Fluid Controls
Concept and Theory

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Purpose and Types of Fluid Controls in a Fluid Handling System

Purpose of Fluid Controls

You may recommend controls to help prevent problems or to resolve problems due to variables in the fluid being moved, the customer's environment, or the system itself. Ideally, you will anticipate the challenges that may occur in a particular system and put appropriate controls in place before the system begins running. If a system is already in place, you will need to analyze the problems the customer is experiencing and recommend controls to resolve those problems.

Types of Fluid Controls

Within a fluid handling system, we can divide types of controls into two main categories: *fluid conditioning controls* and *physical fluid controls.*

Fluid conditioning controls are those controls that impact a fluid's chemistry or chemical condition. Fluid conditioning controls include:

- Contaminant control
- Viscosity control
- Suspension control

Physical controls are those controls that impact a fluid's movement through the system. Physical controls include:

- Pressure control
- Flow control

Contaminant Control

Types of Contaminants

Water, Oil, and Non-Compatible Fluids

When unwanted water, oil, or a non-compatible fluid mixes with a fluid or materials in a system it can cause contamination that results in an undesirable application quality. Contamination most often occurs as the result of a system that is not properly flushed.

Dirt

When dirt particles accumulate in a fluid handling system, they can cause wear to regulators and valves, gun wear, plugged tips, and imperfections in the finished product. Dirt in the system can also cause premature pump and air motor wear. We define dirt as solid particle contaminants such as dust, soil, dried paint, rust, metal chips, or thread sealing compound.

Air

In many fluid systems, air is the primary contaminant. It can cause aeration, cavitation, and fluid changes.

Measuring Contaminant Particle Size

We measure contaminant particles in micrometers (abbreviated as microns), or millionths of a meter. The degree of filtration is expressed in terms of the size, in microns, of the smallest particle that will *not* pass through the filter. You may also hear filtration size referred to as mesh, which refers to the rating of screen wire. For example, a 30 mesh screen is approximately 500 microns. Conversion tables are available to help you convert between the two measurements.

Filtration Devices

A variety of filtration devices are available that can be divided into four basic categories:

- Pre-filters
- Filters that protect the pump inlet
- Pump outlet filters that protect downstream components
- Hose, gun, and tip filters

Pre-Filters

Pre-filters are designed to filter impurities at material supply. Pre-filters can range from 2000-micron to 500-micron for a variety of materials. They are typically the largest micron size filters in a system, used to catch the largest impurities.

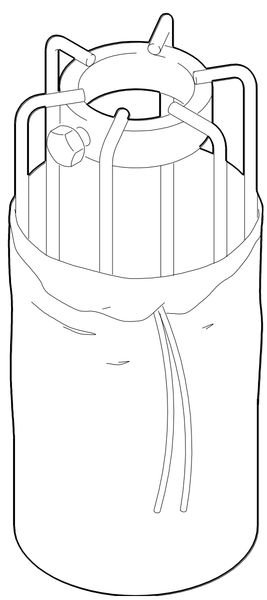

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Figure 1 Pre-filters are the largest micron size filters in a system, used to catch the largest impurities

Filters That Protect the Pump Inlet

Filters that protect the pump inlet are designed to prevent larger objects from entering and possibly damaging the pump. These filters are typically of a smaller micron size than pre-filters, and may range in size from 1000 micron to 250 micron. The most common are in-line ‘Y’ strainers, such as those placed between a feed pump and a proportioning pump, or on an inlet siphon tube.

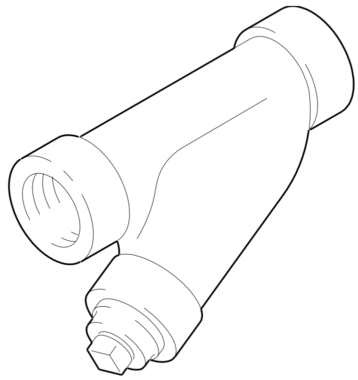

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Figure 2 In-line ‘Y’ strainers are a type of filter designed to prevent larger objects from entering and possibly damaging the pump

Pump Outlet Filters That Protect Downstream Components

Pump outlet filters (element type filters) that protect downstream components are designed to capture impurities exiting the pump. These filters are typically the finest filters in the system. They also have the most surface area to prevent plugging. See Figure 3 for an example showing in-line ‘Y’ strainers used as pump inlet filters and manifold filters on the pump outlets.

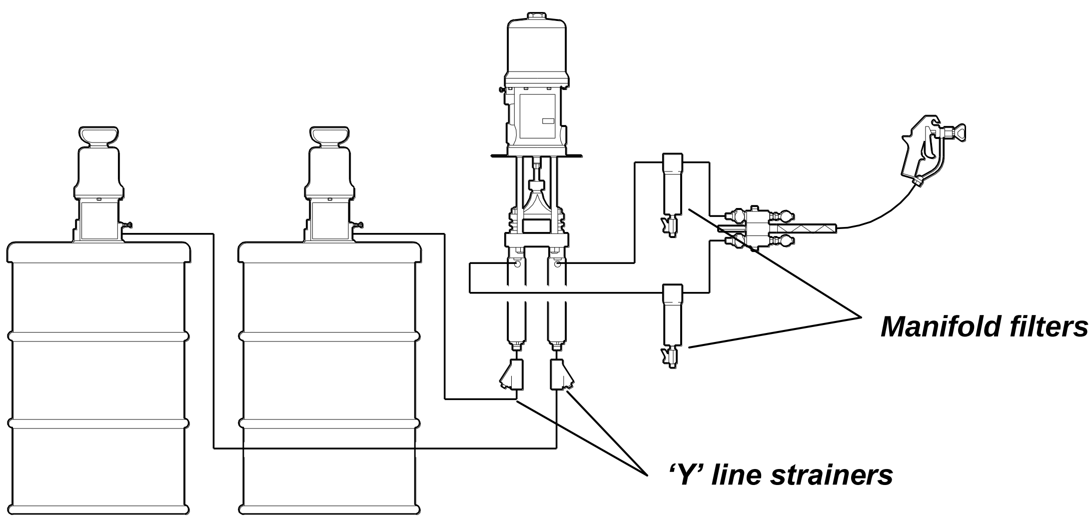

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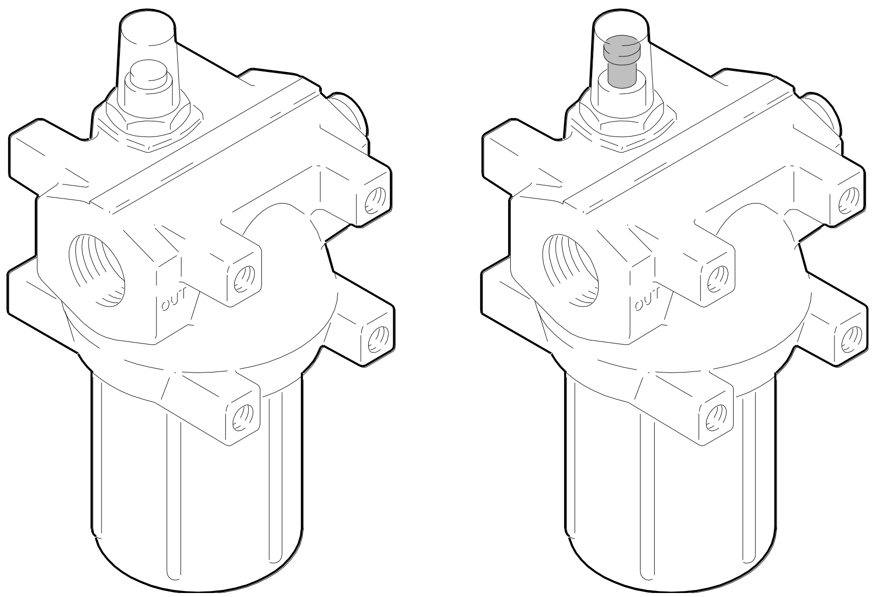
Figure 3 In-line ‘Y’ strainers and manifold filters are designed to control contaminants in a fluid handling system

Another example of a pump outlet filter is an alert- or indicator-type filter, pictured in Figure 4. These filters have an indicator flag on top that pops up when the valve in the filter element is pushed off its seat due to contamination. The flag indicates that the filter is in need of maintenance.



Clean ***Needs maintenance***

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Figure 4 Alert- or indicator-type filters have a flag that pops up when the filter is in need of maintenance.

Hose, Gun, and Tip Filters

Hose, gun, and tip filters are used to catch impurities that originate after the pump. There are usually about 150 micron size filters. Finer size filters may cause frequent plugging. You will achieve best results when both the pump outlet filter and gun or tip filter are the same size. These filters protect the finish from contamination and prevent spray tips from plugging.

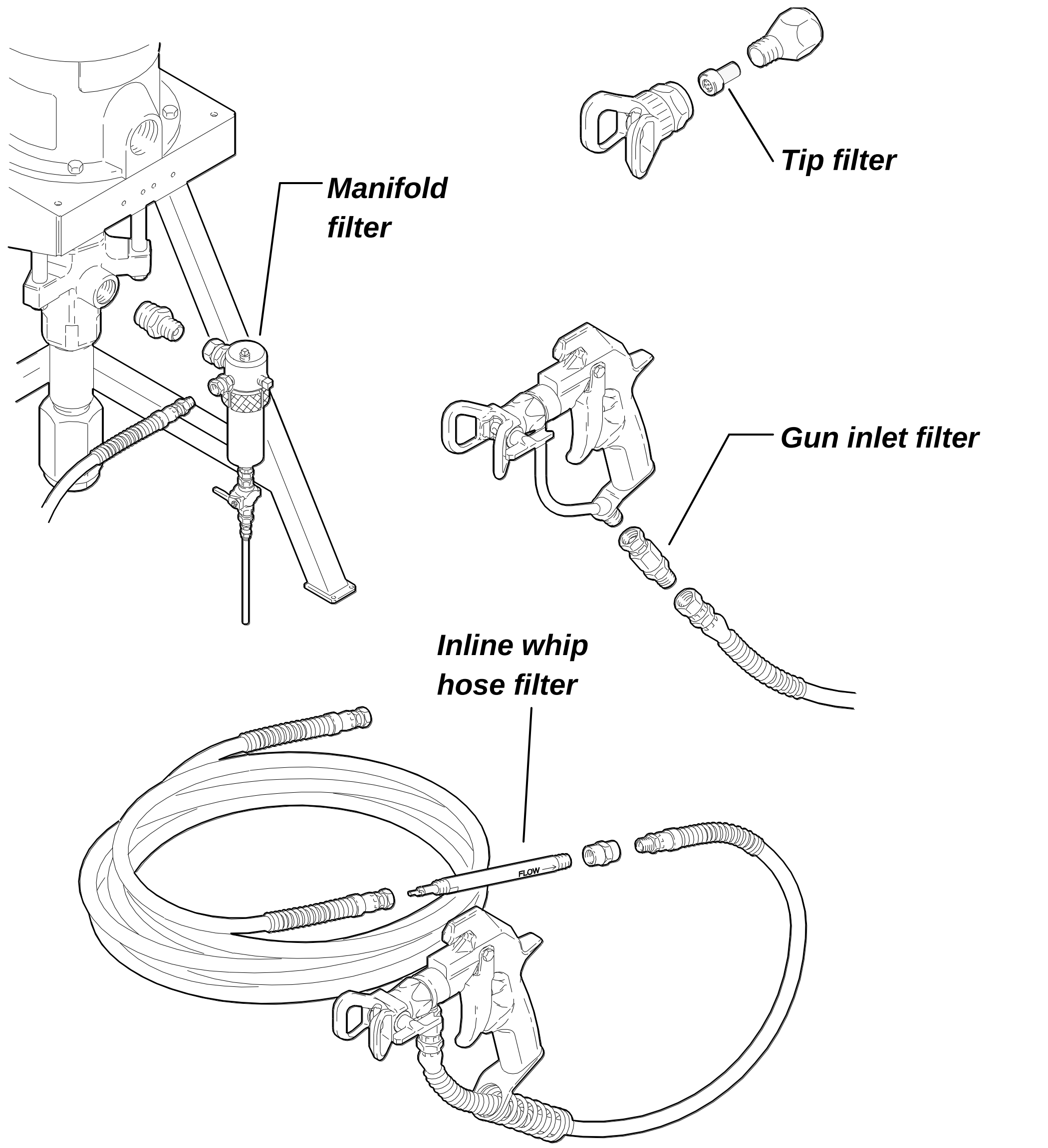

Figure 5 Hose, gun, and tip filters are used to catch impurities that originate after the pump

In a system with multiple filters, as you move from the supply container to the applicator, the filters' sizes should be progressively finer (smaller micron size).

Progress Check

Directions: After answering the following questions, compare your answers with those provided in the answer key following this progress check. If you respond to any items incorrectly, return to the text and review the appropriate topics.

1. Why might you recommend equipment to control the fluid in a fluid handling system? (Select all that apply.)
    a. To help prevent or resolve problems that may occur due to variables in the fluid being moved, the customer's environment, or the system itself.
    b. To help the pump move fluid into the system.
    c. To meet the customer's requirements for application quality.
    d. To meet the fluid's requirements for cleanliness, flow, or pressure.
2. List each of the five major types of fluid controls under its appropriate category.

Fluid Conditioning Controls	**Physical Fluid Controls**
______________________________	______________________________
______________________________	______________________________
______________________________	______________________________

3. Why might you recommend equipment for controlling contaminants in a fluid handling system? (Select all that apply.)
    a. To avoid a finished product with an undesirable application quality.
    b. To impact the amount of material used on a product.
    c. To avoid wear to hoses or tubing, to avoid gun wear, or to avoid plugged tips.
    d. To help prevent settling out of particles or solids found in some fluids.
4. What types of contaminants are commonly found in fluids?

    ____

    ____

5. Which of the following are terms used to describe the measurements of contaminant particle size or to rate screen wire for filtration devices?
    a. Millimeters (milicons)
    b. Micrometers (microns)
    c. Mesh
    d. Element

For items 6 through 9, match the filtration device with its description.

Filtration Device

a. Pre-filters
b. Filters that protect the pump inlet
c. Pump outlet filters that protect downstream components
d. Hose, gun, and tip filters

Description

6. These filters are designed to capture impurities exiting the pump. They are typically the finest filters in the system.
7. These filters are designed to prevent larger objects from entering and possibly damaging the pump. The most common are in-line ‘Y’ strainers.
8. These filters are used to catch impurities that originate after the pump. You will achieve best results when these filters are the same size as the pump outlet filter.
9. These filters are designed to filter impurities at the material supply. They are typically the largest micron size filters in a system, used to catch the largest impurities.

Answers to Progress Check

1. A, C, D. you might recommend equipment to control the fluid in a fluid handling system to meet the customer’s or the fluid’s requirements for cleanliness, flow, pressure, and application quality. You might also recommend fluid control equipment to help prevent or resolve problems that may occur due to variables in the fluid being moved, the customer’s environment, or the system itself.
2. **Fluid Conditioning Controls**

   <u>Contaminant Control</u>

   <u>Viscosity Control</u>

   <u>Suspension Control</u>

   Physical Fluid Controls

   <u>Pressure Control</u>

   <u>Flow Control</u>
3. A, C. You might recommend equipment for controlling contaminants in a fluid handling system to avoid wear to hoses or tubing, to avoid gun wear, to avoid plugged tips, and to avoid an undesirable application quality.
4. Types of contaminants found in fluids include water, oil, and non-compatible fluids, as well as dirt and air.
5. B, C. Micrometers (abbreviated as microns) and mesh are terms used to measure contaminant particle size and to rate screen wire for filtration services.
6. C. **Pump outlet filters that protect downstream components** (element type filters) are designed to capture impurities exiting the pump. They are typically the finest filters in the system.
7. B. **Filters that protect the pump inlet** are designed to prevent larger objects from entering and possibly damaging the pump. The most common are in-line ‘Y’ strainers.
8. D. **Hose, gun, and tip filters** are used to catch impurities that originate after the pump. You will achieve best results when these filters are the same size as the pump outlet filter.
9. A. **Pre-filters** are designed to filter impurities at the material supply. They are typically the largest micron size filters in a system, used to catch the largest impurities.

Viscosity Control

Viscosity Control Purpose and Methods

By controlling viscosity, your customer can impact the quality or amount of the material used on a product. Temperature, solvents, and shear all impact viscosity; by minimizing changes in these, you can minimize changes in viscosity. To maintain the proper viscosity of a material, keep shear stress to a minimum and keep containers closed to the atmosphere to prevent evaporation.

To intentionally change viscosity, you can heat or add solvents. However, material manufacturers are the experts on the composition and formulation of the paints, sealants and other materials they manufacture. Material manufacturers may not guarantee the quality or performance of a product that has been altered. Therefore, make sure you consult with the material manufacturer before using heat or solvent to reduce the viscosity of a fluid.

Relationship between Temperature and Viscosity

Heat reduces viscosity by causing the fluid molecules to move apart, causing the fluid to become thinner. Heat also helps solvents dissolve or disperse pigments and binders. Materials commonly heated include:

- Adhesives
- Sealants
- Paintings and coatings, including standard enamels, oils paints, lacquers, and varnishes

The impact of heat on a material can vary, depending on the type of material and its solids content. Figure 6 illustrates the effect of heat on the viscosity of a typical high solids paint and a typical enamel paint.

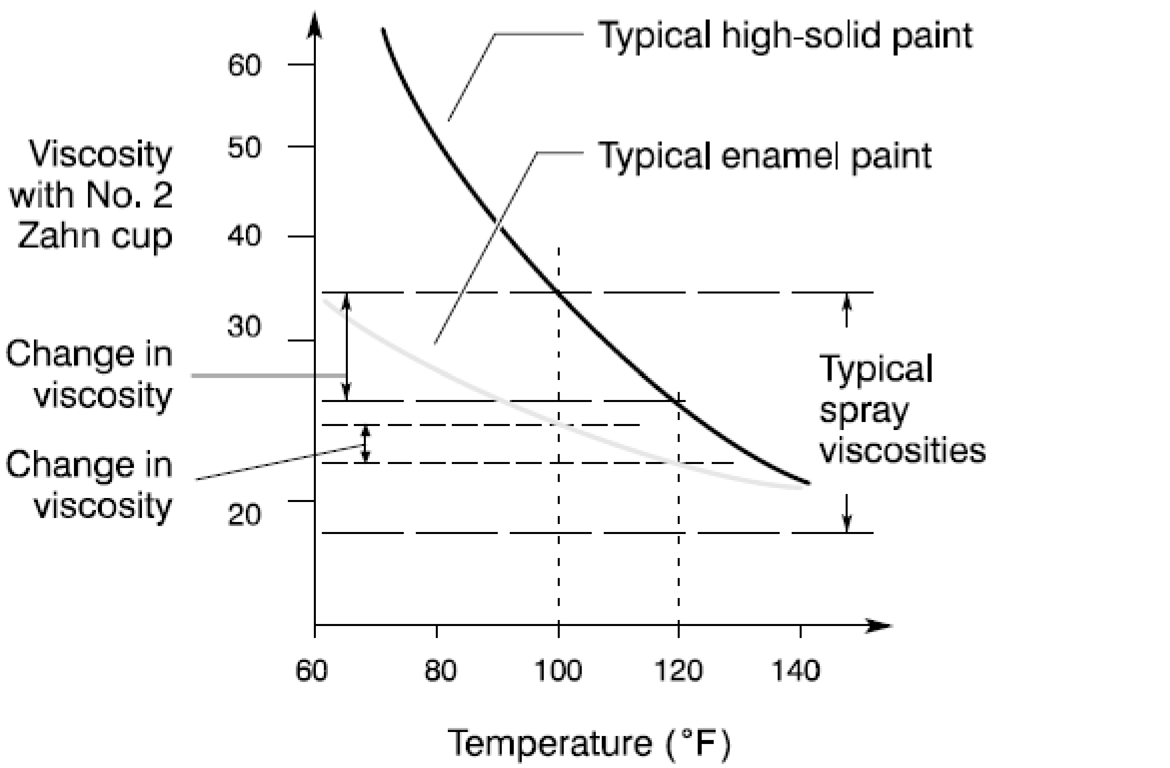

Figure 6 High solids materials are temperature-sensitive and will vary in viscosity with only a small change in temperature

Benefits of Using Heat to Control Viscosity

There are several benefits of using heat to control viscosity. These benefits will often lower your customer’s expenses or increase productivity.

Using Heat to Control Viscosity in Spray Patterns

When heat is used to control viscosity in spray systems, less spray energy is required to atomize, resulting in:

- Improved transfer efficiency
- Lower atomization pressures
- Reduced waste disposal costs
- Improved finish quality

Using Heat to Control Viscosity in Sealant and Adhesive Systems

In sealant and adhesive systems, the benefits of using heat to control viscosity include:

- Less pressure required to apply materials
- More consistent flow rate at the applicator
- Reducing viscosity may make it possible to pump and apply materials that would otherwise be too viscous

Solids by Volume Are Not Reduced or Diluted

Another benefit of using heat to control viscosity is that solids by volume are not reduced or diluted (as they are when solvents are used to control viscosity). This means:

- Volatile organic compound (VOC) requirements are maintained
- Your customer may be able to apply more coating per pass or reduce the number of passes per part, reducing labor or increasing production rates
- There is less of a chance for “sags” or “runs”

Fluid Viscosity Remains Consistent in Heated Systems

Heated systems are *usually closed circulating systems*, systems in which the coating material is constantly circulated (pumped) through the system. In these systems, the fluid viscosity within the system remains consistent even if the ambient temperature changes in the application environment. Heating systems may also be in-line heating systems that modify the temperature of the material on the way to the applicator. These in-line (also called dead end) heating systems cannot maintain the same level of temperature control that circulating systems can.

Heater Selection Factors

A variety of heaters are available to control the viscosity of a material within a system. To select the heater most appropriate for your customer's application, you need to consider several factors. These factors can be grouped into three categories: heater performance factors, installation factors, and selection factors.

Heater Performance Factors

The first set of factors you need to consider are related to the heater's ability to perform. Make sure you answer these questions before selecting a heater:

Capacity

What is the heater's ability to raise temperature with a constant flow rate? For example, can it raise temperature 30 degrees? 60 degrees?

Overshoot

When you turn off the flow, how high does the fluid temperature go? For example, for certain high-solids materials, a 10 degree overshoot may not be acceptable. Some materials can cure or "bake;" so it is important to check with the material manufacturer.

Cycling Temperature

What is the change in fluid temperature with a constant flow rate? For most temperature sensitive materials, cycling temperature should be less than 5 degrees.

Maximum Temperature

What is the maximum temperature the heater is capable of producing?

Pressure Drop

How much does the fluid pressure drop through the heater? Minimizing pressure drop across the heater is a good objective.

Installation Factors

You also need to consider what requirements exist for installing the heater. Make sure you know the answer to these questions:

What voltage is available?
What safety codes must it comply with?
What is its working pressure?
Is the material compatible with the heater's wetted parts?

Selection Factors

Finally, you need to know the specific heat of the material moving through the system and use that information to calculate the appropriate size heater for your customer’s application.

Specific Heat

Specific heat is the amount of energy required to raise the temperature of one pound of material by one degree Fahrenheit. The specific heat of water and water-borne paints is approximately 1.0. The specific heat of a solvent-borne paint is about 0.5. This means that a solvent-borne paint requires approximately one-half the amount of energy to raise its temperature as does water or a water-borne paint. The specific heat of sealants and adhesives varies widely with the materials and fillers used.

Check with the material manufacturer for accurate information regarding specific heat.

Calculating Heater Size

You can calculate the size heater you need for an application by using the guideline that, for solvent- borne paints, 70 watts will raise the temperature of a one gallon-per-minute system by one degree Fahrenheit.

For example, consider a 0.5 U.S. gpm (1.9 l/min) system in which a solvent-borne paint needs to be heated to 120˚F (49˚C). The average temperature of the paint is 70˚F (21˚C), so the heater must raise the temperature 50˚F (28˚C). You would use the following formula to calculate the heater capacity:

> Wattage required = 140 x S.H. x ˚F rise x gpm.
> (Wattage required = 66 x S.H. x ˚C rise x l/min.)

Use a specific heat (S.H.) of 1.0 for water or water-borne paints and a specific heat of 0.5 for oil or solvent-borne paints. Check with the manufacturer for the exact specific heat of a material.

In the above example, a heater with a capacity of 1750 watts is required.

Types of Heaters

Depending on your customer's application, you may need to select more than one type of heater.

Supply Heaters

A supply heater is a device that heats the material supply container. In applications where the environment is cold, the material may need to be pre-heated to allow it to flow into the supply pump. Drum heaters (also called band heaters) are common types of supply heaters.

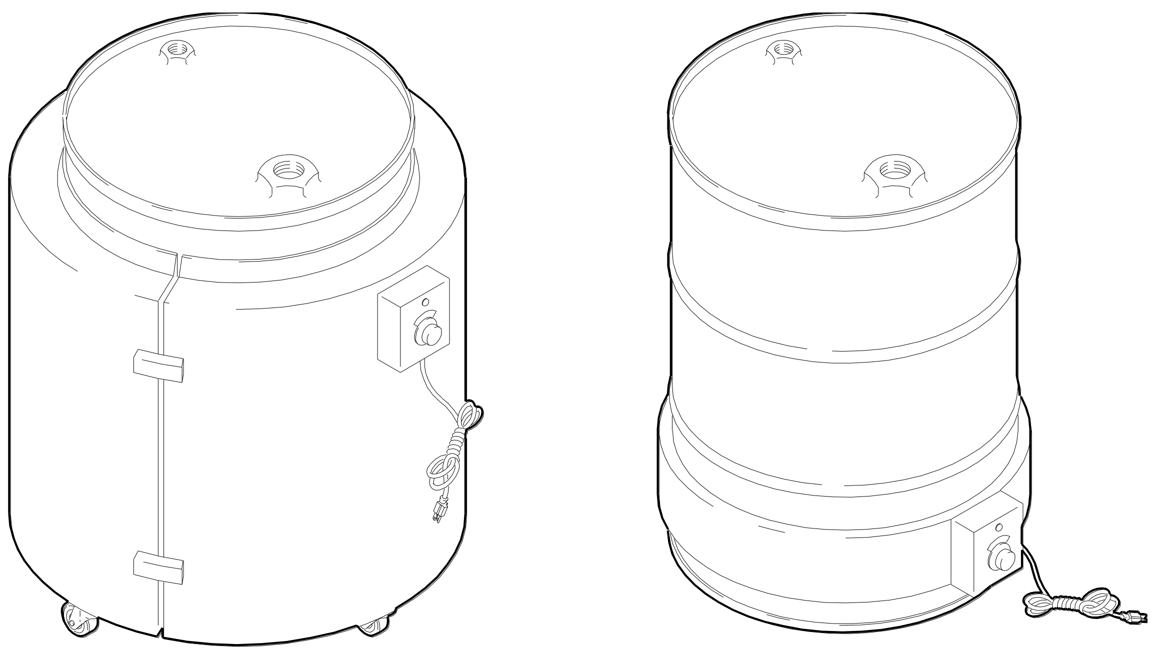

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Figure 7 Drum heaters (left) and band heaters (right) heat the supply container

Heated Ram Plates (Platens) in Ram Systems

In ram systems, heated platens are used to help pump certain types of materials. These materials typically must be heated to reduce their viscosity so they can flow and be pumped at the available pressure. Platens may also be used to melt a material from a solid to a liquid.

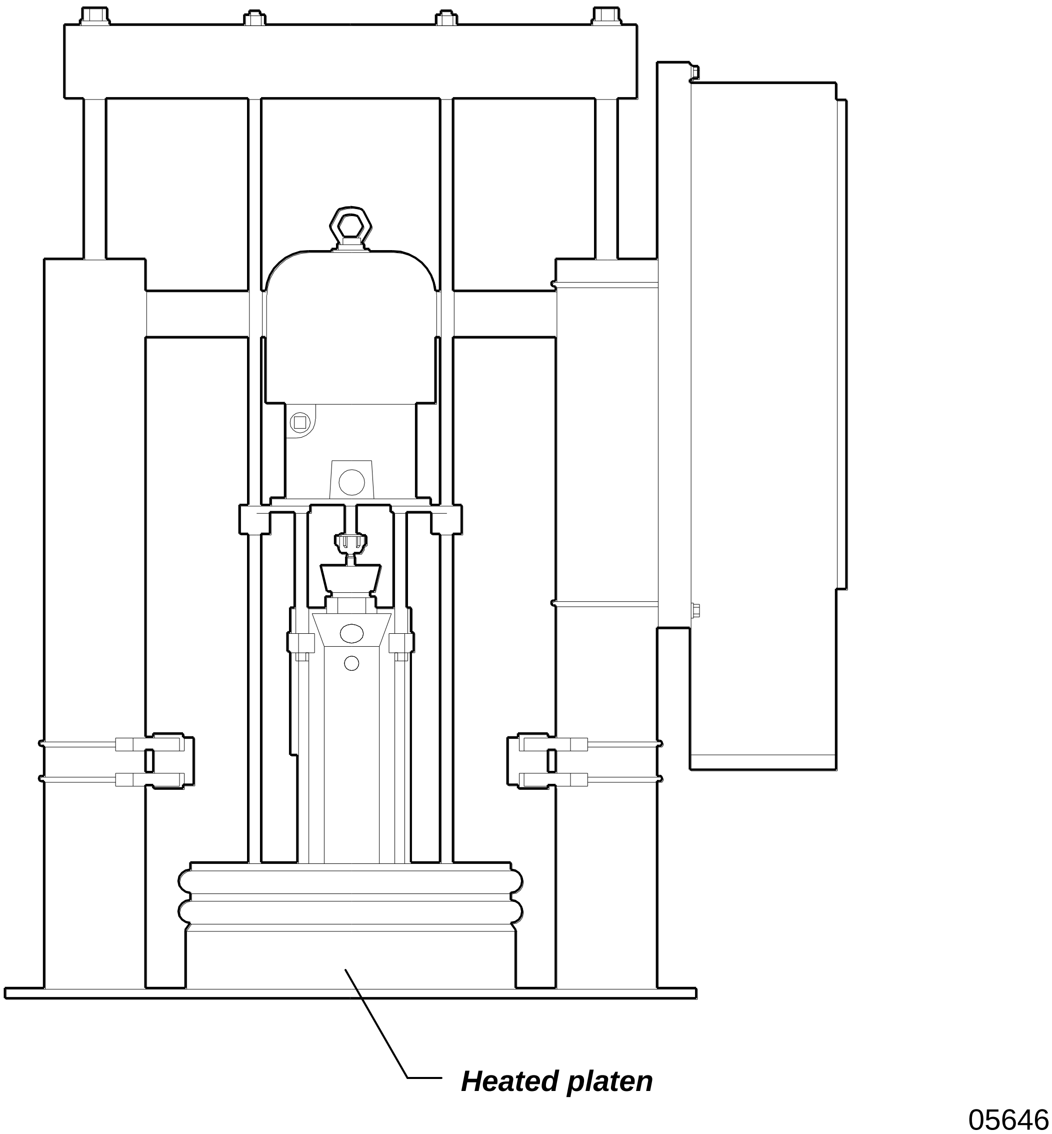

Figure 8 Heated platens are used in ram systems

In-Line Heaters

In-line heaters are heaters placed directly in the pumping line. They are termed “high mass” or oven- type heaters. The temperature of the heater block is set and maintained much the same as an oven. Fluid running through the lines will reach this temperature if left in the heater long enough.

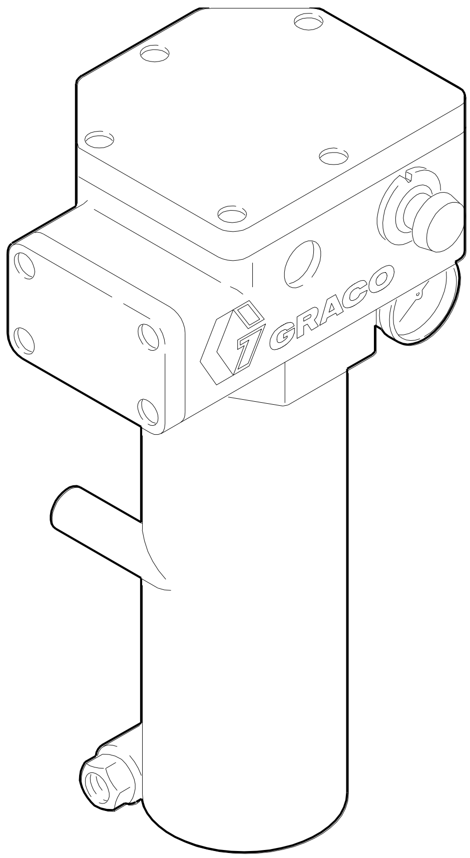

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Figure 9 The Graco Vis-con^2 heater is an example of an in-line heater

Line (Pipe) Heaters

Heated hose and heat tracing are examples of line heaters. Heated hose is appropriate for applications where the material must maintain a certain temperature to the dispensing device and flexibility is required, such as to a spray gun. Heated hoses are only applicable for non-flammable fluids. Flammable fluids require insulated circulating lines. Heat tracing is appropriate for fixed sections of metal piping.

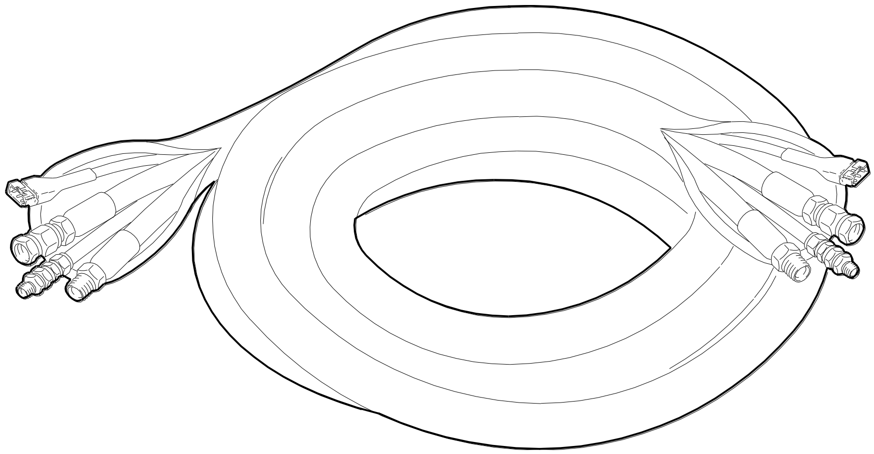

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Figure 10 Heated hose is one method of maintaining a certain temperature material to a dispensing service

Designing a Heated Circulating System: General Recommendations

Before designing a heated circulating system, review these general recommendations and determine any additional information you need from either your customer or the material manufacturer.

Material Issues

Not all materials can be heated. Also, the amount of heat required to impact viscosity varies by material. If you plan to use heat to control viscosity, contact the material manufacturer first.

Consider the set point temperature of the material and the heater's set point accuracy. The *set point temperature* is the temperature, recommended by the material manufacturer, at which a material sprays or moves most efficiently. The thermostat on a heater is fixed at the set point temperature for the material being moved, but actual temperature may vary from that set point.

The amount of variation from the set point determines the heater's *set point accuracy*. If a wide variation in temperature occurs, the viscosity of the fluid in the system will also vary. This variation in viscosity may cause fluctuations in the flow rate and coverage and result in an inconsistent finish on the product being sprayed. It is important to remember that, because high solids materials are temperature sensitive, they vary greatly in viscosity with only a small change in temperature.

Heat materials within the ranges specified by the material manufacturer. And, heat materials to the lowest temperature required—below the boiling point of the lowest boiling point solvent. If heat is above the boiling point of material solvents, liquid viscosity may not be reduced as expected. This means that heating a material to higher temperatures would use more energy and could cause a poor finish due to solvent loss.

To maintain the most consistent viscosity, circulation is preferred. A no-flow, dead-end condition can cure or bake the material in the heater, which could cause pressure loss, inconsistent viscosity, poor heat transfer, and, ultimately, complete plugging. Cleaning baked materials out of a heater is a very difficult task.

Equipment Issues

Configure the return line to flow back into the pump foot valve. To avoid heating the material in the drum, do not return the material to the supply container. Heating the material in the drum may cause solvent loss and poor finish quality.

To avoid system rupture, provide a means for the fluid to expand by:

- Using a flexible hose between the heater and the gun
- Properly sizing the accumulator after the heater
- Setting the pressure relief valve at the maximum working pressure of the system

Install heaters on the drop lines to the guns, rather than on the main circulating loop. A heater's capacity may not be able to handle the flow in the main circulating line.

Install the heater as close to the gun as possible, to avoid losing heat between the heater and the gun.

Use a temperature rise versus flow rate chart to select a heater. *Temperature* rise is the difference between the temperature of the material as it enters the heater and its outlet temperature. Operate heaters at lowest possible temperature for maximum heater life. The chart in Figure 11 compares maximum temperature rise to flow rate for a Graco Vis-con2 heater.

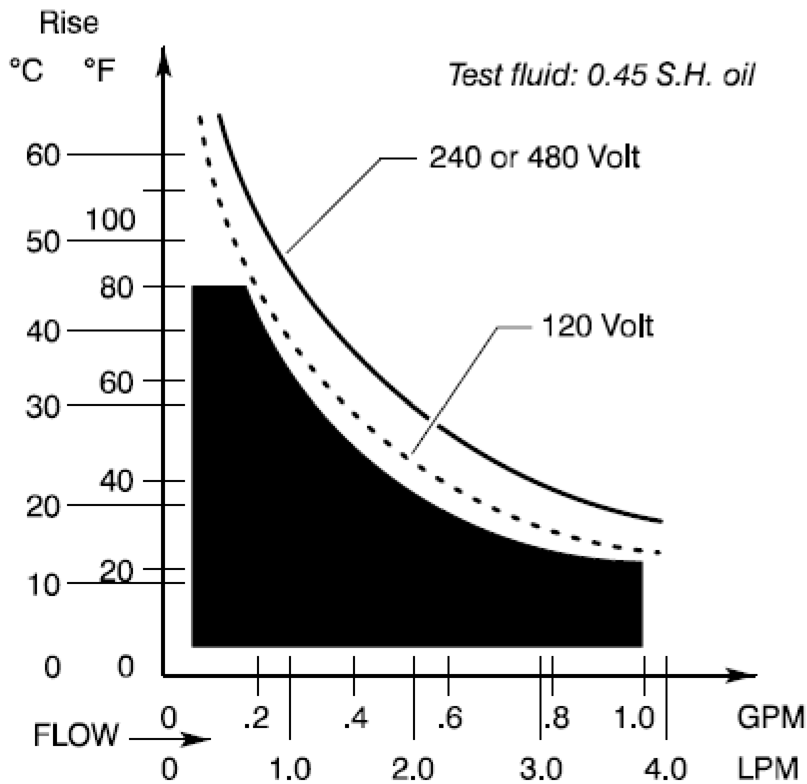

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Figure 11 Shaded area of chart indicates continuous operation capability of one Graco Vis-con^2 heater. Use multiple heaters if customer requirements exceed chart guidelines.

Progress Check

Directions: After answering the following questions, compare your answers with those provided in the answer key following this progress check. If you respond to any items incorrectly, return to the text and review the appropriate topics.

1. Which of the following are factors that impact viscosity?
   a. Particles
   b. Solvents
   c. Temperature
   d. Compatibility
   e. Shear
2. Heat reduces viscosity by causing the fluid molecules to move together, causing the fluid to become thinner.
   a. True
   b. False
3. List five performance factors to consider when selecting a heater.

   ____

   ____

   ____

   ____

   ____
4. Which of the following are installation factors to consider when selecting a heater?
   a. What is the specific heat of the material?
   b. What safety codes does it comply with?
   c. What is its working pressure?
   d. What is its ability to raise temperature?
   e. What voltage is available?

For items 5 through 8, match the heater type with its description.

Heater Type

a. Supply heaters
b. Heated ram plates
c. In-line heaters
d. Line (pipe) heaters

Description

5. These heaters are used in ram systems to help pump certain types of materials. These materials typically must be heated to reduce their viscosity so they can flow and be pumped at the available temperature.
6. These heaters are placed directly in the pumping line. They are termed “high mass” oven-type heaters.
7. Drum heaters (also called band heaters) are examples of these heaters.
8. Heated hose and heat tracing are examples of these heaters.

Answers to Progress Check

1. B, C, E. Solvents, temperature, and shear all impact viscosity; by minimizing changes in these, you can minimize changes in viscosity.
2. B. False. Heat reduces viscosity by causing the fluid molecules to move **apart**, causing the fluid to become thinner.
3. List five performance factors to consider when selecting a heater:

   <u>Capacity</u>

   <u>Overshoot</u>

   <u>Cycling temperature</u>

   <u>Maximum temperature</u>

   <u>Pressure drop</u>
4. B, C, E. Installation factors to include when selecting a heater include: What safety codes does it comply with? What is its working pressure? What voltage is available?
5. B. Heated ram plates (platens) are used in ram systems to help pump certain types of materials. These materials typically must be heated to reduce their viscosity so they can flow and be pumped at the available temperature.
6. C. In-line heaters are placed directly in the pumping line. They are termed “high mass” oven-type heaters.
7. A. Drum heaters (also called band heaters) are common types of devices that heat the supply container.
8. D. Heated hose and heat tracing are examples of line (pipe) heaters.

Suspension Control

Suspension Control Purpose and Methods

Many of the fluids that flow through fluid handling systems contain particles or solids that must be constantly mixed to maintain the fluid's consistency and adhesion characteristics. Examples of these fluids include: high solids paints, metallic paints, zinc-based paints, and coatings.

Suspension control is the process used to help prevent the settling out of the particles or solids found in these fluids. Suspension control is important for two reasons. First, solid paint particles may clog filters and other system components, resulting in damaged equipment or wasted time to clean the system. Second, settling may lead to application problems. For example, in the automotive industry, settling can cause color match problems from one part of a car to another. Suspension control helps maintain the fluid within the system as it was designed by the material manufacturer.

Factors That Impact Settling

Several factors impact the settling out of the particles of a fluid. You must consider these factors and select a suspension control method that will create a fluid velocity that is greater than the settling velocity.

Fluid viscosity. In more viscous fluids, the particles settle more slowly.
Fluid density. In heavier fluids, the particles settle more slowly.
Particle density. Heavier particles (like silica) settle more quickly than light particles (like talc or vermiculite).
Particle size and shape. Small, round particles (like silica) settle more quickly that large, flat particles (like mica).
Percentage of solids by volume. The higher the percentage of solids by volume, the more you need to be concerned about settling.

Initial Mix versus Maintaining

Fluid handling systems include components whose role is to create and maintain mixing so the solids do not settle out. Tumblers, rollers, and shakers provide initial mixing to get a fluid into a homogenous state inside the supply container. Once initial mixing is done and a homogenous mixture exists, that homogeneity must be maintained.

Agitators

Agitators are devices used to create directional flow to overcome gravity and maintain a homogenous mix.

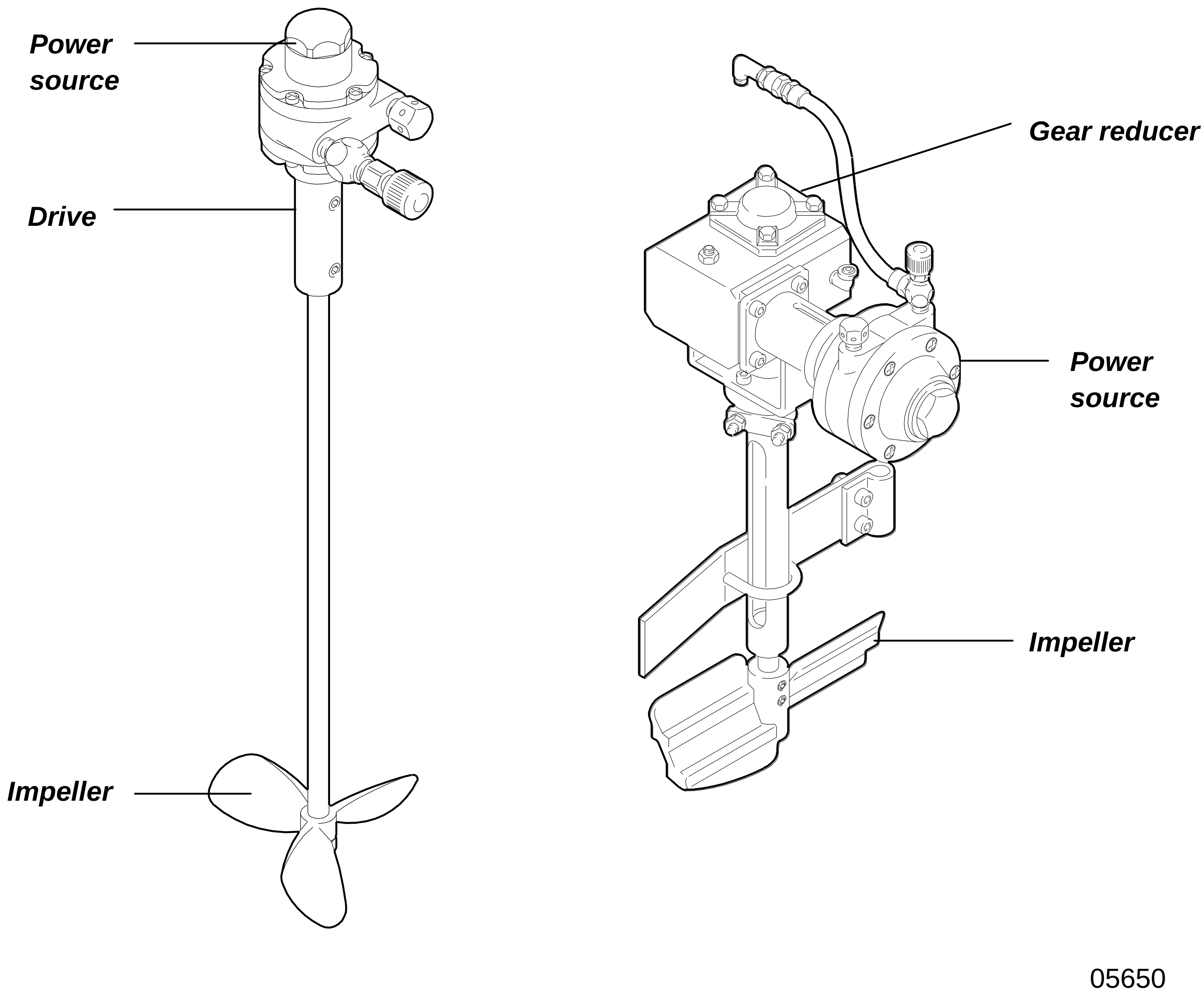

Figure 12 Typical propeller type agitator (left) and agitator with gear reduced drive (right)

Agitator Components

A typical propeller type agitator consists of a power source, a drive mechanism, and impellers.

Power source

A common power source is a vane air motor like the one pictured in Figure 12.

Drive mechanism

In agitators with direct drive mechanisms, the direct drive shaft pinned to the vane motor causes it to spin. In agitators with gear reduced drive (pictured on the right in Figure 12), speed is reduced, but torque is increased for use in more viscous materials.

Impellers

Axial flow, radial flow, tangential flow, and helix blades are available.

Axial flow impellers are the most common and are high speed, direct drive. They are used to agitate fluids up to 2,000 cp. Do not use axial flow impellers in square tanks with flat or concave bottoms.

Radial flow impellers are used with a wide range of material viscosities. They can use tapered blades (also called back swept impellers) with shear sensitive materials like water-borne coatings.

Tangential flow impellers are low speed and operate at close tolerances to a container wall (one- eighth inch to 3 inches or 3 to 76 mm). They are used to agitate high volumes of fluids that are typically less than 1,000 cp.

Helix blades are spiral shaped, auger type blades used with bung port access applications. Their circular motion lifts thick solids from the bottom of the drum to mix and maintain suspension. They can be used with viscosities up to 5,000 cp.

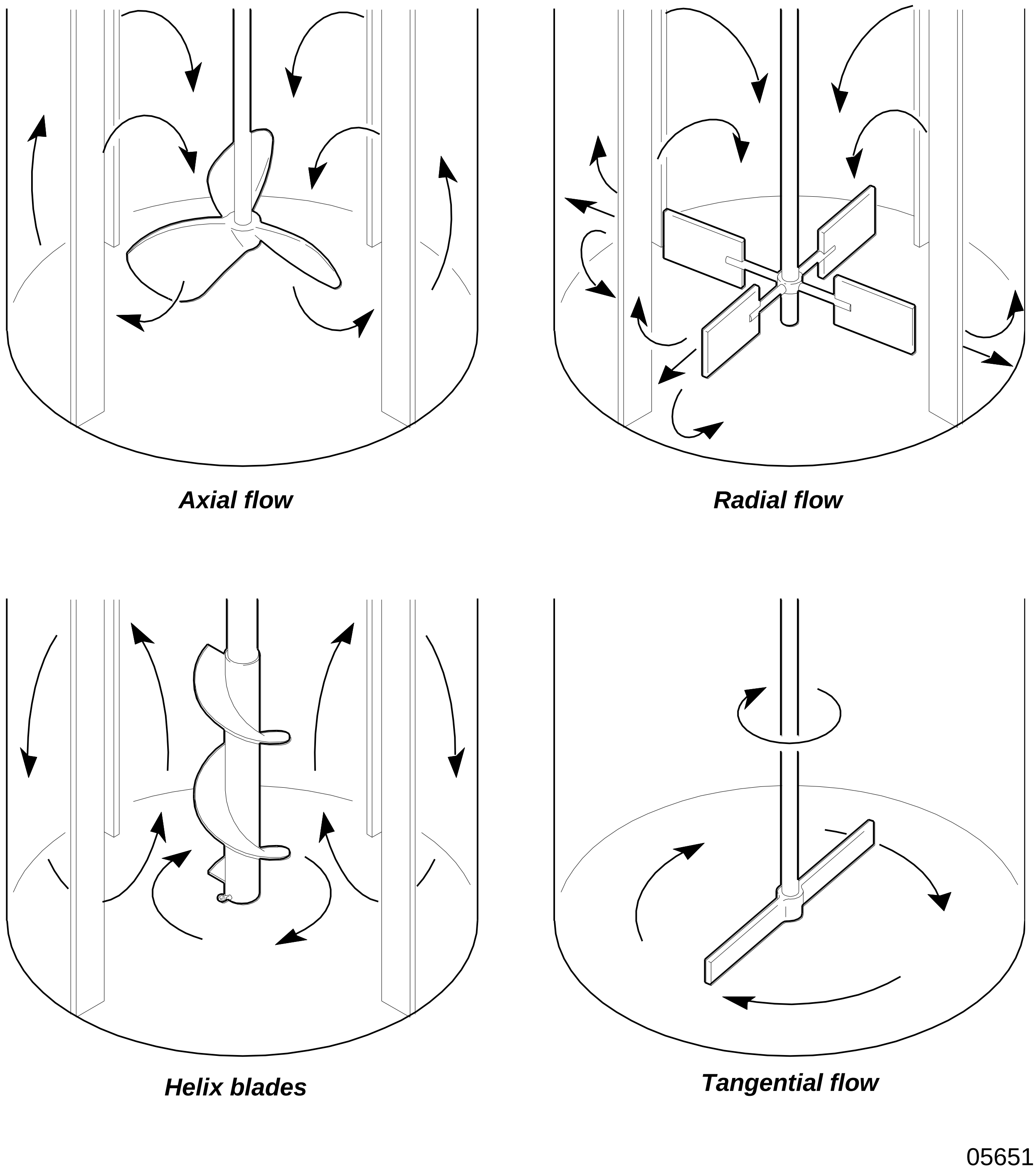

Figure 13 Examples of types of axial, radial, and tangential flow impellers, as well as helix blades

Vortex Flow

One thing to be aware of is, if the agitator speed is too high, a vortex forms inside the supply container. This is a concern because:

- The flow of a vortex tends to be laminar, so effective mixing does not occur. (Turbulent flow is the objective with agitation.)
- A vortex traps air in the fluid and can cause spray guns to “spit” in finishing applications, leading to finishing defects.
- A vortex causes vibration and may damage the agitator. (Materials with abrasive fillers can disintegrate the impeller blade over time.)

Calculating Circulation Flow Rate

After the homogenized fluid is pumped into the piping system, it needs enough flow to create a fluid velocity faster than the settling velocity of the solids. For most solvent-borne coatings, the recommended velocity is 60 ft/min (18.3 m/min) in the main piping system and 30 ft/min (9.2 m/min) in the drops. To calculate the circulation flow rate use this formula:

> 3.11 x inside diameter2 x .7854 = 60 ft/min (18.3 m/min) flow rate

For example, consider an application in which the pipe size is 1-inch outside diameter tubing with a 16-gauge (.065 inch) wall. The calculations for this example would be:

> Step 1. 3.11 x (inside diameter) 2 x .7854
> Step 2. 3.11 X (.87)2 x .7854
> Step 3. 3.11 x .7569 x .7854
> Step 4. 3.11 x .5945
> Step 5. 1.849 U. S. gpm (6.99 l/min)

In this example, 1.849 U. S. gpm (6.99 l/min) is required to achieve a flow rate of 60 ft/min (18.3 m/min).

Progress Check

Directions: After answering the following questions, compare your answers with those provided in the answer key following this progress check. If you respond to any items incorrectly, return to the text and review the appropriate topics.

1. Define suspension control and explain why it is important in a fluid handling system.

   ____

   ____

   ____

2. List at least three factors that impact the settling out of particles of a fluid.

   ____

   ____

   ____

3. Explain the difference between initial mixing and maintaining in a fluid handling system.

   ____

   ____

   ____

Answers to Progress Check

1. *Suspension control* is the process used to help prevent the settling out of the particles or solids found in these fluids. Suspension control is important for two reasons. First, solid paint particles may clog filters and other system components, resulting in damaged equipment or wasted time to clean the system. Second, settling may lead to application problems.
2. Several factors impact the settling out of the particles of a fluid. They include: fluid viscosity, fluid density, particle density, particle size and shape, and percentage of solids by volume.
3. Fluid handling systems include components whose role is to create and maintain mixing so the solids do not settle out. Tumblers, rollers, and shakers provide initial mixing to get a fluid into a homogenous state inside the supply container. Once initial mixing is done and a homogenous mixture exists, that homogeneity must be maintained. Agitators are devices used to create the directional flow that overcomes gravity and maintains a homogenous mix.

Pressure Control

Pressure Control Purpose and Methods

In a fluid handling system, a pump exerts pressure on the fluid in the system to make it flow. Pressure and flow are almost always related in a system. However, factors like viscosity and pressure drop in the system can also impact the pressure-flow relationship. We control fluid pressure to control the flow rate in the system and to meet the customer's requirements for the application quality of an applied material. Several devices exist for controlling fluid pressure in a system, including pulsation dampeners, regulators, back pressure regulators, and pressure relief valves.

Pulsation Dampeners (Surge Tanks, Surge Suppressors)

Surge tanks are the most common type of pulsation dampener. They are frequently used when a customer finds finish quality unacceptable due to pulsation in the spray pattern or when a fluid regulator by itself cannot handle the pulsation.

Surge tanks minimize pressure and flow variation, especially that caused by *pump changeover.* Pump changeover is the point in the cycle of a reciprocating piston pump when the pump stroke changes direction. At that point, the fluid in the pump flows backward momentarily and pressure drops.

Surge tanks store both fluid and pressure that is released at that critical point in the pump's cycle. Air trap surge tanks are used in variety of applications where an acceptable supply of air pressure is available.

Gas charged surge tanks are used where air pressure supply is limited and with moisture sensitive materials. They are available in both a piston and a diaphragm design.

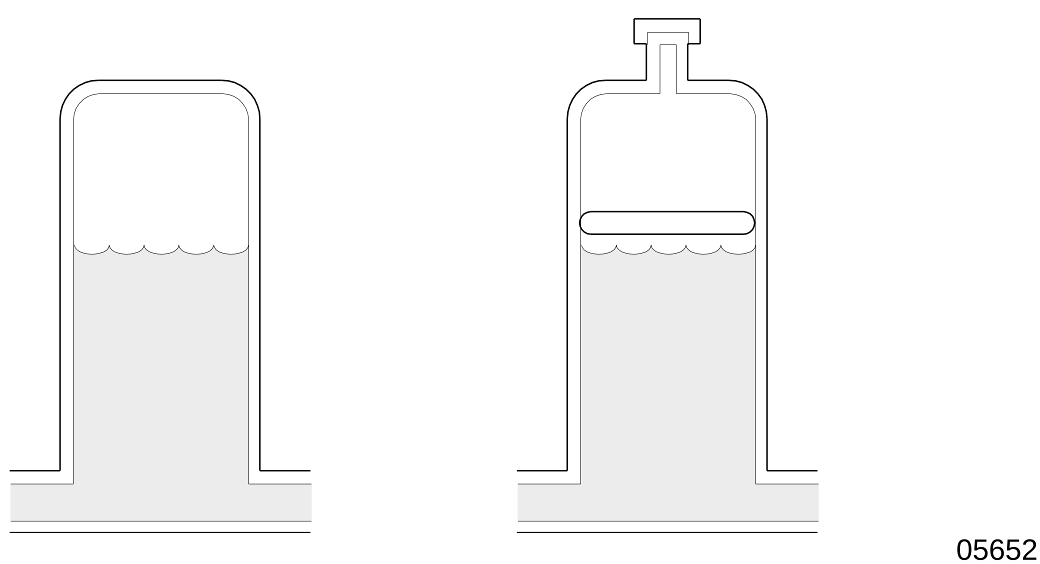

Figure 14 Air trap surge tank (left) and gas charged surge tank (right)

Fluid Regulators

Inconsistent pressures in a system can lead to inconsistent material application. Fluid regulators stabilize and control fluid pressure. They are designed to feed material to the application tool at the proper pressure and to maintain pressure balance within a circulating system. Fluid regulators or back pressure fluid regulators can be used to control gun pressure.

A *fluid regulator* is a self-adjusting valve that senses fluid pressure at the **outlet** of the regulator and holds it constant. As inlet fluid pressures fluctuate (from pump changeover), fluid regulators modulate to allow more or less fluid flow through the regulator to maintain the set outlet pressure.

It is important to note that, unlike surge tanks and suppressors, fluid regulators can only reduce pressure. The desired outlet pressure must always be lower than the lowest inlet pressure for a fluid regulator to work effectively. Conversely, if the inlet pressure is typically more than 50 percent higher than the desired outlet pressure, the regulator will wear out prematurely.

Diaphragm fluid regulators are used in low to medium pressure applications to allow a quicker response and high sensitivity to pressure changes.

Piston fluid regulators are used in high pressure applications. While they are less sensitive, they are more capable of operating in higher pressure ranges.

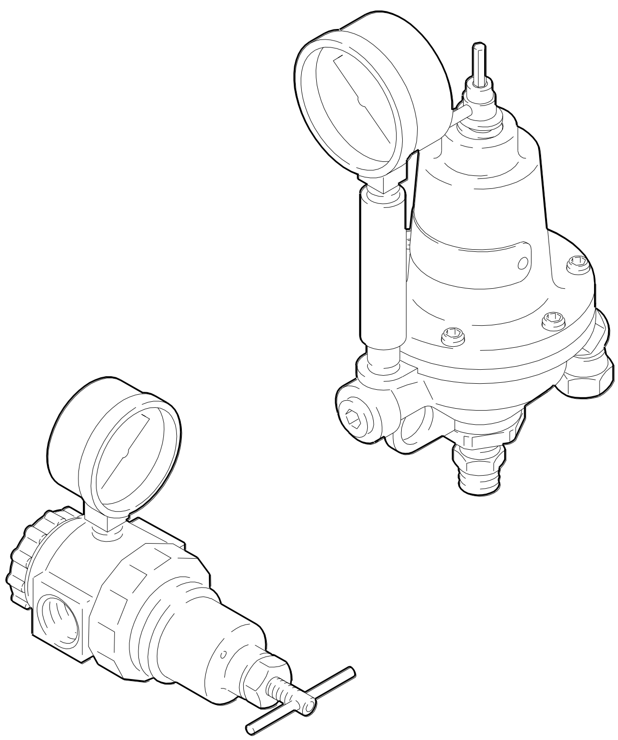

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Figure 15 Fluid pressure regulators stabilize and control fluid pressure in a fluid handling system

Back Pressure Fluid Regulators

Instead of a fluid regulator, a back pressure fluid regulator may be used to stabilize and control the fluid pressure in a system.

A *back pressure fluid regulator* is a self-adjusting valve that senses the fluid pressure at the **inlet** of the regulator and holds it constant. As inlet fluid pressures fluctuate, back pressure regulators modulate to allow more or less fluid flow through to maintain the set inlet pressure.

Diaphragm back pressure fluid regulators are used in low to medium pressure applications to allow a quicker response and higher sensitivity to pressure changes.

Less sensitive, piston back pressure fluid regulators are used in high pressure applications.

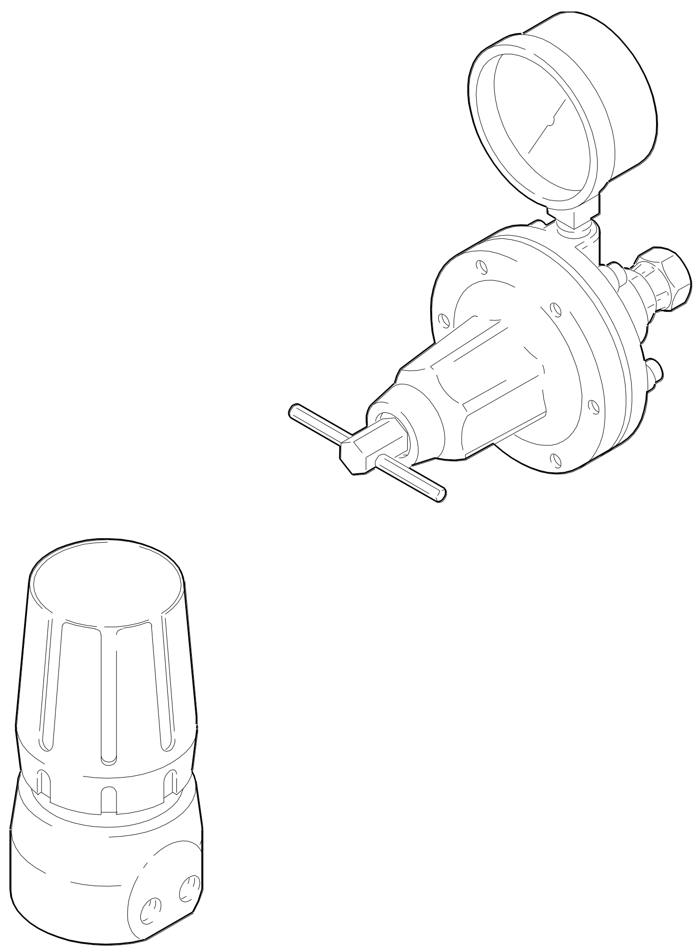

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Figure 16 Back pressure fluid regulators sense the fluid pressure at the inlet of the regulator and hold it constant

Pressure Relief Valves

Pressure relief valves are designed primarily for safety reasons. They protect equipment by venting pressures that exceed a specified level. In a pumping system, this level is usually the maximum working pressure of the lowest rated component in the system.

When pressure rises above a pre-determined pressure, a valve overcomes a spring tension, dumping fluid to relieve the pressure until the system returns to the set pressure.

Both spring loaded valves (which are reloadable) and rupture valves (which must be replaced) are available. Rupture valves are susceptible to false rupture from fatigue on cycling loads such as piston pumps.

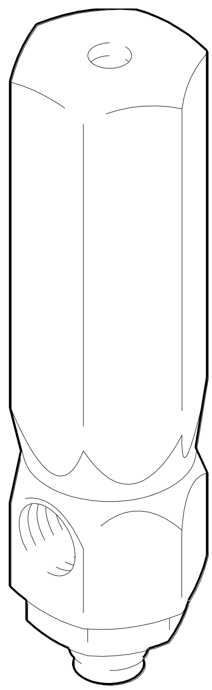

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Figure 17 Pressure relief valves are designed primarily for safety reasons

Flow Control

Flow Control Purpose and Methods

Two factors determine the amount of flow in a system: fluid pressure and the total pressure drop in the system. We control flow in a system to meet the customer’s requirements for the pressure, flow, and application quality. The devices that exist for controlling flow in a system fall into three main categories: on/off valves, adjustable valves, and combination valves.

On/Off Valves

An *on/off* valve is a flow control device with two operating positions: on and off. The valve may be operated manually, activated by a programmable logic controller (PLC), or meters may be used to mea- sure the volume of fluid and to create a package that turns the valve off after the predetermined volume has been delivered. Several types of on/off valves are used in fluid handling systems, including: ball valves, check valves, solenoid valves, and air-operated valves.

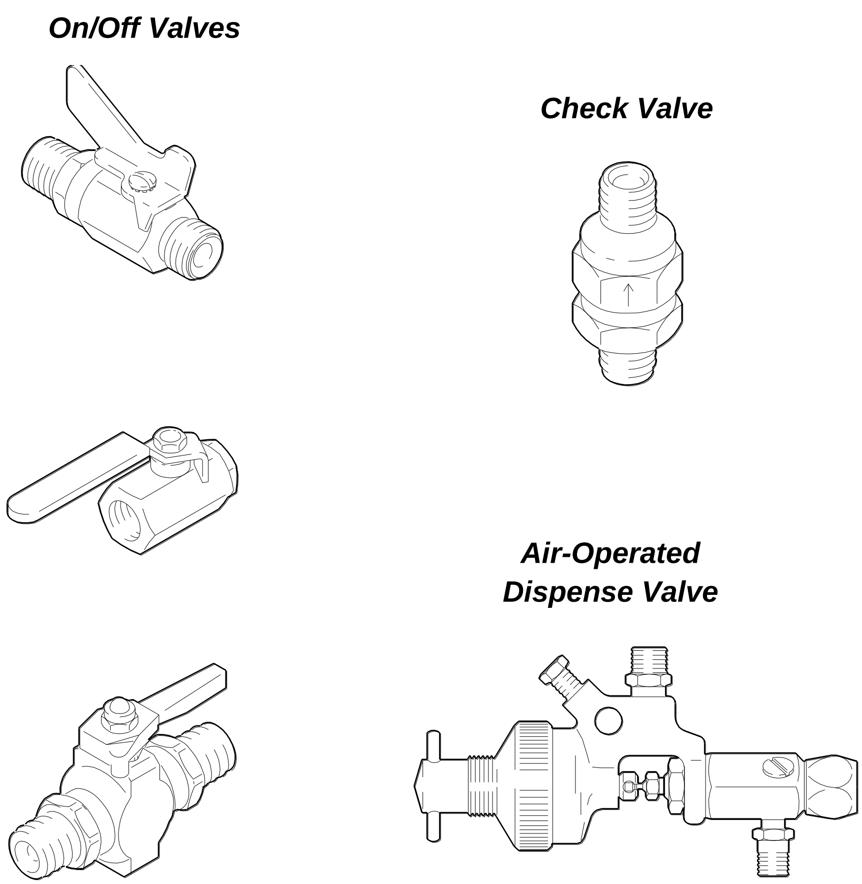

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Figure 18 An on/off valve is a flow control device with two operating positions: on and off

Ball Valves

Ball valves are manually operated valves used to isolate a section of a system that requires adjustment or repairs.

Check Valves

Check valves allow fluid flow only in one direction.

Solenoid Valves

Solenoid valves (also called electronic valves) are electrically operated valves in which an electrical signal controls the on/off. They may be operated by on/off switches, relays, solid state relays, and electronic controls such as programmable logic controllers. Solenoid valves are often used to start and stop the flow of air, as well as some fluids.

Solenoid valves may be used as dispense valves for non-abrasive fluids. For example, dispense valves are used to dispense shots of dielectric material into a capacitor. The lubrication industry also uses solenoid dispense valves to dispense shots of grease into ball bearings. Hot melt guns are another example of solenoid valves.

Air-Operated Valves

In air-operated valves, an air signal is used to turn the fluid valve on or off.

Color change valves are air-operated valves that are designed to allow many of them to be connected together in a system to handle multiple color changes automatically. They are designed for efficient use and for the least amount of wasted fluid. Automatic dispense and spray guns may also be air- operated valves.

Adjustable Valves

Adjustable valves have an infinite number of operating positions for flexibility in a variety of applications. Recall from the previous section on pressure control that pressure and flow are almost always related. Because of this relationship, by controlling flow with an adjustable valve, we also impact system pressure.

Adjustable valves may be adjusted manually by turning a knob or screw, or automatically from a mechanical or electronic controller. This function can be automated with meters and a control device to create a package that adjusts a needle valve to maintain a predetermined flow rate.

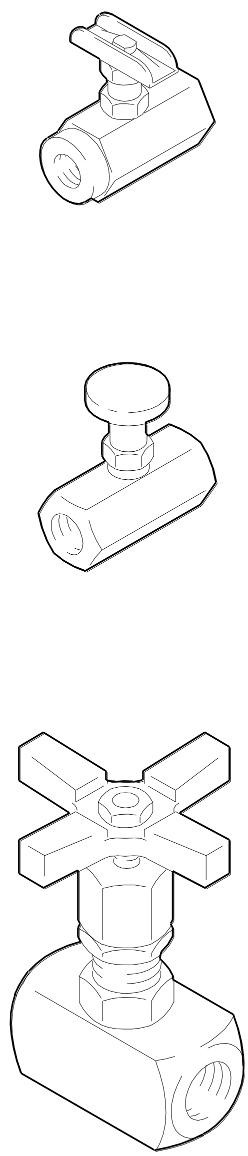

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Figure 21 Adjustable valves may be adjusted manually by turning a knob or screw, or automatically from a mechanical or electronic controller

Manual Adjustable Valves

By manually turning a screw, you can adjust a tapered needle to slide in and out of the fluid stream. Manual adjustable valves are often used to control the flow rate of fluid in a circulating system. Extrusion guns are manual adjustable valves and are often used to lay a bead of material. For example, spa manufacturers use manual needle valves to extrude adhesive from 5- and 55-gallon containers to lay ceramic tile around portable spas.

Automatic Adjustable Valves

A fluid pressure regulator is one example of an automatic, adjustable valve. A diaphragm or spring is used to adjust the valve. In this case, the flow is adjusted to maintain constant pressure. Or, a material manufacturer may use an automatic needle valve to fill tubes of caulking silicone from a 55-gallon container. In this application, a priming piston pump on a ram with heaters would help the flow of the silicone.

Automatic adjustable valves may also be controlled electronically; the valve position is adjusted by a computer, which also monitors the system flow rate. These types of valves are often used in the robotic application of sealants and adhesives in production lines.

Combination Valves

Combination valves can be manually or automatically operated and may be set to be full-on or full-off, or finely adjusted anywhere between full-on and full-off.

One example of combination valves is air spray guns, including high volume low pressure (HVLP) guns and electrostatic guns. Another example is extrusion guns. Window manufacturers use manual extrusion valves to apply caulking material around windows. In automotive assembly plants, automatic extrusion valves apply material that seals the seams between body sheet metal components.

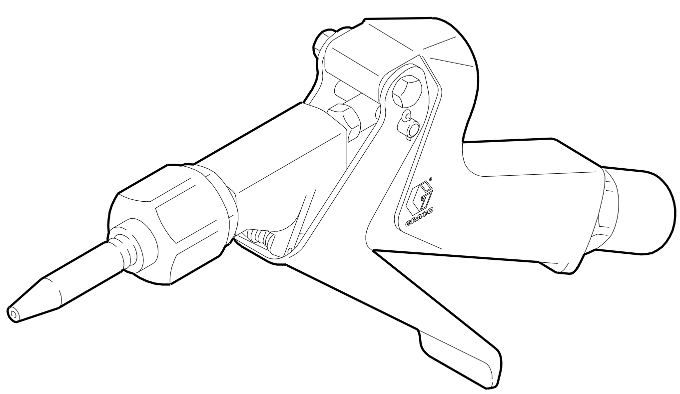

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Figure 20 Extrusion valves are examples of combination valves