitrate | R | R | -- | R | -- | -- | R | R | R | -- | -- | -- | R | R | R |
| Carbon Dioxide, Wet | R | R | -- | R | R | L | R | R | L | R | -- | -- | R | R | R |
| Carbon Disulfide (Bisulfide) | R | R | R | R | R | L | R | R | R | R | -- | -- | U | U | U |
| Carbon Monoxide | R | R | R | R | R | R | R | R | R | -- | -- | -- | R | R | R |
| Carbon Tetrachloride | L | L | U | L | L | L | R | R | R | U | U | U | U | U | U |
| Chlorine, Liquid | -- | -- | -- | R | L | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chlorine Water, Saturated | R | -- | -- | U | U | U | U | U | U | R | -- | -- | R | R | R |
| Chlorobenzene (Phenylchloride) | R | R | -- | R | R | L | R | R | R | U | U | U | U | U | U |
| Chloroform | R | L | U | R | L | L | R | R | R | U | U | U | U | U | U |
| Chlorox Bleach Solution, 5.5% Chlorine | U | U | U | -- | -- | -- | R | -- | -- | -- | -- | -- | -- | -- | -- |
| Chromic Acid, 10% | R | R | -- | R | R | L | R | R | R | U | U | U | U | U | U |
| Citric Acid, 5% | L | L | L | R | U | U | R | R | R | R | -- | -- | R | R | R |
| Copper Chloride | U | U | U | U | U | U | U | U | U | R | -- | -- | R | R | R |
| Copper Sulfate | U | U | U | R | R | R | R | R | R | U | U | U | R | R | R |
| Cresol | R | L | -- | R | R | -- | R | L | -- | U | U | U | U | U | U |
| Crude Oil | R | R | -- | R | R | R | R | R | R | -- | -- | -- | R | R | R |
| Diesel Fuels | R | -- | -- | R | -- | -- | R | -- | -- | -- | -- | -- | R | R | -- |
| Dimethyl Formamide | R | -- | -- | -- | -- | -- | R | R | R | U | U | U | U | U | U |
| Dioxane | R | R | R | R | R | R | R | R | R | -- | -- | -- | U | U | U |
| Ethyl Acetate | R | R | R | R | R | L | R | R | R | U | U | U | U | U | U |
| Ethyl Alcohol | R | R | R | R | R | R | R | R | R | U | U | U | R | -- | -- |
| Ethyl Chloride | R | R | R | R | R | R | R | R | R | U | U | U | -- | -- | -- |
| Ethyl Ether | R | -- | -- | R | R | R | R | R | R | U | U | U | U | U | U |
| Ethylene Glycol | R | R | L | R | R | -- | R | R | R | R | -- | -- | R | R | R |
| Ethylene Oxide | R | R | R | R | R | L | R | R | R | -- | -- | -- | U | U | U |
| Ferric Chloride | U | U | U | U | U | U | U | U | U | R | -- | -- | R | R | -- |
| Formaldehyde, 37% Solution | R | R | R | R | R | R | R | R | R | R | -- | -- | R | R | -- |
| Formic Acid, 10% | R | R | -- | R | R | U | R | R | R | U | U | U | -- | -- | -- |
| Freon, F-22 | R | -- | -- | R | -- | -- | R | R | R | -- | -- | -- | -- | -- | -- |
| Gasoline, Unleaded | R | R | R | R | -- | -- | R | -- | -- | R | U | U | R | R | R |
| Heptane | R | L | -- | R | R | R | R | R | R | -- | -- | -- | R | R | R |
| Hexane | R | -- | -- | R | R | R | R | R | R | R | -- | -- | R | -- | -- |
| Hydrobromic Acid, Dilute | U | U | U | U | U | U | U | U | U | -- | -- | -- | R | R | -- |

The corrosion data given in this table is for general comparison only. (Reference Corrosion Resistance Tables, Second Edition)
 The presence of contaminants in chemical environments can greatly affect the corrosion rate of any material.

R = Recommended L = Limited Use U = Unsatisfactory -- = Information not available Cold = 50-80°F Warm = 130-170°F Hot = 200-212°F

Corrosion Resistance Table

| Non-Metallic Enclosures | | | Door Gasket Materials | | | | |
|-------------------------|---------------|-----------|-----------------------------------|---------------------------|------------------------|------------------------|----------------------|
| Polyamide | Polycarbonate | Polyester | Foam-in-Place Polyurethane Sponge | Poron Polyurethane Sponge | Neoprene Rubber Sponge | Silicone Rubber Sponge | Viton, Rubber Sponge |
| L | L | R | -- | -- | L | R | R |
| R | R | R | L | L | L | R | R |
| R | U | U | U | U | L | U | U |
| L | R | R | R | R | R | R | R |
| L | R | R | R | R | R | R | R |
| U | U | L | R | R | R | -- | U |
| U | U | U | R | R | R | R | R |
| -- | U | L | U | U | U | U | U |
| -- | L | L | U | U | R | U | R |
| U | U | U | U | U | U | R | R |
| -- | L | U | U | U | -- | -- | R |
| R | U | L | U | U | R | U | R |
| L | U | L | R | U | R | R | R |
| L | R | R | R | L | U | R | R |
| -- | U | U | -- | U | U | U | R |
| -- | U | L | R | U | U | R | R |
| R | R | R | -- | -- | U | R | R |
| L | U | L | -- | -- | U | U | R |
| R | R | R | R | R | R | R | R |
| U | -- | U | -- | L | R | R | R |
| L | R | R | -- | L | R | R | R |
| L | -- | R | R | R | R | R | R |
| R | U | L | -- | -- | U | -- | R |
| L | -- | R | -- | R | R | R | R |
| R | U | L | U | U | U | U | R |
| L | L | L | -- | -- | U | U | R |
| R | R | R | -- | U | U | U | R |
| R | U | U | L | U | U | U | R |
| R | U | U | L | U | U | U | R |
| -- | L | R | -- | -- | U | U | U |
| U | R | L | U | U | U | L | R |
| R | R | R | R | -- | R | R | R |
| L | R | -- | -- | R | R | R | R |
| L | R | R | -- | R | R | -- | R |
| U | U | U | -- | U | U | -- | R |
| L | -- | L | -- | L | U | U | R |
| -- | R | R | R | -- | R | U | R |
| U | U | L | U | -- | U | L | L |
| -- | U | L | -- | -- | U | L | L |
| R | U | L | L | U | U | R | U |
| R | L | R | R | U | U | R | U |
| R | U | L | -- | -- | L | U | R |
| R | U | U | -- | U | U | U | U |
| L | R | R | R | R | R | R | R |
| -- | R | R | -- | U | U | U | U |
| L | R | R | -- | R | R | R | R |
| L | R | R | -- | U | R | -- | L |
| R | R | L | U | U | R | R | R |
| -- | U | R | -- | U | R | U | R |
| R | L | R | -- | R | R | U | R |
| R | R | R | R | U | R | U | R |
| -- | L | R | R | R | R | U | R |
| L | -- | L | -- | -- | U | U | R |

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 The presence of contaminants in chemical environments can greatly affect the corrosion rate of any material.

R = Recommended L = Limited Use U = Unsatisfactory -- = Information not available Cold = 50-80°F Warm = 130-170°F Hot = 200-212°F

Corrosion Resistance Table cont.

| Chemical | Unpainted Metal Enclosures | | | | | | | | | Painted Steel Enclosures | | | | | |
|-----------------------------|----------------------------|------|-----|--------------------------|------|-----|--------------------------|------|-----|-----------------------------------|------|-----|------------------------------------|------|-----|
| | Aluminum | | | Stainless Steel Type 304 | | | Stainless Steel Type 316 | | | Acrylic Electrocoat, ANSI 61 Gray | | | Polyester Powdercoat, ANSI 61 Gray | | |
| | Cold | Warm | Hot | Cold | Warm | Hot | Cold | Warm | Hot | Cold | Warm | Hot | Cold | Warm | Hot |
| Hydrochloric Acid, 20% | U | U | U | U | U | U | U | U | U | R | -- | -- | R | R | -- |
| Hydrofluoric Acid, 10% | U | U | U | U | U | U | U | U | U | -- | -- | -- | R | -- | -- |
| Hydrogen Peroxide, 30% | R | R | R | R | R | R | R | R | R | -- | -- | -- | R | -- | -- |
| Hydrogen Sulfide, Wet | R | -- | -- | U | U | U | R | R | R | R | R | -- | R | R | -- |
| Isopropyl Alcohol | R | -- | -- | R | R | -- | R | R | R | -- | -- | -- | U | U | U |
| Jet Fuels | R | R | -- | R | -- | -- | R | R | R | R | -- | -- | R | R | -- |
| Kerosine | R | R | -- | R | R | R | R | R | R | R | -- | -- | R | R | -- |
| Lactic Acid, 10% | R | -- | -- | R | R | L | R | R | R | U | U | U | R | R | R |
| Magnesium Chloride | U | U | U | L | L | L | R | R | R | R | -- | -- | R | R | R |
| Methyl Alcohol | R | L | -- | R | R | L | R | R | R | -- | -- | -- | R | R | -- |
| Methyl Ethyl Ketone | R | L | -- | R | L | -- | R | R | R | U | U | U | U | U | U |
| Methylene Chloride | R | R | R | R | R | L | R | R | R | U | U | U | U | U | U |
| Mineral Oils | R | R | -- | R | -- | -- | R | R | R | R | -- | -- | R | -- | -- |
| Naptha | R | -- | -- | R | R | -- | R | -- | -- | R | U | U | R | R | R |
| Nitric Acid, 10% | U | U | U | R | R | R | R | R | R | R | -- | -- | R | R | U |
| Nitrobenzene | R | -- | -- | R | R | L | R | R | R | U | U | U | U | U | U |
| Oleic Acid | R | -- | -- | R | R | L | R | R | R | R | R | -- | R | R | R |
| Oleum | R | -- | -- | R | -- | -- | R | -- | -- | U | U | U | U | U | U |
| Oxalic Acid, 10% | R | L | -- | U | U | U | U | U | U | R | -- | -- | R | R | -- |
| Oxygen | R | R | -- | R | -- | -- | R | R | R | -- | -- | -- | -- | -- | -- |
| Ozone | R | R | -- | R | R | -- | R | R | R | -- | -- | -- | -- | -- | -- |
| Perchloroethylene | R | R | R | R | R | R | R | R | R | -- | -- | -- | R | U | U |
| Phenol | R | R | R | R | R | R | R | R | R | R | -- | -- | U | U | U |
| Phosphoric Acid, 25% | U | U | U | R | R | L | R | L | U | R | -- | -- | R | R | R |
| Phthalic Acid | R | R | R | R | R | R | R | R | R | -- | -- | -- | R | -- | -- |
| Potassium Chloride, 30% | U | U | U | R | R | R | R | R | R | R | -- | -- | R | R | R |
| Potassium Dichromate, 30% | R | R | L | R | R | R | R | R | R | R | -- | -- | R | R | R |
| Potassium Hydroxide, 10% | U | U | U | R | R | L | R | R | R | R | R | U | U | U | U |
| Potassium Nitrate, 50% | R | R | R | R | R | L | R | R | R | R | -- | -- | R | R | R |
| Potassium Permanganate, 10% | R | R | R | R | L | L | R | R | L | U | U | U | R | R | -- |
| Pyradine | R | R | R | R | R | R | R | R | R | -- | -- | -- | U | U | U |
| Sodium Bicarbonate, 20% | R | -- | -- | R | R | R | R | R | R | R | -- | -- | R | R | -- |
| Sodium Bisulfite, 10% | U | U | U | R | R | L | R | R | R | R | -- | -- | R | R | -- |
| Sodium Carbonate, 10% | U | U | U | R | R | L | R | R | R | U | U | U | R | R | U |
| Sodium Chlorate, 10% | R | R | R | R | R | R | R | R | R | R | -- | -- | R | R | -- |
| Sodium Chloride, 10% | R | U | U | R | R | L | R | R | R | R | -- | -- | R | R | R |
| Sodium Hydroxide, 10% | U | U | U | R | R | R | R | R | R | R | -- | -- | R | U | U |
| Sodium Hypochlorite, 10% | R | L | L | R | L | U | R | -- | -- | R | R | -- | U | U | U |
| Sodium Nitrate | R | R | R | R | R | U | R | R | R | R | -- | -- | R | R | R |
| Sodium Sulfate | R | R | L | R | R | U | R | R | R | R | -- | -- | R | R | U |
| Sulfur Dioxide | R | R | R | R | R | R | R | R | R | R | R | -- | R | R | R |
| Sulfuric Acid, 5% | U | U | U | L | U | U | R | -- | -- | R | -- | -- | R | R | R |
| Tartaric Acid | L | U | U | R | R | R | R | R | R | -- | -- | -- | R | R | R |
| Tetrahydrofuran | U | U | U | R | -- | -- | L | L | L | -- | -- | -- | U | U | U |
| Toluene | R | R | R | R | R | R | R | R | R | U | U | U | R | U | U |
| Trichloroacetic Acid | U | U | U | U | U | U | U | U | U | -- | -- | -- | R | R | U |
| Trichloroethylene | R | R | L | R | L | L | R | R | L | U | U | U | U | U | U |
| Trisodium Phosphate | U | U | U | R | R | -- | R | R | -- | -- | -- | -- | R | R | U |
| Turpentine | L | -- | -- | R | R | -- | R | R | L | R | -- | -- | R | R | -- |
| Water | R | R | L | R | R | R | R | R | R | R | -- | -- | R | R | R |
| Xylene | R | R | R | R | R | R | R | R | R | -- | -- | -- | R | -- | -- |
| Zinc Chloride | U | U | U | U | U | U | L | L | L | R | -- | -- | R | R | R |
| Zinc Sulfate | U | U | U | R | R | R | R | R | R | R | -- | -- | R | R | R |

The corrosion data given in this table is for general comparison only. (Reference Corrosion Resistance Tables, Second Edition)
 The presence of contaminants in chemical environments can greatly affect the corrosion rate of any material.

R = Recommended L = Limited Use U = Unsatisfactory -- = Information not available Cold = 50-80°F Warm = 130-170°F Hot = 200-212°F

Corrosion Resistance Table

| Non-Metallic Enclosures | | | Door Gasket Materials | | | | |
|-------------------------|---------------|-----------|-----------------------------------|---------------------------|------------------------|------------------------|----------------------|
| Polyamide | Polycarbonate | Polyester | Foam-in-Place Polyurethane Sponge | Poron Polyurethane Sponge | Neoprene Rubber Sponge | Silicone Rubber Sponge | Viton, Rubber Sponge |
| L | L | L | R | R | R | R | R |
| L | R | L | -- | -- | R | U | R |
| -- | R | R | -- | -- | U | R | R |
| L | R | R | -- | -- | R | L | U |
| R | R | R | -- | U | U | U | U |
| R | L | R | -- | U | U | U | R |
| R | R | R | -- | U | R | U | R |
| L | R | R | -- | -- | R | R | R |
| L | R | R | R | R | R | R | R |
| R | L | L | U | U | R | U | U |
| R | U | L | U | U | U | U | U |
| R | U | U | U | U | -- | -- | R |
| L | R | R | R | R | R | R | R |
| -- | R | R | -- | R | U | U | R |
| L | R | L | U | U | U | U | R |
| L | U | L | -- | U | U | U | R |
| L | R | R | R | R | L | U | R |
| U | -- | U | -- | U | L | U | R |
| L | R | R | -- | -- | U | R | R |
| L | R | R | -- | -- | U | R | R |
| -- | U | L | R | -- | L | R | R |
| R | -- | U | U | U | U | U | R |
| L | U | U | -- | U | R | U | R |
| L | L | L | -- | -- | R | -- | -- |
| L | -- | R | -- | -- | R | R | R |
| -- | R | R | R | R | R | R | R |
| U | -- | L | -- | R | R | R | R |
| L | U | U | -- | R | R | L | R |
| L | R | R | -- | -- | R | R | R |
| U | R | L | -- | -- | R | -- | R |
| L | U | -- | -- | -- | L | R | R |
| U | R | R | -- | -- | R | R | R |
| -- | R | R | -- | -- | R | R | R |
| U | R | R | -- | -- | R | R | R |
| -- | R | R | -- | -- | R | L | R |
| L | R | R | R | R | R | R | R |
| R | U | L | -- | -- | R | R | R |
| U | R | L | -- | -- | L | R | R |
| L | U | R | -- | -- | R | U | R |
| L | R | R | -- | R | R | R | R |
| L | R | R | -- | R | R | R | R |
| -- | U | U | U | -- | U | U | U |
| L | U | L | L | U | -- | R | R |
| -- | R | U | -- | -- | U | U | L |
| L | -- | L | L | U | U | U | R |
| U | L | -- | -- | R | R | R | R |
| -- | L | R | R | U | U | U | R |
| R | R | R | R | R | U | -- | R |
| -- | U | L | L | U | U | U | R |
| L | R | R | -- | -- | R | R | R |
| L | R | R | -- | -- | R | R | R |

The corrosion data given in this table is for general comparison only. (Reference Corrosion Resistance Tables, Second Edition)
 The presence of contaminants in chemical environments can greatly affect the corrosion rate of any material.

R = Recommended L = Limited Use U = Unsatisfactory -- = Information not available Cold = 50-80°F Warm = 130-170°F Hot = 200-212°F

Wireway Selection (Reference NFPA 70, National Electrical Code 2002)

Definition

Wireways are troughs with hinged or removable covers for housing and protecting electric wires and cable. Conductors are laid into the wireway after the wireway has been installed as a complete system.

Uses

The use of wireways are permitted as follows:

1. For exposed work in dry locations. For outdoor or wet locations, use Type 3R wireway.
2. If installed in inaccessible spaces, the use of wireway is permitted only for use with audio signal conductors (per NEC[®] 376-10).
3. In hazardous locations as permitted by NEC[®] sections 501, 502 and 504.
4. For extensions through walls, if the length passing through the wall is unbroken and access to conductors can be maintained from both sides.

The use of wireways is not permitted where a risk of severe physical damage or corrosive vapor is present.

Size of Conductors

Table I shows maximum allowable cable sizes for varying wireway sizes. (Based on UL 870 Table 7.1)

Table I

| Wireway Size Inches | Maximum Cable Size AWG or kcmil |
|------------------------|------------------------------------|
| 2.5x2.5 | 2 |
| 3x3 | 1 |
| 4x4 | 4/0 |
| 4x6 | 4/0 |
| 6x6 | 500 |
| 12x6 | 500 |
| 8x8 | 900 |
| 10x10 | 1250 |
| 12x12 | 2000 |

Conductors entering the wireway only at the ends of runs are limited in size only by the 20 percent fill requirement of the NEC[®]. However, it is recommended that wire sizes not exceed those in Table I above.

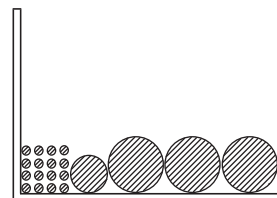
Number of Conductors

Wireways which contain no more than 30 current-carrying conductors at any cross section, and for which the sum of the cross-sectional areas of all contained conductors at any cross section does not exceed 20% of the interior cross-sectional area of the wireway, require no derating of cables. (Refer to Table II below)

Table II

| Wireway Size Inches | Allowable Cable Area sq. in. |
|------------------------|---------------------------------|
| 2.5x2.5 | 1.2 |
| 3x3 | 1.8 |
| 4x4 | 3.2 |
| 4x6 | 4.8 |
| 6x6 | 7.2 |
| 8x8 | 12.8 |
| 12x6 | 14.4 |
| 10x10 | 20.0 |
| 12x12 | 28.8 |

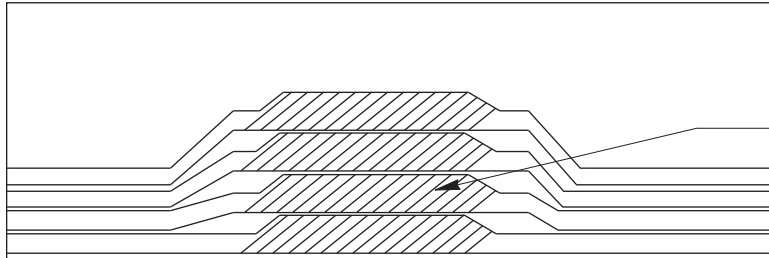
Cross sectional area of conductors
≤ 20% of cross sectional
area of wireway.



For exceptions allowing more conductors, see NEC[®] 362-5.

Splices and Taps

Splices and taps are permitted within a wireway, provided they are accessible. The conductors, including splices and taps, shall not fill the wireway to more than 75 percent of its area at the point of a splice or tap.



Cross sectional area of splices and taps is less than 75% of wireway's cross sectional area

Cross Sectional Area of Conductors

Single Conductor Cable 600V

| SIZE | Cross Sectional Area of Conductors (sq. in.) | | | | | | | |
|------|--|--------------------------|----------------------|--------------------------|---------------------|--------------------------|----------------------|--------------------------|
| | XXHW, XXHW-2, XHH | | THHN, THWN THWN-2 | | THW, THW-2, TTHW | | RHH*, RHW* RHW-2* | |
| | Diameter in. | Area in. ² | Diameter in. | Area in. ² | Diameter in. | Area in. ² | Diameter in. | Area in. ² |
| 14 | 0.1330 | 1.0139 | 0.1110 | 0.0097 | 0.1630 | 0.0209 | 0.1930 | 0.0293 |
| 12 | 0.1520 | 1.0181 | 0.1300 | 0.0133 | 0.1820 | 0.0260 | 0.2120 | 0.0353 |
| 10 | 0.1760 | 0.0243 | 0.1640 | 0.0211 | 0.2060 | 0.0333 | 0.2360 | 0.0437 |
| 8 | 0.2360 | 0.0437 | 0.2160 | 0.0366 | 0.2660 | 0.0556 | 0.3260 | 0.0835 |
| 6 | 0.2740 | 0.0590 | 0.2540 | 0.0507 | 0.3040 | 0.0726 | 0.3640 | 0.1041 |
| 4 | 0.3220 | 0.0814 | 0.3240 | 0.0824 | 0.3520 | 0.0973 | 0.4120 | 0.1333 |
| 3 | 0.3500 | 0.0962 | 0.3520 | 0.0973 | 0.3800 | 0.1134 | 0.4400 | 0.1521 |
| 2 | 0.3820 | 0.1146 | 0.3840 | 0.1158 | 0.4120 | 0.1333 | 0.4720 | 0.1750 |
| 1 | 0.4420 | 0.1534 | 0.4460 | 0.1562 | 0.4920 | 0.1901 | 0.5850 | 0.2688 |
| 1/0 | 0.4820 | 0.1825 | 0.4860 | 0.1855 | 0.5320 | 0.2223 | 0.6220 | 0.3039 |
| 2/0 | 0.5280 | 0.2190 | 0.5320 | 0.2223 | 0.5780 | 0.2624 | 0.6680 | 0.3505 |
| 3/0 | 0.5800 | 0.2642 | 0.5840 | 0.2679 | 0.6300 | 0.3117 | 0.7200 | 0.4072 |
| 4/0 | 0.6380 | 0.3197 | 0.6420 | 0.3237 | 0.6880 | 0.3718 | 0.7780 | 0.4754 |
| 250 | 0.7050 | 0.3904 | 0.7110 | 0.3970 | 0.7650 | 0.4596 | 0.8950 | 0.6291 |
| 300 | 0.7600 | 0.4536 | 0.7660 | 0.4608 | 0.8200 | 0.5281 | 0.9500 | 0.7088 |
| 350 | 0.8110 | 0.5166 | 0.8170 | 0.5242 | 0.8710 | 0.5958 | 1.0010 | 0.7870 |
| 400 | 0.8580 | 0.5782 | 0.8640 | 0.5863 | 0.9180 | 0.6619 | 1.0480 | 0.8626 |
| 500 | 0.9430 | 0.6984 | 0.9490 | 0.7073 | 1.0030 | 0.7901 | 1.1330 | 1.0082 |
| 600 | 1.0530 | 0.8790 | 1.0510 | 0.8676 | 1.1130 | 0.9729 | 1.2430 | 1.2135 |
| 700 | 1.1240 | 0.9923 | 1.1220 | 0.9887 | 1.1840 | 1.1010 | 1.3140 | 1.3561 |
| 750 | 1.1580 | 1.0532 | 1.1560 | 1.0496 | 1.2180 | 1.1652 | 1.3480 | 1.4272 |
| 800 | 1.1900 | 1.1122 | 1.1880 | 1.1085 | 1.2500 | 1.2272 | 1.3800 | 1.4957 |
| 900 | 1.2540 | 1.2351 | 1.2520 | 1.2311 | 1.3140 | 1.3561 | 1.4440 | 1.6377 |
| 1000 | 1.3120 | 1.3519 | 1.3100 | 1.3478 | 1.3720 | 1.4784 | 1.5020 | 1.7719 |
| 1250 | 1.4790 | 1.7180 | - | - | 1.5390 | 1.8602 | 1.7290 | 2.3479 |
| 1500 | 1.6020 | 2.0156 | - | - | 1.6620 | 2.1695 | 1.8520 | 2.6938 |
| 1750 | 1.7160 | 2.3127 | - | - | 1.7760 | 2.4773 | 1.9660 | 3.0357 |
| 2000 | 1.8220 | 2.6073 | - | - | 1.8820 | 2.7818 | 2.0720 | 3.3719 |

* RHH, RHW and RHW-2 without covering have the same dimension as THW.

Wireway Selection

Sample Calculation

A. Wireway dimensions are obtained as follows:

1. List cables by size and types.
2. List cable cross sectional areas.
3. List the number of each size of cable.
4. Multiply cable cross sectional areas by number of each cable.
5. Sum the total cross sectional areas of each cable type to obtain the total cross sectional areas for the conductors.

| List Cable Sizes and Types | List Cable Cross Sectional Areas (A) sq. in. | List Number of Cables (N) | Multiply (A) x (N) = Total Cross Sectional Area for Each Size sq. in. |
|--|---|---------------------------|---|
| 2 AWG-XXHW | 0.1182 | x 4 | = 0.4728 |
| 2/0-TW | 0.2290 | x 2 | = 0.4580 |
| 750 kcmil-RHH | 1.1300 | x 2 | = 2.2600 |
| Sum of the total cross sectional areas = | | | 3.1908 |

6. The wireway must first meet the dimensional requirements for the largest conductor. In the example above, the largest conductor is 750 kcmil. The minimum wireway cross section based on the largest conductor size requirements is 8" x 8", as shown in Table I on page 462.
7. The wireway dimensions must meet 20% fill requirements. Based on the sum of the total conductor cross sectional areas (3.19 sq. in.), the minimum wireway cross section, based on the 20% fill requirements is 4" x 4" as shown in Table II on page 462.
8. In this example, the wireway dimensions must be the larger of the two cross sections obtained in steps 6 and 7. In this case, 8" x 8" wireway is required.

Decimal and Metric Equivalents

| 4ths | 8ths | 16ths | 32nds | 64ths | To 3 places | To 2 places | Millimeters |
|------|------|-------|-------|-------|-------------|-------------|-------------|
| | | | | 1/64 | .016 | .02 | 0 |
| | | | 1/32 | 3/64 | .031 | .03 | 1 |
| | | | | 5/64 | .047 | .05 | 1 |
| | | 1/16 | | 7/64 | .062 | .06 | 2 |
| | | | | 9/64 | .078 | .08 | 2 |
| | | | 3/32 | 11/64 | .094 | .09 | 2 |
| | | | | 13/64 | .109 | .11 | 3 |
| | 1/8 | | | 15/64 | .125 | .12 | 3 |
| | | | | 17/64 | .141 | .14 | 4 |
| | | | 5/32 | 19/64 | .156 | .16 | 4 |
| | | | | 21/64 | .172 | .17 | 4 |
| | | 3/16 | | 23/64 | .188 | .19 | 5 |
| | | | | 25/64 | .203 | .20 | 5 |
| | | | 7/32 | 27/64 | .219 | .22 | 6 |
| | | | | 29/64 | .234 | .23 | 6 |
| 1/4 | | | | 31/64 | .250 | .25 | 6 |
| | | | | 33/64 | .266 | .27 | 7 |
| | | | 9/32 | 35/64 | .281 | .28 | 7 |
| | | | | 37/64 | .297 | .30 | 8 |
| | | 5/16 | | 39/64 | .312 | .31 | 8 |
| | | | | 41/64 | .328 | .33 | 8 |
| | | | 11/32 | 43/64 | .344 | .34 | 9 |
| | | | | 45/64 | .359 | .36 | 9 |
| | 3/8 | | | 47/64 | .375 | .38 | 10 |
| | | | | 49/64 | .391 | .39 | 10 |
| | | | 13/32 | 51/64 | .406 | .41 | 10 |
| | | | | 53/64 | .422 | .42 | 11 |
| | | 7/16 | | 55/64 | .438 | .44 | 11 |
| | | | | 57/64 | .453 | .45 | 12 |
| | | | 15/32 | 59/64 | .469 | .47 | 12 |
| | | | | 61/64 | .484 | .48 | 12 |
| 1/2 | | | | 63/64 | .500 | .50 | 13 |
| | | | | | .516 | .52 | 13 |
| | | | 17/32 | | .531 | .53 | 13 |
| | | | | 35/64 | .547 | .55 | 14 |
| | | 9/16 | | 37/64 | .562 | .56 | 14 |
| | | | | 39/64 | .578 | .58 | 15 |
| | | | 19/32 | | .594 | .59 | 15 |
| | | | | 41/64 | .609 | .61 | 15 |
| | 5/8 | | | 43/64 | .625 | .62 | 16 |
| | | | | 45/64 | .641 | .64 | 16 |
| | | | 21/32 | | .656 | .66 | 17 |
| | | | | 43/64 | .672 | .67 | 17 |
| | | 11/16 | | 45/64 | .688 | .69 | 17 |
| | | | | 47/64 | .703 | .70 | 18 |
| | | | 23/32 | | .719 | .72 | 18 |
| | | | | 47/64 | .734 | .73 | 19 |
| 3/4 | | | | 49/64 | .750 | .75 | 19 |
| | | | | 51/64 | .766 | .77 | 19 |
| | | | 25/32 | | .781 | .78 | 20 |
| | | | | 51/64 | .797 | .80 | 20 |
| | | 13/16 | | 53/64 | .812 | .81 | 21 |
| | | | | 55/64 | .828 | .83 | 21 |
| | | | 27/32 | | .844 | .84 | 21 |
| | | | | 55/64 | .859 | .86 | 22 |
| | 7/8 | | | 57/64 | .875 | .88 | 22 |
| | | | | 57/64 | .891 | .89 | 23 |
| | | | 29/32 | | .906 | .91 | 23 |
| | | | | 59/64 | .922 | .92 | 23 |
| | | 15/16 | | 61/64 | .938 | .94 | 24 |
| | | | | 61/64 | .953 | .95 | 24 |
| | | | 31/32 | | .969 | .97 | 25 |
| | | | | 63/64 | .984 | .98 | 25 |
| 1 | | | | | 1.000 | 1.00 | 25 |

Metric Conversion Tables

LENGTH

U.S. to Metric

| | | |
|--------|---|--------------------|
| 1 inch | = | 25.40 millimeters |
| 1 inch | = | 2.540 centimeters |
| 1 foot | = | 30.480 centimeters |
| 1 foot | = | 0.3048 meter |
| 1 yard | = | 91.440 centimeters |
| 1 yard | = | 0.9144 meter |
| 1 mile | = | 1.609 kilometers |

Metric to U.S.

| | | |
|--------------|---|--------------|
| 1 millimeter | = | 0.03937 inch |
| 1 centimeter | = | 0.3937 inch |
| 1 meter | = | 39.37 inches |
| 1 meter | = | 3.2808 feet |
| 1 meter | = | 1.0936 yards |
| 1 kilometer | = | 0.62137 mile |

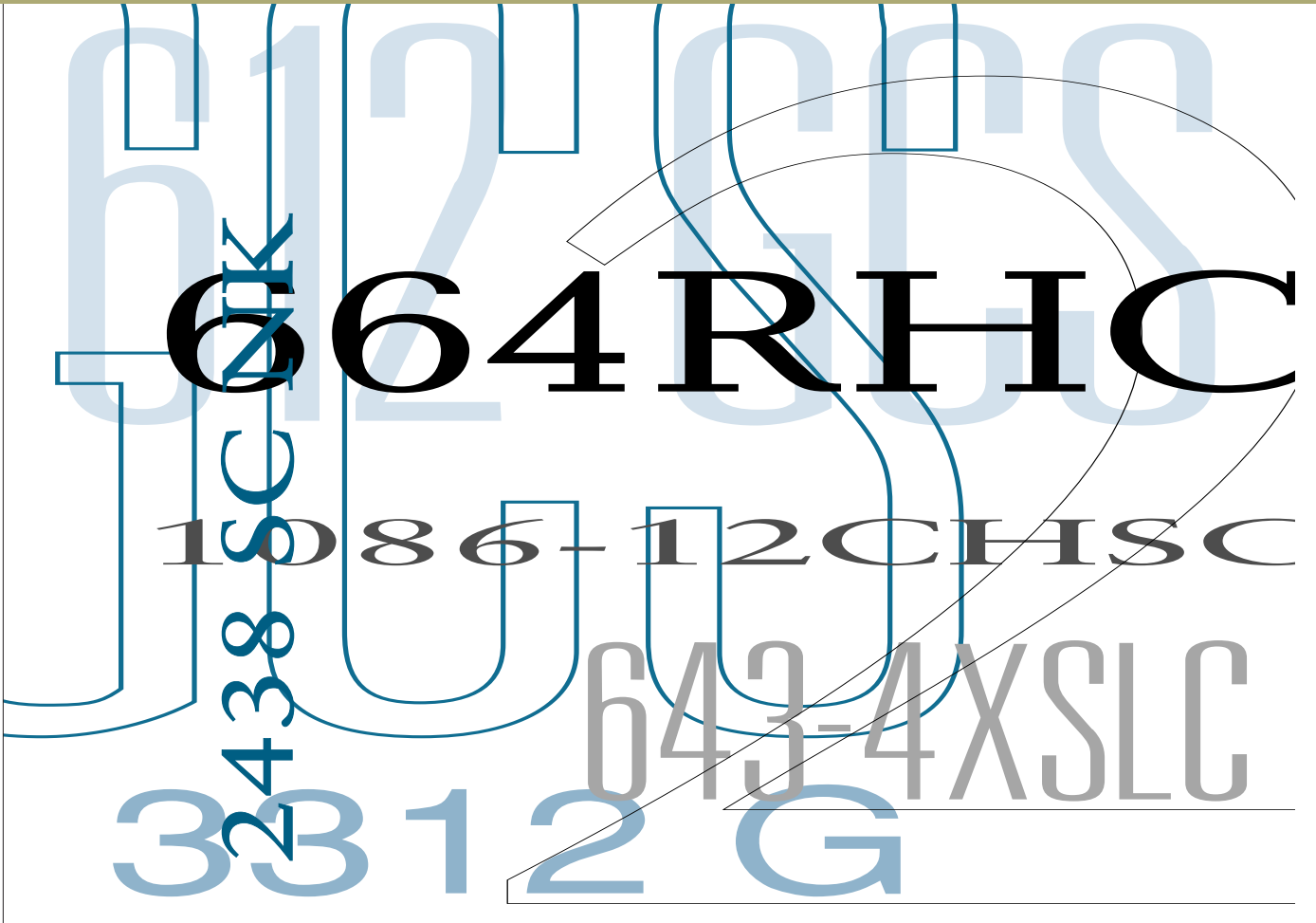
AREA

U.S. to Metric

| | | |
|------------|---|------------------------|
| 1 sq. inch | = | 645.16 sq. millimeters |
| 1 sq. inch | = | 6.4516 sq. centimeters |
| 1 sq. foot | = | 929.03 sq. centimeters |
| 1 sq. foot | = | 0.0929 sq. meter |
| 1 sq. yard | = | 0.836 sq. meter |

Metric to U.S.

| | | |
|------------------|---|------------------|
| 1 sq. millimeter | = | 0.00155 sq. inch |
| 1 sq. centimeter | = | 0.1550 sq. inch |
| 1 sq. meter | = | 10.7640 sq. feet |
| 1 sq. meter | = | 1.196 sq. yards |



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Service Facility - United States:

Cooper B-Line - USA

509 West Monroe Street
Highland, IL 62249
United States
Phone: (800) 851-7415
Fax: (800) 356-1438
Email: blineus@cooperindustries.com

Service Facility - Canada:

Cooper B-Line - Canada

Div. of Cooper Ind. Canada, Inc.
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Mississauga, ON L5R 1B8
Canada
Phone: (800) 569-3660
Fax: (888) 753-3355
Email: blinecanada@cooperindustries.com

Service Facility - Europe:

Cooper B-Line, Ltd. - UK

Walrow, Highbridge
Somerset, TA9 4AQ
United Kingdom
Phone: + 44 (0) 1278 783371
Fax: + 44 (0) 1278 789037
Email: sales@cooperbline.co.uk

Cooper B-Line - Saudi Arabia:

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Kingdom of Saudia Arabia
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600 Travis, Ste. 5600
Houston, TX 77002-1001
Phone: 713-209-8400
www.cooperindustries.com