

PUSHBUTTONS AND STACKLIGHTS 101

BASIC TRAINING FROM EATON



New Information
May 2007

101 Basic Training



Pushbuttons

What You Will Learn

Listed under “Contents” are the topics we’ll step through. After completing the manual, you will: understand the mechanical operation of a pushbutton, be familiar with the domestic and international standards that apply to pushbuttons, and be able to match the different types of pushbuttons with the applications for which they are best suited.

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PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING

Pushbuttons and stacklights are devices to help someone **change how a machine works, or understand its current state.**

The term “pushbutton” is used to refer to two different things. The first is a **specific type of button assembly** that you actually push on a panel. The second is the **general group of components, or mechanical man/machine interface products**, which includes: *Indicating Lights*, *Selector Switches*, *Potentiometers* — and pushbuttons — by which people interact with machines.



This training presents small, manageable sections of new material followed by a series of questions about that material. Study the material carefully, then answer the questions without referring back to what you’ve just read. You are the best judge of how well you grasp the material. Review the material as often as you think necessary. The most important thing is establishing a solid foundation to build on.

Introduction

These days, one machine often performs multiple functions. Humans control the machine, initiating changes based on work assignments or advancing the machine to the next step of the process. This is where pushbuttons come in. **Through pushbuttons, workers can interact with the machine’s operation.**

What Is a Pushbutton?

Let’s look at examples of what people typically mean when they say “pushbutton.” The part that you can see or adjust on the front of the panel is called the **operator**. Here are four common operators:



Selector Switch



Pushbutton



Key Selector Switch



Indicating Light

PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

At the back of the panel, you'll find **contact blocks** and **light units**. As the operator is activated, the contact block "makes" the electrical circuit, and the machine starts, stops or runs in the manner that the worker has selected. If the pushbutton is an indicating light, the lamp lights to signal what stage the machine is in.



Contact Block



Light Unit

When you select a pushbutton from the wide variety available, you make **choices that help accomplish specific goals**, such as:

- Keeping machines off when power has been restored after a power outage. This allows a worker to manually — and safely — turn the machines back on when the time is right.
- Providing the longest lasting indicating lights for important indications and to save labor replacement expenses

Remember that indicating lights are part of the pushbutton family. Setting a selector switch, or pushing a button, is what workers do to tell the machine how to operate. Indicating lights tell the worker what the machine is doing (or failing to do).

You can think of pushbuttons and selector switches as being the light switch in your kitchen; they are where you make the decision to turn the light on. Indicating lights are simply the light that turns on. When the light is connected to a machine process, and the light is on, the machine is telling you that it's working.

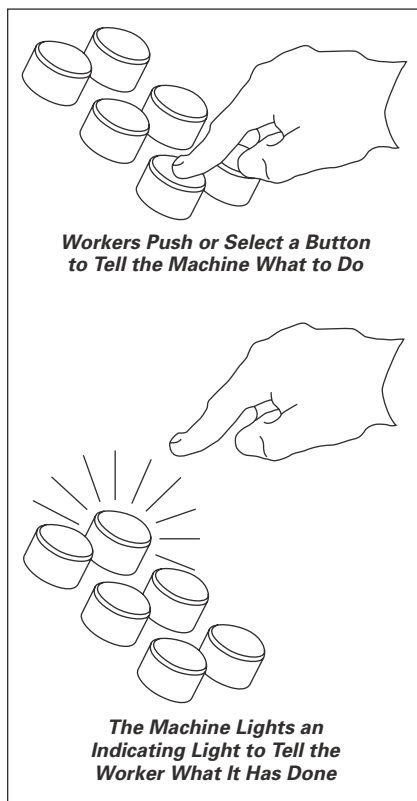


Figure 1. Pushbuttons Are How Workers Interact with Machines

What Is a Stacklight?

Stacklights are a special form of indicating light. They are not lights mounted on the face of a panel for a single operator. Instead, stacklights are a mini-tower of independent lights usually mounted on top of a machine.

Because stacklights are towers, they can be seen from all directions (360°). This way, workers from every angle can see the machine's status.

Workers know what the machine is doing by checking **either the position or the color** of the lights that are lit.

Stacklights can also provide an audio alarm and/or a strobe light signal.



Stacklight



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Pushbutton Basics

Pushbuttons are used in applications that require people to start, stop or change a machine as well as wherever workers need to keep track of what stage the machine is in.

In the Workplace

Pushbuttons on this carnival ride send the cars forwards or backwards. Turning a potentiometer makes them run faster. Want to get on? One mode of the selector switch “jogs” the cars up to the loading platform.



Carnival Ride Application

After you and your partner slide in, another mode hurtles the cars forward.

Where Are Pushbuttons Used?

Here are a few other common uses of pushbuttons:

- Assembly lines — From bottling plants to automobiles, pushbuttons set machines for varying operations to help workers make inspections, add parts, correct tools and route equipment. Modern production would be difficult without pushbuttons.
- Stand-alone machines — Every industrial machine, an air compressor, a drill, a saw or a molding clamp, is controlled by a pushbutton.
- Car washes — Did you want a little hot wax and an underflush with your car wash? The operator who hosed off your wheel rims hits the pushbutton that automates the rest of your passage. At every stage, indicating lights tell you what’s going on.
- Airline passenger bridges — Look for the pushbutton station the next time you board an airplane. Operators use pushbuttons to extend passenger bridges up to the aircraft, rotate into exact position, then lock on to the plane’s hatchway.

Market Growth

The last few years have seen dramatic growth in the pushbutton market. Much of that growth has been caused by **more automation** and **more complicated equipment**. Production automation is no longer a static process. Instead, the human operator now runs the show. For example, where previously a worker may have done no more than stop or start a machine, that person is now making decisions on the entire process to improve quality, increase productivity, or run tests. Indicating lights provide the information needed to make such decisions, and then the operator makes changes to the process by using selector switches and other pushbuttons.



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Review 1

Answer the following questions without referring to the material just presented. Begin the next section when you are confident that you understand what you've just read.

1. How does the general meaning of a pushbutton differ from a specific pushbutton?

2. "Pushbuttons" may be input and output devices.
TRUE FALSE

3. Name three common kinds of operators.

- a) _____
- b) _____
- c) _____

4. List two applications for pushbuttons, including one not mentioned in this module. (Over the next couple of days, note how many times you see applications for pushbuttons.)

- a) _____
- b) _____

5. The recent growth in the pushbutton market is due to more _____ and more _____.

6. Where are stacklights usually mounted and why are they mounted there?

Answers to review are on page Z-68.



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Pushbutton and Selector Switch Mechanics

Pushbuttons

Now let's take a look inside a pushbutton and a selector switch to see how their mechanics work. We'll begin by looking at pushbutton mechanics.

Remember, pushbuttons consist of operators and contact blocks. The illustrations in **Figure 2** show how your "finger push" is converted into a circuit connection (or disconnection).

The part you see, and which your finger operates, is called the **operator**. Inside, there is a companion part that translates the finger movement into the **movement of a plate or bar**. The plate pushes the **plungers** down in the **contact block** and a set of contacts actually moves, opening and closing the electrical circuits.

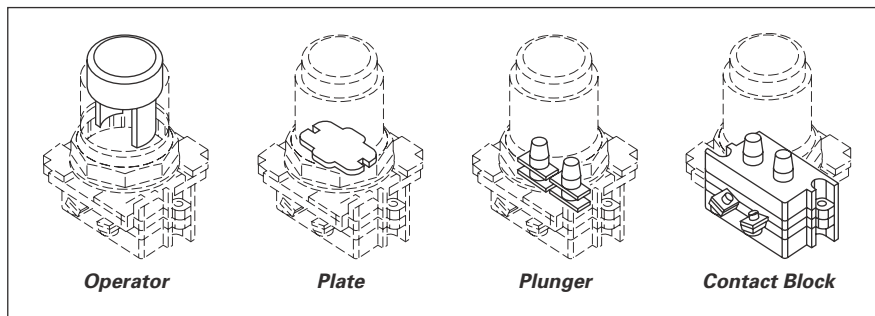


Figure 2. From Finger Push to Circuit (Dis)Connection

Selector Switches

Selector switches all work on the same general principle: they contain a simple selector switch on the front of the panel, and a broad range of potential contact combinations (via the contact blocks) on the inside of the enclosure. The major difference between the selector switch and the pushbutton is that, while a pushbutton has a plate that pushes down both

contact plungers at the same time, a selector switch has a **rotating Cam** with **ridges** and **flats** on it, allowing you to actuate the plungers independently. See **Figure 3**.

Selector switches are available in 2-, 3- or 4-position versions, and are often **used when more than one control option is needed**.

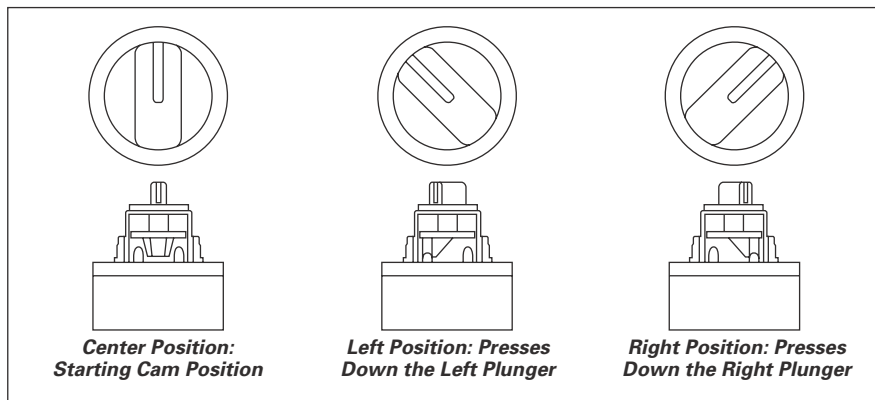


Figure 3. Selector Switch and Cam Positions

How Cams Work

Selector switches use **cams in combination with contact blocks** to provide a wide range of circuit openings and/or closings. In the following cam results, we'll use "X" to designate a closed circuit (energized or "on") for a particular selector switch position, and "O" to designate an open circuit (not energized or "off").

In **Figures 4, 5, and 6**, a three-position selector switch is used to open or close two circuits, "hand" and "auto," for a pump application. Here is how the control works (keep in mind that the positions reflect a left, center and right position of the selector switch).

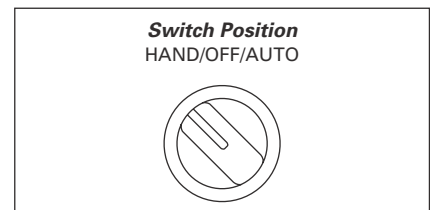


Figure 4. Switch on HAND

Cam Results

HAND	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
AUTO	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Control Results

Hand Circuit = Closed
Auto Circuit = Open

Control Effect

When the switch is on "hand," the pump has energy available to it. The person running the pump can turn it on or off by a separate, manual control.

Because control is now based on the worker's decision, it is referred to as "hand" (manual) control.

PUSHBUTTONS AND STACKLIGHTS 101

BASIC TRAINING, CONT.

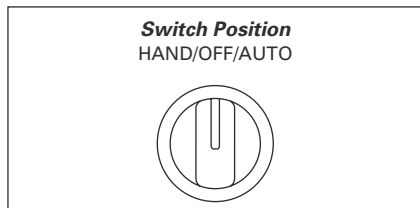


Figure 5. Switch on OFF

Cam Results

HAND X O
 AUTO O X

Control Results

Hand Circuit = Open
 Auto Circuit = Open

Control Effect

When the switch is on “off,” the pump has no power and cannot run, even if the worker attempted to operate it from the manual control.

Note that both circuits are open or disconnected.

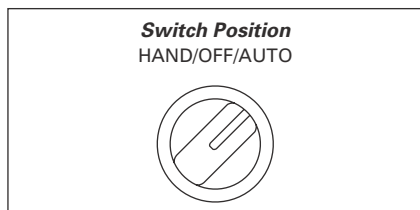


Figure 6. Switch on AUTO

Cam Results

HAND X
 AUTO O X

Control Results

Hand Circuit = Open
 Auto Circuit = Closed

Control Effect

When the switch is on “auto,” the pump has energy available to it, and will activate under control of an automatic device. For example, a level gauge can rise and trigger the pump to turn on. Because this is independent of human decision, it is referred to as “auto” (for automatic).

Momentary and Maintained

When you activate a pushbutton, you should know how long the effect of your change will last. Pressing or setting a pushbutton results in either a **momentary** or **maintained** condition.

Pressing a door bell is a typical example of a *Momentary* pushbutton. When you release the door bell, the button returns to the position it was in before you used it and the bell tone stops.

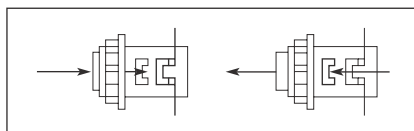


Figure 7. Example of Momentary Pushbutton

A *Maintained* pushbutton keeps its new position. The light switch on a wall is a common maintained connection. Once you switch it to “on” or “off,” it stays that way until you switch it back.

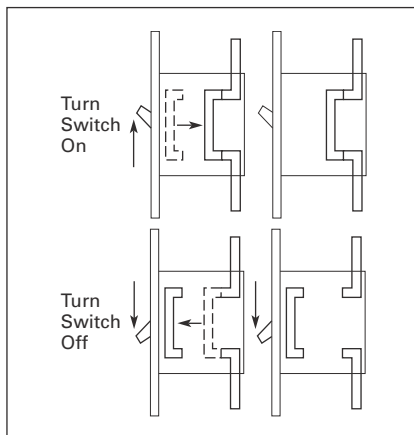


Figure 8. Example of Maintained Pushbutton

Momentary

Often, momentary buttons are wired to a relay, or auxiliary contact, that **holds the electrical loop even after the momentary button is released.** The result is that the machine continues to run, even though the START button has returned to its original “off” position.

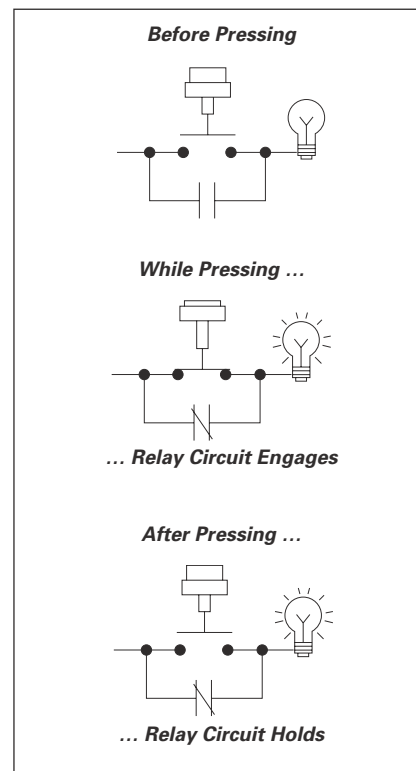


Figure 9. Operation of a Momentary Pushbutton

The pushbutton returns to its original setting when the finger is withdrawn.

Momentary pushbuttons often bear the current for only an instant before a second circuit — a relay circuit — “takes over.”



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

It seems confusing to have a momentary button that produces a result as if the button were maintained. Why is this? Safety. Check out this real life example.

In the Workplace

This electric saw has a START pushbutton that is momentary. When the button is pushed, another circuit holds the electrical loop, which is why the saw keeps running when the button is released.



Electric Saw Application

The START button is momentary in case there is a power outage. If the power is lost, the additional circuit opens. When power returns, the worker will have to press the START button again to start the saw because the button has already returned to its original off position. If the START button were maintained, the instant power would "jump start" the saw, and possibly hurt somebody.

Maintained

Maintained buttons are easy to understand because they simply continue in the position they were set at.

But, if momentary buttons can produce a result similar to maintained buttons, why bother using maintained pushbuttons? The reason, again, is safety. Sometimes you want to "freeze" an assembly line, or a saw while you work on it. A maintained setting overrides any default settings that might automatically turn it on.

Note: Most pushbuttons are used on applications that call for momentary contact. However, when an application demands maintained contact, selector switches are likely to be the product of choice.

Front of Panel

Now let's look at how pushbuttons and indicating lights appear when they are mounted on what is called the **Front of Panel**. It is here that the machine meets the worker who uses it.

Two Standard Sizes

Pushbuttons come in two sizes: **30 mm** and **22 mm**. These sizes refer to the size of hole that is cut to mount the device. The **actual hole sizes** are: **30.5 mm** and **22.5 mm**.

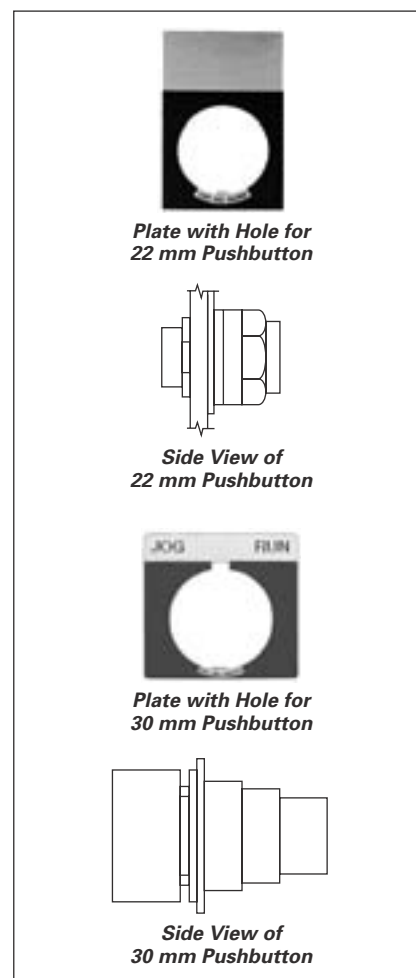


Figure 10. Pushbutton Sizes

PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Most 30 mm and 22 mm pushbuttons are electrically and mechanically similar.

■ **30 mm pushbuttons make up the largest segment of the North American market.** They are often chosen for heavy-duty use because they are usually made of metal and have a large mounting nut.

- Generally offer a wider range of operator and contact block types to satisfy a broad range of applications
- Preferred by most North American “users”

■ **22 mm pushbuttons are sized to meet the largest market segment for the rest of the world.** Because they are often made of plastic, they usually cost less than 30 mm pushbuttons. Some other advantages to 22 mm pushbuttons include:

- Save panel space, allowing smaller panels and increased wire space
- Internationally accepted, if OEMs export machines

Even though they mount in a 22.5 mm hole, **the button surface for 22 mm devices is similar in size to that for 30 mm devices.** Both pushbutton sizes are designed to be easily operated, even while wearing gloves.

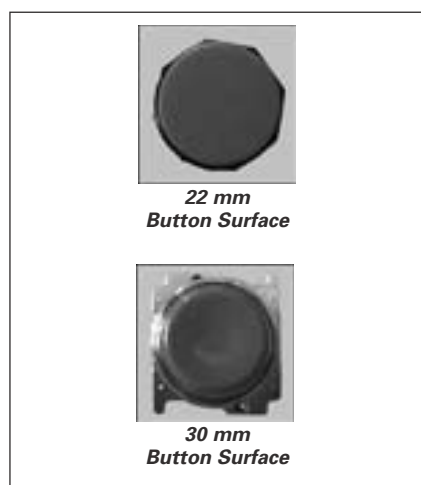


Figure 11. Button Surfaces

Codes and Ratings

The governing standards and approvals for industrial control include ANSI, CSA, *IEC*, CE, IEEE, *NEMA* and *UL*.

These standards are rules that determine what kinds of equipment can be used, how it should be installed, and how it should perform in specific types of applications.

In addition to electrical ratings, pushbutton products are tested and rated for specific environmental conditions. These “environmental ratings” or “ingress protection ratings” are

defined by either IEC (*IP* Ratings) or UL/*NEMA* (Type Ratings) and identify how well the pushbutton:

- Prevents liquid from leaking into the panel
- Operates in dusty or icing conditions
- Holds up in a corrosive environment

Because a pushbutton basically fills a hole in an enclosure, **it must be suitably rated for the environmental conditions expected in the application.** Some important standards include:

Table 1. Environmental Standards

Provides a degree of protection against:	IP20/ NEMA Type 1	IP65/ NEMA Type 4	NEMA Type 4X	IP65/ NEMA Type 13
Falling Dirt	√	√	√	√
Dust, lint, fibers	—	√	√	√
Hosedown and splashing water	—	√	√	—
Oil or coolant spray	—	—	—	√
Corrosive agents	—	—	√	—

Which standards apply is dependent on where the product is specified and/or where the equipment will be ultimately installed. Generally speaking, the IEC electrical and environmental standards are applied throughout Europe, and the UL and *NEMA* standards are applied throughout North America. Other regions in the world apply IEC standards, *NEMA* standards or both.

Note: For more information on *NEMA* and IEC standards, see “*NEMA* Standards” and “IEC (*IP*) Ratings” on **Page 21** of this manual. The next review section contains a question about information contained in these tables; you should therefore study them before continuing.



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Pushbutton Styles and Uses

Now that you understand what you are looking at on the front of the panel, study the information on the following pages to learn more about specific styles and uses for different pushbuttons. **The reason for so many styles is that each one provides an answer to a field problem**, usually regarding greater security (a stray finger or falling part shouldn't activate a process) or greater access ("Stop" means right now!).

Some styles, such as a potentiometer, are not so much a "style" as a special function. In the potentiometer's case, the function is varying the amount of voltage sent to the machine.

As you review the next few pages, stop and think of what kind of problems in the field created the need for the style you are looking at. The main idea is to select the proper pushbutton for the application.



Pushbutton Style — Selector Switches

Application

Selector switches are also used when more than one control option is needed (e.g., HAND/OFF/AUTO). Selector switches are usually the preferred pushbutton when a maintained contact is needed.



Pushbutton Style — Push-Pull Operators

Application

This operator must be physically pushed in or pulled out to change its status.

Two-position maintained contacts for START/STOP or UP/DOWN. Three-position maintained or momentary for START/STOP/RUN or HAND/OFF/AUTO functions.



Pushbutton Style — Extended

Application

An exposed button raised further off the panel than other buttons. Often used for a machine's most important function, such as "Stop."



Pushbutton Style — Guarded

Application

These take prevention of unwanted operation one step further than flush pushbuttons by having a metal guard around the actuator portion of the button.



Pushbutton Style — Twist-to-Release

Application

These are maintained contact pushbuttons that you push in and then twist to release. The Twist-to-Release is often used for "Stop" or "Emergency Stop." The extra effort needed to restart a machine forces a more active decision on the part of the worker.



Pushbutton Style — Flush

Application

The button is flush with its housing. Direct pressure must be applied to actuate flush pushbuttons; they are not easily bumped into changing state. Often used as a START button.



Pushbutton Style — Mushroom and Jumbo Mushroom

Application

Most often used for Stop and Emergency Stop pushbuttons. Very easy to actuate because they make such a big target.



Pushbutton Style — Key Release

Application

These are maintained contact pushbuttons that you push in and need a key to release. Often used for safety reasons; for example, to lock off a machine during maintenance.

PUSHBUTTONS AND STACKLIGHTS 101

BASIC TRAINING, CONT.



Pushbutton Style — Illuminated Pushbutton Operator



Pushbutton Style — Illuminated Pushbutton Lens

Application

Saves space and money by combining the function of a pushbutton and an indicating light.

Even though the button contains both an operator and a light, these are actually separate items that have to be wired separately inside. For example, the pushbutton might connect to a starter, while the light is wired to a microchip that reads “the engine is running.”



Pushbutton Style — Roto-Push

Application

A combination of a selector switch and a pushbutton in one unit. The outer guard of the pushbutton rotates to two or more positions and provides different contact actions when the pushbutton is either free or pushed-in at each selector position.



Pushbutton Style — Potentiometer

Application

Often used for speed control because turning the dial varies the resistance (ohms).



Pushbutton Style — Joystick

Application

Mounts in a standard hole size, although space must be left on the panel for the lever action.

Because the joystick extends outwards and often corresponds to the direction of movement sought, it is easy and intuitive to use.



Pushbutton Style — Multifunction Square Operator

Application

Used when space is at a premium and more than one function is required.

Pushbutton Stations

When you combine pushbuttons in a common enclosure, it is referred to as a *Pushbutton Station*. Like pushbuttons themselves, pushbutton stations are manufactured in a variety of styles and may be customized to suit a broad array of applications.



Pushbutton Stations

Legend Plates

When you are the operator of a pushbutton station it may be hard to remember what each light, button or switch does. That’s where **legend plates** come in. These are small plates on the panel that identify a button.

Legend plates come in a variety of sizes and colors. Standard legend plates fit closely to the space around a pushbutton and allow lots of pushbuttons to fit onto a panel.

Extra large plates — often colored red and used for Stop functions — are prominent and allow more space for printing. However, they also take up more “real estate” on the panel.



Standard





PUSHBUTTONS AND STACKLIGHTS 101

BASIC TRAINING, CONT.

Review 2

Answer the following questions without referring to the material just presented. Begin the next section when you are confident that you understand what you've just read.

1. Pushbuttons are the operative force that either _____ or _____ an electrical circuit.
2. Name two parts of a pushbutton. _____
3. When you remove your finger from the button, a maintained pushbutton continues in the state that it has changed to.
TRUE FALSE
4. What circuit device allows a momentary pushbutton to sometimes provide the same effect as a maintained?

5. Match these NEMA and IP ratings with their definition:

- | | |
|------------------|--|
| (1) NEMA Type 13 | (A) Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, falling dirt and dripping non-corrosive liquids. |
| (2) NEMA Type 4X | (B) Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, spraying of water, oil and non-corrosive coolant. |
| (3) IP Rating 34 | (C) Dust-Protected. Protected against water jets |
| (4) IP Rating 55 | (D) Enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water and hose-directed water; undamaged by the formation of ice on the enclosure. |
| (5) NEMA Type 12 | (E) Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, spraying of water, oil and non-corrosive coolant.
(F) Protected against solid foreign objects with a diameter of 12.5 mm and greater. Protected against spraying water. |

6. List two styles of pushbuttons and their applications.

- a) _____
- b) _____

7. Potentiometers are most often used for what kind of application?

8. What is the major difference between the mechanics of a pushbutton and a selector switch?

9. In the diagram below, the circuit is closed in the right position. TRUE FALSE

HAND	OFF	AUTO
X	O	O

10. Are twist-to-release and key release pushbuttons momentary or maintained contact pushbuttons? _____

11. What is a disadvantage of using a large legend plate?

Answers to review are on page Z-68.

PUSHBUTTONS AND STACKLIGHTS 101

BASIC TRAINING, CONT.

Back of Panel

Now we'll look at the **Back of Panel**, where the pushbutton carries out its tasks. We'll look at how contact blocks, light units and selector switches work.

Normally Open and Normally Closed

When the pushbutton operator pushes the plate onto the contact block, the circuits connected to the block open or close based on how the circuit was designed. Circuits are set up as either **Normally Open (NO)** or **Normally Closed (NC)**.

Normally Open

Normally open (NO) means that contacts are "at rest" in the open (off) position, and current does not pass through. The contacts close only when the plunger goes down and forces them together.

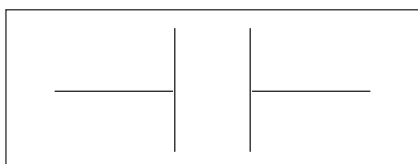


Figure 13. Normally Open Electrical Symbol

Normally Closed

In **normally closed (NC)** contact blocks, the contacts are "at rest" in the closed (on) position, allowing current to pass through. The contacts open only when the plunger goes down and separates them.

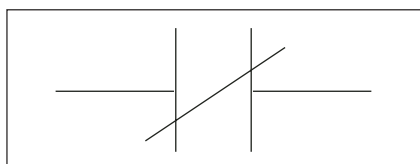


Figure 15. Normally Closed Electrical Symbol

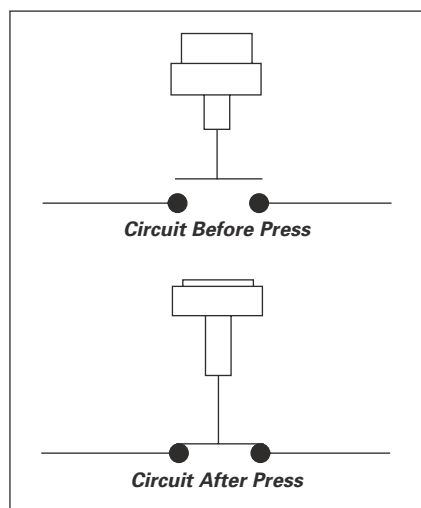


Figure 14. Normally Open Circuit

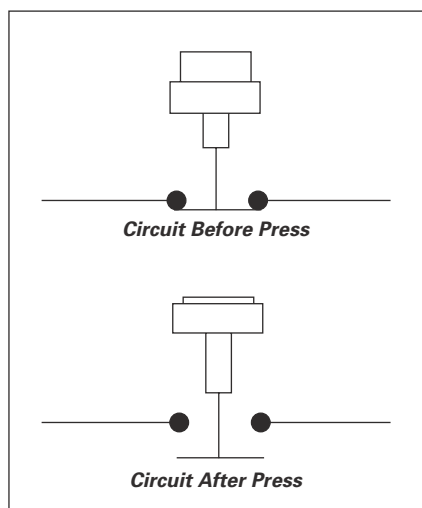


Figure 16. Normally Closed Circuit

Contact Block Configuration

The contact block can have a number of NO and/or NC configurations. **Single circuits** contain a contact block of either one normally open or one normally closed circuit. For applications that need only one contact, a single circuit is an efficient, inexpensive way of getting the job done. **Dual circuits**, as the name suggests, offer two contacts in a single contact block. The combinations of contacts can be:

- 1 normally open and 1 normally closed contact
- 2 normally open contacts
- 2 normally closed contacts
- Combinations with special delayed opening or early closing contacts

Dual circuit contact blocks save space in an enclosure, and **add twice the functionality to a button** because one button operates two circuits. For example, an emergency stop pushbutton connected to a dual circuit contact block with one NO and one NC contact can both shut off a motor and turn on an EMERGENCY STOP indicating light.

Multiple contact blocks can be added to increase the functionality. For example, you can mount 4 dual circuit blocks to a 30 mm pushbutton for a total of 8 circuits.



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Light Unit Styles and Uses

Light units are also found behind the panel. Their purpose is to hold the lamp and provide wiring terminals. Different conditions, such as how much the equipment is vibrating, or how long the lamp needs to stay on, provide reasons for selecting different styles of light units and bulbs.

This table explains the different types of light units, and the reasons to use them.



Light Unit Style — Transformer

Application

Drops the supply voltage to the lamp to 6V or 24V. Provides lamp with a long lamp life and filters for voltage spikes. Works only with AC.



Light Unit Style — Full Voltage

Application

Least expensive, but shorter lamp life than either transformer or resistor styles. Works with AC or DC.

The DC lamp operates at higher voltages.



Light Unit Style — Resistor

Application

Uses a resistor to drop the voltage to the lamp (it can also use a lower voltage lamp). Results in a longer lamp life than full voltage, but not as long as a transformer style. Less expensive than transformer styles. Works with AC or DC.



Light Unit Style — Neon

Application

Highly resistant to shock and vibration. Long lamp life, but not very bright. Recommended only with clear or amber lenses, and when the ambient light is not too intense.



*Light Unit Style — LED
(Light Emitting Diode)*

Application

Very long lamp life, and resistant to shock and vibration. Lamps emit color (blue, red, green, amber). Often not as bright as an incandescent lamp.

Pushbuttons Combined with Indicating Lights

To save space and money, **you can combine pushbuttons with indicating lights** so that if you push the button (or move the selector switch) a light inside the button turns on.

Here is an indicating light combined with pushbuttons.

1. When the START button is pushed, the motor starts.
2. The motor starting causes a **separate circuit** to close, turning on the MOTOR RUN pilot light.
3. The STOP button turns the motor off, causing the MOTOR RUN light to turn off.



Indicating Light with Pushbuttons

Illuminated Pushbuttons

An **illuminated pushbutton** combines a pushbutton and pilot light into one device. When the button is "on," the light inside will be lit. Again, even though the button contains both an operator and a light, these are actually separate items that have to be wired separately inside.



An Extended, Illuminated Pushbutton

PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Accessories

A host of accessories can modify pushbuttons at the worksite. Legend plates are often called an accessory. Here are some others that are available, and the reasons they would be used.



Accessory — Protective Boots

Application

A rubber boot fits over the pushbutton operator to further protect it against moisture, especially if the application is subject to ice buildup.



Accessory — Padlockable Covers

Application

Extra security that requires an authorized person to open the lock with a key. Remember the sawmill example we talked about earlier? Only the operator should hold the key.



Accessory — Locating Rings

Application

A notched ring to prevent selector switches from rotating out of position.



Accessory — Shrouds

Application

An extension surrounding the button to prevent accidental operation.

Design and Installation Issues

Right now, it's not necessary for you to know every engineering decision that must be made when selecting or installing a pushbutton. However, it's a good idea to know the most common issues when having to spec out or install a pushbutton station.

Minimum Spacing

Having to drill a hole, install legend plates, and leave your fingers room to maneuver calls for a certain amount of additional space around a pushbutton. The spec sheet for each product lists this necessary working space as **minimum spacing**. The vertical and horizontal dimensions are referred to as the **mounting matrix**. For example, some operators are larger than the 30 mm mounting hole, extending 40 or 50 mm in diameter. Legend plates and padlockable covers require up to 70 mm to install.

Enclosure

Complicated machines can require a lot of pushbuttons. Different enclosure sizes are needed to hold them all, with additional room left over for cables, conduits and wire harnesses.

When selecting enclosures, you also have to understand **rear of panel extensions**. Though pushbuttons have standard mounting holes, they extend to varying depths in an enclosure. Make sure the enclosure is deep enough to hold them. Although a single circuit contact block might only need 51 mm (roughly 2 inches), make that a double circuit contact block — and add a transformer light unit — and suddenly you're up to 115 mm (roughly 4.5 inches) deep. That's more than twice what you started with.

Pushbuttons must comply with the same environmental or ingress protection ratings as enclosures: UL, NEMA, IEC (IP). The code issues involve protection against water, oil, dust and vibration.

Light Units

Light units are affected by two considerations: one simple and one not so simple. The first design issue is whether the unit works in **alternating current** (AC) or **direct current** (DC) — or both. That's easy. Check the circuit and choose accordingly. The second issue, **lamp life and usage**, needs more careful thought. For lights that will not often be lit, a shorter lamp life will be acceptable (and will cost less). For a critical application, however, the expense for a long-life bulb may be worth the security and piece of mind it brings.

Let's think through one example: You want to mount an ON indicating light to a machine that will require thousands of hours of ON time and make the light susceptible to vibration. An LED light unit is resistant to shock and has a long lamp life; however, it's more expensive. As an engineer, you still might choose the LED light unit to save installation and replacement bulb costs.



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Review 3

Answer the following questions without referring to the material just presented. Begin the next section when you are confident that you understand what you've just read.

1. Does the contact in a normally closed contact block open or close when the pushbutton is pressed?
2. Which of the following is not an accurate dual circuit contact block configuration?
2 normally closed contacts
1 normally closed contact
Combinations with special delayed opening or early closing contacts
3. What is one advantage and one disadvantage of working with a transformer light unit?
Advantage: _____
Disadvantage: _____
4. What is the purpose of a shroud?
5. When combining a pushbutton and an indicating light, why does the wiring need to be connected separately?
6. What two factors should you consider when choosing light units?
 - a) _____
 - b) _____

Answers to review are on page Z-68.

PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Stacklights

People respond to sight faster — and from further distances — than any other sense. That’s the idea behind stacklights. These mini-towers of colored lights rise above equipment so they can be seen from all directions (360°) and from across a crowded factory floor.

Think of a stacklight as a multiple-level indicating light.

Lens casings can be in several colors, so **machine functions can be tied to a specific color** (i.e., blue = “parts are low”), or **by the position of the light** (i.e., third light = “line has stopped”).



Stacklight

For an **even quicker response**, swap out a standard light with either a xenon strobe light or an audio alarm.

Where Stacklights Are Used

Stacklights are used when you want lots of people in the plant, on the assembly line, or around the machine to know and respond to important condition changes. Let’s follow the story of this milling factory, and how they use stacklights.

In the Workplace

Tom operates six stations at a milling factory, watching over the parts supply and keeping the clamps and cutters free from jams. He used to operate two stations, but stacklights have allowed him to effectively watch an additional four. Tom knows what each station is doing by keeping watch on the stacklights above each machine. Here is the key to the lights:

- All OK (all lights off)
- Low on parts (green)
- Out of parts (yellow)
- Parts jam, machine stopped (red)
- Start/Alarm



Stacklight in Action

If Tom is clearing one machine, and another machine is low on parts, the fork lift driver can spot the #2 green stacklight and bring another bin over. The alarm connects to a START pushbutton to provide a 3-second delay, with alarm, before actually starting the machine. Together, the stacklights allow Tom to be more productive, inform the fork lift driver from all points on the factory floor, and provide an extra layer of safety for other staff members.



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Putting a Stacklight Together

The whole assembly of a stacklight is shown in **Figure 17**.

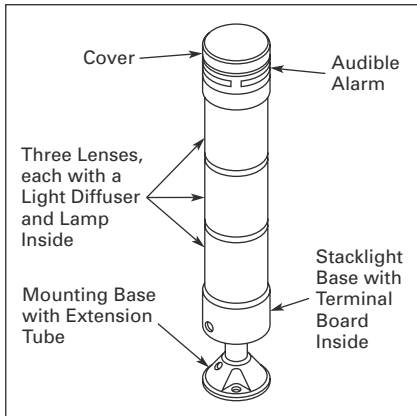


Figure 17. Stacklight with 3 Lights and Alarm

Now we'll show you the pieces individually, from the bottom up, even though stacklights are strong enough to be installed upside down or even sideways.

Mounting Base & Extension Tube

This optional mounting base raises the stacklight tower further away from the machine. It connects to the lights via an extension tube. O-rings and sealing washers keep out water and contaminants. This base can also be fitted with a vibration damper.

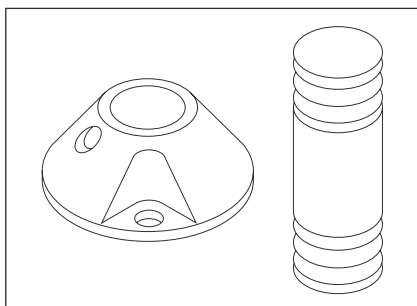


Figure 18. Mounting Base & Extension Tube

Stacklight Base

This holds the terminal board, and is the foundation of the stacklight tower.

You can mount the stacklight from this base or the mounting base.

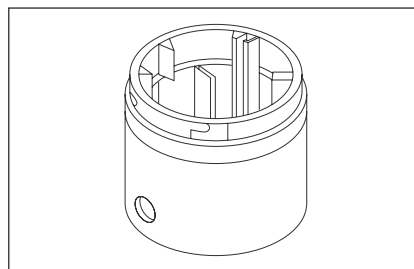


Figure 19. Stacklight Base

Terminal Board

Power and lamp wiring connections are made into screw terminals on this board. Either solid or stranded wires can be used. Connecting a "flashing wire" makes continuous lights flash instead.

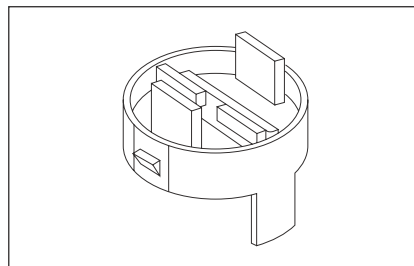


Figure 20. Terminal Board

Lamp

Either bright, readily available incandescent lamps, or long-lasting LEDs can be used. Stacklights can use both at the same time.

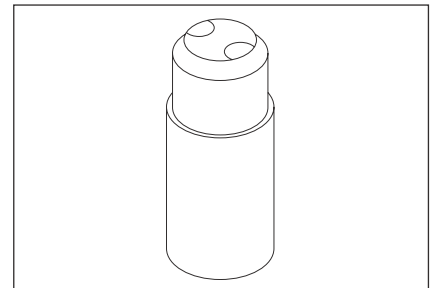


Figure 21. Lamp — Incandescent

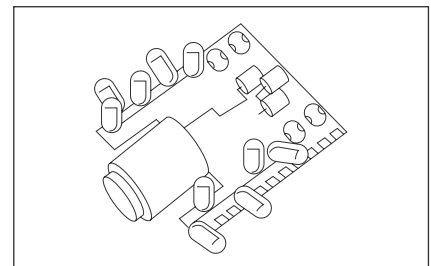


Figure 22. Lamp — LED

Light Diffuser

This insert distributes the light evenly across the lens and passes the circuit up and down the stacklight. Normally frosted, a clear diffuser can be used for LED lamps.

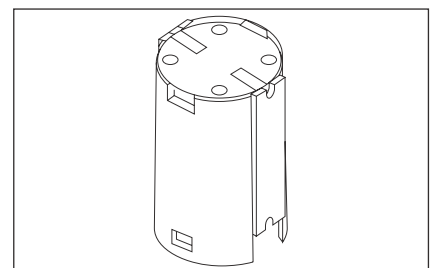


Figure 23. Light Diffuser

PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

Lens

The lens not only adds color to the light signal, it is also the “skin” of the stacklight. Made up of impact-resistant, non-corrosive plastic, these lenses protect the unit from harsh environments.

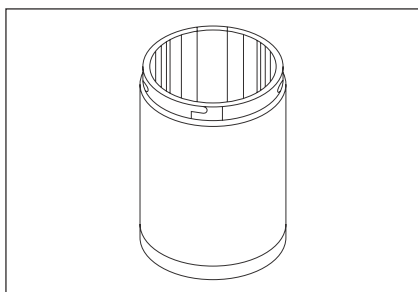


Figure 24. Lens

Cover by Itself

This secures the top of the stacklight. Using an o-ring ensures a leak-proof seal to meet difficult UL, CSA, NEMA and CE standards.

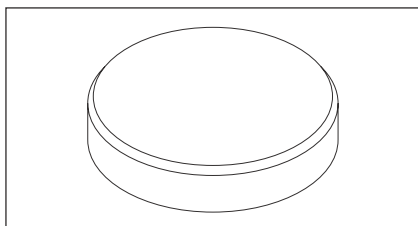


Figure 25. Cover by Itself

Alarm

The audible alarm provides an extra level of protection, sounding a piercing alarm.

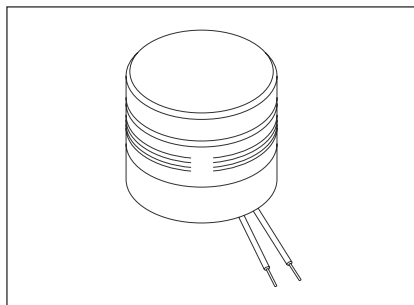


Figure 26. Alarm (Capped with a Cover)

Xenon Strobe Light

The Xenon strobe light also provides an extra level of protection, signaling an intermittent, intense flash.

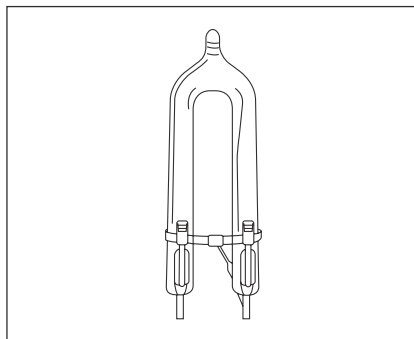


Figure 27. Xenon Strobe Light



PUSHBUTTONS AND STACKLIGHTS 101

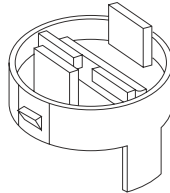
BASIC TRAINING, CONT.

Review 4

Answer the following questions without referring to the material just presented.

1. Why are lenses made in different colors?
2. Identify these stacklight components from their photos, and describe their purpose.

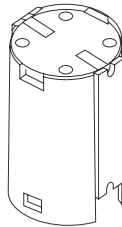
A.



Part:

Purpose:

B.



Part:

Purpose:

3. An LED is one type of lamp that functions in a stacklight. Which is the other?
4. What are two styles of alarms that can be added to stacklights?
 - a) _____
 - b) _____

Answers to review are on page Z-68.



PUSHBUTTONS AND STACKLIGHTS 101 BASIC TRAINING, CONT.

NEMA Standards

As a way of **standardizing enclosure performance**, organizations such as NEMA and IEC have created rating systems to identify a product's ability to withstand outside environmental forces. The chart below gives brief descriptions of NEMA standards to explain what each code means.

Type Designation	NEMA Definition
1	Enclosures are intended for indoor use, primarily to provide a degree of protection against contact with the enclosed equipment or locations where unusual service conditions do not exist.
2	Enclosures are intended for indoor use, primarily to provide a degree of protection against limited amounts of falling water and dirt.
3	Enclosures are intended for outdoor use, primarily to provide a degree of protection against windblown dust, rain, and sleet; undamaged by the formation of ice on the enclosure.
3R	Enclosures are intended for outdoor use, primarily to provide a degree of protection against falling rain and sleet; undamaged by the formation of ice on the enclosure.
4	Enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose directed water; undamaged by the formation of ice on the enclosure.
4X	Enclosures are intended for indoor or outdoor use, primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose-directed water; undamaged by the formation of ice on the enclosure.
6	Enclosures are intended for use indoors or outdoors where occasional submersion is encountered.
12	Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, falling dirt, and dripping non-corrosive liquids.
13	Enclosures are intended for indoor use, primarily to provide a degree of protection against dust, spraying of water, oil, and non-corrosive coolant.

IEC (IP) Ratings

As **Figure 28** indicates, Ingress Protection (IP) ratings include the code letters IP and two numbers, each of which explains the degree of protection the application offers. The first number represents the degree of protection against solid foreign objects; the second number represents the degree of protection against water.

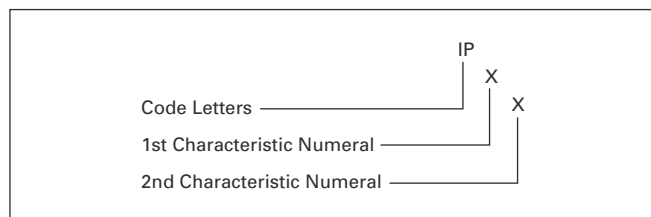


Figure 28. IP Code

The chart below gives brief descriptions of IEC Standards (IP ratings) to explain what each code means.

First Characteristic Numeral	Brief Description	Second Characteristic Numeral	Brief Description
0	Non-protected	0	Non-protected
1	Protected against solid foreign objects with a diameter of 50 mm and greater	1	Protected against vertically falling water drops
2	Protected against solid foreign objects with a diameter of 12.5 mm and greater	2	Protected against vertically falling water drops when enclosure tilted up to 15°.
3	Protected against solid foreign objects with a diameter of 2.5 mm and greater	3	Protected against spraying water
4	Protected against solid foreign objects with a diameter of 1.0 mm and greater	4	Protected against splashing water
5	Dust-protected	5	Protected against water jets
6	Dust-tight	6	Protected against powerful water jets



PUSHBUTTONS AND STACKLIGHTS 101

BASIC TRAINING, GLOSSARY

Glossary

Cam	A rotating or sliding piece that imparts motion to, or receives motion from, a roller moving against its edge.
Indicating Light	Also known as pilot lights. Lights on a panel that show if a control circuit or power circuit is energized, or show the state of the logic in the circuitry.
IP	Ingress Protection. European environmental ratings similar to USA NEMA ratings.
IEC	The International Electro-technical Commission. With headquarters in Geneva, Switzerland, it is associated with equipment used internationally. IEC devices are built with materials required for specific applications.
Maintained	The circuit remains closed after pressure is released from the button.
Momentary	The closed circuit lasts only as long as pressure is maintained on the button.
NEMA	National Electrical Manufacturers Association. This group has ratings of an enclosure's ability to provide a degree of protection against contact with equipment and against specified environmental conditions.
Potentiometer	A dial that adjusts the amount of voltage sent to a machine.
Pushbutton	(A) The operative force that either opens or closes an electrical circuit. (B) The button assembly you push on a panel. (C) Indicating lights, selector switches, potentiometers — and pushbuttons — through which people interact with machines.
Pushbutton Station	One or more pushbuttons in a common enclosure.
Selector Switch	An operator which is mechanically linked to one or more contacts and which makes or breaks the contacts when rotated to two or more positions.
Stacklight	A mini-tower of independent, colored lights providing 360° visual and/or audible indication of machine faults, low part levels, etc.
UL	Underwriter's Laboratories, Inc. A non-profit organization that establishes, maintains and operates laboratories for the examination and testing of devices, systems and materials, primarily for safety.



PUSHBUTTONS AND STACKLIGHTS 101

BASIC TRAINING, REVIEW ANSWERS

Review 1

1. Answer should say something similar to: "The word pushbutton is used to refer to general group of components, or mechanical man/machine interface products, that includes: indicating lights, selector switches, potentiometers — and pushbuttons — by which people interact with machines. The word is also used to refer to the specific type of button assembly that you actually push on a panel."
2. True
3. Any three of the following: Selector switch, Pushbutton, Key selector switch, Indicating light
4. Mentioned applications include: assembly lines, car washes, airline passenger bridges, stand-alone machines, carnival rides.
5. Automation, complicated equipment
6. Answer should say something similar to: "Stacklights are usually mounted on top of a machine so they can be seen easily from all angles."

Review 2

1. Answer should say something similar to: "Pushbuttons are the operative force that either open or close an electrical circuit."
2. Operator, Contact Block
3. True
4. A relay or auxiliary contact
5. 1E, 2D, 3F, 4C, 5A
6. Many possible answers. Naming and describing the application of any two of those pushbuttons will constitute a correct answer.
7. Speed control
8. Answer should say something similar to: "The major difference between the selector switch and the pushbutton is that, while a pushbutton has a plate that pushes down both contact plungers at the same time, a selector switch has a rotating cam with ridges and flats on it, allowing you to actuate the plungers independently."
9. False
10. Maintained
11. They take up a lot of space.

Review 3

1. Open
2. 1 normally closed contact
3. Advantage: Provides lamp with a long lamp life and filters for voltage spikes. Disadvantage: Works only with AC.
4. Prevents accidental operation.
5. Answer should say something similar to: "The pushbutton actuates the machine; the indicating light is a separate device that measures whether the machine is functioning."
6. Whether the unit works in AC or DC or both, Lamp life in relation to usage

Review 4

1. Answer should say something similar to: "So machine functions can be linked to a specific color."
2. A. Terminal board, Power and lamp wiring connections are made into screw terminals on this board. B. Light Diffuser, Distributes the light evenly across the lens and passes the circuit up and down the stacklight.
3. Incandescent
4. Prevents accidental operation.
5. Audible alarm, Xenon strobe

