Allen-Bradley

IEC vs. NEMA Push Buttons

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Introduction

The globalization of industrial manufacturing has resulted in a convergence of electromechanical operator interface device styling and performance standards. That convergence is evident in the design of push button products.

A common misconception holds that any operator manufactured or designed in Europe is, by definition, an IEC push button. Another is that IEC push buttons are manufactured only in IEC countries. Neither belief is true. Conversely, not all NEMA operators are designed, manufactured, or even sold in the United States or Canada.

What is factual is that the traditional target markets for IEC and NEMA rated devices were Europe and North America, respectively. These traditional markets are expanding with the globalization of product manufacturing, product support, and product sales.

An industrial operator interface device can be described by four general characteristics: ingress protection, electrical performance, panel opening size, and styling. We will consider the differences between IEC and NEMA approaches to operator design for each of those criteria in greater detail in the pages that follow.

Ingress Protection

Both IEC and NEMA have defined degrees of protection from ingress of solids or liquids for enclosures. IEC ingress protection (IP) and NEMA Type ratings have been extrapolated to include push button products installed in ingress rated enclosures. Push button stations including operators installed into enclosures are subject to ingress tests. Upon successful completion of ingress testing, a manufacturer will list the appropriate IP or NEMA Type rating for a given push button.

IP Ratings assess a device's ability to withstand ingress of water and solid foreign objects. IP Ratings also specify protection of persons against contact with live and/or moving parts.

Typical NEMA Type ratings assess a device's ability to withstand dirt, dust, water spray, salt spray, oil spray, coolant contact, and rust buildup; and degrees of protection from rain, sleet, snow, ice, and corrosion.

Tables A…C summarize both IEC IP and NEMA Type ratings. Refer to the appropriate standard for detailed information.

NEMA Type Ratings

Table A. Comparison of Specific Applications of Enclosures for Indoor Non-Hazardous Locations (from NEMA Standard 1-10-1985, a copyrighted publication of the National Electrical Manufacturers Association)

Provides a Degree of Protection Against the Following Environmental Conditions	Type of Enclosure										
	1 ❶	2 ❶	4	4X	5	6	6P	11	12	12K	13
Incidental contact with the enclosed equipment	X	X	X	X	X	X	X	X	X	X	X
Falling dirt	X	X	X	X	X	X	X	X	X	X	X
Falling liquids and light splashing		X	X	X		X	X	X	X	X	X
Dust, lint, fibers, and flyings ❷			X	X	X	X	X		X	X	X
Hosedown and splashing water			X	X		X	X				
Oil and coolant seepage									X	X	X
Oil or coolant spraying and splashing											X
Corrosive agents				X			X	X			
Occasional temporary submersion						X	X				
Occasional prolonged submersion							X				

❶ These enclosures may be ventilated. However, Type 1 may not provide protection against small particles of falling dirt when ventilation is provided in the enclosure top. Consult the manufacturer.

❷ These fibers and flyings are non-hazardous materials and are not considered the Class III type ignitable fibers or combustible flyings. For Class III type ignitable fibers or combustible flyings see the National Electrical Code, Section 500-6(a).

IEC IP Ratings

Table B. Degrees of Protection Indicated by the First Characteristic Numeral (from IEC Standard 60529; used with permission)

First Characteristic Numeral	Degree of Protection		
	Short Description ❶	Definition (See Complete Standard, Clause 3)	Test Conditions (See Sub-Clause)
0	Non-protected	No special protection	No tests
1	Protected against solid objects greater than 50 mm	• A large surface of the body, such as a hand (but no protection against deliberate access) • Solid objects exceeding 50 mm in diameter	7.1
2	Protected against solid objects greater than 12.5 mm	• Fingers or similar objects not exceeding 80 mm in length • Sold objects exceeding 12.5 mm in diameter	7.2
3 ❷	Protected against solid objects greater than 2.5 mm	• Tools, wires, etc., of diameter or thickness greater than 2.5 mm • Solid objects exceeding 2.5 mm in diameter	7.3
4 ❷	Protected against solid objects greater than 1.0 mm	• Wires or strips of thickness greater than 1.0 mm • Solid objects exceeding 1.0 mm in diameter	7.4
5 ❸	Dust-protected	Ingress of dust is not totally prevented but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment.	7.5
6	Dusttight	No ingress of dust	7.6

❶ The short description given in column 2 of this table should not be used to specify the form of protection. It should only be used as a brief description.

❷ For first characteristic numerals 3 and 4, the application of this table to equipment containing drain holes or ventilating openings is the responsibility of the relevant Technical Committee.

❸ For first characteristic numeral 5, the application of this table to equipment containing drain holes is the responsibility of the relevant Technical Committee.

Table C. Degrees of Protection Indicated by the Second Characteristic Numeral (from IEC Standard 60529; used with permission)

Second Characteristic Numeral	Degree of Protection		
	Short Description ❶	Definition (See Complete Standard, Clause 4)	Test Conditions (See Sub-Clause)
0	Non-protected	No special protection	No tests
1	Protected against dripping water	Dripping water (vertically falling drops) have no harmful effect.	8.1
2	Protected against dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at any angle up to 15° from its normal position.	8.2
3	Protected against spraying water	Water falling as a spray at an angle up to 60° from the vertical shall have no harmful effect.	8.3
4	Protected against splashing water	Water splashed against the enclosure from any direction shall have no harmful effect.	8.4
5	Protected against water jets	Water projected by a nozzle against the enclosure from any direction shall have no harmful effect.	8.5
6	Protected against heavy seas	Water from heavy seas or water projected in powerful jets shall not enter the enclosure in harmful quantities.	8.6
7	Protected against the effects of temporary submersion in water	Ingress of water in a harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time.	8.7
8	Protected against the effects of continuous submersion in water	The equipment is suitable for continuous submersion in water under conditions which shall be specified by the manufacturer. **Note:** Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment it can mean that water can enter but only in such a manner that it produces no harmful effects.	8.8

❶ The short description given in column 2 of this table should not be used to specify the form of protection. It should only be used as a brief description.

Electrical Performance

In addition to ingress ratings, push buttons are subject to electrical performance standards. Both IEC and NEMA rated devices must successfully pass tests as described in IEC 60947-5-1 and NEMA ICS 5, Part I. Both standards have significant overlap of performance criteria. For example, each specifies continuous current, voltage, and contact make and break energy.

Since there is considerable overlap of IEC and NEMA contact ratings, many push button manufacturers will dual-rate a device by both IEC and NEMA electrical standards for AC and DC operation.

IEC Electrical Ratings

IEC 60947-5-1 defines rated operational current, voltage, and power factors for make and break conditions. Values are given for both AC and DC contacts under normal and abnormal conditions.

NEMA Electrical Ratings

NEMA ICS 5, Part I classifies the electrical performance of contacts based upon the results of continuous test thermal current capacity, maximum current, and make and break volt-ampere ratings.

The AC and DC contact rating designations are given in Tables D….F

NEMA ratings establish maximum contact performance. A contact manufacturer should be consulted for minimum energy level performance, since neither IEC nor NEMA standards consider this potentially important variable.

Table D. Examples of Contact Rating Designation Based on Utilization Categories (from IEC 60947-5-1. Used with permission.)

Designation ❶ AC	Utilization Category	Conventional Thermal Current I_{the} (A)	Rated Operational Current I_e (A) at Rated Operational Voltages U_e 120V	240V	380V	480V	500V	600V	VA Rating Make	Break
A150	AC-15	10.0	6.0	—	—	—	—	—	7200	720
A300	AC-15	10.0	6.0	3.0	—	—	—	—	7200	720
A600	AC-15	10.0	6.0	3.0	1.9	1.5	1.4	1.2	7200	720
B150	AC-15	5.0	3.0	—	—	—	—	—	3600	360
B300	AC-15	5.0	3.0	1.5	—	—	—	—	3600	360
B600	AC-15	5.0	3.0	1.5	0.95	0.75	0.72	0.6	3600	360
C150	AC-15	2.5	1.5	—	—	—	—	—	1800	180
C300	AC-15	2.5	1.5	0.75	—	—	—	—	1800	180
C600	AC-15	2.5	1.5	0.75	0.47	0.375	0.35	0.3	1800	180
D150	AC-14	1.0	0.6	—	—	—	—	—	432	72
D300	AC-14	1.0	0.6	0.3	—	—	—	—	432	72
E150	AC-14	0.5	0.3	—	—	—	—	—	216	36

Designation ❶ DC	Utilization Category	Conventional Thermal Current I_{the} (A)	Rated Operational Current I_e (A) at Rated Operational Voltages U_e 125V	250V	440V	500V	600V	VA Rating Make	Break
N150	DC-13	10.0	2.2	—	—	—	—	275	275
N300	DC-13	10.0	2.2	1.1	—	—	—	275	275
N600	DC-13	10.0	2.2	1.1	0.63	0.55	0.4	275	275
P150	DC-13	5.0	1.1	—	—	—	—	138	138
P300	DC-13	5.0	1.1	0.55	—	—	—	138	138
P600	DC-13	5.0	1.1	0.55	0.31	0.27	0.2	138	138
Q150	DC-13	2.5	0.55	—	—	—	—	69	69
Q300	DC-13	2.5	0.55	0.27	—	—	—	69	69
Q600	DC-13	2.5	0.55	0.27	0.15	0.13	0.1	69	69
R150	DC-13	1.0	0.22	—	—	—	—	28	28
R300	DC-13	1.0	0.22	0.1	—	—	—	28	28

❶ The letter stands for the conventional thermal current, and identifies AC or DC For example, B is 5 A AC. The numbers following the letter are the rated insulated voltage.

Table E. Ratings and Test Values for AC Control Circuit Contacts at 50 or 60 Hz (from NEMA Standard ICS 5-2000, Part 1, a copyrighted publication of the National Electrical Manufacturers Association)

NEMA Contact Rating Designation	Thermal Continuous Test Current (Amps)	Maximum Current (Amps)								Voltamperes	
		120V		240V		480V		600V			
		Make	Break	Make	Break	Make	Break	Make	Break	Make	Break
A150	10	60	6.0	—	—	—	—	—	—	7200	720
A300	10	60	6.0	30	3.00	—	—	—	—	7200	720
A600	10	60	6.0	30	3.00	15	1.50	12	1.20	7200	720
B150	5	30	3.0	—	—	—	—	—	—	3600	360
B300	5	30	3.0	15	1.50	—	—	—	—	3600	360
B600	5	30	3.0	15	1.50	7.50	0.75	6	0.60	3600	360
C150	2.50	15	1.5	—	—	—	—	—	—	1800	180
C300	2.50	15	1.5	7.50	0.75	—	—	—	—	1800	180
C600	2.50	15	1.5	7.50	0.75	3.75	0.375	3	0.30	1800	180
D150	1.00	3.60	0.60	—	—	—	—	—	—	432	72
D300	1.00	3.60	0.60	1.80	0.30	—	—	—	—	432	72
E150	0.50	1.80	0.30	—	—	—	—	—	—	216	36

Table F. Ratings and Test Values for DC Control Circuit Contacts (from NEMA Standard ICS 5-2000, Part 1, a copyrighted publication of the National Electrical Manufacturers Association)

NEMA Contact Rating Designation	Thermal Continuous Test Current (Amps)	Maximum Make or Break Current (Amps)			Make or Break at 300V or Less Voltamperes
		125V	250V	301…600V	
N150	10	2.20	—	—	275
N300	10	2.20	1.10	—	275
N600	10	2.20	1.10	0.40	275
P150	5	1.10	—	—	138
P300	5	1.10	0.55	—	138
P600	5	1.10	0.55	0.20	138
Q150	2.50	0.55	—	—	69
Q300	2.50	0.55	0.27	—	69
Q600	2.50	0.55	0.27	0.10	69
R150	1	0.22	—	—	28
R300	1	0.22	0.11	—	28

Panel Hole Size

Industrial push buttons have three standard panel opening sizes: 16 mm, 22.5 mm, and 30.5 mm. The 16 and 22.5 mm conventions originated in Europe, and the 30.5 mm size gained popularity in North America. Today, all sizes enjoy global acceptance. Hole size is specified by IEC standards, but not by NEMA standards.

The advantage of a 16 or 22.5 mm operator is its compact size. A panel space savings often results from a small operator's reduced spacing requirements. A continuing trend to downsize available panel area has led to increased use of 16 and 22.5 mm operators instead of 30.5 mm units.

On the other hand, 30.5 mm operators offer a larger package for enclosing additional internal components. A common perception is that a larger 30.5 mm push button is more robust than a 22.5 mm one. The greater percentage of metallic components common in larger push buttons often supports this view. However, robustness is not solely indicated by hole size, and there is an overlap in the robustness of 22.5 and 30.5 mm devices.

Figure 1.

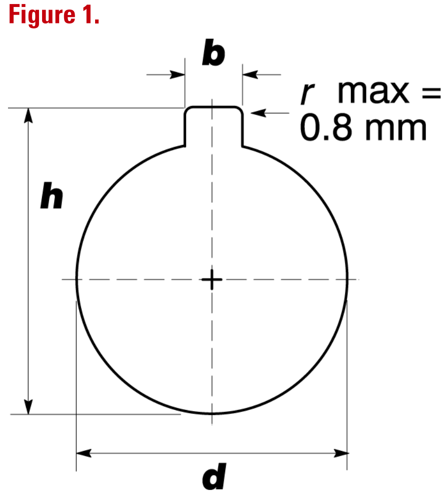


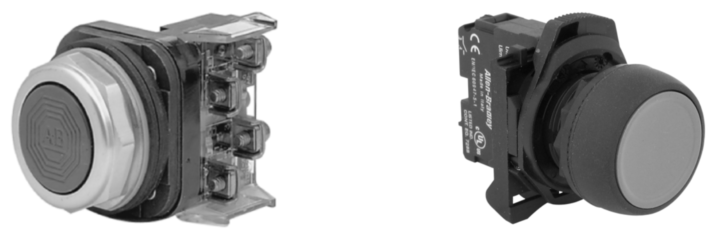
Table G. Mounting Hole Diameter and Dimensions of the Key Recess (if any) (from IEC 60947-5-1. Used with permission.)

Size	Mounting Hole ∅ d (mm)	Key Recess (if any)	
		Height h (mm)	Width b (mm)
D30	30.5 +0.5/0	33.0 +0.5/0	4.8 +0.2/0
D22	22.3 +0.4/0	24.1 +0.4/0	3.2 +0.2/0
D16	16.2 +0.2/0	17.9 +0.2/0	1.7 +0.2/0
D12	12.1 +0.2/0	13.8 +0.2/0	1.7 +0.2/0

Operator Styling

There are no specific IEC or NEMA standards governing operator styling. As a result, many of the characteristic features of a push button reflect nothing more than a manufacturer's or customer's preferences. Examples of a variety of styles appear in Figure 2.

Figure 2.



NEMA Style **IEC Style**

A wide range of operator styles are available in both IEC and NEMA push buttons. Typical styling criteria include construction, assembly and packaging, panel sealing, and connection terminals.

Construction

In the past, many operator manufacturers in the United States touted a design containing a high proportion of metallic components. Die case construction was often preferred for heavy industrial applications. A robust design was specified by many users despite the resulting higher cost.

European designs often used a higher proportion of plastic components and less robust construction, since application demands did not warrant exceeding typical requirements.

Today, many manufacturers offer a range of push buttons with both metallic and non-metallic components. This variety ensures that customers can order a push button that meets their needs, whether for heavy or light industrial applications.

Assembly and Packaging

IEC- and NEMA-style operators have historically differed in how they are assembled and packaged.

A NEMA-style push button typically has a button cap that is smaller than the panel opening. Installation of a NEMA-style device involves removing a mounting ring, inserting the operator and sealing gaskets from inside a panel, tightening the mounting ring from the front, and connecting field wiring.

As an option, some manufacturers offer operators, lamps, lens and button caps, power modules, and contact blocks in separate packaging for installation in the field.

An IEC-style push button typically features a button cap that is larger than the panel mounting opening in which it is installed. During installation, the operator is inserted from the front of the panel, and secured from inside the panel. Contact blocks and power modules are then attached to the operator inside the panel. Since factory assembly would require a user to disassemble the device before installation and wire connection, IEC-style push buttons are rarely sold as complete assembled units.

Panel Sealing

As mentioned above, IEC-style operators are inserted through the front of the panel and secured from the rear. Typically, IEC-style ingress sealing gaskets are found on the front of the panel. Accessories, such as legend plates or locking attachments often require additional gasketing to maintain a watertight seal.

By contrast, NEMA-style push buttons have panel seals located inside the panel. If properly installed, addition of a legend plate or locking accessory does not compromise the panel seals.

Connection Termination

Both IEC- and NEMA-style push buttons offer a wide range of wire termination options. Many push buttons use screw-type connectors with pressure plates, barrel terminals, or stab-on connectors to make electrical connection to contact or lamp terminals. Spring-clamp technology is gaining acceptance as an alternative to standard screw-type styles.

Figure 3.

Many connection styles are available in both IEC and NEMA push buttons. Shown above are pressure plates (left) and barrel terminals (right).

Screw terminals on many European-manufactured devices accept a 3 mm (0.118 in.) slotted head screwdriver blade. Typical North American devices accept a 6.4 mm (0.25 in.) slotted head screwdriver blade. Market requirements have pressed manufacturers to provide screw terminations accepting combinations of slotted, Phillips, and Posi-Drive screwdrivers.

Finger Safety

An IEC IP2X enclosure rating category exists to define back-of-hand-safe and finger-safe terminations. IEC 60529 defines requirements for wiring terminals that protect against direct contact of exposed flesh with high control voltages and moving parts. Proper stripping and connection of wires to shrouded terminals permits compliance with IP2X standards.

NEMA electrical and ingress standards do not cover finger and back-of-hand safety. As a result, NEMA-compliant devices often have open terminations for maximum access and visibility. However, for products destined for markets governed by IEC standards, some NEMA-style devices include IP2X features, or will accept finger-safe accessories that can be installed in the field.

Conclusion

This paper has discussed differences between industrial push buttons relating to electrical standards and ingress protection ratings relating to NEMA and IEC standards. Additional discussion was given to hole size and styling conventions typically found with European and North American-designed and -manufactured operators. The paper suggests that market demand will dictate the features offered with push buttons. Finally, it indicates that no operator can be considered a definitive example of a pure IEC or NEMA type.

When selecting an industrial push button, the specifier must make an informed product selection based on the trade-offs associated with the available choice of devices. This decision should not be made solely on the basis of initial cost, but also with due consideration to specific application requirements. To aid the decision process, a push button specifier should consult a vendor who offers a broad line and complete understanding of various performance standards and styling criteria.

Notes

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