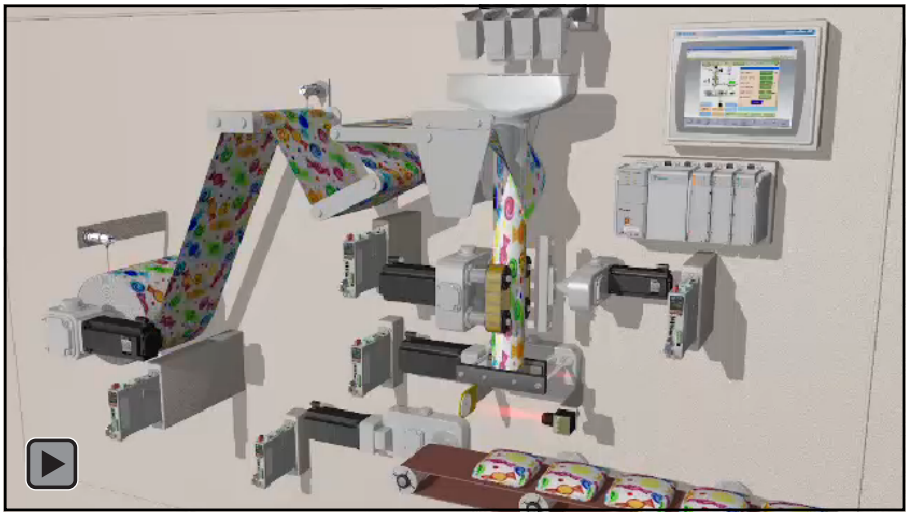
Allen-Bradley

Vertical Form Fill and Seal

Catalog Numbers ControlLogix, CompactLogix, Integrated Motion on the EtherNet/IP Network

The Vertical Form Fill & Seal (VFFS) application is a way of packaging that vertically forms a tube (pouch), fills the pouch with product, and then seals the pouch. These types of applications are usually in the primary packaging area of a packaging line, where machines take finished products and put them in a package.



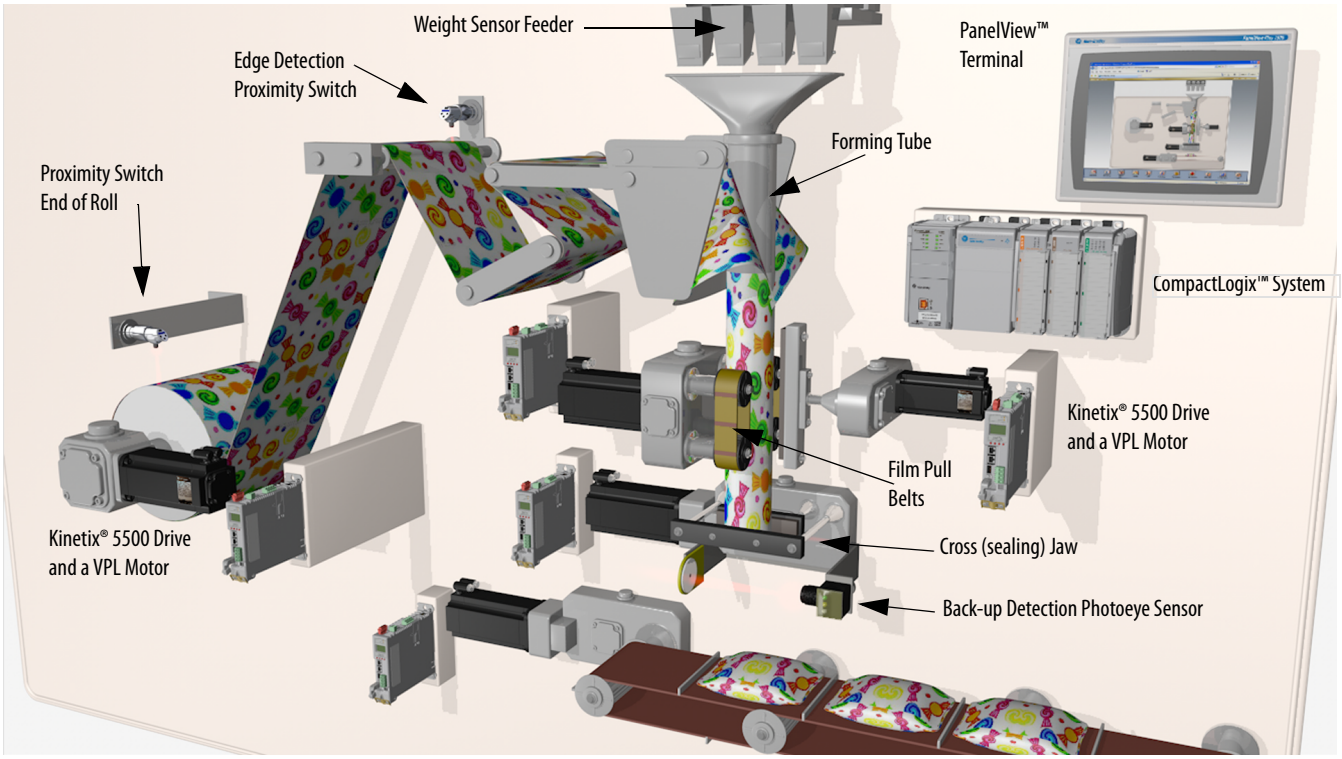
Vertical Form, Fill, and Seal (VFFS) machines are used in the consumer products industry for a wide variety of packaging applications. Various products like salt, tea, sugar, spices, snack foods, wafers, detergent, and candies are placed into formed pouches and then sealed. The pouch material is flexible and typically heat-sealable plastic. Paper is also used and sealed by glue.

Some systems include vertical-form-fill-and-seal baggers, computer combination weighers, and bag-in-box systems. A bagger is a high-speed continuous motion system for poly or supported films, which forms a wide variety of bag styles, ideally suited for USDA applications.

For more information see the following Rockwell Automation websites.

- http://ab.rockwellautomation.com/Motion-Control/Kinetix-5500-Servo-Drive
- http://ab.rockwellautomation.com/Motion-Control

The Rockwell Automation Integrated Architecture™ with Integrated Motion on the EtherNet/IP network is ideal for VFFS machines.



A servo axis on the roll of film is used to maintain tension in the process, so the exact amount of film material can be used with minimal waste. This servo axis feeds the correct length of film into the formed film tube. If the film is pre-printed, a registration sensor adjusts the film position to maintain the correct print position. As the feed servo axis pulls the film down, the goods to be packaged are gravity-fed into the tube, often by a precision scale, which ensures that the proper amount of goods are placed in the pouch. Before product is put into the pouch, the cross jaw servo axis seals the bottom of the pouch, then it is filled and the cross jaw seals and cuts the pouch.

Built-in PID functionality provides accurate control of the film unwind mechanism by controlling such devices as unwind brakes or motors, as well as accurate temperature control of a variety of devices. Native math capabilities in the Logix processor provide a powerful environment for creating complex algorithms.

Registration inputs to the Logix processor are able to record not only the position of any physical axes independent of the process, but also the time the input occurred. This time can be used to determine precise positions for all other physical and virtual axes in the system to help control accurate film positioning. Pending cams on an otherwise continuously recurring cam motion bring the bagging hands to a stop and restart them within half a product cycle to control dwelling when product is unavailable. Plant-floor operators can select appropriately-sized cam profiles by entering parameters from the operator terminal, or calculate profiles on the fly with the MCCP instructions.

Intermittent and Continuous VFFS Applications

VFFS machines can be intermittent or continuous motion. Intermittent motion machines operate on the principle that vertical bag seals are made when the film is moving and horizontal seals occur when the film stops. Intermittent motion machines offer a suitable solution for applications where speed is not absolutely paramount.

An intermittent motion machine is used for washdown applications, such as poultry or seafood. These machines can weigh everything from dry flowables, such as seasonings and snacks, to large, irregularly shaped semi-moist foods, like fresh-poultry parts. A machine can have variable speeds, depending on the volume and product characteristics.

Continuous motion machines operate on the principle that both vertical and horizontal bag seals are made when the film is in motion. These machines operate at the highest attainable speeds and require a reciprocating sealing-jaw motion format.

There are two major process advantages for a continuous motion machine over an intermittent type:

- Faster cycles times. On a continuous motion machine, the cross jaw moves with the film and can perform the horizontal sealing application while the film is still moving. The typical intermittent machine operates at 60...80 packs per minute (ppm) maximum, while a continuous machine can operate up to speeds of 180 ppm. The highest machine speed attainable is determined by the weighing mechanism.
- Control over the cross jaw along the vertical plane provides additional bag making possibilities.

For instance, for a basic intermittent VFFS machine there will be some sort of timing axis or PLS channel to coordinate the dosing section with the bag making process, for example multi-head scale, auger, or volumetric cup filler.

The film pull belt axis is indexed at either specific lengths and then stopped, or at calculated stop distances, which are based on control variables and machine dynamics, and then stopped on the registration mark.

Once the film pull belts have stopped, the cross jaw can commence the sealing process. The Film Unwind control is handled as a separate function based on dancer position and whether or not the film is in motion. Vertical and horizontal bag seals are made when the film is in motion.

Fully automatic VFFS machines require limited operator intervention. The operator need only replenish product by loading supply hoppers or changing packaging film drums. For machines that are semi-automatic, operators are required to perform part of the packaging operation.

The VFFS machine can be divided into four functional areas:

- Mixing, weighing, and dosing
- Forming
- Feeding, aligning, and registration
- Closing, sealing, cutting

Typically, roll-fed flexible packaging film is unwound from a feeder roll. A dancer roll maintains a constant tension on the unwinding web of film. The unwinding motor and dancers are required for maintaining tension and critical accuracy in feed.

The film is threaded up over a forming collar and then down, forming the web into a chute-like tube. For perishable food products, gas flushing is executed to prolong the shelf life. The process involves injecting an inert gas, like carbon monoxide, into the package cavity before it is sealed. A vertical overlap seam and bottom seal are applied. The pouch is then filled and a top seal applied while a knife cuts the sealed pouch from the descending web of film.

A VFFS application can consist of the following:

Hardware

- Feeding system
- Film unwind
- Analog dancer
- Film registration
- Registration sensor
- Forming tube
- Film pull belts
- Cross jaws

Software

- PID control
- Discrete control
- Servo
- VFD
- Servo control
- Registration correction code
- Electronic camming

Bagger

If a machine packs milk powder bags in a continuous manner, while the bagger pulls film from roll stock and forms it into a tube, continuous motion sealing tools apply heat to the seal areas to form the vertical seal and the cross seal of the bag. Each time a cross seal for a new bag is made, the bagger calls for a charge of product from the feeder. As soon as the correct amount of product is dispensed, the filled bag is advanced to receive a top seal. As the top seal is made, the finished bag gets cut off from the next bag to be filled.

Servo Drives

Servo drives are used for the product-metering pump, and they are used as linear actuators to control the filling cycle. The servo motor is used to control the main injector, and manages the speed and acceleration of the bag-making process. To help lower costs, a metering system can be used to focus on additional product precision for reduced waste. In addition, servo metering assists in reconfiguring the machine very quickly, helping to save time and increase throughput.

The machine must manage the measurement and insertion of product into the pouch, which requires tight coordination with the scales, augers, and mixers:

- For perishable product, the machine needs to be washed down for sanitary purposes.
- For food products, gas flushing with inert gas or O2 extraction is required to extend food shelf life.

Film Unwind

In the film unwind section, packaging material is unwound into the machine. When designing your system, consider material splice, roll change out, and film tension. Depending on required machine performance, you will use a stepper, servo, DC gear motor, or VFD.

Film unwind is responsible for unwinding film into the machine, providing operator ease-of-splice (optional), roll change-out features (optional), and film tension. Many unwind sections are static mandrel (un-powered) types and use either a pneumatic brake or friction brake to control unwind action and provide applicable film tension. Although, occasionally the unwind mandrel will require VFD, Servo, or DC gear motor type control.

In the unwind section, often there are roll change features, such as dual mandrels, roll lifts, and vacuum splice bars. A vacuum splice bar is a horizontal bar with a vacuum manifold built in and a small horizontal slot (suitable to accommodate a utility knife blade) through the middle of the bar. The unwind section includes the film tension and/or dancer. The dancer can provide a speed feedback (analog or discrete) to the unwind control circuit, as well as a film accumulator area for bag index purposes, especially on an intermittent type machine. Additional options possible for the unwind section are functions like zipper applicators and breather inserters.

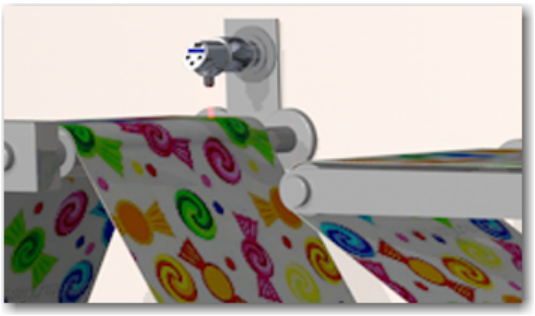
Sensors

These are the types of sensors you can use in an application:

- A diffuse sensor to detect the end of a film roll
- An Inductive sensor to detect the over and under travel of a tension arm and checking for a missing lug
- A registration sensor to detect registration marks that synchronize the sealing and cutting operations
- An optical torque sensor to detect an edge for centering a trim
- A retro-reflective photo eye to jams at the outlet

Film Registration

The registration mark with a registration sensor is used as a method to make minor adjustments to the actual end placement of the seal and cut on a bag. The film registration sensor, film alignment, and tracking adjustment mechanisms must be considered.



This section includes the film registration sensor and placement adjustment mechanisms. The film registration is used on film with graphics or pre-printed information. Printing process variations, film stretch, film slippage during acceleration, and other factors can allow the graphics to drift away from ideal cosmetic/marketing placement on the finished bag. The registration mark provides a method to make minor adjustments to the actual end placement of the seal and cut on a bag. When there is no printing or graphics on the bag, the process is defined solely on length. Also located in the film registration section, it is common to have the film alignment/tracking adjustment mechanisms. These are used to make sure that the film stays in the correct place on the forming tube.

Forming Tube

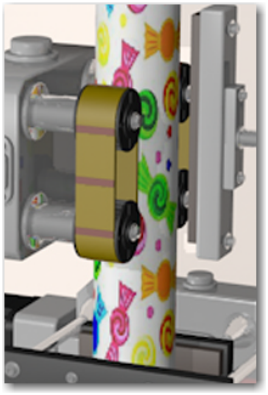
Flat film is converted into a tubular or tunnel shape. The film travels on the outside of the forming tube. The cone and correct diameter tube are combined to form the flat film into a tubular or tunnel-type shape.

You can use unique mechanical designs for different machines , for example, films and products being sealed - inverted cone with radius corners. You would use PID loop to control the heating elements of the static bar via the main controller or separate standalone PID controllers.

The forming tube mechanics are often unique designs for different machines, films, and products. However, the general description is an inverted cone with radius corners. This cone and the correct diameter tube (shapes can differ from round for special package needs) are combined to form the flat film into a tubular or tunnel-type shape, which ends up being wrapped around the external surface of the actual forming tube. To provide extra film for the long or 'back' seal, the width of the film must be greater than the circumference of the forming tube. The long seal is formed by several heater mechanical configurations that are typically placed on the front of the forming tube and are 8...12 in. long. Linear film speed and type are factors in determining the correct minimum length of the long seal. There are two main types of long seal.

The first type of long seal is the static bar, which is a heated bar with a heating element and thermocouple. This bar is engaged into the film and forming tube only while the film is in motion, with slight timing delays to prohibit melting of the film when stationary. There can also be two bars, but placed where they are facing one another in a manner to allow the long seal flaps to be placed in between the two bars. This method is used instead of the overlapping method used for single bar configurations. This can provide stronger seals/seams and the product ambient temperature (that is, forming tube temperature) has less of a factor on the loop control.

The second type of long seal is the dynamic belt, which is a single-heated stainless steel belt with two pulleys. A heated plate transfers the heat to the stainless steel band or belt and is engaged into the film and forming tube while the film is in motion. Like the static bar type, there can also be dual dynamic belts/bands. The benefit of dynamic belts is that they can move with the film and also be adjusted to operate faster than the base film speed or even slower. These are process decisions made based on many product, machine, and material factors.



Film Pull Belts

The film pull belts provide the actual force to pull the film through the machine and are used to maintain good film tension on the forming 'plow' and tube.

You can use a vacuum belt type for better gripping control in dusty, high moisture, or cold operating environments. Use discrete control, servo, VFD, and registration code.

There are typically two film pull belts—right side and left side. They are typically vacuum belts, which allows for better gripping. The belt mechanics are often powered by VFD motors with encoder feedback, servo axes, or perhaps stepper motors. Occasionally, there is only one motor that is mechanically transferred to the separate belts, but the general practice is to eliminate the additional special mechanical costs in lieu of the additional, but more flexible, controls cost. The film pull belts provide the actual force to pull the film through the machine and are used to maintain good film tension on the forming plow and tube. Often code is used to monitor position and velocity error to be sure that slight mechanical differences are not allowing one side to pull more than the other.

Rotary Jaw

The first type of continuous bagger is the rotary 'D' jaw. For a rotary type bagger, the horizontal plane motion for the front and back cross jaws is replaced with a rotary type motion. This is accomplished with special mechanisms, orbital gearboxes, and/or four-bar type linkages. In general, each jaw is attached between two gears. Each jaw end gear is actuated by a driving gear. Along with some orientation linkages, these jaws operate in a mirrored fashion so the jaws maintain the same distance to the vertical plane as they rotate in a top-to-bottom and around fashion. The main benefit of a continuous type bagger over the intermittent is that as the cross jaw is now moving along the vertical plane as well as the horizontal plane, the sealing process can occur without stopping the film completely.

Vertical Jaw

The second type of continuous bagger is the box or square jaw type. This differs from the rotary jaw in that there are now two mechanical movers for the overall cross jaw—one is the horizontal-only plane and the other is for the vertical-only plane.

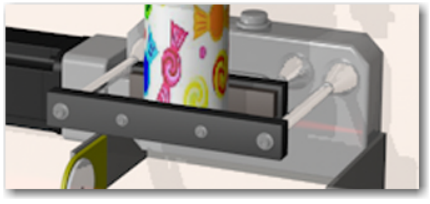
Although this adds increased controls and mechanical costs, it can also provide additional bag making process options, longer bags with fewer constraints, and more control for product sweeping type functions. Mechanically, the cross jaw mechanics and motor are contained on a carriage. This carriage is controlled and moved along the vertical plane via the vertical mechanics and motor.

The speed of the VFFS machine is the rate at which it is able to the following.

1. Form the bag (pouch).
2. Fill the bag with product.
3. Seal the bag.
4. Cut the bag.
5. Transfer the package for shipment or further end-of-line packaging, such as a case packer or over wrapper.

The speed of the machine is one of the main attributes in many end users' buying criteria. Machine builders design their machines to operate at the highest speed possible.

Cross (sealing) Jaw



The cross jaw seals the top of filled bag and creates a bottom seal of next bag. It then cuts and separates these two bags. When designing, keep in mind whether to use an intermittent or a continuous feeding line in relation to the complexity of the sealing jaw. You will be using discrete control, servo, VFD, PID, and electronic Camming.

The cross jaw is responsible for three major functions—to seal the top of the previously filled bag, to create the bottom seal for the soon-to-be-filled bag, and to cut or separate the completed bag from the bottom of the new bag.

The front and back cross jaws operate as a pair. The front and back jaw both have a top seal area (horizontally) and a bottom seal area. Additionally, either the front (typically due to maintenance reasons) or the back jaw set has a knife that runs horizontally in the middle of the jaw face. This knife is recessed and is activated by a pneumatic actuator. The opposite jaw set contains the anvil for the knife.

Each jaw has have one or two heating elements and a thermocouple for temperature control. Additionally, the cross jaw section can have options like product wipers, bag deflators, bag hanger punch, gusset (single and double) creation mechanics, and flat bottom bag mechanics.

Cross jaws are typically configured mechanically, where the front and back jaws interpose each other and therefore meet in the vertical center-line of the bag and forming tunnel. However, there are also versions where either the front or back jaw is stationary and the opposite jaw is moveable. Servo drive/motor combinations, VFD drives with induction motors, and high-power pneumatic cylinder actuators are used to close the jaws and provide the necessary sealing pressure to provide a suitable bag seal.

It is very common for the jaws to contain built-in springs to allow for some closure error as well as a default force. Often, position and torque data are monitored for the cross jaws. This data can be used to detect product in the seal or between the jaws. Any time there is product in the seal, these two bags must be discarded due to potential seal/seam leakage.

The previous sections are typical for an intermittent VFFS machine; however, a continuous machine contains a section called the rotary or vertical jaw, depending on the bagger type.

VFFS Machine Formats

The type of products to be packaged influences the type of application schematic required for the machine sections. Product characteristics, such as size, consistency, and weight, are important details that influence the control system application modules. Product mis-feeds can lead to product jams in the sealing section, for example. Suitable jam detection sensors are required to detect this early.

There are three types of VFFS machine formats.

Single Lane

A single lane tube is formed to the shape of the pouch during each cycle. This format is suitable for many pouch sizes. This is the most common VFFS configuration.

Multi Lane

A multiple lane of tube is used to form multiple pouches during each cycle. This type is mostly used for small packets, such as sugar and salt.

Exposed/Open and Closed Machines

An exposed machine that is closed is sealed so that it is not exposed to the washdown.

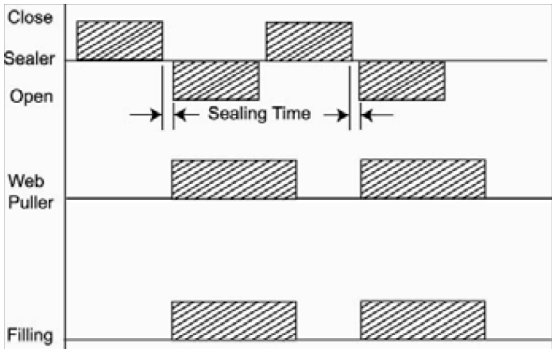
An exposed machine that is open is completely made of stainless steel.

Machine Speed

Challenges in designing machines for speed include the following.

- How to design the mechanics of the machine to operate at a high speed and maintain the correct tension of the film feed in order to maintain the quality of the packaging.
- How to position the film accurately based on eye mark registration.
- How to design the optimum sequence of machine operation.

This is an example of a example of a Form, Fill, and Seal operation intermittent duty cycle timing diagram.



Packaged Product Types

The type of a product influences the application design. The following are the packaged product types in a VFFS application.

Product Type	Example	Machine Function	Application Needs
Liquid	Sauces and shampoos	Dosing	The machine must manage the measurement and insertion of product into the pouch, which requires tight coordination with the scales, augers, and mixers. For perishable products, the machines need to be washed down for sanitary purposes. For food products, gas flushing with inert gas or 02 extraction is required to extend food shelf life.
Fine granules	Sugar and salt	Dosing, mixing	
Coarse granules	Cereals and spices	Dosing, mixing	
Powders	Detergent	Dosing, mixing	
Solids	Candy, pharmaceuticals, and hardware	Weighing	
Fresh produce	Vegetables	Dosing, gas flushing for product protection, and wash down	
Perishables	Meat and fish	Dosing, gas flushing for product protection, and wash down	

Packaging Materials

Packaging material selection is based on the type of products packaged. Plastics and paper based films are widely used in most packaging machines. The packaging material used can generate unique application requirements.

For instance, high static charges are generated when plastic packaging film is fed from a wind-off roll. The static charge attracts powder and lightweight dust from the filling product onto the internal film surface, thus preventing effective sealing. A static eliminator bar or contaminant spray can be used to reduce this problem. Film tension must be maintained.

Sealing and cutting jaws must take action after the product is received, completing the process of bag formation. There may be multiple designs for these components but there is one general requirement—film velocity and jaw sealer velocity must be identical. Any disturbance in timing can damage the bag and waste both packaging and product.

Your choice in package materials is based on what type of products you need to package. The most common packaging materials are plastics and paper based films.

Material Type	Application Needs
Plastic	Film tensions must be maintained. Sealing and cutting jaws must take action after the product received, completing the bag formation process. There can be multiple designs for these components but there is one general requirement. The film velocity and jaw sealer velocity must be identical. Any disturbance in timing can damage the bag and waste both packaging and product.
Plastics performed	
Plastics multilane	
Paper	
Composites	

Rockwell Automation Support

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For an additional level of technical phone support for installation, configuration, and troubleshooting, we offer TechConnect℠ support programs. For more information, contact your local distributor or Rockwell Automation representative, or visit http://www.rockwellautomation.com/support/.

Installation Assistance

If you experience a problem within the first 24 hours of installation, review the information that is contained in this manual. You can contact Customer Support for initial help in getting your product up and running.

United States or Canada	1.440.646.3434
Outside United States or Canada	Use the Worldwide Locator at http://www.rockwellautomation.com/rockwellautomation/support/overview.page, or contact your local Rockwell Automation representative.

New Product Satisfaction Return

Rockwell Automation tests all of its products to help ensure that they are fully operational when shipped from the manufacturing facility. However, if your product is not functioning and needs to be returned, follow these procedures.

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Outside United States	Please contact your local Rockwell Automation representative for the return procedure.

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