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Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The Illustrations, charts, sample programs and layout examples shown in this catalog are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Rockwell Automation does not assume responsibility or liability including intellectual property liability, for actual use based upon the examples shown in this publication.

Related Safety Information

The installer is responsible for the safety of the entire installed control system and for meeting all applicable laws, codes, and safety requirements.



ATTENTION: As the installer of this control system, you must be knowledgeable of other applicable standards pertaining to safety recommendations related to:

- Machine Construction
- General Electrical
- Machine Guarding
- Point of Operation guards, safety light curtains, mechanical guards, and two-hand controls, and safety monitoring relays

In addition to local laws and codes, you are responsible for the safety recommendations detailed in all applicable national and international codes and standards including:

- National Electric Code
- National Regulations Implementing European Directives
- OSHA Regulations
- ANSI Standards
- ISO and IEC Standards
- NFPA
- CSA

Terms and Conditions

For applicable "Terms and Conditions of Sale" please see page G-4.

IMPORTANT

Rockwell Automation reserves the right to make revisions to the material contained in this catalog and specifically disclaims all liability for any incidental or consequential damages resulting from the furnishing, performance or use of this material.

Application Considerations

Selection of Equipment—Because of the variety of uses for the products described in this catalog, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts and layout examples shown in this catalog are intended solely for purposes of example. Because there are many variables and requirements associated with any particular installation, Rockwell Automation does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Rockwell Automation Publication SGI-1.1, "Safety Guidelines for the Application, Installation and Maintenance of Solid-state Control" (available from your local Rockwell Automation Sales Office) describes some important differences between solid-state equipment and electromechanical devices which should be taken into consideration when applying products such as those described in this catalog.

Service and Installation Conditions—Unless otherwise noted, the products described in this catalog are designed to meet "usual service and installation conditions" as defined in NEMA (National Electrical Manufacturers Association) Standards Publication—Part ICS 1-108. Open style devices must be provided with environmental protection by proper mounting in enclosures designed for specific application conditions.

See page G-7 and page G-11 of this section for information on enclosures and an explanation of the degrees of protection provided by the different types, based on NEMA Standards Publication 250 and IEC Publication 529, as applicable.

Performance Data—Performance data given in this catalog is provided as a guide for the user in determining suitability and does not constitute a warranty. It may represent the result of accelerated testing at elevated stress levels, and the user should correlate it to actual application requirements. Actual performance is subject to Rockwell Automation WARRANTY and LIMIT OF LIABILITY (see page G-4).

Metric Conversion Factors		
From	To	Multiply by
Length		
Inches (in.)	Millimeters (mm)	25.4
Inches (in.)	Centimeters (cm)	25.4
Feet (ft)	Meters (m)	0.305
Yards (yd)	Meters (m)	0.914
Millimeters (mm)	Inches (in.)	0.0394
Centimeters (cm)	Inches (in.)	0.394
Meters (m)	Feet (ft)	3.28
Meters (m)	Yards (yd)	1.09
Area		
Square inches (in. ²)	Square millimeters (mm ²)	645.0
Square inches (in. ²)	Square centimeters (cm ²)	6.45
Square feet (ft ²)	Square meters (m ²)	0.0929
Square yards (yd ²)	Square meters (m ²)	0.836
Square millimeters (mm ²)	Square inches (in. ²)	0.00155
Square centimeters (cm ²)	Square inches (in. ²)	0.155
Square meters (m ²)	Square feet (ft ²)	10.8
Square meters (m ²)	Square yards (yd ²)	1.20
Weight		
Ounces (oz)	Grams (g)	28.3
Pounds (lb)	Kilograms (kg)	0.454
Grams (g)	Ounces (oz)	0.0353
Kilograms (kg)	Pounds (lb)	2.20
Volume		
Cubic inches (in. ³)	Cubic centimeters (cm ³)	16.4
Cubic feet (ft ³)	Cubic meters (m ³)	0.0283
Cubic inches (in. ³)	Litres (L)	0.0164
Cubic feet (ft ³)	Litres (L)	28.3
Gallons (Imp)	Litres (L)	4.55
Gallons (US)	Litres (L)	3.79
Cubic centimeters (cm ³)	Cubic inches (in. ³)	0.061
Cubic meters (m ³)	Cubic feet (ft ³)	35.3
Liters (L)	Cubic inches (in. ³)	61.0
Liters (L)	Cubic feet (ft ³)	0.0353
Liters (L)	Gallons (Imp)	0.220
Liters (L)	Gallons (US)	0.264
Pressure		
Pounds/square inch (psi)	Kilopascals (kPa)	6.89
Pounds/square inch (psi)	Bars (Bar)	0.0689
Kilopascals (kPa)	Pounds/square inch (psi)	0.145
Bars (Bar)	Pounds/square inch (psi)	14.5
Torque		
Pound inch (lb•in)	Newton meters (N•m)	0.113
Newton meters (N•m)	Pound inch (lb•in)	8.85
Temperature		
Degrees Fahrenheit (°F)	Degrees Celsius (°C)	Conversion Formula: 5/9 (°F – 32°F) = °C
Degrees Celsius (°C)	Degrees Fahrenheit (°F)	Conversion Formula: 9/5 (°C) + 32°F = °F

Terms and Conditions of Sale

These general terms and conditions of sale only apply to direct sales by the manufacturer or its affiliates. Sales by appointed distributors and other independent authorized resellers will be subject to terms and conditions of sale and may be separately established by each such distributor or reseller. Sales outside of North America, as well as sales of other Rockwell Automation products and services, also may be subject to separate or supplemental terms and conditions of sale. For further information, please consult a Rockwell Automation sales office or an Allen-Bradley distributor.

General—These general terms and conditions of sale (along with any directly associated written Seller specification or quotation) exclusively will govern the sale or licensing by Seller of all goods and services (including without limitation, hardware, firmware and software products, training, programming, maintenance, engineering, parts and repair services—collectively, the "Products") furnished hereunder. No addition or modification to these terms and conditions will be binding on Seller unless agreed to in writing signed by an authorized representative at Seller's headquarters. Seller objects to other terms and conditions that may be proposed by the customer not otherwise consistent with these or other terms and conditions set forth in Seller's written specification, quotation or order acknowledgment.

Payment Terms—Net thirty (30) days from date of invoice with ongoing approved credit as determined by Seller. Seller reserves the right to suspend any further performance under this agreement or otherwise in the event payment is not made when due. No payment by offset is permitted unless approved by Seller.

Delivery Terms—Delivery terms are Ex Works with respect to shipping costs, risk of loss and title transfer, except that title to all intellectual property rights associated with the Products (e.g., software and firmware) remains with Seller (or its suppliers and licensors), and such Products are made available or licensed only for use by the customer pursuant to this agreement or other Seller license agreement. Acknowledged shipping dates are approximate only and based on prompt receipt of all necessary information from the customer.

Warranty—

- A. **Hardware:** Seller warrants for a period of one (1) year from the date of invoice from Seller or its appointed distributor, as the case may be, that hardware Products furnished hereunder will be of merchantable quality, free from defects in material, workmanship and design. Repaired or replacement Products provided under warranty are similarly warranted for a period of six (6) months from the date of shipment to Customer or the remainder of the original warranty term, whichever is longer.
- B. **Software and Firmware:** Unless otherwise provided in a Seller or third party license agreement, Seller warrants for a period of one (1) year from the date of invoice from Seller or its appointed distributor, as the case may be, that standard software or firmware Products furnished hereunder, when used with Seller-specified hardware, will perform in accordance with published specifications prepared, approved, and issued by Seller's headquarters. Seller makes no representation or warranty, express or implied, that the operation of the software or firmware Products will be uninterrupted or error free, or that the functions contained therein will meet or satisfy the Customer's intended use or requirements. Software and firmware corrections are warranted for a period of three (3) months from the date of shipment to Customer or the remainder of the original warranty term, whichever is longer.

- C. **Factory Repair and Field Exchange:** Seller warrants for a period of six (6) months from the date of invoice from Seller or its appointed distributor, as the case may be, that billable or non-warranty factory-repaired or field-exchanged hardware Products furnished hereunder will be free from defects in material and workmanship. Products furnished on an exchange basis may be new or reconditioned.
- D. **Service:** Seller warrants that Products comprised of services, including engineering and custom application programming services, whether provided on a fixed cost or time and material basis, will be performed in accordance with generally accepted industry practices to the extent such services are subject to written acceptance criteria agreed to in advance by Seller. All other warranties relative to provided services are disclaimed.
- E. **Customer Specifications:** Seller does not warrant and will not be liable for any design, materials or construction criteria furnished or specified by Customer and incorporated into the Products or for Products made by or source from other manufacturers or vendors specified by Customer. Any warranty applicable to such Customer-specified Products will be limited solely to the warranty, if any, extended by the original manufacturer or vendor other than Seller to the extent permissible thereunder.
- F. **Remedies:** Satisfaction of the above warranties will be limited, at Seller's option, to the replacement, repair, re-performance or modification of, or issuance of a credit for the purchase price of the Products involved, and where applicable, only after the return of such Products with Seller's consent. Replacement Products may be new or reconditioned. Any warranty service (consisting of time, travel and expenses related to such services) performed other than at Seller's factory, will be at Customer's expense.
- G. **General:** Warranty satisfaction is available only if (a) Seller is promptly notified in writing and (b) Seller's examination discloses, to its satisfaction, that any alleged defect has not been caused by misuse; neglect; improper installation, operation, maintenance, repair, alteration or modification; accident; or unusual deterioration or degradation of the Products or parts thereof due to physical environment or electrical or electromagnetic noise environment.
- H. THE ABOVE WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES WHETHER EXPRESSED, IMPLIED OR STATUTORY, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE, OR PERFORMANCE OR APPLICATION WARRANTIES, AND EXTEND ONLY TO CUSTOMERS PURCHASING FROM SELLER OR ITS APPOINTED DISTRIBUTOR.

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Packing and Marking—Customer-specified packing or marking may be subject to additional charges not otherwise included in the price of the Products.

Weights and Dimensions—Published weights and dimensions are estimates or approximate only and are not warranted.

Quotations—Written quotations are valid for 30 days from issue unless otherwise stated. Verbal quotations expire the same day they are made. All typographical and clerical errors are subject to correction.

Prices—Prices and other information shown in any Seller publication (including product catalogs and brochures) are subject to change without notice and confirmation by specific quotation. Such publications are not offers to sell and are maintained only as a source of general information. The customer will pay or reimburse Seller for all sales, use, excise or similar taxes. Products comprised of time and material services will be provided in accordance with Seller's published service rates (including applicable overtime and travel expenses) in effect as of the date such services are provided, unless otherwise confirmed by Seller's written quotation or order acknowledgment. Billable service time includes travel time to and from the job site and all time Seller's representatives are available for work and waiting (whether on or off the job site) to perform the services.

Changes—Customer-requested order changes, including those affecting the identity, scope and delivery of the Products, must be documented in writing and are subject to Seller's prior approval and adjustments in price, scheduling and other affected terms and conditions. In any event, Seller reserves the right to reject any change that it deems unsafe, technically inadvisable or inconsistent with established engineering or quality guidelines and standards, or incompatible with Seller's design or manufacturing capabilities.

Returns—All returns of Products will be subject to prior Seller approval. Non-warranty returns of unused and salable Products for credit will be subject to Seller's return policies in effect at the time, including applicable restocking charges and other conditions of return. Products returned under warranty must be properly packed and shipped to Seller-specified locations. Shipping containers must be clearly marked per Seller's instruction and shipped freight prepaid by the customer.

Order Cancellation—An order may be cancelled by the customer prior to shipment only by written notice and upon payment to Seller of reasonable cancellation and restocking charges, including reimbursement for direct costs, plus allowances for disruption. Cancellation charges associated with orders for custom Products or Products specifically manufactured to the customer's specification may equal the actual selling price of the Products. Seller has the right to cancel an order for cause at any time by written notice, and Seller will be entitled to cancellation and restocking charges as identified above. No termination by the customer for cause will be effective unless and until Seller has failed to correct such alleged cause within forty-five (45) days after receipt of the customer's written notice specifying such cause.

Force Majeure—Seller will not be liable for any loss, damage or delay arising out of its failure to perform hereunder due to causes beyond its reasonable control, including without limitation, acts of God or the customer, acts of civil or military authority, fires, strikes, floods, epidemics, quarantine restrictions, war, riots, delays in transportation, or transportation embargoes. In the event of any such delay, Seller's performance date(s) will be extended for that length of time as may be reasonably necessary to compensate for the delay.

Government Clauses and Contracts—No government contract regulations or clauses will apply to the Products or this agreement or act to bind Seller unless specifically agreed to by Seller in writing at Seller's headquarters. Products sold or licensed hereunder are not intended to be used, nor should they be used, in any nuclear-related application either as a "Basic Component" under 10 CFR 21 (United States NRC) or otherwise under similar nuclear laws and regulations of this or any other country.

Terms and Conditions of Sale

Export Control—Products and associated materials supplied or licensed under this agreement may be subject to various export laws and regulations. It is the responsibility of the exporter to comply with all such laws and regulations.

Disputes—The parties will attempt in good faith promptly to resolve any dispute arising out of this agreement by negotiations between representatives who have authority to settle the controversy. If unsuccessful, the parties further will attempt in good faith to settle the dispute by non-binding third-party mediation, with fees and expenses of such mediation apportioned equally to each side. Any dispute not so resolved by negotiation or mediation may then be submitted to a court of competent jurisdiction in accordance with the terms of this agreement. These procedures are the exclusive procedures for the resolution of all such disputes between the parties.

Governing Law—This agreement and all disputes arising thereunder will be governed by and interpreted in accordance with the internal laws of the state, province or other governmental jurisdiction in which Seller's principal place of business resides, but specifically excluding the provisions of the 1980 UN Convention on Contracts for the International Sales of Goods.

Assignment—This agreement may not be assigned by either party without the written consent of the other, however, consent will not be required for internal transfers and assignments as between Seller and its parent corporations, subsidiaries or affiliates as part of a consolidation, merger or other form of corporate reorganization.

Language—The parties acknowledge that they have required that this agreement be drawn up in English. Les parties reconnaissent avoir exigé la rédaction en anglais du Contrat. In the event of a conflict between the English and other language versions of this agreement, the English version will prevail.

ATTENTION: Servicing energized Industrial Control Equipment can be hazardous. Severe injury or death can result from electrical shock, burn, or unintended actuation of controlled equipment. Recommended practice is to disconnect and lockout control equipment from power sources, and release stored energy, if present. Refer to **National Fire Protection Association Standard No. NFPA70E, Part II and (as applicable) OSHA rules for Control of Hazardous Energy Sources (Lockout/Tagout) and OSHA Electrical Safety Related Work Practices** for safety related work practices, including procedural requirements for lockout/tagout, and appropriate work practices, personnel qualifications and training requirements where it is not feasible to de-energize and lockout or tagout electric circuits and equipment before working on or near exposed circuit parts.

Periodic Inspection—Industrial control equipment should be inspected periodically. Inspection intervals should be based on environmental and operating conditions and adjusted as indicated by experience. An initial inspection within three to four months after installation is suggested. See National Electrical Manufacturers Association (NEMA) Standard No. ICS 1.3, Preventive Maintenance of Industrial Control and Systems Equipment, for general guidelines for setting-up a periodic maintenance program. We suggest that a periodic maintenance program is set up. Some specific guidelines for Allen-Bradley products are listed below.

Contamination—If inspection reveals that dust, dirt, moisture or other contamination has reached the control equipment, the cause must be eliminated. This could indicate an incorrectly selected or ineffective enclosure, unsealed enclosure openings (conduit or other) or incorrect operating procedures. Replace any improperly selected enclosure with one that is suitable for the environmental conditions—refer to NEMA Standard No. 250, Enclosures for Electrical Equipment for enclosure type descriptions and test criteria. Replace any damaged or embrittled elastomer seals and repair or replace any other damaged or malfunctioning parts (e.g., hinges, fasteners, etc.). Dirty, wet or contaminated control devices must be replaced unless they can be cleaned effectively by vacuuming or wiping. Compressed air is not recommended for cleaning because it may displace dirt, dust, or debris into other parts or equipment, or damage delicate parts.

Cooling Devices—Inspect blowers and fans used for forced air cooling. Replace any that have bent, chipped, or missing blades, or if the shaft does not turn freely. Apply power momentarily to check operation. If unit does not operate, check and replace wiring, fuse, or blower or fan motor as appropriate. Clean or change air filters as recommended in the product manual. Also, clean fins of heat exchangers so convection cooling is not impaired.

Hazardous Location Enclosures—



ATTENTION: Explosion hazard. Always disconnect power before opening enclosures in hazardous locations. Close and secure such enclosures before re-applying power.

Location Enclosures—NEMA Types 7 & 9 enclosures require careful handling so machined flanges do not get damaged. For removable covers, remove the cover and set aside with machined surface up. For hinged covers, open the cover fully and restrain in the full open position if necessary. Clean and examine the flanges on both the body and cover before re-assemble. If there are scratches, nicks, grooves or rust on the mating surfaces, replace the body or cover as necessary. Examine all bolts and replace any that have damaged threads. Also check mating threads for damage and replace enclosure if necessary. Covers and bodies of some enclosures are manufactured as matched sets (not interchangeable). The manufacturer should be consulted before replacing a cover or body unless it is specified by the manufacturer as interchangeable.

Operating Mechanisms—Check for proper functioning and freedom from sticking or binding. Replace any broken, deformed or badly worn parts or assemblies according to individual product renewal parts lists. Check for, and re-tighten securely, any loose fasteners. Lubricate if specified in individual product instructions.

Note: Allen-Bradley magnetic starters, contactors and relays are designed to operate without lubrication—**do not** lubricate these devices because oil or grease on the pole faces (mating surfaces) of the operating magnet may cause the device to stick in the "ON" mode. Some parts of other devices are factory-lubricated—if lubrication during use or maintenance of these devices is needed, it will be specified in their individual instructions. If in doubt, consult your local Allen-Bradley Sales Office for information.

Contacts—Check contacts for excessive wear and dirt accumulations. Vacuum or wipe contacts with a soft cloth if necessary to remove dirt. Contacts are not harmed by discoloration and slight pitting. Contacts should never be filed, as dressing only shortens contact life. Contact spray cleaners **should not be** used as their residue on magnet pole faces or in operating mechanisms may cause sticking, and on contacts can interfere with electrical continuity. Contacts should only be replaced after silver has become badly worn. Always replace contacts in complete sets to avoid misalignment and uneven contact pressure.

Vacuum Contactors—Contacts of vacuum contactors are not visible, so contact wear must be checked indirectly. Vacuum bottles should be replaced when:

The estimated number of operations equals one million, or

The contact life line indicator shows need for replacement, or

The vacuum bottle integrity tests show need for replacement.

Replace all vacuum bottles in the contactor at the same time to avoid misalignment and uneven contact wear. If the vacuum bottles do not require replacement, check and adjust overtravel to the value listed on the maintenance instructions.

Terminals—Loose connections in power circuits can cause overheating that can lead to equipment malfunction or failure. Loose connections in control circuits can cause control malfunctions. Loose bonding or grounding connections can increase hazards of electrical shock and contribute to electromagnetic interference (EMI). Check the tightness of all terminals and bus bar connections and tighten **securely** any loose connections. Replace any parts or wiring damaged by overheating, and any broken wires or bonding straps.

Arc Hoods—Check for cracks, breaks, or deep erosion. Arc hoods and arc chutes should be replaced if damaged or deeply eroded.

Coils—If a coil exhibits evidence of overheating (cracked, melted or burned insulation), it must be replaced. In that event, check for and correct overvoltage or undervoltage conditions, which can cause coil failure. Be sure to clean any residue of melted coil insulation from other parts of the device or replace such parts.

Batteries—Replace batteries periodically as specified in product manual or if a battery shows signs of electrolyte leakage. Use tools to handle batteries that have leaked electrolyte; most electrolytes are corrosive and can cause burns. Dispose of the old battery in accordance with instructions supplied with the new battery or as specified in the manual for the product.

Pilot Lights—Replace any burned out lamps or damaged lenses.

Photoelectric Switches—The lenses of photoelectric switches require periodic cleaning with a soft dry cloth. Reflective devices used in conjunction with photoelectric switches also require periodic cleaning. Do not use solvents or cleaning agents on the lenses or reflectors. Replace any damaged lenses and reflectors.

Solid-State Devices



ATTENTION: Use of other than factory-recommended test equipment for solid-state controls may result in damage to the control or test equipment or unintended actuation of the controlled equipment. Refer to paragraph titled HIGH-VOLTAGE TESTING.

Solid-state devices require little more than a periodic visual inspection. Discolored, charred or burned components may indicate the need to replace the component or circuit board. Necessary replacements should be made only at the PC board or plug-in component level. Printed circuit boards should be inspected to determine whether they are properly seated in the edge board connectors. Board locking tabs should also be in place. Solid-state devices must also be protected from contamination, and cooling provisions must be maintained—refer to paragraphs titled CONTAMINATION and COOLING DEVICES on previous page. Solvents should not be used on printed circuit boards.

High-Voltage Testing—High-voltage insulation resistance (IR) and dielectric-withstanding voltage (DWV) tests should not be used to check solid-state control equipment. When measuring IR or DWV of electrical equipment such as transformers or motors, a solid-state device used for control or monitoring must be disconnected before performing the test. Even though no damage is readily apparent after an IR or DWV test, the solid-state devices are degraded and repeated application of high voltage can lead to failure.

Locking and Interlocking Devices—Check these devices for proper working condition and capability of performing their intended functions. Make any necessary replacements only with Allen-Bradley renewal parts or kits. Adjust or repair only in accordance with Allen-Bradley instructions.

Maintenance After a Fault Condition—Opening of the short circuit protective device (such as fuses or circuit breakers) in a properly coordinated motor branch circuit is an indication of a fault condition in excess of operating overload. Such conditions can cause damage to control equipment. **Before restoring power**, the fault condition must be corrected and any necessary repairs or replacements must be made to restore the control equipment to good working order. Refer to NEMA Standards Publication No. ICS 2, Part ICS2 302 for procedures.

Replacements—Use only replacement parts and devices recommended by Allen-Bradley to maintain the integrity of the equipment. Make sure the parts are properly matched to the model, series and revision level of the equipment.

Final Check Out—After maintenance or repair of industrial controls, always test the control system for proper functioning under controlled conditions that avoid hazards in the event of a control malfunction.

For additional information, refer to NEMA ICS 1.3, PREVENTIVE MAINTENANCE OF INDUSTRIAL CONTROL AND SYSTEMS EQUIPMENT, published by the National Electrical Manufacturers Association, and NFPA70B, ELECTRICAL EQUIPMENT MAINTENANCE, published by the National Fire Protection Association.

Degree of Protection

IEC Publication 60259 describes standard Degrees of Protection that enclosures of a product are designed to provide when properly installed.

Summary

The publication defines degrees of protection with respect to:

- Persons
- Equipment within the enclosure
- Ingress of water

It does **not** define:

- Protection against risk of explosion
- Environmental protection (e.g. against humidity, corrosive atmospheres or fluids, fungus or the ingress of vermin)

Note: The IEC test requirements for Degrees of Protection against liquid ingress refer only to water. Those products in this catalog, which have a high degree of protection against ingress of liquid, in most cases include Nitrile seals. These have good resistance to a wide range of oils, coolants and cutting fluids. However, some of the available lubricants, hydraulic fluids and solvents can cause severe deterioration of Nitrile and other polymers. Some of the products listed are available with seals of Viton® or other materials for improved resistance to such liquids. For specific advice on this subject refer to your local Rockwell Automation sales office.

IEC Enclosure Classification

The degree of protection is indicated by two letters (IP) and two numerals. International Standard IEC 529 contains descriptions and associated test requirements that define the degree of protection each numeral specifies. The table on this page indicates the general degree of protection—refer to the **Abridged Descriptions of IEC Enclosure Test Requirements** starting below. For complete test requirements refer to IEC 60259.

Abridged Descriptions of IEC Enclosure Test Requirements

(Refer to IEC 60259 for complete test specifications—e.g., test apparatus configuration; tolerances; etc. For Metric Conversion factors—see page G-3.)

Tests for Protection Against Access to Hazardous Parts (first characteristic numeral)

The first characteristic numeral of the IP number indicates compliance with the following tests for the degree of protection against access to hazardous parts. It also indicates compliance with tests as shown in the next section for the degree of protection against solid foreign objects.

The protection against access to hazardous parts is satisfactory if adequate clearance is kept between the specified access probe and hazardous parts. For voltage less than 1000V AC and 1500V DC, the access probe must not touch the hazardous live parts. For voltage exceeding 1000V AC and 1500V DC, the equipment must be capable of withstanding specified dielectric tests with the access probe in the most unfavorable position.

First Numeral*	Second Numeral*
Protection of persons against access to hazardous parts and protection against penetration of solid foreign objects.	Protection against ingress of water under test conditions specified in IEC 60259.
0 Non-protected	0 Non-protected
1 Back of hand; objects greater than 50 mm in diameter	2 Vertically falling drops of water
3 Finger; objects greater than 12.5 mm in diameter	4 Vertically falling drops of water with enclosure tilted 15°
5 Tools or objects greater than 2.5 mm in diameter	6 Spraying water
7 Tools or objects greater than 1.0 mm in diameter	8 Splashing water
9 Dust-protected (dust may enter during specified test but must not interfere with operation of the equipment or impair safety)	10 Water jets
11 Dusttight (no dust observable inside enclosure at end of test)	12 Powerful water jets
	13 Temporary submersion
	14 Continuous submersion

Example: IP41 describes an enclosure that is designed to protect against the entry of tools or objects greater than 1 mm in diameter and to protect against vertically dripping water under specified test conditions.

Note: All first numerals and second numerals up to and including characteristic numeral 6, imply compliance also with the requirements for all lower characteristic numerals in their respective series (first or second). Second numerals 7 and 8 do not imply suitability for exposure to water jets (second characteristic numeral 5 or 6) unless dual coded; e.g., **IP_5/ IP_7**.

* The IEC standard permits use of certain supplementary letters with the characteristic numerals. If such letters are used, refer to IEC 60259 for the explanation.

IP0_—No test required.

IP1_—A rigid sphere 50 mm in diameter shall not completely pass through any opening. Force = 50 N.

IP2_—A jointed test finger 80 mm long and 12 mm in diameter may penetrate to its 80 mm length, but shall have adequate clearance as specified above, from hazardous live parts, in every possible position of the test finger as both joints are bent through an angle up to 90°. Force = 10 N.

IP3_—A test rod 2.5 mm in diameter shall not penetrate and adequate clearance shall be kept from hazardous live parts (as specified in table above). Force = 3 N.

IP4_—A test wire 1 mm in diameter shall not penetrate and adequate clearance shall be kept from hazardous live parts (as specified in table above). Force = 1 N.

IP5_—A test wire 1 mm in diameter shall not penetrate and adequate clearance shall be kept from hazardous live parts (as specified in table above). Force = 1 N.

IP6_—A test wire 1 mm in diameter shall not penetrate and adequate clearance shall be kept from hazardous live parts (as specified in the table above). Force = 1 N.

Tests for Protection Against Solid Foreign Objects (first characteristic numeral)

For first numerals **1, 2, 3,** and **4** the protection against solid foreign objects is satisfactory if the full diameter of the specified probe does not pass through any opening. Note that for first numerals **3** and **4** the probes are intended to simulate foreign objects which may be spherical. Where shape of the entry path leaves any doubt about ingress or a spherical object capable of motion, it may be necessary to examine drawings or to provide special access for the object probe. For first numerals **5** and **6** see test descriptions below for acceptance criteria.

IP0—No test required.

IP1—The full diameter of a rigid sphere 50 mm in diameter must not pass through any opening at a test force of 50 N.

IP2—The full diameter of a rigid sphere 12.5 mm in diameter must not pass through any opening at a test force of 30 N.

IP3—A rigid steel rod 2.5 mm in diameter must not pass through any opening at a test force of 3 N.

IP4—A rigid steel wire 1 mm in diameter must not pass through any opening at a test force of 1 N.

IP5—The test specimen is supported inside a specified dust chamber where talcum powder, able to pass through a square-meshed sieve with wire diameter 50 mm and width between wires 75 mm, is kept in suspension.

Enclosures for equipment subject to thermal cycling effects (category 1) are vacuum pumped to a reduced internal pressure relative to the surrounding atmosphere: maximum depression = 2 kPa; maximum extraction rate = 60 volumes per hour. If extraction rate of 40 to 60 volumes/hr. is obtained, test is continued until 80 volumes have been drawn through or 8 hr. has elapsed. If extraction rate is less than 40 volumes/hr. at 20 kPa depression, test time = 8 hr.

Enclosures for equipment not subject to thermal cycling effects and designated category 2 in the relevant product standard are tested for 8 hr. without vacuum pumping.

Protection is satisfactory if talcum powder has not accumulated in a quantity or location such that, as with any other kind of dust, it could interfere with the correct operation of the equipment or impair safety; and no dust has been deposited where it could lead to tracking along creepage distances.

IP6—All enclosures are tested as category 1, as specified above for **IP5**. The protection is satisfactory if no deposit of dust is observable inside the enclosure at the end of the test.

Tests for Protection Against Water (second characteristic numeral)

The second characteristic numeral of the IP number indicates compliance with the following tests for the degree of protection against water. For numerals **1** through **7**, the protection is satisfactory if any water that has entered does not interfere with satisfactory operation, does not reach live parts not designed to operate when wet, and does not accumulate near a cable entry or enter the cable. For second numeral **8** the protection is satisfactory if no water has entered the enclosure.

IP0—No test required.

IP1—Water is dripped onto the enclosure from a "drip box" having spouts spaced on a 20 mm square pattern, at a "rainfall" rate of 1 mm/min. The enclosure is placed in its normal operating position under the drip box. Test time = 10 min.

IP2—Water is dripped onto the enclosure from a "drip box" having spouts spaced on a 20 mm square pattern, at a "rainfall" rate of 3 mm/min. The enclosure is placed in 4 fixed positions tilted 15° from its normal operating position, under the drip box. Test time = 2.5 min. for each position of tilt.

IP3—Water is sprayed onto all sides of the enclosure over an arc of 60° from vertical, using an oscillating tube device with spray holes 50 mm apart (or a hand-held nozzle for larger enclosures). Flow rate, oscillating tube device = 0.07 l/min. per hole x number of holes; for hand-held nozzle = 10 l/min. Test time, oscillating tube = 10 min.; for hand-held nozzle = 1 min./m² of enclosure surface area, 5 min. minimum.

IP4—Same as test for **IP3** except spray covers an arc of 180° from vertical.

IP5—Enclosure is sprayed from all practicable directions with a stream of water at 12.5 l/min. from a 6.3 mm nozzle from a distance of 2.5 to 3 m. Test time = 1 min./m² of enclosure surface area to be sprayed, 3 min. minimum.

IP6—Enclosure is sprayed from all practicable directions with a stream of water at 100 l/min. from a 12.5 mm nozzle from a distance of 2.5 to 3 m. Test time = 1 min./m² of enclosure surface area to be sprayed, 3 min. minimum.

IP7—Enclosure is immersed in water in its service position for 30 min. Lowest point of enclosures less than 850 mm tall = 1000 mm below surface of water. Highest point of enclosures more than 850 mm tall = 150 mm below surface of water.

IP8—Test conditions are subject to agreement between manufacturer and user, but shall be at least as severe as those for **IP7**.

Specify the Correct Enclosure for Your Motor Controls

Type 1 General Purpose Surface Mounting

Type 1 enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment in locations where unusual service conditions do not exist. The enclosures are designed to meet the rod entry and rust-resistance design tests. Enclosure is sheet steel, treated to resist corrosion.



Type 1 Flush Mounting

Type 1 Flush mounting enclosures for installation in machine frames and plaster wall. These enclosures are for similar applications and are designed to meet the same tests as Type 1 surface mounting.

Type 3 Rainproof Dusttight

Type 3 enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain and sleet; and to be undamaged by the formation of ice on the enclosure. They are designed to meet rain *, external icing †, dust, and rust-resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.

Type 3R Rainproof

Type 3R enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain, and to be undamaged by the formation of ice on the enclosure. They are designed to meet rod entry, rain ‡ external icing †, and rust-resistance design tests. They are not intended to provide protection against conditions such as dust, internal condensation, or internal icing.

Type 4 Watertight

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; and to be undamaged by the formation of ice on the enclosure. They are designed to meet hosedown, dust, and external icing tests †. They are not intended to provide protection against conditions such as internal condensation or internal icing.



Type 4X Non-Metallic, Corrosion-Resistant

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; and to be undamaged by the formation of ice on the enclosure. They are designed to meet the hosedown, dust, external icing †, and corrosion-resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.



Type 6P For Prolonged Submersion at a Limited Depth

Type 6P enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against the entry of water during prolonged submersion at a limited depth; and to be undamaged by the formation of ice on the enclosure. They are designed to meet air pressure, external icing †, hosedown and corrosion-resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.

Type 7 For Hazardous Gas Locations

Type 7 enclosures are for indoor use in locations classified as Class I, Groups C or D, as defined in the U.S. National Electrical Code. Type 7 enclosures are designed to be capable of withstanding the pressures resulting from an internal explosion of specified gases, and contain such an explosion sufficiently that an explosive gas-air mixture existing in the atmosphere surrounding the enclosure will not be ignited. Enclosed heat generating devices are designed not to cause external surfaces to reach temperatures capable of igniting explosive gas-air mixtures in the surrounding atmosphere. Enclosures are designed to meet explosion, hydrostatic, and temperature design tests. Finish is a special corrosion-resistant, gray enamel.



Type 9 For Hazardous Dust Locations

Type 9 enclosures are intended for indoor use in locations classified as Class II, Groups E, F, or G, as defined in the U.S. National Electrical Code. Type 9 enclosures are designed to be capable of preventing the entrance of dust. Enclosed heat generating devices are designed not to cause external surfaces to reach temperatures capable of igniting or discoloring dust on the enclosure or igniting dust-air mixtures in the surrounding atmosphere. Enclosures are designed to meet dust penetration and temperature design tests, and aging of gaskets. The outside finish is a special corrosion-resistant gray enamel.



Type 12 Dusttight Industrial Use

Type 12 enclosures are intended for indoor use primarily to provide a degree of protection against dust, falling dirt, and dripping non-corrosive liquids. They are designed to meet drip †, dust, and rust-resistance tests. They are not intended to provide protection against conditions such as internal condensation.



Type 13 Oiltight

Type 13 enclosures are intended for indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and noncorrosive coolant. They are designed to meet oil exclusion and rust-resistance design tests. They are not intended to provide protection against conditions such as internal condensation.



* Evaluation criteria: No water has entered enclosure during specified test.

† Evaluation criteria: Undamaged after ice buildup during specified test has melted. (**Note:** Not required to be operable while ice-laden.)

‡ Evaluation criteria: No water shall have reached live parts, insulation or mechanisms.

ENCLOSURES:

Refer to the brief descriptions below for the various types of enclosures offered by Rockwell Automation. For definitions, descriptions and test criteria, see National Electrical Manufacturers Association (NEMA) Standards Publication No. 250. Also see individual product listings within this Rockwell Automation catalog for available enclosure types and for any additional information relating to these descriptions.

NOTE: Enclosures do not normally protect devices against conditions such as condensation, icing, corrosion or contamination that may occur within the enclosure or enter via the conduit or unsealed openings. Users must make adequate provisions to safeguard against such conditions and satisfy themselves that the equipment is properly protected.

Selection Criteria

Enclosures for Non-Hazardous Locations

For a Degree of Protection Against:	Designed to Meet Tests No. *	Type							
		For Indoor Use			For Outdoor Use		Indoor or Outdoor		
		1	12	13	3R	3	4	4X	6P
Incidental contact with enclosed equipment	6.2	✓	✓	✓	✓	✓	✓	✓	✓
Falling dirt	6.2	✓	✓	✓	✓	✓	✓	✓	✓
Rust	6.8	✓	✓	✓	✓	✓	✓	✓	✓
Circulating dust, lint, fibres and flyings*	6.5.1.2 (2)		✓	✓		✓	✓	✓	✓
Windblown dust	6.5.1.1 (2)					✓	✓	✓	✓
Falling liquids and light splashing	6.3.2.2		✓	✓		✓	✓	✓	✓
Rain (Test evaluated per 6.4.2.1)	6.4.2.1				✓	✓	✓	✓	✓
Rain (Test evaluated per 6.4.2.2)	6.4.2.2					✓	✓	✓	✓
Snow and sleet	6.6.2.2				✓	✓	✓	✓	✓
Hosedown and splashing water	6.7						✓	✓	✓
Occasional prolonged submersion	6.11 (2)								✓
Oil and coolant seepage	6.3.2.2		✓	✓					
Oil or coolant spraying and splashing	6.12			✓					
Corrosive agents	6.9				✓	✓	✓	✓	✓

* See page G-13 for abridged description of NEMA enclosure test requirements. Refer to NEMA Standards Publication No. 250 for complete test specifications.

* Non-hazardous materials, not Class III ignitable or combustible.

Enclosures for Hazardous Locations (Division 1 or 2)*

For a Degree of Protection Against Atmospheres Typically Containing: ➤	Designed to Meet Tests ‡	Class (National Electrical Code)	7, Class I Group				9, Class II Group		
			A	B	C	D	E	F	G
Acetylene	Explosion Test Hydrostatic Test Temperature Test	I	✓						
Hydrogen, Manufactured Gas			✓	✓					
Diethyl Ether, Ethylene, Hydrogen Sulfide					✓				
Acetone, Butane, Gasoline, Propane, Toluene					✓	✓			
Metal dusts and other combustible dusts with resistivity of less than 10 ⁵ Ω-cm	Dust Penetration Test Temperature Test with Dust Blanket	II					✓		
Carbon black, charcoal, coal or coke dusts with resistivity between 10 ² ...10 ⁸ Ω-cm								✓	
Combustible dusts with resistivity of 10 ⁵ Ω-cm or greater									✓
Fibers, flyings	§	III							✓

* For indoor locations only, unless cataloged with additional NEMA Type enclosure number(s) suitable for outdoor use as shown in the table on this page. Some control devices (if so listed in the catalog) are suitable for Division 2 hazardous location use in enclosures for nonhazardous locations. For explanation of CLASSES, DIVISIONS and GROUPS, refer to the National Electrical Code.

➤ For listing of additional materials and information noting the properties of liquids, gases and solids, refer to NFPA 497M-1991, Classification of Gases, Vapors, and Dusts for Electrical Equipment in Hazardous (Classified) Locations.

‡ See abridged description of test requirements on page G-13. For complete requirements, refer to UL Standard 698, compliance with which is required by NEMA enclosure standards.

§ UL 698 does not include test requirements for Class III. Products that meet Class II, Group G requirements are acceptable for Class III.

Abridged Description of NEMA Enclosure Test Requirements

6.2 Rod Entry Test—A 3.18 mm (0.125 in.) diameter rod must not be able to enter enclosure except at locations where nearest live part is more than 102 mm (4 in.) from an opening — such opening shall not permit a 13 mm (0.5 in.) diameter rod to enter.

6.3 Drip Test—Water is dripped onto enclosure for 30 minutes from an overhead pan having uniformly spaced spouts, one every 12,900 mm² (20 in.²) of pan area, each spout having a drip rate of 20 drops per minute.

Evaluation 6.3.2.2: No water shall have entered enclosure.

6.4 Rain Test—Entire top and all exposed sides are sprayed with water at a pressure of 0.35 kg/cm² (5 psi) from nozzles for one hour at a rate to cause water to rise 457 mm (18 in.) in a straight-sided pan beneath the enclosure.

Evaluation 6.4.2.1: No water shall have reached live parts, insulation or mechanisms.

Evaluation 6.4.2.2: No water shall have entered enclosure.

6.5.1.1 (2) Outdoor Dust Test (Alternate Method)—Enclosure and external mechanisms are subjected to a stream of water at 170.5 liters (45 gallons) per minute from a 25.4 mm (1 in.) diameter nozzle, directed at all joints from all angles from a distance of 3...3.7 m (10...12 ft). Test time is 48 seconds times the test length (height + width + depth of enclosure in feet), or a minimum of 5 minutes. No water shall enter enclosure.

6.5.1.2 (2) Indoor Dust Test (Alternate Method)—Atomized water at a pressure of 2.11 kg/cm² (30 psi) is sprayed on all seams, joints and external operating mechanisms from a distance of 305...381 mm (12...15 in.) at a rate of 11 liters (3 gallons) per hour. No less than 142 gms (5 oz) of water per linear foot of test length (height + length + depth of enclosure) is applied. No water shall enter enclosure.

6.6 External Icing Test—Water is sprayed on enclosure for one hour in a cold room +2°C (36°F); then room temperature is lowered to approximately -5°C (-23°F) and water spray is controlled so as to cause ice to build up at a rate of 6.4 mm (0.25 in.) per hour until 19 mm (0.75 in.) thick ice has formed on top surface of a 25.4 mm (1 in.) diameter metal test bar, then temperature is maintained at -5°C (-23°F) for 3 hours.

Evaluation 6.6.2.2: Equipment shall be undamaged after ice has melted (external mechanisms not required to be operable while ice-laden).

6.7 Hosedown Test—Enclosure and external mechanisms are subjected to a stream of water at 246 liters (65 gallons) per minute from a 25.4 mm (1 in.) diameter nozzle, directed at all joints from all angles from a distance of 3...3.7 m (10 to 12 ft). Test time is 48 seconds times the test length [height + width + depth] of enclosure in meters (feet), or a minimum of 5 seconds. No water shall enter enclosure.

6.8 Rust Resistance Test (Applicable Only to Enclosures Incorporating External Ferrous Parts)—Enclosure is subjected to a salt spray (fog) for 24 hours, using water with five parts by weight of salt (NaCl), at 35°C (95°F), then rinsed and dried. There shall be no rust except where protection is impractical (e.g., machined mating surfaces, sliding surfaces of hinges, shafts, etc.).

6.9 Corrosion Protection—Sheet steel enclosures are evaluated per Underwriter's Laboratories (UL) 50, Part 13 (test for equivalent protection as G-90 commercial zinc coated sheet steel). Other materials per Underwriter's Laboratories (UL) 508, 6.9 or 6.10.

6.11 (2) Air Pressure Test (Alternate Method)—Enclosure is submerged in water at a pressure equal to water depth of 2 m (6 ft), for 24 hours. No water shall enter enclosure.

6.12 Oil Exclusion Test—Enclosure is subjected to a stream of test liquid for 30 minutes from a 9.5 mm (0.375 in.) diameter nozzle at 7.57 liters (2 gallons) a minute. Water with 0.1% wetting agent is directed from all angles from a distance of 305...457 mm (12...18 in.), while any externally operated device is operated at 30 operations per minute. No test liquid shall enter the enclosure.

Abridged Description of UL Standard 698 Test Requirements

Explosion Test—During a series of tests in which gas-air mixtures of the specific gas, over its range of explosive concentrations, are ignited inside the enclosure, the enclosure shall prevent the passage of flame and sparks capable of igniting a similar gas-air mixture surrounding the enclosure. In addition, there shall be no mechanical damage to enclosed electrical mechanisms or the enclosure.

Hydrostatic Test—The enclosure shall withstand for one minute a hydrostatic test based on the maximum internal explosion pressure developed during the explosion tests, as follows: cast metal, four times the explosion pressure without rupture or permanent deformation; fabricated steel, twice the explosion pressure without permanent deformation and three times the explosion pressure without rupture. Exception: Hydrostatic tests may be omitted if calculations show safety factor of 5:1 for cast metal and 4:1 for fabricated steel.

Temperature Test—The enclosed device is subjected to a temperature test to determine maximum temperature at any point on the external surface. The device must be marked with a temperature code based on the result only if the temperature exceeds +100°C (+212°F).

Dust Penetration Test—The device is operated at full rated load until equilibrium temperatures are attained, then allowed to cool to ambient (room) temperature, through six heating and cooling cycles covering at least 30 hours, while continuously exposed to circulating dust of specified properties in a test chamber. No dust shall enter the enclosure.

Temperature Test with Dust Blanket—This test is conducted as described for the Dust Penetration test except that the re-circulating dust nozzles are positioned so that the dust is not blown directly on the device under test. The device is operated at full rated load (and under abnormal conditions for equipment subject to overloading) until equilibrium temperatures are attained. Dust in contact with the enclosure shall not ignite or discolour from heat, and the exterior temperatures based on +40°C (+104°F) ambient shall not exceed:

Group	Normal Operation	Abnormal Operation
E	+200°C (+392°F)	+200°C (+392°F)
F	+150°C (+302°F)	+200°C (+392°F)
G	+120°C (+248°F)	+165°C (+329°F)

