Tri-Blender®
Principles of Operation

Introduction

The purpose of this booklet is to help those who apply and use the Tri-Blender understand its principles of operations. With these principles the blender can be utilized to the fullest.

Basic Operation

The Tri-Blender basically consists of a centrifugal pump head and impeller mounted so that the normal suction port, or inlet, is pointed upward (see illustration 1). The inlet piping consists of a patented tube-within-a-tube arrangement. This serves to keep the liquid and dry ingredients separated until they are in the mixing chamber. This tube-within-a-tube arrangement eliminates one of the major problems of wet-dry mixing, that of prewetting.

The natural suction of a centrifugal pump is used to pull the powder from the hopper through the diffuser tube.

The outer tube is used to direct the liquid into the impeller. The liquid is introduced at the leading edge of the impeller blades where the pressure gradient of the Blender head is zero (see illustration 2). Since there is no suction at this point, liquid must be pumped to the blender by external means, such as the supply pump (see illustration 3).

The liquid inlet is mounted tangentially. The liquid entering the blender mixing chamber enters the chamber tangentially, in the same direction the impeller is rotating. The impeller then strikes the liquid and accelerates it, with a minimum of splashing. This is how the powder inlet tube can be kept dry during operation (see illustration 4).

Should excessive splashing occur or the inlet tube plug up, the first thing to check are impeller rotation and proper inlet tee installation. To check for proper tee installation, trace an arrow in a continuous path from the inlet to the outlet, without reversing direction (see illustrations 4 & 5).

In operation, the liquid being pumped into the blender is accelerated outward until it strikes the blender screen. This creates a natural back pressure that causes the liquid to flow downward and back toward the eye of the impeller (see illustration 6). This forms a hollow envelope into which the powder is introduced by the natural suction of the blender. When the blender is operating properly the inlet tube is dry.

If the hollow envelope collapses inward problems may occur: "Prewetting" which can cause lumps in the product and/or "wetout" which can cause plugging of the inlet tube.

Illustration 1

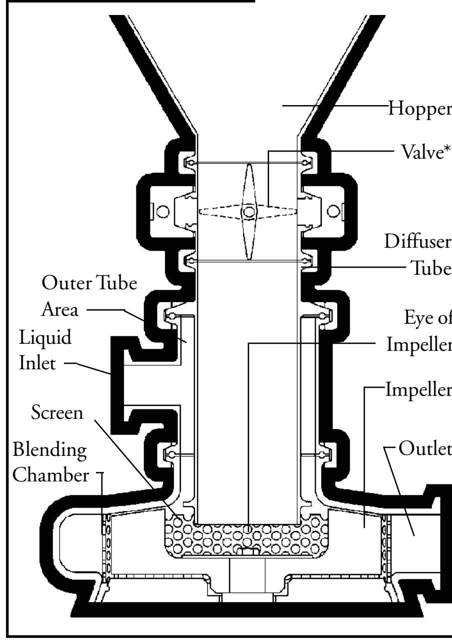


Illustration 2

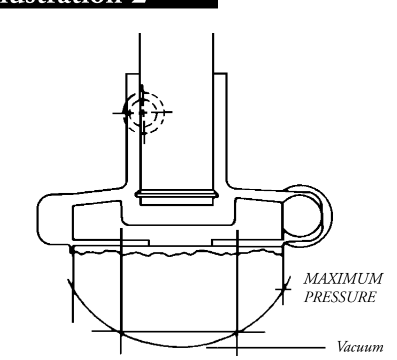
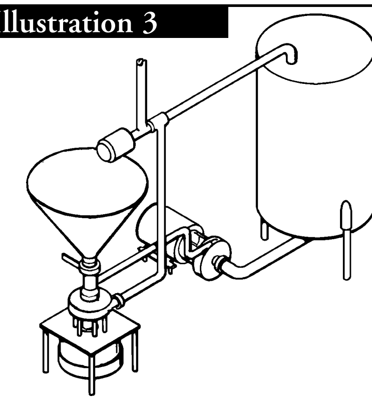


Illustration 3



**Valves meeting 3A standards, also available*

Illustration 4

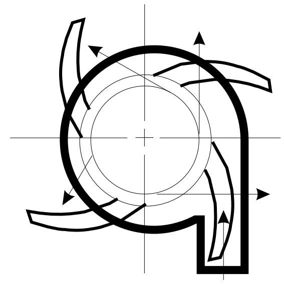


Illustration 5

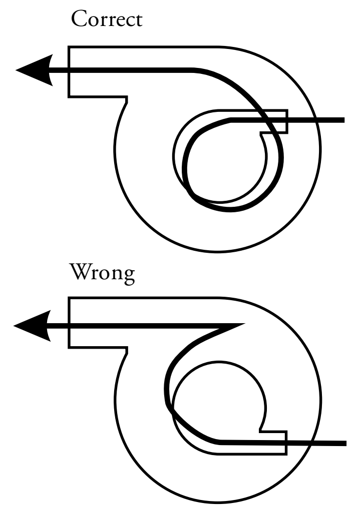
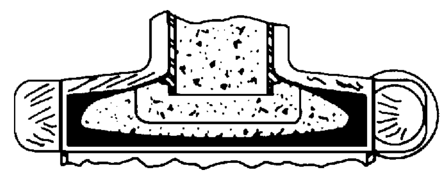


Illustration 6



Reasons why "prewetting" and/or "wetout" may occur.

1. **Inlet flow:** Too much flow or high an inlet pressure will cause the envelope to collapse because the blender cannot pump the liquid away fast enough. It is also possible to have too little flow which results in a dry blender. This is evident when powder builds up on parts of the impeller because the envelope did not form at all.

2. **High Viscosity:** This causes a natural back pressure and the added back pressure caused by the screen may be too much. On higher viscosity products, the screen is normally removed.

3. **High Discharge Pressure:** This may be caused by too small a discharge line, too long a discharge line or too high a viscosity.

The solution to these problems is proper line sizing and the addition of a discharge pump. Even though the Tri-Blender is basically a centrifugal pump, its pumping ability is limited if it is going to do a good job blending. As the back pressure increases in the blender, the hollow envelope is forced to collapse, which reduces its ability to blend ingredients with liquid.

Powder addition rates are difficult things to predict because there are so many variables involved. Some of the more important ones are:

1. Flowability
2. Moisture content
3. Humidity
4. Fat Content
5. Microscopic texture (smooth, rough)
6. Fluidity (amount of air in the product)
7. Density
8. Type of powder (granular, flake, fine,coarse, etc.)

Vacuum is one variable over which there is some control. The amount of vacuum formed in the blender is largely dependent on the flow and temperature.

A graph of vacuum versus flow is shown in illustration 7 for the three blenders.

Flow and sizing of the auxiliary supply and discharge pumps is very important for proper operation of the blender.

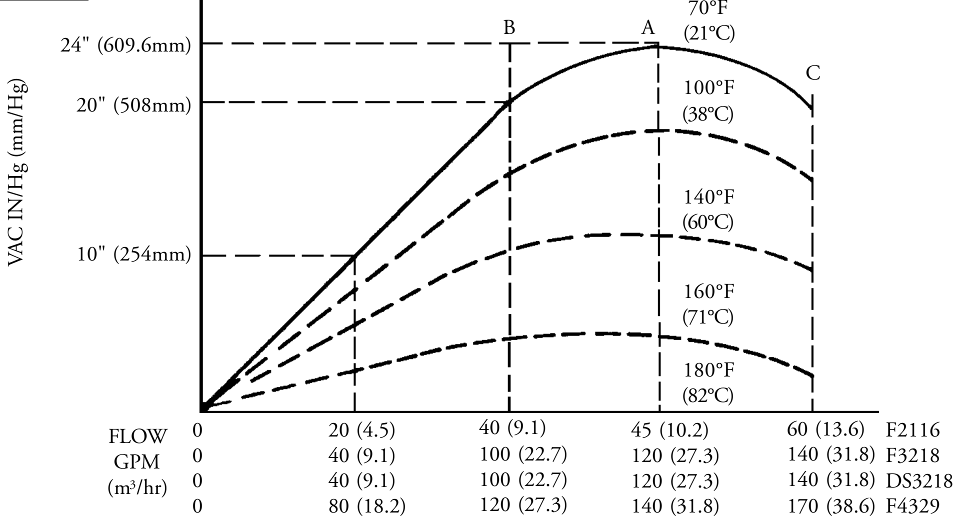
Pumps are sized to maintain recommended flow at final viscosity. In centrifugal pump systems the desired flow, before addition of powder, is between Points A and B, as shown on the graph. Flow should never exceed the upper limit, Point C on the graph. Point C is where the horsepower requirements of the blenders will be exceeded.

If the flow would drop below Point B at final viscosity, a noticeable drop in addition rates will occur. To correct this it will be necessary to use positive supply and discharge pumps. This approach assures a uniform flow rate regardless of viscosity increases.

When positive pumps are used, the flow rates are not necessarily those which would give maximum vacuum by the graph. By running the discharge pump faster than the supply pump, the vacuum formed by the discharge pump can be used to increase the vacuum in the blender. The advantage of this is that smaller, less expensive positive pumps can be used to accomplish the same purpose.

The graph also shows the effect of temperature on the blender vacuum. It has been found that the maximum practical limit for aqueous products is 140°F (60°C). Above 140°F (60°C) the water will vaporize rapidly because of the high vacuum. Vaporizing rapidly enough to seriously effect the vacuum as well as

Illustration 7



"wetout" the internal surfaces. This "wetout" could cause a buildup of powder that will plug up the inlet tube. Temperature in excess of 160°F (71°C) can actually cause "blow back," air will come out of the hopper through the powder. At 180°F (82°C) there is a complete loss of vacuum.

Non-aqueous solutions may have different temperature limits depending on the vapor pressure of the liquid.

Pump Sizing

The sizing of the supply and discharge pumps is very critical to the operation of the blender and, in many ways, more important. The addition rate of powders and the degree of blending is very dependent on the proper sizing of the supply and discharge pumps.

It is important to maintain a constant flow of liquid through the blender.

A constant flow will maintain a constant vacuum. Without a constant vacuum the powder addition rates will not be uniform. This constant flow must be maintained even though the viscosity may be increasing due to the addition of powders. Therefore, the pumps must be sized to pump the final viscosity of the product.

The most important piece of information that needs to be obtained is the final viscosity. If necessary, samples can be tested at Tri-Clover to determine the final viscosity. Other vital information required for determining the final viscosity properly are; concentration, temperature and time.

The simplest system to use is a centrifugal supply pump and the blender, with no discharge pump. This configuration is used where the final viscosity is under 500 CPS and the total discharge head is under 25 ft (7.6m).

As the viscosity approaches 500 CPS and/or the total discharge head approaches 25 ft. (7.6m), it may be necessary to add a centrifugal discharge pump.

The blender, although it is basically a centrifugal pump, if it is used as a pump, becomes less effective as a blender. As the back pressure increases in the blender the liquid envelope begins to collapse. The envelope collapses until the envelope recedes into the eye of the impeller. This can cause "prewetting" and improper mixing. Evidence of this may be in the form of "fish eye" (dry centered lumps with a glossy wet surface). In extreme cases, the normally dry powder inlet tube may become wet. This would cause a buildup of powder on the powder inlet tube I.D., even up to the butterfly valve. This usually results in the inlet tube becoming plugged.

Further evidence of insufficient discharge pumping capacity and the need for a discharge pump is shown by a rapid addition rate on the first powder added and a gradual slow down as the batch continues. The powder addition may stop entirely if the extremes shown on the graph are exceeded. In some border line cases, a centrifugal pump on the discharge may be all that is needed to make the system work. Usually, a duplication of the supply pump, except for a 1" larger impeller, is all that is needed for a discharge pump. A larger pump or a high speed pump of slightly higher capacity may also be used.

The supply pump is always a slow speed pump because the blender requires a flow at low pressure to effect a good blend. This will also keep splashing to a minimum.

Normal flow rates required at the blender for centrifugal pump systems are:

F2116 40-45 GPM (9.1-10.2 m^3/hr) @ 5-10 psi (0.34 - 0.7 bar)
F3218 and DS3218 110-120 GPM (25.0-27.3 m^3/hr) @ 10-15 psi (0.7 - 1 bar)
F4329 130-140 GPM (29.5-31.8 m^3/hr) @ 10-15 psi (0.7 - 1 bar)

These flow rates should not be exceeded or the motors will be overloaded.

In most cases, where final viscosity is 500 CPS or higher, positive pumps on both the supply and discharge are required. Two pumps are required to maintain constant flow into and away from the Blender. This is necessary because the viscosity will increase when mixing a batch.

The discharge pump is always sized to run faster than the supply pump because; one, it has to handle a larger volume of product, and secondly, it effects the vacuum and, therefore, the addition rates.

It is desirable to use a vari-drive to power the discharge pump because of this effect on vacuum. Varying the speed allows you to adjust the vacuum for maximum addition rates and top performance.

Normally the discharge pump is run 30 RPM faster than the supply pump. The Tri Blender Bulletin TBM shows the speeds normally used. These values may vary somewhat depending on particular product characteristics.

The normal flow requirements at final viscosity for the blender in positive pump systems are:

F2116 40-45 GPM (9.1-10.2 m^3/hr)
F3218 & DS3218 45-55 GPM (10.2-12.5 m^3/hr)
F4329 60-70 GPM (13.6-15.9 m^3/hr).

The Tri-Blender Bulletin TBM gives a guideline to pump sizes. However, this may vary depending on product characteristics and discharge heads.

Lining sizing is also important in determining heads and flows as the viscosity increases. This also has an important bearing on pump size.

When operating properly, the discharge pump is actually maintaining a consistant vacuum in the blender. The discharge pump should be located close to the blender. It should be running fast enough to pull proper vacuum but not so fast that the pump cavitates. Evidence of insufficient vacuum (and too high a product temperature) is a puffing of air from the surface of the powder in the hopper. Under these conditions powder addition rates would be very slow or non-existent.

The use of a centrifugal supply pump and a positive discharge pump is very hard to balance flow, particularly, where the flow is changing as viscosity increases when more powder is added. The system requires constant adjustment through the use of valves making it very difficult to operate. For this reason it is NOT recommended even though earlier Tri-Blender Bulletins specified its use for some concentrations.

The ultimate criteria for sizing the supply and discharge pumps is the final viscosity. If at all possible, this should be obtained. Even a comparison to something else can be extremely useful. In many cases, solids content can be used to determine pump sizing, but this can be misleading. One exception to this would be products like stabilizers that thicken at very low concentrations. In this case, concentrations as low as 2% may require positive pumps. An exception to this, on the other extreme, is sugar where viscosity is a function of temperature and at higher temperatures concentration in excess of 50% can be mixed with centrifugal pump systems.

It all depends on the final viscosity at final temperatures and if there is a time relationship to the viscosity.

Products that should be avoided are:

1. **Abrasive:** Products that will deteriorate seals and impellers.
2. **Effervescent:** Products that emit gases will destroy the vacuum and the powder will not flow from the hopper.
3. **High temperature:** Aqueous products requiring mixing over 140°F because the resulting vapors will plug up the powder tube.
4. **Very high viscosity:** The typical viscosity range for Tri-Blenders is up to 25,000 cps. If viscosity exceeds 25,000 cps contact Tri-Clover.
5. **Incompatible products:** Products not compatible with available seats and gaskets.

Powder Addition Rates

The three Blenders have been nominally rated as follows:

F2116 50lb/min. (23kg/min.)
F3218 & DS3218 100 lb/min. (45kg/min.)
F4329 350 lb/min. (159kg/min.)

These rates are strictly estimates and do not hold true for all powders. Such things as flowability, type of powder, density, texture, all have a bearing on the addition rates. Also, some powders, such as stabilizers, must be metered in slowly to get proper blending. Addition rates of less than 50% of rated capacity can be expected. On the other extreme, addition rates double that of rated capacity have been obtained with granular products such as sugar. Some products with high fat content like chocolate powder have poor flowability and are difficult to get out of the hopper so addition rates are slow. Using a larger blender, with a larger hopper opening, is required to handle these powders. Adding better flowing powders in the hopper with these powders, when possible, often helps.

Continuous vs. Batching

The decision of using a continuous system or a batch system is really determined by what the blender can do. By using the flow rates required by the blender and the powder addition rates for each blender, it can readily be seen what the cut off point is between using the continuous or batch method.

The F2116 requires a flow of 45 gal/min. or approximately 375 lb/min. of liquid. Using 50 lb/min. powder addition rate the maximum, percent solids is:

$$\frac{50}{375} \times 100 = 13.3\% \text{ theoretical}$$

The F3218 requires a flow of 120 gal/min. or approximately 1000 lb/min. of liquid. Using 100 lb/min. powder addition rate the maximum percent solids is:

$$\frac{100}{1000} \times 100 = 10\% \text{ theoretical}$$

The F4329 requires a flow of 140 gal/min. or approximately 1164 lb/min. of liquid. Using 350 lb/min. addition rate the maximum percent solids is:

$$\frac{350}{1164} \times 100 = 30\% \text{ theoretical}$$

The theoretical percent solids shown above have never been reached in actual operation. It would take ideal conditions to approach these values. There are simply too many variables involved in the powders. In actual practice we do not consider continuous systems for concentrations over 8% solids for either the F2116 or F3218 Blenders.

Extreme care must be used in continuous systems where precise ratios of liquid to dry are desired. If just one lump in the powder lodged in the butterfly valve the ratio would be upset.

Continuous systems are seldom used because of the variations in solid content the cost of manufactured equipment, and other difficulties of metering the powder. The number of continuous systems probable total up to less than 3% of the blenders in operation today.

If one studies the flow rates, it may appear that in positive pump systems, since the flow rates are lower, the ratio would be higher. In a sense this is true. The F3218 blender in a positive pump system has a flow of 55 gal./min or 457 lb./min. of liquid. If the vacuum were essentially the same and we were to add 100 lb/min. of powder the solids content would then be:

$$\frac{100}{475} \times 100 = 21.8\%$$

However, this problem occurs; at these reduced flow rates there may not be sufficient liquid available in the Blender head to properly absorb that much powder, resulting in incomplete blending. In extreme cases actual dry product may enter the positive discharge pump and cause damage to the rotors and casings.

The solution to this is to restrict the powder addition rates by throttling the butterfly valve on the hopper which lowers the solids to liquid ratio. Then we are back to essentially where we started.

The batch system is by far the best system: to assure proper mixing, with all product incorporated, providing overall dependability.

Dual-Stage Tri-Blender - DS3218

The dual stage concept provides for “double-blending”, as the product passes through the initial liquid/dry ingredient blending chamber directly below to a second chamber, which effectively acts as a discharge pump.

Tri-Blender®

Because of its close proximity, the dual or second chamber concept actually increases, rather than decreases, vacuum, as the vacuum from the suction of the second pumping stage is added to that of the first stage, greatly improving product addition rates. The "double-blend" feature actually improves end product consistency, providing a smoother, more uniform blend.

With the dual stage, in applications up to 500 CPS and up to 50 feet of discharge head, no discharge pump is required. This is a significant improvement over single stage units, which normally require an auxiliary discharge pump at 25 feet of discharge head and above. On some applications with higher viscosity a discharge pump may be necessary.

By incorporating the discharge pump function into the blender itself, it is possible to significantly increases the vacuum over a wider range of process conditions. The increased vacuum provides for fast, consistent powder addition rates with minimal drop off throughout the entire production run. This results in an overall higher addition rate and a higher total capacity compared to the single stage blender.

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