Spray Polyurethane Foam Equipment Guidelines

Spray Polyurethane Foam Alliance
4400 Fair Lakes Court, Suite 105
Fairfax, VA 22033
Revised April 2005

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Spray Polyurethane Foam Equipment Guidelines

Preface

The purpose of this guide is to assist those entering the spray polyurethane foam (SPF) business in the selection of application equipment. This guide discusses the equipment components necessary to spray-apply polyurethane foam as well as capacities and alternatives.

Introduction

Spray polyurethane foam (SPF) is the reacted product of two components which are mixed and sprayed to a substrate. The two components are:

“A” Component Ingredient: Polymeric isocyanate (MDI)
Synonyms: Iso

Comments: “A” component will react with moisture in ambient or compressed air to form hard polymerized crystals or flakes. Therefore, equipment handling the “A” component must be designed to exclude moisture.

“B” Component Ingredients: Polyols, blowing agents, catalysts, flame retardants, surfactants
Synonyms: Resin, polyol, R-component

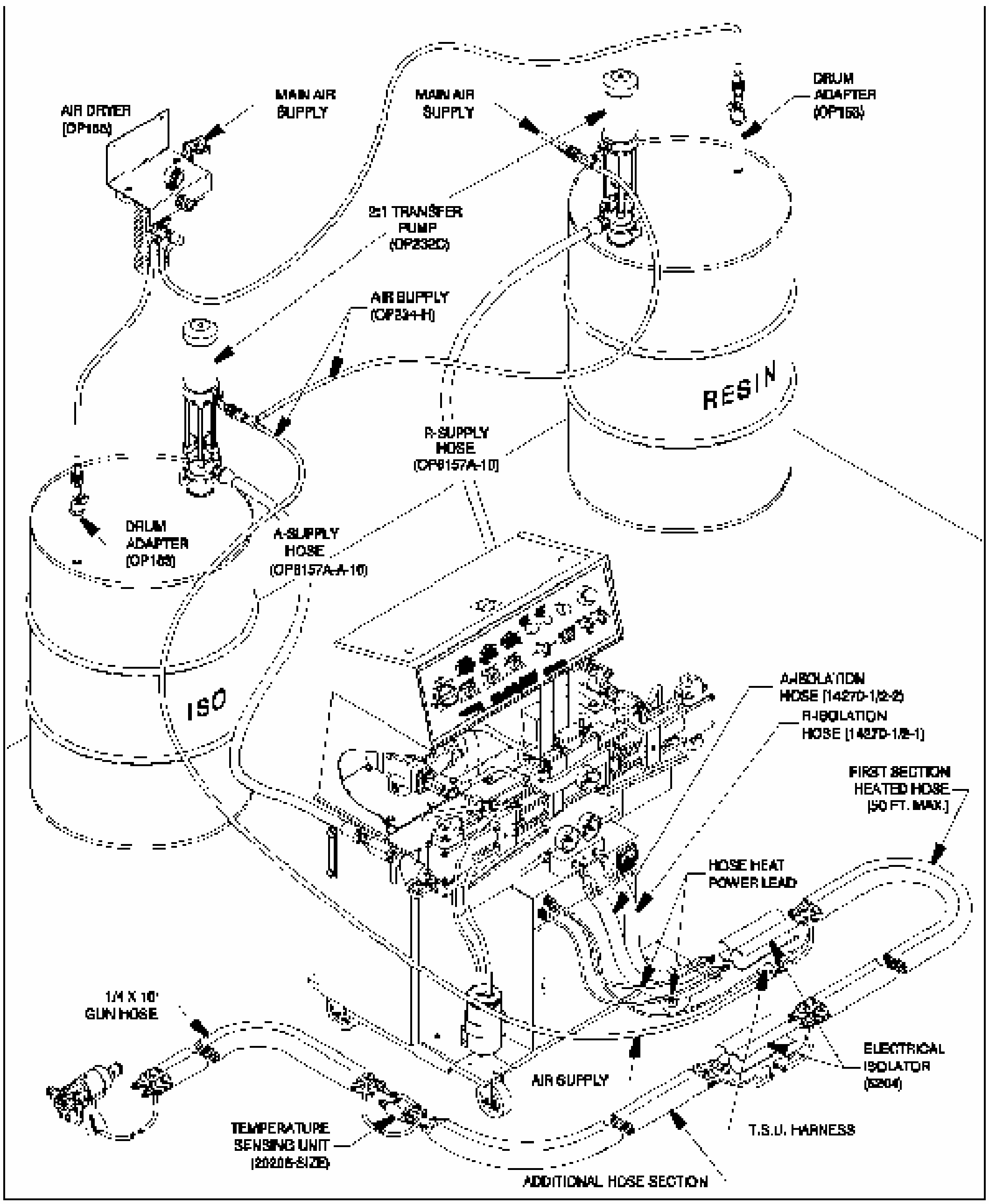
Comments: The blowing agent in the “B” component may vaporize (boil) if the material becomes too hot before application.

In order to properly spray polyurethane foam, the equipment must be capable of storing, pumping, heating, mixing, and spraying these two components at the material supplier’s recommended temperature, viscosity, and material ratio.

In general, five equipment elements are necessary to spray polyurethane foam:

1. Material storage and handling system
2. Material feed system
3. Proportioner pumping/heating system
4. Material Delivery hose system
5. Spray gun.

These elements will be discussed in detail in later sections.



Typical spray polyurethane foam equipment setup
diagram courtesy Gusmer Corp.

Most SPF applicators install their equipment in self-contained trucks or trailers. Auxiliary equipment (such as air compressors, coating spray equipment, and electrical generators) may be mounted in the same truck or trailer. Such a truck or trailer is commonly called a “foam rig.” Foam rigs are normally insulated and heated to keep the “A” and “B” components at their appropriate storage or feed temperatures.

OEM’s (Original Equipment Manufacturers) install their equipment at a fixed location or shop. Whether mobile in a foam rig or fixed in a shop, equipment needs are similar.

It is critical to keep the “A” and “B” components separate until they reach the spray gun. It is also critical that equipment elements designed for one component never be used for the other. To do otherwise will result in plugged and blocked equipment which will cause downtime and costly equipment repairs or replacement. Always plan and design your foam rig to minimize the opportunity to inadvertently misuse the equipment. Color coding your equipment components to match your polyurethane foam supplier’s color coding system will help prevent mixups.

CAUTION: Spray polyurethane foam and coating application equipment operate at very high pressures. Always relieve the pressure before disconnecting or servicing equipment components. Never exceed the pressure rating of equipment components.

Equipment Output

Size your equipment based on the type of projects you expect to undertake. Generally, output is expressed in weight per unit time such as kg/min or lb/min.

Market	Typical Projects	Output Range
Residential, light commercial, light industrial	Residential insulation, small tank insulation, small roof spray adhesive, etc.	Up to 7 kg/min (15 lb/min)
Large residential, commercial, industrial	Roofing, residential insulation, medium tank insulation, large roof spray adhesive, etc.	Up to 14 kg/min (30 lb/min)
Heavy commercial, heavy industrial	Large roofing, large tank insulation, etc.	Up to 21 kg/min (45 lb/min)
OEM (Original Equipment Manufacturer)	Boat floatation, spa insulation, specialty molding, manufactured housing, insulated consumer products	Up to 27 kg/min (60 lb/min)

Once an output range is selected, choose your equipment to meet this requirement. It may be advantageous to select certain equipment elements oversized to allow for future expansion into other markets.

Material Storage and Handling System

The material storage and handling system stores and moves the “A” and “B” components prior to application. The configuration you use will depend on the containers you buy your materials in. Most material is delivered in 55-gallon drums but 5-gallon pails and 275-gallon totes are also available.

The material storage facility must be capable of storing the “A” and “B” components within the temperature ranges specified by the material supplier.

Direct feed from containers

The “A” and “B” components can be fed directly from the shipping containers. In this case, you will need storage on your foam rig or shop for at least a day’s supply of SPF chemical containers. When feeding directly from

55-gallon drums, you will need a drum dolly and perhaps a fork lift to handle the drums. When feeding directly from 275-gallon totes, you will need a fork lift.

Consider positioning drums of "A" and "B" components in different locations of your foam rig or shop to minimize the possibility of accidental drum pump switching.

Feed from tanks

Alternatively, you may use feed tanks or day tanks. These tanks store at least a day's supply of "A" and "B" components and can be filled up at the beginning of each day or the beginning of a project. Feed tanks are typically 250 gallon capacity or larger. Follow DOT regulations when selecting tanks for over-the-road foam rigs.

Extended use of feed tanks may result in the accumulation of material residues. Inspect and maintain these tanks and clean as needed.

Feed tanks should be equipped with the following systems/devices:

A. PRESSURE BLANKET SYSTEM for nitrogen or dry air with a dew point of -45 ^{o}C (–50 ^{o} F). Pressurized systems should include a large diameter pressure gauge with the gauge range not exceeding three (3) times the working pressure of the tank, and a suitable safety relief valve and blanketing gas bleed valve to allow displacement of the inert gas while tank refilling. This system should be mounted remotely from the tank refill port in order to eliminate material splash and possible contamination. Additionally, the pressure gauge, safety valve and inert gas inlet should be positioned well above the bleed valve to insure no contamination due to tank overfilling.

   Tanks requiring pressurization above 80 kPa (12 psig) must be ASME rated. Should additional penetration be made into the tank after ASME certification, the certification is void and the tanks must be re-certified. Pressurization below 80 kPa (12 psig) does not require an ASME certification.

B. MATERIAL LEVEL INDICATORS should be compatible to "A" and "B" component. Design consideration to the vibration of over-the-road movement should be taken. All level indicators should be outfitted with shut-off valves at each penetration and these valves placed in the off position during all over-the-road movement.

C. MATERIAL TEMPERATURE MONITORING and control is vital. A material thermometer located approximately 1/3 from the bottom of the tank is recommended. Penetration of the thermometer into the tank should be not less than 150 mm (6 inches). Should a material temperature heating system be employed, use low wattage heaters to avoid material hot spots. Wrapping of the tank with a low wattage heat trace line is preferred to insure even heat build-up. A high temperature safety cut-off switch is recommended. Avoid using thermostats employing mercury switches in over-the-road foam rigs.

D. MATERIAL REFILL SYSTEMS should have the inlet located to insure no material contamination with the pressure blanketing system. A ½-inch NPT quarter turn ball valve for material shut-off is recommended for maximum material flow with a dip leg mounted inside the tank. Teflon seals for the ball valve will insure minimum maintenance. Check valves should be installed on each tank's inert gas inlet line to avoid mixing of "A" and "B" components in the event of over filling a tank.

E. MATERIAL OUTLET SYSTEM should insure the material feed to the proportioning unit is above the tank bottom. A 2" NPT penetration into the tank is recommended. Material drains should allow drainage of all materials. If the valving for the drain system protrudes below the floor level of the foam rig, a positive shut-off valve as well as a suitable pipe plug is recommended. Additional guarding around the valve is desired to insure no damage due to over-the-road movement.

Material Feed System

The feed system delivers “A” and “B” components to the proportioner at sufficient volume and pressure to prevent cavitation. The feed system consists of (usually) a pump for each component and a hose. Alternatively, the proportioner may be fed by pressure from a feed tank.

When designing your material feed system, make sure it delivers “A” and “B” components to the proportioner at the needed pressure and volume. Typically, proportioners utilize double-acting positive displacement pumps which draw in material at twice the proportioner’s output for half the time. Thus, if your proportioner’s rated output is 14 kg/min (30 lb/min), the minimum output of the material feed system must be twice this or 28 kg/min (60 lb/min).

Proportioners have different feed pressure requirements; check with your proportioner’s manufacturer to determine the minimum and maximum pressure limitations.

Caution: If the material feed system cannot feed “A” and “B” components as required by the proportioner, cavitation will occur causing intermittent off-ratio foam and/or plugged equipment.

Inert gas blanketing

Whether feeding from 55-gallon drums, feed tanks, or 275-gallon totes, always keep a blanket of inert gas (such as nitrogen) or dry air on the “A” component vessel. Moisture in the air will react with the “A” component forming crystals or flakes that will clog equipment strainers. Air dryer canisters are available to insert into the vent bung of the 55-gallon drum or 275-gallon tote; these canisters change color when used up and can be readily changed.

“B” component vessels may require inert gas blanketing to keep the blowing agent in solution under high ambient temperature conditions.

A nitrogen gas blanket can be utilized using a nitrogen cylinder, regulator, and safety relief valve. Take care not to overpressure a drum or tote (20 - 35 kPa [3 - 5 psi] maximum).

Pumped feed from 55-gallon drums

Material in 55-gallon drums can be fed using drum pumps which are inserted into the bung in the top of the drum. Drum pumps are usually air operated.

“A” component drum pumps are usually of a “divorced design,” whereby the fluid and air sections of the pump are separated (“divorced”). This prevents the “A” component from being contaminated from moisture in the exhausting air from the air motor. Divorced design drum pumps normally have a 2:1 pressure ratio (i.e., 100 psig air pressure fed to the air motor will develop 200 psig material output pressure).
“B” component drum pumps may use a 1:1 pressure ratio “in-line design,” where moisture contamination is less critical. Many spray polyurethane foam applicators use a 2:1 divorced design drum pump for the “B” component for commonality of components for maintenance, spare parts, etc. Either approach is acceptable.

Caution: When changing out empty drums, it is frighteningly easy to mistakenly insert the “A” drum pump into a “B” drum (or vice versa). To prevent this: (1) keep “A” and “B” components in different sections of the foam rig; (2) color code the drum pumps, hoses, and valves with paint and/or tape; and (3) fully train your workforce as to the importance of keeping the “A” and “B” components separate.

Pumped feed from feed tanks or 275-gallon totes

Air-powered double diaphragm pumps are commonly used with feed tanks or totes. These pumps usually have pressure ratios of 1:1. The same size pumps are used for both "A" and "B" components. Wetted parts of the "A" component pump are normally aluminum; wetted part of the "B" component pump are normally polypropylene. Diaphragms may be Teflon® or polypropylene. Be sure diaphragm pumps are equipped with anti-stalling air motors.

Pressure feed from feed tanks

Pressurized feed tanks may be used in lieu of pumps to supply the proportioner. However, in using pressurized feed tanks, insure the feed tanks are rated for the intended pressure. Also, make sure all lines and hoses are sized properly for the material delivery requirements of the proportioner.

Material feed hoses

The hoses used to link the feed pumps to the proportioner are normally 100 mm (3/4-inch), 3500 kPa (500 psi) rated nylon-lined, vapor jacketed hose. Hose length should always be as short as possible, yet sufficient to allow ease of transfer pump movment. These are typically available in 3-meter (10-foot) sections and can be fitted together for additional length if required. High capacity applications will require larger diameter hoses.

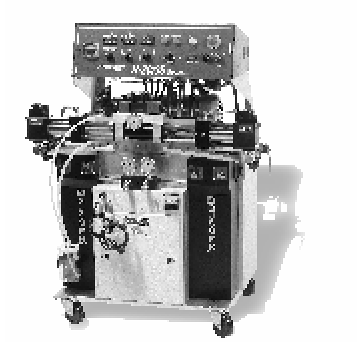
Proportioner Pumping/Heating System

The proportioner/heating system is the heart of the SPF equipment setup. It determines the maximum output capacity of the SPF application system and is designed to accomplish four tasks:

1. Proportion the "A" and "B" component materials in the appropriate feed ratio (usually 1:1);
2. Pressurize the "A" and "B" materials so that they will mix properly in the spray gun;
3. Move the "A" and "B" materials at the desired output to the spray gun; and
4. Heat the "A" and "B" materials so that viscosities allow for proper mixing in the spray gun.

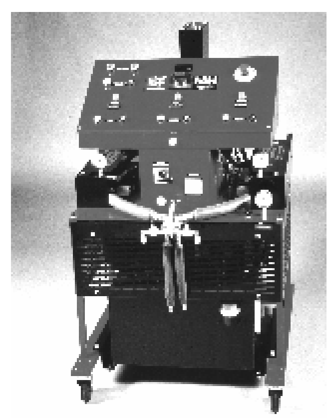
Graco Reaction Proportioner

Photo courtesy Graco



H-20/35 Proportioner

Photo courtesy Gusmer



MH Proportioner

Photo courtesy Glass-Craft

The proportioner

The proportioner commonly consists of two positive displacement, double acting piston pumps with a common drive system. This design assures that the “A” and “B” components will be delivered to the spray gun at constant ratio at high pressure. The piston pumps may be mounted vertically or horizontally.

Proportioners are available in output capacities of 3.5 kg/min (8 lb/min) to 27 kg/min (60 lb/min) and output pressures of 7 Pa (1000 psi) to 11 Pa (1600 psi). The type and size of projects should determine the output capacity of the equipment you select.

Proportioner drive systems may be air, electric, or electric/hydraulic powered. The selection of drive system is largely determined by the output capacity: smaller units tend to be powered by air or electric while larger units tend to be powered hydraulically. Availability of job site services (air or electrical power) may influence your selection. However, most SPF applicators have selected the proportioner based on output and acquired the auxiliary equipment (air compressor and/or electrical generator) necessary to power their unit; this approach allows for maximum flexibility.

All proportioning pumps should be of Teflon® or inert plastic packing design for material compatibility and chromed or hardened cylinders and rods for lower maintenance cost. A wetting cup or lube cylinder is a must for the "A" proportioning pump due to isocyanate reaction with moisture to form hardened crystals. A wiper ring is recommended for the resin proportioning pump due to dirt contamination of the resin film on the proportioning pump shaft and its subsequent damage to the Teflon packings. These lube cylinders or wetting cups should be filled with a plasticizer agent (TCP, DOP, etc.). Lubrication oil is not recommended due to its moisture content and subsequent reaction with the isocyanate material.

The positive displacement pumps of proportioners can develop very high pressure and must be equipped with a safety system to insure that the maximum working pressure of the equipment is not exceeded. Either proportioners are outfitted with over-pressure safety switches which deactivate the drive system or all the components must be rated to safely handle any pressure imbalance that the proportioner could generate.

All proportioners should be equipped with pressure gauges to measure output pressure of both “A” and “B” components. Gauges should be at least 60 mm (2½ inches) in diameter and of the oil-filled type. Gauge range should be twice the operating pressure of the proportioner.

Proportioners are normally supplied with inlet material strainers to remove foreign particles and crystallized isocyanate before it can reach the displacement pumps. These strainers are typically 60-80 mesh.

The heating system

Note: Some polyurethane spray adhesive materials are formulated with lower viscosities so that a heating system is not required.

A heating system is necessary to raise the temperature of the “A” and “B” components in order to lower their viscosities. Without lower viscosities, the materials would not mix properly at the spray gun resulting in poor foam quality.

Material heat is normally supplied in two stages: a primary heater (or pre-heater) and a heated hose (discussed in the next section). Generally, the primary heaters are responsible for heating the “A” and “B” components to their application temperatures while the heated hose is designed to maintain that temperature during application. Most proportioners have a primary heating system built into them. However, some do not and a separate primary heating system will need to be selected. In either case, the heating system operates independently of the proportioner pumps.

Primary heaters are electrically powered. Here the similarity between manufacturers ends. Some primary heaters use electric rods in contact with the “A” and “B” side chemicals (direct contact); others use electric rods to heat plates which in turn heat the chemicals (high mass). Some primary heaters heat both “A” and “B” components in a single heater; some have dual heating units, one for each component. Some primary heaters are manual control while others are automatic.

The crucial factor in selecting a primary heater is the total wattage. Increased material output and increased material temperature rise (?T) require greater wattage. Check with the proportioner manufacturer to determine the wattage you will need for your primary heater based on output capacity and temperature rise.

The material output temperature may be controlled manually or automatic. Manually controlled units require the operator to monitor the output temperature and adjust thermostat to maintain the desired temperature. Automatic primary heaters require the operator to only set the desired output temperature on a controller which in turn automatically controls the electrical input to the heating rods.

All primary heaters should be equipped with high temperature safety switches to prevent over heating of the material.

Primary heaters must be capable of handling the high fluid pressures of the proportioner.

Material Delivery Hose System

The obvious function of the material delivery hose system is to transfer "A" and "B" components from the proportioner to the spray gun. But it does more than this, including:

- Heat the "A" and "B" components within the hoses at the beginning of the day and maintaining material temperatures during SPF application;
- Delivers operating and/or purge air to the spray gun;
- Delivers solvent to solvent-flushed spray guns.

In addition, the hose system (or hose "bundle") must be thermally insulated to minimize heat loss; covered with an abrasion resistant covering to protect the hoses and its electrical components; and constructed of materials to withstand the hydraulic pressures and resist the absorption of moisture (particularly with the "A" side).

The hose system, therefore, is a complicated piece of equipment in its own right and specially designed for spraying plural component materials.

When selecting a material deliver hose system, you need the following information:

- What type of spray gun will you be using? Will it require air for operation and/or purging? Will it require solvent for flushing?
- What type of proportioner will you be using?

  Many proportioners provide electrical feed to the hose system and the hose system will have to be compatible with the proportioner.
- What output capacity (kg/min or lb/min) will you need?

  Material delivery hoses are available in 6 mm (¼") to 12 mm (½") diameters; larger diameter hoses deliver more material with less pressure drop (excessive pressure drop in the hose system will result in poor mix at the spray gun).
- What pressures will you be operating your proportioner and gun?

  Most SPF applications will be below 14 Pa (2000 psi), but special materials may require higher operating pressures.
- What length of hose will you need?

Hose bundles vary in length from 6.5 meters (22 feet) to 15 meters (50 feet), depending on the manufacturer. They may be linked together to extend the hose reach but the total length is limited by the hose heating voltage. 100 meters (300 feet) is typically the maximum length of a material delivery hose system. Smaller proportioners and smaller diameter hoses further limit maximum hose length.

Material delivery hoses are typically equipped with a whip hose at the gun end. Whip hoses are lighter and more flexible than the main hose bundle and eases handling and spraying. Additionally, should a crossover* occur, most likely only the whip hose would be contaminated minimizing replacement expense. Whip hoses come in various lengths up to 4.5 meters (15 feet).

Spray Gun

Fusion Gun
Photo courtesty Graco Corp

GX7 Spray Gun
Photo courtesy Gusmer Corp

Probler2 Spray Gun
Photo courtesy Glasscraft Inc.

The function of the spray gun is to mix the “A” and “B” components and discharge the mixture in a uniform spray pattern. The trick with spray guns is to mix and spray out the “A” and “B” components without the mixed material reacting in or on the gun. Different guns employ different strategies to accomplish this. Elements common to most guns include:

- Hose connection block(s)
- Material shutoff valves
- Material filter screen(s)
- Material check valves
- Mixing chamber
- Spray tip or nozzle
- Trigger
- Air cylinder and piston (except on mechanically operated guns)

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*Crossover: An undesirable mixing of iso (“A”) and resin (“B”) components as a result of unbalanced pressures at the spray gun. May result in an equipment blockage.

Plural component spray guns operate by mixing the “A” and “B” components at high velocity and discharging the mix out the spray tip or nozzle. This “direct impingement” mixing relies on the kinetic energy of the two materials rather than on moving parts. Some guns also employ a static mixer. Mixing requires controlled and constant material viscosities (a function of temperature) and pressures to effect the proper mix and spray pattern.

The material delivery hose is connected to one or two hose connection blocks. The connection block allows for disconnecting the gun assembly from the hose for easier maintenance and safe gun strorage. Connection blocks may have material shutoff valves, check valves (to hinder back flow and crossover), and material filter screens (to remove small particles which might clog the gun orifices).

Most spray guns have “A” and “B” material inlet ports opening into a mixing chamber. The ports are designed so that the “A” and “B” components directly impinge on one another to mix the streams. The mixed material is then forced out a spray tip or nozzle forming a spray pattern. When the gun is “off,” some mechanism of positive material shut-off is employed.

To keep reacted material from accumulating in and on the spray gun, the gun must be equipped with a purge mechanism. Spray guns employ one of the following purge methods:

- Mechanical self-cleaning: A rod or plunger completely fills the mixing areas of the gun physically forcing material out of the gun.

- Air purge: Air is blown through the gun’s mixing areas at high velocity to blow out residual material. Purge air must be dry.

- Solvent flush: A solvent is flushed through the gun at high pressure and velocity to remove residual material. Solvents used for flushing should be non-flammable and leave no residue.

Some guns are equipped with an air purge at the spray tip or nozzle to prevent the buildup of reacted polyurethane on the tip.

Most guns operate with a trigger activated air piston to initiate mixing and spraying. Release of the trigger or loss of air pressure shuts the mixing off. Some guns are mechanically operated and do not require air for this purpose.

Many guns can be modified with internal parts to operate over a broad range of application rates. Additionally, they can be modified to spray a round or flat spray pattern. Consider your anticipated maximum output when selecting a spray gun. Many foam applicators use a low output gun for detail work and a high output gun for production.

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