BEARCAT PUMPS

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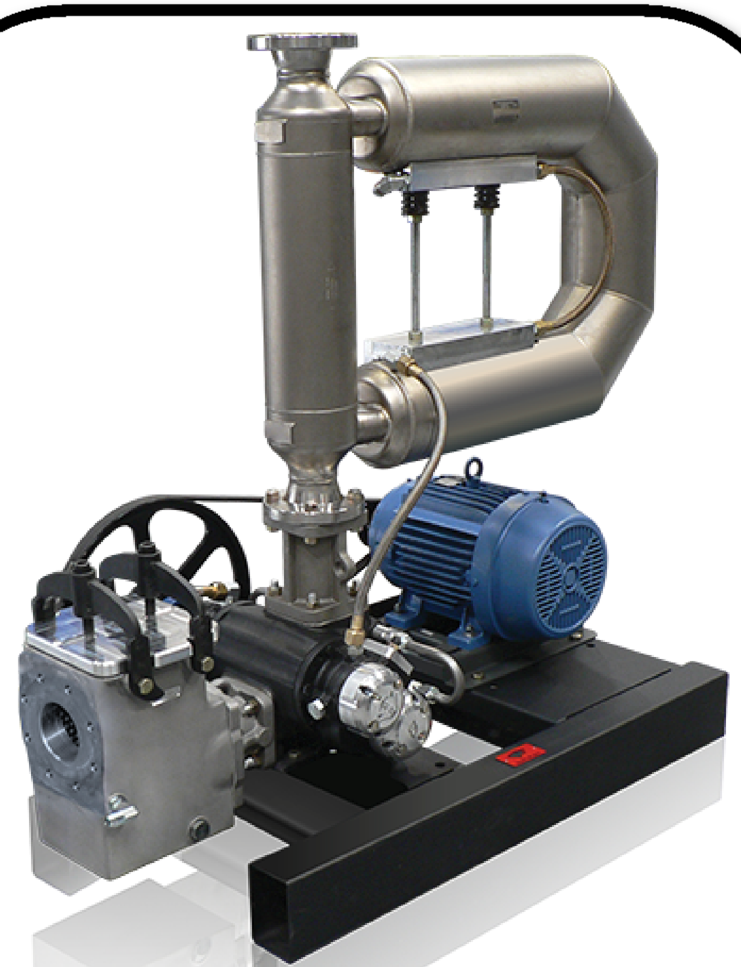
Metering Rubberized Asphalt

2nd Edition, By Kevin T. Hill 3-18-2012



600R Metering Pump

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INTRODUCTION:

Since its inception, BearCat Pumps has been manufacturing pumps designed to handle asphalt rubber. Rubberized Asphalt is considerably more difficult than standard grades of asphalt. The addition of ground crumb rubber dramatically increases the abrasiveness to an otherwise lubricating material. Temperature is increased by 100°F in ranges of (375°-425°F). Viscosities can be as high as 4000cP. Rubberized asphalt has higher occurrence of coking, material separation and, in general, requires a much higher degree of monitoring. The penalty for failure is high... destroyed meters, pumps, tanks, agitation systems, etc.

This paper covers three topics, critical to pumping and metering rubberized asphalt:

- **Heat and Pressure for start-up**
- **Liquid Flow Stability for metering**
- **Monitoring the System**

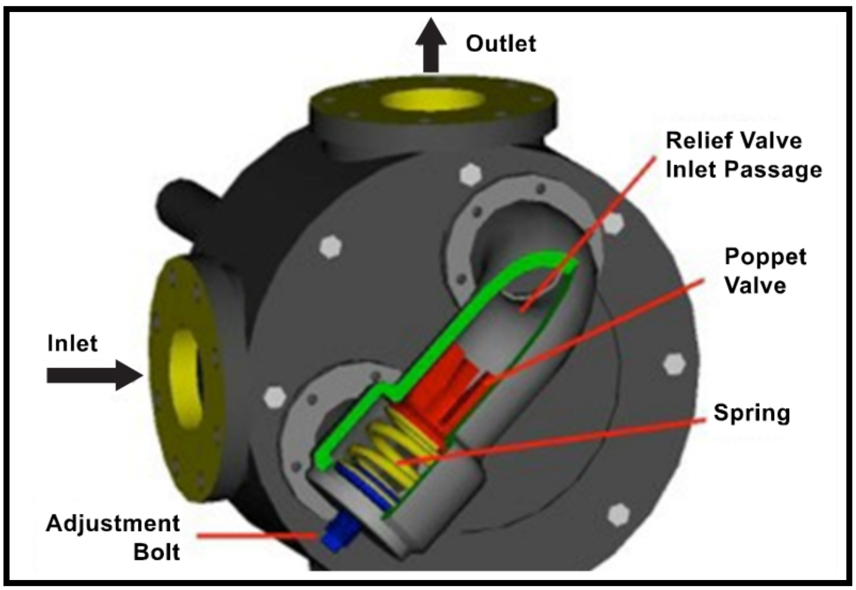
The purpose is to explain these topics and how they commonly contribute to the sequence that leads to system failure. Within the explanations, are detailed solutions that have evolved into best practices for avoiding failure reoccurrences.

SECTION 1: HEAT AND PRESSURE

A fundamental component in handling asphalt is heat. In this section, the discussion centers on how heat affects specific components within the system, focusing on the Mass Flow Meter and the Pressure Relief Valve.

At the core of most pumping problems is the Pressure Relief Valve or RV, also often referred to as the Bypass Valve. The function of this valve is to prevent line pressure from exceeding a certain set pressure. When not functioning properly, the relief valve becomes a contributing factor in many meter related problems as well.

The Relief Valve is a fairly simple design: a plate (or poppet) covers a port to a passage that allows the asphalt to bypass or short circuit when maximum pressure is exceeded. A poppet is held over the intake port by a compressed spring. By increasing spring tension with an adjustment bolt, the pressure necessary to lift the poppet increases. Normally the adjustment is set at the factory to a specified level (80psi for example) before the pump is shipped.



- **The vast majority of the pumps used in the asphalt industry have a *non-heated relief valve*. We believe this to be a significant problem. Consider the following:**

At start-up, the entire pump and ***RV inlet passage*** are full of cold asphalt. The perimeter of the pump body, as well as all the piping, valves and screen box are jacketed so they heat quickly and allow the pump to start. The hot oil surrounds the pump body encompassing the gears, but *not* the relief valve. With this configuration, a non-heated Relief Valve must scavenge its heat from the back plate of the pump and contend with the outside air that can flow around the outer body surrounding the poppet. It is very possible that the pump can circulate material with the relief valve still frozen solid! If the system is plugged downstream, pressure can build to a dangerous level. What commonly happens in this case is the circuit breaker of the drive motor overloads. However, before the breaker trips, the pressure may build well beyond the intended relief pressure setting. This is a dangerous condition and, over time, it contributes to wear and tear on the pump, motor and all valves and flange joints between the pump and the offending stoppage.

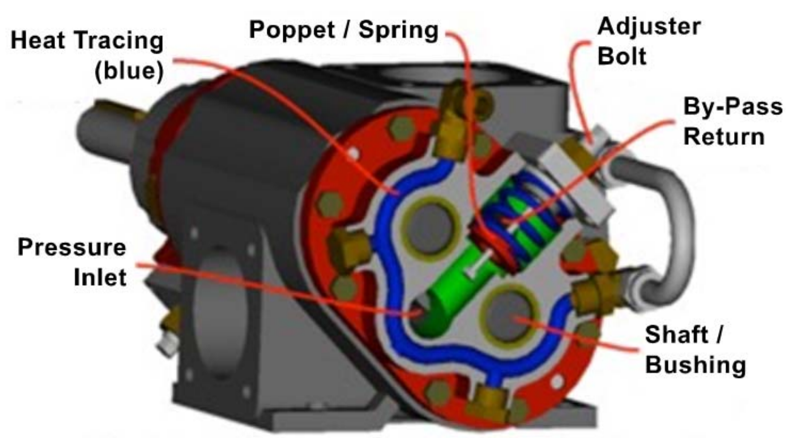
Un-Heated Relief Valve

In this picture, the paint reveals an important message. Notice that around the body of the pump, screen box and outlet plumbing the paint is browned, cracked or burned off completely, as a result of the oil jacketing. In contrast, the paint on the relief valve is still glossy, indicating a lack of heat.

Heated Relief Valve:

The heat-jacketed end plate (shown in the picture below) insures that the asphalt left in the *relief valve inlet passage* liquefies before the pump thaws enough to rotate. In doing so, it not only insures that the pump relieves at its intended pressure setting, but it also becomes a valuable tool to the overall start-up procedure.

Circulation can be obtained by heating 100% of the entire series of piping, valves, meters, pumps, etc., which can be time consuming and elusive, as ALL unheated sections (such as flange joints) must be torch-heated. However, if the pump can be utilized to produce a safe level of pressure (80psi), achieving circulation becomes a much easier task. A properly functioning relief valve opens allows the pump to maintain a lower pressure setting without overloading the electric motor.



Relief Valve (cut-away view)

Cold slugs that generally reside between components, such as a flange joints, are slowly pushed into the jacketed pipe. At this point, they liquefy as they enter a heated area.

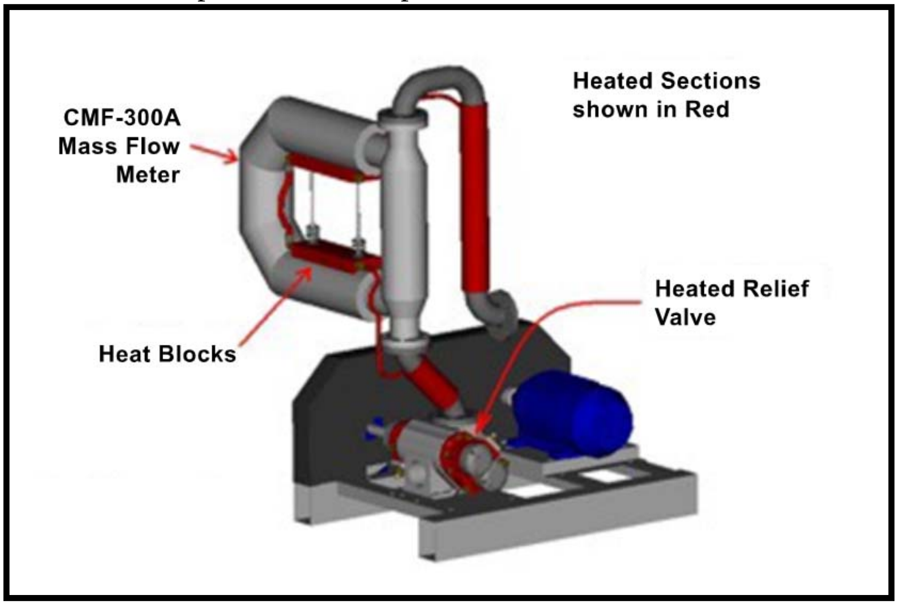
Mass Flow Meter:

The most commonly used Coriolis flowmeter (the Micro Motion® CMF300) was not originally designed for asphalt. Although it is a reliable instrument, the heat and harsh environment of the asphalt industry have been stressful to its design. Over recent years, we have seen significant improvements. In particular, the development of a ruggedized high temperature model (the CMF300A) that has a rating of 662°F. This alone is significant improvement and goes far to prevent higher temperature failures of the past.

Absent in many systems currently used today, is an adequate method to heat the meter prior to circulation. Most asphalt plants have heated tanks, valves, pumps, piping, etc. Everything is oil jacketed. Some manufactures mandate that everything be oil-jacketed in order to eliminate use of a torch. Adding a mass flow meter, without an adequate heat source, is a problem waiting to happen. Critical internal wires and solder connections prevent the use of torch heating since temperatures above 662°F can melt the solder joints and destroy the meter. Many disastrous outcomes have resulted from desperate attempts to thaw a frozen meter using a torch.

A System Equipped to do the Job:

The solution is a combination of both heat and pressure. In the picture below, the red areas indicate heat-jacketed surfaces. Within the meter sensor are aluminum blocks contoured to fit the outer shield. The blocks have oil tracing that tap into the existing heating oil at neighboring pipe sections.



The method used in mounting the heat blocks does not require any fabrication and does not affect the function or accuracy of the meter.

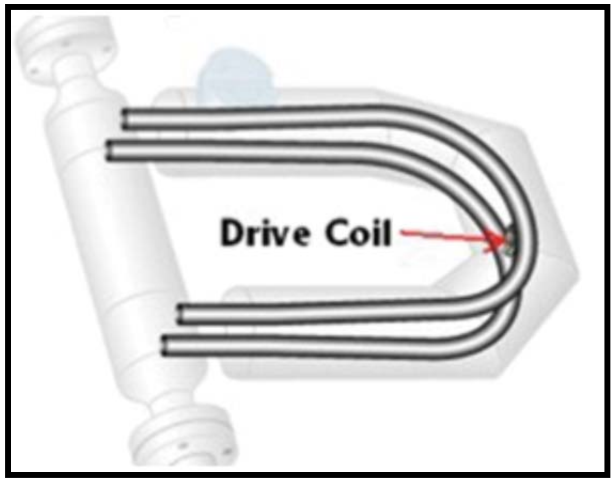
Coupled with a heated relief valve, the heat blocks complete a system that is able to purge and circulate rubberized asphalt. This works because it provides three valuable functions that were absent in previous systems; a meter that can withstand higher temperatures, oil traced heat blocks to safely heat the meter with the existing transfer oil, and a heated relief valve so that a safe level of pressure can be applied to slowly purge blockages from the system.

CHAPTER 2: LIQUID NOISE

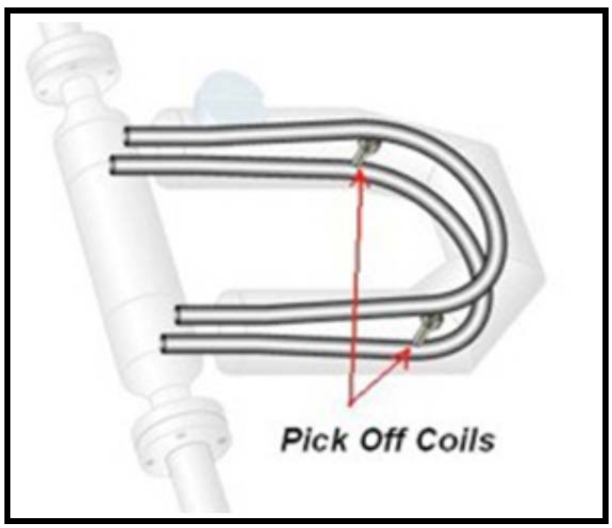
Liquid Noise: The definition of liquid noise, as it applies here, includes entrained air, cavitation, and pump pulsations. Any of which can adversely affect the metering function.

The meter itself works like a tuning fork. Two identical tubes, a drive coil, and two adjacent pick off coils are the primary components within the meter.

> *During operation, a drive coil is energized, causing the tubes to oscillate in opposition to one another.*
>
> *Micro Motion magnet and coil assemblies (called pick-offs) are mounted on the opposing flow tubes. Pick off coils are mounted on the side legs of one flow tube, and magnets are mounted on the side legs of the opposing flow tube.*
>
> *Each coil moves through the uniform magnetic field of the adjacent magnet. The voltage generated from each pick off coil creates a sine wave. Because the magnets are mounted on one tube, and the coils on the opposing tube, the sine waves generated represent the motion of one tube relative to the other.*
>
> *-Micro Motion® 2009*



Much can be said about the details in how the functions between the drive and pick off coils correlate and produce a signal that can then be translated into density and mass flow rates. The focus here is how liquid noise (as described above) can adversely affect these functions.



When the drive coil energizes, it causes the tubes to oscillate at their natural frequency (based on internal content of the tubes). It is important that the oscillation timing remain consistent. Slow steady changes due to density change within the liquid are acceptable. Abrupt changes from the pump due to internal vibrations created by entrained air, cavitation and/or pulsations can create problems.

Pump pulsations and cavitation:

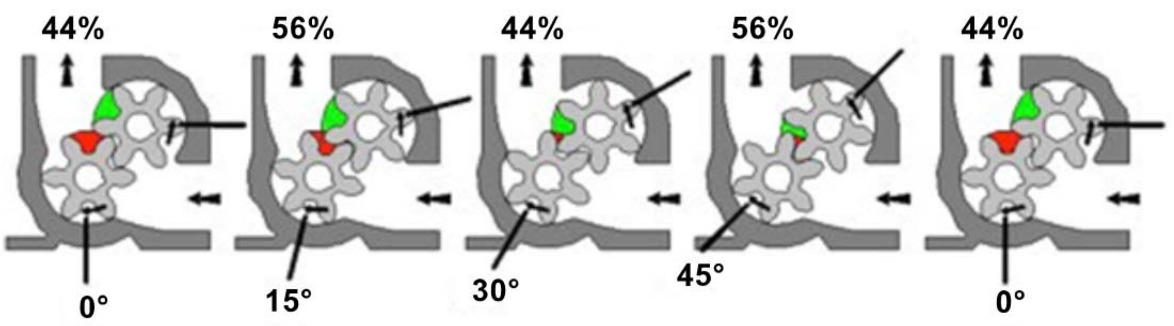
Positive displacement pumps inherently create pulsations. The number of pulsations is directly related to the number of gear teeth. If a pump has two gears, each with six teeth, the pump will create 12 pulses per revolution.

- **Example: a pump rotating at 400 RPM is creating 4800 pulses per minute.**

This frequency is high enough that it would not affect many traditional methods of metering and pumping asphalt. However, when a Mass Flow meter is used, the pulsations created by the pump can have an adverse effect. If the pump's pulsation frequency is near or at a rate that coincides with the meter functioning frequencies, there could be problems. Previous solutions have been to slow the pump down which is not an appealing option. Slowing the pump means slowing the entire production process.

The pump creates displacement when the solid tooth of one gear enters the adjacent root of the other gear and displaces the liquid. The pulse is created because the total liquid displaced throughout the engagement is not linear.

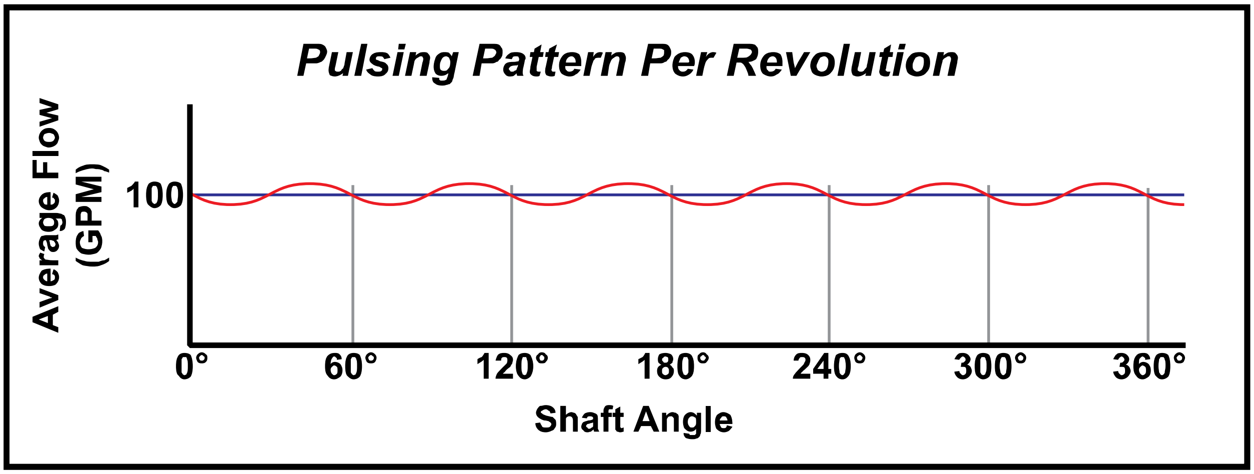
Think of it this way, a six-tooth gear will displace six root chambers per revolution; each chamber is 60°, and six of them equal 360° or one rotation. Looking at the discharge of one 60° root, less than half of the total discharge is done during the first and last halves of the rotation, while more than half is done in the middle part. As a result, the material flows out of the pump in a pulsing flow that amounts to 12 pulses per revolution.



Rotational Angle / Discharge Rate

The above graph shows the rotation of 60°. The position of 0° and 30° are symmetrical in displacement at a rate of 44%. While 15° and 45° discharge at a rate of 56% of the total tooth volume. This correlates to 12 pulses per revolution.

The following graph shows the discharge of one revolution. When a pump is producing 100 GPM, as may be indicated by the flat blue line. In reality, the pump is averaging the flow at a pulsing rate as indicated by the red waved line.



While much has been done within the electronics to filter the pulsing within the meter itself, there is still a potential for these pulsations to affect the operational frequencies of the coil and pick off sensors.

Until recently, we had accepted this as a problem that came with the territory. The meters were mounted far downstream in hopes of stabilizing the flow and the pump speeds were lowered in order to reach an acceptable level of accuracy through the meter. As a result, production suffered and even achieving calibration (T-109) could be a difficult and costly challenge.

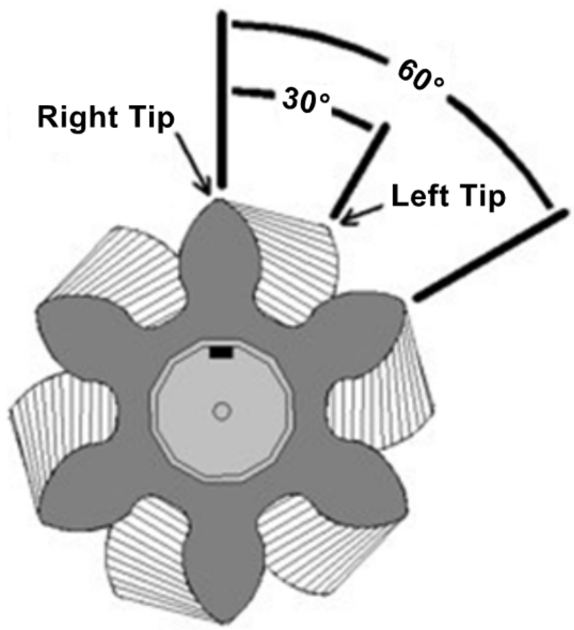
Helical Gears:

Fortunately, there is a method to reduce pulsations created by the pump. The basic solution lies in gear design. The pulsation, as previously described, applies to straight-cut gears. For years, the use of helical shaped gears has been known to reduce pulsations, but not eliminate them entirely. The gear length and its helix angle have a direct effect on the amplitude of each pulse. The longer the gear, the more it will dilute (or lower) the pulse amplitude. This stabilizes the flow. Longer gears also have more gear tooth surface area, resulting in a higher production rate.

Phase Balancing Gears:

In other industries, pulse dampers are used to stabilize the pulsations created by a positive displacement pump. The problem in utilizing these dampers is that they are constructed out of materials (rubber or plastics) that cannot withstand the high temperatures of asphalt.

Our solution is gear ***Phase Balancing***. A surprisingly simple concept, the helix rotation stops at exactly half a tooth rotation from its left side to its right side. The half helix creates a phase discharge balance. If the right side of the gear is at maximum discharge, the left side is at minimum discharge. This pattern volleys back and forth as the pump rotates, but the net result downstream is a cancellation of the pulse resulting in a steady stabilized flow.



Phased Balanced Gear

We have discovered that this balanced flow has many benefits, the most prominent being a stabilized stream that can be accurately metered. Removed are the contradictory effects of pulsation on the drive coil and pick off sensors.

A phased balanced pump also has a higher maximum flow rate. The maximum flow rate is most often limited by the point at which the pump cavitates. Previously, the discussion had been about the pressure pulse on the outlet side of the flow. Offsetting that pressure pulse is a counteracting vacuum pulse on the inlet side. If the pump is already close to its critical point, the added vacuum is all it takes to initiate cavitation.

Stabilization of the flow has a two-fold benefit, elimination of the pulse and its effect on *both* the outlet pressure and the inlet vacuum. This stabilized flow increases accuracy in the meter and at the same time raises the cavitation point (and maximum flow) of the pump.

Entrained Air:

When air is sucked in to the stream and flows through the Coriolis flowmeter, it creates an imbalance in the harmonic vibration of the tubes. To compensate, the drive coil must work harder to maintain a consistent frequency. An imbalance can easily exceed maximum range of the drive coil. The easiest way to determine if air is leaking in to the system is by observing the **drive gain** function on the transmitter. With a rapid fluctuation or a pegged value of 100% on the drive gain, steps should be taken to find and eliminate possible air leaks in the system.

The source of air leaks is always on the upstream side of the pump. When possible, reducing the vacuum created by the pump will help. Flow restrictions such as a coked or clogged intake, small diameter or excessively long lines and cold or highly viscous material all can contribute and increase the suction head of the pump. Below, is a table of common air leaks.

Air Leak Causes	Examples	Remedies
• **Inlet clogging**	• **Coke build up at intake**	• **Clear obstructions**
• **Flow Restrictions**	• **High viscosity** • **Cold temperatures** • **Pipe diameter too small** • **Excessive pipe length**	• **Lower viscosity** • **Raise Temperature** • **Increase pipe diameter** • **Move pump closer to source**
• **Deteriorating or damaged gaskets or seals**	• **Flange gaskets** • **Plug valve packing**	• **Retighten bolts** • **Replace packing**
• **Screen box lid**	• **Large thin kettle type lids with perimeter bolts**	• **Replace entire screen box with 1" thick lid.**
• **Pump packing**	• **Worn packing** • **Drive shaft out of alignment**	• **Re-tighten, add or replace packing** • **Replace pump**

Viton® O-ring port connections or screen box lids can also help to eliminate the potential for air leaks. Far superior to the gaskets typically used, the O-ring is embedded in a machined groove. This allows the metal face of the flanges to bolt directly together. The seal remains tight at operating temperatures and has proven to be a reliable connection.

CHAPTER 3: HOW TO PROPERLY MONITOR THE SYSTEM

Drive Gain Monitoring:

A proper system monitoring method is a vital key in preventing problems. Key in this method is a system that allows easy access to the “Drive Gain” status of the meter. The biggest concern is a slow to develop air leak. When this type problem occurs, BIG problems can ensue. Inaccurate flow rates can occur resulting in ‘out of tolerance’ mix designs. Freshly paved roads have been milled up as a result of air leaks that went unnoticed.

As mentioned in the previous chapter, air leaks can occur in a number of different areas and be aggravated by continually changing process variables such as; tank level/head pressure, blend consistencies, temperature, etc. Pump shaft seals are continually wearing, and as these and other areas deteriorate, an early warning system becomes a vital tool in preventing mix failures.

Drive Gain, is a status value correlating the work of the drive coil to maintain consistent tube vibrations. The feature can and should be monitored on a frequent (hourly or better) schedule. In the past, Drive Gain was a feature checked during calibration, and assumed to be good, thereafter. Many older transmitters, simply do not have the capacity to display the Drive Gain, and should be upgraded. In place, this feature is critical in displaying status of what can really amount to the flow stability of the liquid. Problems such as entrained air, cavitation, and pump pulsations can all be ruled out with a stable Drive Gain. If it is not stable, you need to STOP the production, and figure out what is wrong.

Series 3000 Transmitter with BearCat® Standard Configuration:

The Micro Motion® 3000 series transmitters are well suited for this type of monitoring. The multi-page feature allows for multiple must have variables such as; flow rate, flow total, temperature, density and, of course, Drive Gain. Further, BearCat Pumps uses a standard display variable configuration. This standard allows our technicians to know variables displayed on each page. When problems occur, little time is lost when sifting through the details. Our technician can direct the customer to any of the pre-programmed screens for quick system diagnostics that are contained on one of the three primary pages, rather than sequencing into the locked aspects of the display.

Our ability to know in advance what they are looking at helps to trouble-shoot problems of the meter the general health of the pump and piping system. Drive Gain is used in conjunction with pump motor amperage in order to isolate issues of flow blockage, pump bearing/bushing failure, cavitation and material “foaming”.

SUMMARY:

This article is intended to shed light on common problems and offer solutions related to safely pumping and accurately metering rubberized asphalt. The importance of a heated relief valve and heat blocks (on meter) will provide a more efficient means of streamlining the daily start-up process. It is worth noting that the simple application of heat in these key areas and a proper understanding of how to achieve ***and monitor*** liquid stability not only improve meter function, they also enhance safety, longevity of equipment and ultimately – productivity.