Current and anticipated coating regulations to reduce atmospheric emissions to protect drinking water systems are pushing tank owners and coating specifiers towards the use of 100% solids-by-volume (SBV) coatings. The majority of the high-solids coatings, whether epoxy, polyurethane, or polyurea, can and in some instances must be applied using plural-component spray equipment. Specialized and complex, plural-component spray units meter and then mix the components of the coating within the equipment or at the spray gun. In addition to being a large investment for a contractor, plural-component equipment requires the contractor to be knowledgeable in its set up, operation, troubleshooting, cleaning, and maintenance. The equipment should be configured to meet the coating manufacturer’s recommendations to help ensure a problem-free application and afford a lining system that will provide long-term performance.

This article will address basic information about plural-component spray equipment, including the types of coatings used, the environmental conditions necessary for successful application and cure, considerations for surface preparation, equipment types and components, and factors affecting application.

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Photo courtesy of JEO and the City of Wahoo, Nebraska
Coating Types Using Plural-Component Application

The following three coating types can be formulated as 100% SBV coatings with little or no volatile organic compounds (VOGs). Each of the three coatings types can be applied using plural-component equipment.

- Epoxy: A two-component material that mixes a base (resin or epoxy) with an activator (catalyst, hardener, or converter).
- Polyurethane: A two-component, fast-set coating formed by reacting (or mixing) an isocyanate with a polyol resin.
- Polyurea: A two-component fast set coating that is formed by reacting an isocyanate with an amine resin.

Environmental Conditions and High-Solids Coatings Application

Generally speaking, the applicator who applies high SBV coatings must know the minimum and maximum application temperature and humidity recommended by the manufacturer of the specific coating. Proper material storage temperatures, ambient and substrate temperatures, and humidity are essential for good film formation and coating cure.

Polyurethanes and polyureas can be formulated for low-temperature applications and can be tolerant of higher humidity; however, applicators must still strictly follow good painting practice. The dew point must be 5 degrees F above the substrate temperature and stable or ascending, and the substrate must be dry when the coating is applied and through initial cure. 2

Generally speaking, epoxies require similar environmental conditions. In the case of amine cured epoxy, the conditions of high humidity and low temperature can cause amine oxidatesanknown as amine blush, to form on the surface of the coating. If it is not removed, amine blush will interfere with the adhesion of subsequently applied coatings.

Temperatures outside the range recommended by the coating manufacturer can also hinder good film formation for all three types of coatings.

Adequate ventilation during coating application and through final cure must be in place to assure proper film formation of high SBV coatings throughout the tank. ANSI/AWWA D102-06 (“Coating Steel Water Storage Tanks”) also states that ventilation shall be used for proper cure of the coating system as well as for worker safety. 3

Surface Preparation

The service life of a coating system depends on the degree and quality of the surface preparation specified and achieved before coating application. Because 100% SBV coatings are formulated to contain no solvent, their ability to wet out the substrate can be diminished significantly. For steel substrates, coating manufacturers typically recommend a more aggressive three- to four-mil (75- to 100-micron) angular anchor profile for single-coat applications. For concrete substrates, a concrete surface profile (CSP) range of CSP3 to CSP5 (per ICRI Technical Guideline No. 03732) is typically recommended when utilizing 100% SBV coatings for single-coat applications. 4

Surface contamination, such as spent abrasive particulate matter or "backside contamination" (generated from contaminants in the metallic abrasive), however slight, will affect the adhesion of 100% SBV coatings. 5 Airborne particulate matter or statically charged ultra-fine particles may impede the process of effectively blowing down the substrate with clean and dry compressed air before coating application. Therefore, vacuuming the substrate may become the only option to achieve a clean and contaminant-free surface.

One possible alternative to the daily cycle of blasting and painting is the use of dehumidification equipment during interior work. Ambient temperatures can be raised or lowered, depending on the particular need at the time, and the humidity can be lowered. The applicator can then perform surface preparation for a few days longer, spend adequate time to clean the substrate, and let airborne contaminants settle out, thus reducing the risk of poor coating adhesion.

Equipment Types and Requirements

Two basic types of plural-component equipment are available today: mechanical proportioners, or fixed ratio (Fig. 1) 6 and electronic proportioners, or dosing units (Fig. 2). 7 The two equipment systems function basically the same. The coating components are fed to the proportioner (the pump), circulated and heated, proportioned at the proper mix ratio, mixed, and then spray applied.

Coating manufacturers, however, may have special needs for the application of
their coatings that require modifications or additions to the standard equipment configurations. If the equipment manufacturer does not have the means to modify the equipment to meet the coating manufacturer’s needs, the equipment maker should be able to direct the coating applicator to an approved distributor or supplier that can.

The coating manufacturer should be contacted regarding the specific equipment requirements for the application of its material. In some cases, applicator training may be necessary before the coating manufacturer will feel comfortable with an applicator purchasing and applying the coating. When an applicator needs equipment training, the equipment manufacturer should be contacted. Seldom, if ever, will a coating manufacturer assume responsibility for the actual operation of the equipment system used to apply its coatings.

**Equipment Components**

The individual components in a typical plural component setup are the feed system, heating system, proportioning system (mechanical or electronic), circulation system, hose bundle, mixing system, and spray gun.

**Feed System**

Whether supplied in five-gallon (19-liter) containers, 55-gallon (208-liter) drums, or tote tanks, the coating components will need to be transferred and fed to the proportioning unit. A variety of feed pumps come in a wide range of configurations and gallon per minute (GPM) outputs that will ensure that the proportioning unit has a sufficient volume of each of the coating’s components to provide the proper mix ratio (Fig. 3). An improper feed pump GPM rating, in conjunction with an improper pressure setting (either of which is too high or too low), can cause improper feeding of the proportioning unit. Off-ratio coating can result.

Two ways to help prevent improper feeding are as follows: make sure that the GPM output of the feed pump is twice the amount of the GPM output of the proportioning pump or spray tip, and do not let the feed pump pressure exceed 20% of the proportioning pump pressure.

The equipment feed system should also include material agitators (Fig. 4). There is, however, one concern to be aware of: polyurea and polyurethane coatings both include an isocyanate component, which under most circumstances is not agitated, due primarily to its sensitivity to moisture and secondarily to its viscosity. Excessive agitation, regardless of the generic composition of the material, can also force air to become entrained in the material (resulting in air bubbles or foaming), which can cause the proportioning system to give improper material ratios. Desiccant filters may also be required on material containers, especially those holding an isocyanate.

**Heating System**

Material heating requirements vary with each product. The time of year and geographical location of the job also affect how well one can achieve and then maintain the proper temperature for material
application. In colder regions, for instance, heating, circulating, and maintaining the material temperature will require more time, labor, and heating equipment than in warmer regions. Heating equipment setups can include double wall heated material tanks, 55-gallon drum heaters (or 5-gallon bucket heaters), in-line heaters mounted on the proportioning unit, and hose-bundle heat systems (Figs. 5–9). Double-wall heated tanks normally have a water and antifreeze mixture that is kept at the desired temperature by separate thermostatically controlled heaters within the double wall of the tanks. Heat for an insulated paint hose bundle can be provided by either an electric heat trace (similar to the type used to prevent residential water pipes from freezing) or hollow tubing for circulating hot water from a small heated tank through the tubing by means of a circulation pump. Either way, the intent of providing heat to a paint hose bundle is strictly to help maintain material temperature from the pump to the spray gun. Either setup should have thermostats to control the temperature. The high-solids content and sometimes significantly high viscosity of some materials may require a combination of heating methods. When thinking about heating, another requirement for consideration is a source of electricity that will provide adequate amperage.

Proportioning System

With mechanical proportioning systems, the material ratio is set and maintained by the inside diameter of the fluid cylinders and/or the number of fluid cylinders. Through the mechanics of the proportioner, all the fluid cylinders stroke at the same time. To change the material ratio, the inside diameter and/or the number of fluid cylinders must be changed.

Mechanical proportioning systems can handle materials mixed by static mixers and applied with standard airless spray guns, as well as polyureas that require application using impingement mix spray guns. Most mechanical proportioning systems can be configured to achieve a maximum pressure rating ranging between 3,500 psi and 5,000 psi (241 and 345 bar).

Mechanical proportioning systems have a ratio tolerance range of 2%, fewer sensors and valves than electronic proportioners, and one air motor.
Recording. However, electronic proportioning systems have more sensors, valves, and switches, as well as a higher ratio tolerance range of 5% (i.e., more to keep track of, more to go wrong). In addition, the pump mechanic must have more comprehensive troubleshooting skills than those required for mechanical proportioners.

Circulation System

The circulation system for plural-component equipment moves the separate components of the coating material from their heated material containers through the proportioning pump and inline heaters, through the paint lines in the heated hose bundle, and then back to their heated material containers. In the field, the process is referred to as the “recirculation mode.” The material is circulated using a combination of feed pump pressure and proportioner pressure. By monitoring and adjusting the heat of the material container, the inline heaters on the proportioner, and the hose bundle heat, the material that is being readied for application can be brought to a uniform and consistent application temperature throughout the entire plural-component system, as the material manufacturer recommends.

If the material is too cold, it may not feed the proportioner effectively, thus causing the proportioner pressure to

Due to the limited number of moving parts, troubleshooting equipment problems can be less complicated than with electronic proportioners. As with any type of equipment, however, there are also disadvantages. With mechanical proportioning systems, changing the material ratio can be difficult because the equipment must be shut down and cleaned. The fluid cylinders must then be removed from the proportioner, and the correct number or size of fluid cylinders must be installed. Fluid pressure gauges must be monitored at all times to ensure a balance of pressure between the fluid cylinders, or off-ratio material will be applied. The pump mechanic must know troubleshooting procedures that require interpretation of differences in fluid gauge pressure.

With an electronic proportioner, material ratio is set and maintained electronically through metering valves (Fig. 10). The proportioner is made up of two air motors that run separately from each other, with each motor driving its own fluid section. The material ratio is changed electronically rather than mechanically.

Electronic proportioning systems are not recommended for materials such as polyureas because they require application using an impingement mix spray gun. Most electronic proportioning systems can be configured to achieve a maximum pressure rating ranging between 3,500 and 7,250 psi (241 and 500 bar).

Electronic proportioning systems can offer advantages such as the ability to easily change the material ratio, electronic monitoring of the proportioning pumps and metering valves, automatic system shutdown when an error is sensed, error reporting, and data

![Fig. 7: Bucket band heater](https://example.com/fig7.png)

Fig. 7: Bucket band heater

Courtesy of Tnemec

![Fig. 8: In-line heating systems](https://example.com/fig8.png)

Fig. 8: In-line heating systems

Courtesy of Graco (left) and WIWA (right)

![Fig. 9: Hose bundle heat systems](https://example.com/fig9.png)

Fig. 9: Hose bundle heat systems

Courtesy of Tnemec

![Fig. 10: Electronic (dosing) system](https://example.com/fig10.png)

Fig. 10: Electronic (dosing) system

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be set too high to compensate for the cold material and increased viscosity. Therefore, a properly functioning heating system can be considered vital to the application. Attempting to force material that is not properly heated through the equipment could have an undesirable effect on the application, such as an off-ratio material or improper spray atomization of the material.

Occasionally, the recirculation mode may not include the material in the hose bundle paint lines. Instead, after going through the proportioner and then the inline heaters, the material goes directly back to the heated material containers. When it is time to apply the coating, the material in the paint lines that is not at the proper temperature is discarded due to an inability to obtain a good spray pattern and proper atomization.

Hose Bundle
The hose bundle typically comes in 50-foot (15-meter) lengths and includes the paint lines (one for each material component), a solvent purge line, a hose bundle heat source (i.e., an electric heat trace or hot water tubing), hose bundle insulation (for retention of hose bundle heat), and a solvent-resistant protective hose bundle cover. Recirculation lines in the hose bundle may be a standard feature or may need to be specially ordered. To maintain proper material ratios, the inside diameter of the individual material component hoses may need to be offset (e.g., 7/8-inch diameter for the base component and 3/8-inch diameter for the activator component). The inside diameter of the material hose will vary from one product to another, depending on the material's individual component viscosity and the material mix ratio, and on whether the atomizing pressure between the two components can be balanced.

Mixing System
Polyurea is applied using an impingement mix spray gun (Fig. 11). The spray gun is attached directly to the end of the hose bundle with a special adapter. In the event of a spray gun malfunction, check valves inside the spray gun will stop a crossover of material back into the paint lines, which would result in premature mixing of the components, and limit the problem to the spray gun. Located at the front of the spray gun, a mix module mixes the material together, while the fluid tip controls the fan pattern and supplies the proper amount of material. To prevent clogging of the mix module, material screens in the spray gun filter the material. The coating manufacturer should recommend the mix module and tip size, which must be paired together to obtain the proper mix.

Coatings that are not applied with an impingement mix spray gun use a different type of setup that starts with a mix manifold (or block) with internal check valves, which is attached to the end of the hose bundle (Fig. 12). The mix manifold will have an assortment of fluid valves and should, but may not always, have material heat and fluid pressure gauges. The setup includes fluid valves for the solvent purge system, separate material component fluid valves that are connected by a bar and are referred to as the "dual control valve," and, if the hose bundle is so equipped, material component fluid valves for material recirculation lines.

The material line from the mix manifold to the spray gun can be configured in several different ways, depending on the coating's generic composition and the recommendations of the equipment and material manufacturers. This portion of the system can consist of one or more static mixers (Fig. 13), an integration line, a whip hose, and an airless spray gun (Fig. 14) with an appropriate spray tip.

Static mixer size is designated by inside diameter measurements—the most common, ¾ and ⅜ in.—and by the number of "folds"—the most common,
Personnel at the Atlanta Braves Spring Training Facility at Wide World of Sports Disney in Orlando, Florida realized that a membrane between the 125,000 square-foot stadium’s structural concrete slab and the topping slab had failed in spots. As a result, water had seeped through cracks in the concrete and started to damage the superstructure. They needed an expert team to develop a winning game plan.

Our vision for a waterproof topcoat built on polyaspartic resin technology from Bayer MaterialScience was a home run. The polyaspartic color topcoat was applied to a new external membrane installed above the concrete topping. Once applied, it provided a high film build to develop the waterproof coat needed to protect the stadium’s structural concrete from further water damage. It’s exceptionally durable, protecting the external membrane from wear or damage due to heavy cart and foot traffic from thousands of fans.

Initial performance tests conducted during the first four-and-a-half years of service have indicated that the polyaspartic color coat will outperform traditional polyurethane coats. It will retain its sheen much longer and will be easier to clean.

Plus despite a late start, the coating was applied quickly and dried fast . . . just in time for the year’s 400 professional and little league baseball games.

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At Bayer MaterialScience, vision works. All it takes is the know-how to transform that vision into products you can use.

R · O · I, acronym, **Return On Investment**: profit made from a purchase, i.e. “5 years of operation with nothing more than oil changes, one transfer hose, and some vacuum filters. Hard to beat that for simple and cost-effective.”

*Jim Cannon, Allied Painting Inc.*
The folds of a static mixer are the concave blades that mix the two pressurized material components together as the materials pass through the blades. The greater the number of folds, the more thoroughly the material is mixed. Stainless steel static mixers are usually preferred over plastic static mixers, which can be damaged more easily. Should the plastic static mixer be damaged, the applied material may not be mixed adequately. (Contractors should have spare static mixers on hand). Static mixers are directional and must be positioned with the flow arrow pointed toward the spray gun. The inside diameter, number of folds, and number of static mixers required should be recommended by the coating manufacturer.

An integration line, if required, begins combining the two coating components through the friction created by material flow through the line before the components flow through the static mixer(s), ensuring that the coating is thoroughly mixed. The airless spray gun should be rated for the proper pressure range and be the proper type for the application of high-solids material. In addition, the spray tip should be sized in accordance with the material manufacturer’s recommendations.

Generally, the solvent purge system is comprised of an electric or air-driven high pressure solvent pump and a dedicated paint line from the solvent pump to the mix manifold (Figs. 15–16). The mix manifold should include a primary solvent purge shut-off valve and a separate shut-off valve for each side of the mixing block. The solvent pump must be capable of delivering enough solvent under sufficient pressure to purge mixed material from the integration line, whip hose(s), static mixer(s), spray gun, and spray tip.

Determined by the coating manufacturer, material purge time can range from several seconds to a minute or longer. Failure to purge mixed material in time can result in the coating setting up and the loss of that portion of the equipment from the mix manifold to the spray tip.

Factors Affecting Application

Many factors can affect the application of high SBV coatings. Some of these factors have been discussed, and others will be determined after job specifics are known. Take, for example, the earlier discussion of substrate cleanliness. Persons familiar with the lining of potable water storage tanks can recognize that, often, abrasive residue is left on lower portions of the tank to protect those surfaces from overspray and is then removed prior to coating application. If spent abrasive residue is removed from the tank before painting and the substrate is cleaned to a degree that will minimize or reduce airborne particulate matter during the application, then the substrate should be covered with visquene or clean tarps to prevent the accumulation of overspray. With 100% SBV coatings, the amount of overspray generated can be significantly more than that generated by conventional thin-film epoxy and can be difficult to remove from a prepared substrate before the coating is applied.

Another consideration, this one regarding equipment usage, pertains to cross contamination of the plural-component equipment. Most equipment manufacturers recommend that plural component equipment remain dedicated to a particular generic coating type. Thus, plural component equipment for epoxy coatings should be dedicated to epoxy coatings, with the base (resin or epoxy) always on the same side of the proportioner and the activator (catalyst, hardener, or converter) always on the opposing side. Switching sides on the proportioner with material components when any residual material is left in the system from the last application can cause a very large and very expensive equipment problem.

With polyurethane or polyurea mater-
ial, this recommendation should be the same. What might happen if plural-component equipment used regularly to apply an amine-cured epoxy was brought to the next job to apply polyurethane? Before leaving for the next job, the plural-component equipment setup is flushed, but a residual amount of material is left in the fittings and miscellaneous hoses in the system. At the next job, the isocyanate portion of the polyurethane material is run through the right side of the proportioner, the same side where the amine portion of the epoxy system was run on the previous job. Enough amine residual in the system combined with isocyanate yields a chemical reaction similar to that of polyurea components. Again, the end result will cause a very large and very expensive equipment problem.
Conclusion
Much more information is available on the use of plural-component equipment with high SBV coatings. However, the intent of this article is not to provide readers with a "how-to" manual but to provide a basic understanding of plural-component equipment and how it is used to apply coatings. Remember, the most important starting point is to open communication among the applicator, equipment manufacturer, material manufacturer, and specifier to help ensure a problem-free application and afford a lining system that will provide the expected long-term performance.

References
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