Technical Data

Allen-Bradley

Industrial Components Preventive Maintenance, Enclosures, and Contact Ratings Specifications

Additional Resources

These documents contain additional information concerning related products from Rockwell Automation.

Resource	Description
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, http://www.ab.com	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at http://www.rockwellautomation.com/literature/. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

Important User Information

This guide has been developed as a quick reference tool to Allen-Bradley industrial automation controls and factory assemblies. It is not intended to replace factory user manuals or technical documentation supplied with Allen-Bradley equipment.

Because of the variety of uses for the products described in this publication, those responsible for the application and use of these products 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. Factory-provided user manuals and technical documentation should not be solely relied on for those purposes.

Rockwell Automation reserves the right to change the features or characteristics of its products at any time. Therefore, the information contained in this publication is subject to change at any time without notice.

The illustrations, charts, diagrams, and layout examples shown in this guide are intended solely as examples. Since there are many variables and requirements associated with any particular installation, Rockwell Automation does not assume responsibility or liability (including intellectual property infringement liability) for actual use based upon the examples shown in this publication.

Allen-Bradley 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 publication.

Preventive Maintenance & Repair

Maintenance of Solid-State Control

This section is excerpted from Rockwell Automation publication SGI-1.1, Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control and parts of Section 5 of NEMA Standards Publication No. ICS 1.1-1987, titled Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control. The text from the NEMA Standard has been reprinted verbatim with NEMA's permission. Text set off from the NEMA standard content under the heading Information contains Rockwell Automation comments for the NEMA content immediately preceding it. The comments provide information to help readers better understand the characteristics of industrial equipment employing solid-state technology. NEMA text is provided solely as a convenience to the reader, and Rockwell Automation assumes no responsibility for its completeness or validity.

NEMA Standards Publication No. ICS 1.1-1984, Rev. No. 1 - October 1987, is available from the National Electrical Manufacturers Association, 2101 L Street, N.W., Washington, DC, 20037. Allen-Bradley Publication SGI-1.1 is available from www.rockwellautomation.com/literature.

NEMA Standard Text

From Section 5, Preventive Maintenance and Repair Guidelines

General

A well-planned and executed maintenance program is essential to the satisfactory operation of solid-state electrical equipment. The kind and frequency of the maintenance operation will vary with the kind and complexity of the equipment as well as with the nature of the operating conditions. Maintenance recommendations of the manufacturer or appropriate product standards should be followed.

Useful reference publications for setting up a maintenance program are NFPA 70B-1983, Maintenance of Electrical Equipment, and NFPA 70E-1983, Electrical Safety Requirements for Employee Workplaces.

Preventive Maintenance

The following factors should be considered when formulating a maintenance program:

1. Maintenance must be performed by qualified personnel familiar with the construction, operation, and hazards involved with the control.
2. Maintenance should be performed with the control out of operation and disconnected from all sources of power. If maintenance must be performed while the control is energized, the safety related practices of NFPA 70E should be followed.
3. Care should be taken when servicing electrostatic sensitive components. The manufacturer's recommendations for these components should be followed.
4. Ventilation passages should be kept open. If the equipment depends upon auxiliary cooling, e.g., air, water, or oil, periodic inspection (with filter replacement when necessary) should be made of these systems.
5. The means employed for grounding or insulating the equipment from ground should be checked to assure its integrity (see 4.5).
6. Accumulations of dust and dirt on all parts, including on semiconductor heat sinks, should be removed according to the manufacturer's instructions, if provided; otherwise, the manufacturer should be consulted. Care must be taken to avoid damaging any delicate components and to avoid displacing dust, dirt, or debris in a way that permits it to enter or settle into parts of the control equipment.
7. Enclosures should be inspected for evidence of deterioration. Accumulated dust and dirt should be removed from the top of the enclosures before opening doors or removing covers.
8. Certain hazardous materials removed as part of maintenance or repair procedure (e.g., polychlorinated biphenyls (PCB) found in some liquid filled capacitors) must be disposed of as described in Federal regulations.

Lithium batteries are frequently used for memory backup in solid state equipment due to their excellent shelf life and high energy-to- weight ratio. Lithium is a highly reactive metal that can cause burns if there is contact with skin. The batteries are sealed so there is seldom a problem of contact with lithium as long as reasonable care is exercised when handling them. They should only be used in their intended application and not subjected to rough handling. When batteries are replaced in equipment, the batteries removed should be disposed of in accordance with the battery supplier's instructions.

The Department of Transportation has certain regulations that prohibit shipment of equipment with batteries installed if the batteries contain 0.5 grams or greater of lithium. The batteries must be removed from equipment and shipped separately in a container approved by the Department of Transportation. Additional Department of Transportation restrictions apply to the shipment of lithium batteries.

NEMA Standards Publication No. ICS 1.3-1986, Preventive Maintenance of Industrial Control and System Equipment, is recommended for personnel responsible for maintenance of equipment.

Repair

If equipment condition indicates repair or replacement, the manufacturer's instruction manual should be followed carefully. Diagnostic information within such a manual should be used to identify the probable source of the problem, and to formulate a repair plan. The level of field repair recommended by the manufacturer should be followed.

When solid-state equipment is repaired, it is important that any replacement part be in accordance with the recommendations of the equipment manufacturer. Care should be taken to avoid the use of parts which are no longer compatible with other changes in the equipment. Also, replacement parts should be inspected for deterioration due to "shelf life" and for signs of rework or wear, which may involve factors critical to safety.

After repair, proper start-up procedures should be followed. Special precautions should be taken to protect personnel from hazards during start-up.

Follow manufacturer's instructions exactly when replacing power semiconductors mounted on heatsinks since improper installation may become the source of further difficulties. Torque semiconductors or bolts retaining semiconductors to the value specified with a torque wrench. Too much pressure against a heatsink can damage a semiconductor, while too little can restrict the amount of heat transferred from the semiconductor to the heatsink, resulting in operation at higher temperature with decreased reliability.

Exercise care when removing modules from a system during maintenance. Failed modules are frequently returned to the manufacturer for repair. Any physical damage sustained during removal may result in more expensive repair or render the module unable to be repaired if damage is too great.

Modules with electrostatic sensitive components should be handled by the edges without touching components or printed circuit conductors. Use packaging material supplied with the replacement module when shipping the module to the manufacturer for repair.

When the scope of repairs exceeds the manufacturer's recommendations for field repair, the module(s) should be returned to the manufacturer for repair. Doing so will help to ensure that only properly selected components are used and that all necessary hardware and firmware revisions are incorporated into the repair. Failure to make necessary updates may result in safety, compatibility, or performance problems, which may not become apparent for some time after the repaired module has been placed back in service. When firmware is protected by copyright law, updates can be provided legally only by the manufacturer or licensee.

Safety Recommendations for Maintenance Personnel

All maintenance work should be done by qualified personnel familiar with the construction, operation, and hazards involved with the equipment. The appropriate work practices of NFPA 70E should be followed.

NEMA Enclosures

Specify the Correct Enclosure for Your Motor Controls

Refer to the brief descriptions below for the various types of enclosures offered by Allen-Bradley. See page 6 for selection criteria. For definitions, descriptions and test criteria, see National Electrical Manufacturers Association (NEMA) Standards Publication No. 250. Also see individual product listings within the Allen-Bradley catalog for available enclosure types and for any additional information relating to these descriptions.

IMPORTANT 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.

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 ❶, external icing ❷, 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 ❸, external icing ❷, 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 ❷. 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 ❷, and corrosion-resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.

❶ Evaluation criteria: No water has entered enclosure during specified test.
❷ Evaluation criteria: Undamaged after ice buildup during specified test has melted (**Note:** Not required to be operable while ice-laden).
❸ Evaluation criteria: No water shall have reached live parts, insulation or mechanisms.

Type 7
For
Hazardous
Gas
Locations

Type 7 & 9 Bolted Enclosure for Hazardous Locations

Type 7 & 9 Unilock Enclosure for Hazardous 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 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 ❶, hosedown and corrosion-resistance design tests. They are not intended to provide protection against conditions such as internal condensation or internal icing.

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 ❷, 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.

❶ Evaluation criteria: Undamaged after ice buildup during specified test has melted (**Note:** Not required to be operable while ice-laden).
❷ Evaluation criteria: No water has entered enclosure during specified test.

Enclosures for Non-Hazardous Locations

For a Degree of Protection Against:	Designed to Meet Tests No. ❶	Type							
		For Indoor Use			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, fibers and flyings ❷	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				✓	✓	✓	✓	✓

❶ See page 7 for abridged description of NEMA enclosure test requirements. Refer to NEMA Standards Publication No. 250 for complete test specifications.
❷ Non-hazardous materials, not Class III ignitable or combustible.

Abridged Description of NEMA Enclosure Test Requirements

6.2 **Rod Entry Test —** A 1/8 in. (3.18 mm) diameter rod must not be able to enter enclosure except at locations where nearest live part is more than 4 in. (102 mm) from an opening — such opening shall not permit a 1/2 in. (13 mm) 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 20 sq. in. (12,900 mm^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 5 psi (0.35 kg/cm^2) from nozzles for one hour at a rate to cause water to rise 18 in. (457 mm) 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 45 gallons (170.5 liters) per minute from a 1 in. (25.4 mm) diameter nozzle, directed at all joints from all angles from a distance of 10 to 12 feet (3 to 3.7 meters). 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 30 psi (2.11 kg/cm^2) is sprayed on all seams, joints and external operating mechanisms from a distance of (12 to 15 in.) 305 to 381mm at a rate of 3 gallons (11 liters) per hour. No less than 5 ozs (142 gms) 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 35.6°F (+2°C); then room temperature is lowered to approximately –23°F (–5°C) and water spray is controlled so as to cause ice to build up at a rate of 1/4 in. (6.4 mm) per hour until
3/4 in. (19 mm) thick ice has formed on top surface of a 1 in. (25.4 mm) diameter metal test bar, then temperature is maintained at –23°F (–5°C) 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 65 gallons (246 liters) per minute from a 1 in. (25.4 mm) diameter nozzle, directed at all joints from all angles from a distance of 10 to 12 ft. (3 to 3.7 meters). Test time is 48 seconds times the test length [height + width + depth of enclosure in ft. (meters), 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 (NaCI), at 95°F (35°C), 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 6 ft. (20 meters), 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 3/8 in. (9.5 mm) diameter nozzle at 2 gallons (7.57 liters) a minute. Water with 0.1% wetting agent is directed from all angles from a distance of 12 to 18 in. (305 to 457 mm), while any externally operated device is operated at 30 operations per minute. No test liquid shall enter the enclosure.

Enclosures for Hazardous Locations (Division 1 or 2) ❶

For a Degree of Protection Against Atmospheres Typically Containing: ❸	Designed to Meet Tests ❷	Class (National Electrical Code)	Type						
			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		I	✓	✓					
Diethyl Ether, Ethylene, Hydrogen Sulfide		I			✓				
Acetone, Butane, Gasoline, Propane, Toluene		I			✓	✓			
Metal dusts and other combustible dusts with resistivity of less than 10^5 ohm-cm.	Dust Penetration Test Temperature Test with Dust Blanket	II					✓		
Carbon black, charcoal, coal or coke dusts with resistivity between $10^2 \ldots 10^8$ ohm-cm		II						✓	
Combustible dusts with resistivity of 10^5 ohm-cmIndustrial Components Preventive Maintenance, Enclosures, and Contact Ratings Specifications or greater		II							✓
Fibers, flyings	❹	III							✓

❶ For indoor locations only unless cataloged with additional NEMA Type enclosure number(s) suitable for outdoor use as shown in table on page 6. Some control devices (if so listed in the catalog) are suitable for Division 2 hazardous location use in enclosures for non-hazardous locations. For explanation of CLASSES, DIVISIONS and GROUPS, refer to the National Electrical Code.
Note: Classifications of hazardous locations are subject to the approval of the authority having jurisdiction. Refer to the National Electrical Code.

❷ See abridged description of test requirements below. For complete requirements, refer to UL Standard 698, compliance with which is required by NEMA enclosure standards.

❸ 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.

❹ 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 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 1 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 (+212°F) +100°C.

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 recirculating 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 discolor from heat, and the exterior temperatures based on (+104°F) +40°C ambient shall not exceed:

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

IEC Enclosures

Degree of Protection

IEC Publication 529 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)

IMPORTANT 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, consult your local Rockwell Automation sales office or Allen-Bradley distributor.

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 following table indicates the *general* degree of protection — refer to Abridged Descriptions of IEC Enclosure Test Requirements below and on page Important-11. **For complete test requirements refer to IEC 529.**

First Numeral❶	Second Numeral❶
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 529.
0. Non-protected	0. Non-protected
1. Back of hand; objects greater than 50 mm in diameter	1. Vertically falling drops of water
2. Finger; objects greater than 12.5 mm in diameter	2. Vertically falling drops of water with enclosure tilted 15 degrees
3. Tools or objects greater than 2.5 mm in diameter	3. Spraying water
4. Tools or objects greater than 1.0 mm in diameter	4. Splashing water
5. Dust-protected (dust may enter during specified test but must not interfere with operation of the equipment or impair safety)	5. Jetting water
6. Dusttight (no dust observable inside enclosure at end of test)	6. Powerful jetting water
	7. Temporary submersion
	8. Continuous submersion
	9. Protected against high pressure and temperature water jets

❶ The IEC standard permits use of certain supplementary letters with the characteristic numerals. If such letters are used, refer to IEC 529 for the explanation.

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.

Abridged Descriptions of IEC Enclosure Test Requirements

(Refer to IEC 529 for complete test specifications — e.g., test apparatus configuration; tolerances; etc. For Metric Conversion factors — see page 14.)

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 voltages less than 1000V AC and 1500V DC, the access probe must not touch the hazardous live parts. For voltages 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.

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 IEC Enclosure Classification table). 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 IEC Enclosure Classification table). 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 on page IEC Enclosure Classification table). 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 on IEC Enclosure Classification table). 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/h is obtained, test is continued until 80 volumes have been drawn through or 8 h has elapsed. If extraction rate is less than 40 volumes/h at 20 kPa depression, test time = 8 h.

Enclosures for equipment not subject to thermal cycling effects **and** designated category 2 in the relevant product standard are tested for 8 h 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…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.

IP_0 — No test required.

IP_1 — 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.

IP_2 — 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.

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

IP_3 — 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.

IP_4 — Same as test for IP_3 except spray covers an arc of 180° from vertical.

IP_5 — 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 = 1min./m2 of enclosure surface area to be sprayed, 3 min. minimum.

IP_6 — 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 = 1min./m2 of enclosure surface area to be sprayed, 3 min. minimum.

IP_7 — 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.

IP_8 — Test conditions are subject to agreement between manufacturer and user, but shall be at least as severe as those for IP_7.

IP_9 — The test is made by spraying the enclosure with a stream of water, force shall be verified at upper and lower limits of distance tolerance range, the water temperature shall be (80 ± 5) °C.

a. For small enclosures (largest dimension less than 250 mm), mounted on- turntable speed: 5 r/min ± 1 r/min, - spray position: 0, 30, 60, 90 degrees, Test duration 30s per position
b. For large enclosures (largest dimension greater than 250 mm), entire enclosure sprayed from all directions, distance between nozzle and sample 175 +/- 25mm, test duration is 1 min/m^2 of the calculated surface area, minimum duration 3 minutes.

NEMA Ratings and Test Values for AC Control Circuit Contacts at 50 or 60 Hz Maximum Current [A]

NEMA Contract Rating Designation	Thermal Continuous Test Current [A]	120V		240V		480V		600V		VA	
		Make	Break	Make	Break	Make	Break	Make	Break	Make	Break
A150	10	60	6.00	—	—	—	—	—	—	7200	720
A300	10	60	6.00	30	3.00	—	—	—	—	7200	720
A600	10	60	6.00	30	3.00	15	1.50	12	1.20	7200	720
B150	5	30	3.00	—	—	—	—	—	—	3600	360
B300	5	30	3.00	15	1.50	—	—	—	—	3600	360
B600	5	30	3.00	15	1.50	7.50	0.75	6	0.60	3600	360
C150	2.5	15	1.50	—	—	—	—	—	—	1800	180
C300	2.5	15	1.50	7.50	0.75	—	—	—	—	1800	180
C600	2.5	15	1.50	7.50	0.75	3.75	0.375	3	0.30	1800	180
D150	1.0	3.60	0.60	—	—	—	—	—	—	432	72
D300	1.0	3.60	0.60	1.80	0.30	—	—	—	—	432	72
D600	0.5	1.80	0.30	—	—	—	—	—	—	216	36
2X A300	20	120	12	60	6.00	—	—	—	—	14400	1440
2X A600	20	120	12	60	6.00	30	3.00	24	2.40	14400	1440

NEMA Ratings and Test Values for DC Control Circuit Contacts

NEMA Contract Rating Designation	Thermal Continuous Test Current [A]	Maximum Current [A]				
		5…28V	125V	250V	301…600V	Make or Break at 300V or less [VA]
N150	10	10	2.2	—	—	275
N300	10	10	2.2	1.1	—	275
N600	10	10	2.2	1.1	0.40	275
P150	5.0	5.0	1.1	—	—	138
P300	5.0	5.0	1.1	0.55	—	138
P600	5.0	5.0	1.1	0.55	0.20	138
Q300	2.5	2.5	0.55	0.27	0.11	69
Q600	2.5	2.5	0.55	0.27	0.11	69
2X P600	10	10	2.2	1.1	0.40	275

NEMA Definitions for Contact Arrangements

Form "A" Contacts

A Form "A" contact arrangement is one that has single-pole single- throw normally open contacts. The function of this arrangement is to close a circuit when actuated.

Form "B" Contacts

A Form "B" contact arrangement is one that has single-pole single- throw normally closed contacts. The function of this arrangement is to open a circuit when actuated.

Form "C" Contacts

A Form "C" contact arrangement is one that has single-pole double- throw contacts with three terminals — one for normally open, one for normally closed, and one common. The function of this arrangement is to transfer a circuit when actuated.

Form "X" Contacts

A Form "X" contact arrangement is one that has single-pole single- throw normally open double make contacts. The function of this arrangement is to close a circuit when actuated.

Form "Y" Contacts

A Form "Y" contact arrangement is one that has single-pole single- throw normally closed double break contacts. The function of this arrangement is to open a circuit when actuated.

Form "Z" Contacts

A Form "Z" contact arrangement is one that has single-pole double- throw contacts with four terminals — two for normally open and two for normally closed. The function of this arrangement is to open one circuit and close the other.

Metric Conversions

Metric Conversion Factors		
From	**To**	**Multiply by**
Length		
Inches (in.)	Millimeters (mm)	25.4
Inches (in.)	Centimeters (cm)	2.54
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

Metric Conversion Factors		
From	**To**	**Multiply by**
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

Metric Conversion Factors		
From	**To**	**Multiply by**
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

Metric Conversion Factors		
From	**To**	**Multiply by**
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

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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