Lubrication System Audit Report Paper Machine *

For
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By

SKF

SKF Lubrication Services Division

August ****
Rev. B

Index

Introduction and Audit Objectives:

********** Kraft Paper Company requested SKF do an audit of the oil circulation system that lubricates the dryer sections of Paper Machine 14 at their paper mill in **********. The people conducting this audit were Dana Hatton and Alan Rogers of SKF and *********.

SKF was asked to evaluate the capability and general condition of the oil circulation systems that lubricates the five main sections of dryers and one that lubricates the two calander stacks and a three dryer After Section. This evaluation included gathering information on such items as oil pumps, drive motors, filters, heat exchanger, reservoir, oil flowmeters, pipe size, condition, etc.

*********************** requested this audit by SKF point out improvements necessary for these systems to supply the recommended oil flows to the machine's bearings and gears.

Paper Machine General Information:

Paper Machine 14 at the ************** Kraft mill in ********** is a 1950's vintage machine supplied by Beloit in 1956. There have been several modifications to the machine over the years including major modifications to the dryer sections in 1998 and 2006.

This machine has a line shaft type drive with the Beloit differential drive gear boxes still in use in the dryer sections. The mill has indicated there are no immediate plans to upgrade to electric drives and do away with the line shaft

The machine has five main sections of dryers consisting of 69 dryer cylinders in the two main layers and four felt dryers located above the first two layers. All five dryer sections of the machine have top felting. All dryer sections except the 5th have bottom felting, each with several basement felt rolls. There is a full dryer hood at the operating floor and basement levels. The hood appears to be in good condition.

The dryer cylinders are 60 inches in diameter and have a face width of approximately 270 inches. The machine makes brown paper using 120 PSI saturated steam in the majority of the dryer cylinders. Steam enters the dryers through the drive side dryer journals and the condensate is also removed through the drive side journals. The mill has done some investigation and reported that the drive side journals do have insulating sleeves to help protect the drive side dryer bearing. All dryer sections have enclosed drive side gearing with intermediate gears and bearings lubricated by the machines dry end circulating oil system.

There are approximately 626 lubrication points in the five dryer sections. We counted all existing drive side and tending side oil sight glasses and found only 538 that actually had oil flowing through them. This oil was supplied by the main dry end oil circulation system. This system lubricates the dryer bearings, felt roll bearings, drive gears and gear bearings in the five main dryer sections.
We counted 82 meters, 42 on the drive side and 40 on the front that were disconnected, shut off or in some way appeared to be out of service. This leaves us to believe that some of the felt roll bearings have been converted to grease over the years in an effort to reduce oil leaks or perhaps some of the drive side gearing has been removed, reducing the need for oil to some intermediate gear bearings and gear nips.

The oil pumps, filters, reservoir and other components of the main lube system are located in the basement on the drive side of the machine. It is closer to the wet end, not in the middle of the machine as most are. See the next picture showing part of this system.

After the fifth dryer section there is a Calander Stack one King and one Queen Roll and two calander rolls. Next is a three dryer cylinder After Dryer section. Following that is a second Calander Stack with a King and Queen Roll and four more calander rolls. The bearings in this part of the machine are lubricated by a second oil system. This one is much smaller than the one lubricating the five main dryer sections. This oil circulation unit is in the machine basement, drive side not far from the after dryer sections. See the following two pictures. The picture on the left shows the systems oil pump and oil filter while the one on the right shows the systems oil reservoir.

This section of the machine consisting of the two calendars and the after dryer section has approximately 19 drive side lube points and 13 tending side lube points. It appears that the felt and paper rolls in this section of the machine are grease lubricated.

While we were not asked to audit the lube system for the machine’s differential drives we felt some basic information about it needed to be included in this report. This machine’s dryer sections are still driven by a line shaft and Beloit style differential drives. Please see the following two pictures. The one on the left is a shot down the line shaft towards the steam turbine that drives it. The other is one of the eight differential drive gear boxes connected to the line shaft.

The gearboxes, transfer cases and PIV units are lubricated with oil from a third lube system also located in the machine basement. That is shown in the next picture.

In all, the eight differential drives, associated transfer cases and PIV units have a total of 60 lubrication points which are supplied oil by this oil system. All three oil circulation systems on this machine use ISO 220 oil.

Equipment Condition and Capacity:

Maine Dryer Section Oil Circulation System: When this system was first installed in the mid to late 1950's it was designed to supply approximately 90 gallons of ISO 220 oil per minute to the machine's lubrication points. At that time there were approximately 6 fewer dryers to lubricate. Six additional dryers were added in the late 90's or early 2000's. The current oil pumps and drive motors appear to be the original installation and are rated for 90 GPM at about 100 psi.

One of the first things we did at the start of the audit was to count the number of oil sight glasses. These are devices regulating oil flow to the various lube points that service the dryer sections of the paper machine. We counted 620 of them but only approximately 538 were in operation. All but the meters for the drive side of the Calander stacks and after dryer section are the Beloit C-Shur type. See the next picture.

These meters are a type that visually indicate oil flow but do not give an indication of how much oil is flowing through each. Anyone of them could stop flowing oil for some reason and no one would know it until the lube technicians made their next round of inspections. This only happens once per day and maybe not at all on weekends.

Next we gathered the bearing numbers, machine speed, steam pressure and other information needed to calculate the correct oil flows for all the lube points. We came up with the following flow rates as the required flow for these points.

PPM = pints per minute.

The oil flow requirements to the dryer bearings are based on using ISO 220 oil and 120 pound steam into the dryer cylinders.

Drive side dryer bearings 23152	6.0 PPM
Front side dryer bearings 22244	4.0 PPM
Felt Roll Bearings 22318	0.75 PPM
Intermediate gear bearings 22314	1.50 PPM
Gear nip lube point	3.0 PPM

Our best estimate is that the machine has the following numbers of oiled lube points in the five main dryer sections at this time.

73	drive side dryer bearings	@	6.0 PPM	= 438 PPM
73	front side dryer bearings	@	4.0 PPM	= 292 PPM
228	felt roll bearings	@	1.0 PPM	= 228 PPM
132	idler gear bearings	@	1.0 PPM	= 132 PPM
32	gear nips	@	3 PPM	= 96 PPM

The total is 538 lube points on oil. There are apparently 27 felt rolls or 54 bearings that are lubricated with grease. Some of these could be the felt guide and stretch rolls. The total required flow based on the 538 active points we counted at the SKF recommended flow rates on page 10 is 1,186 pints per minute or approximately 148.25 gallons per minute. If we add 10% extra to the system capacity so we will have good system pressure and temperature control margin we should have a system that should supply 165 gallons per minute. If we also add in the 27 felt rolls that may have been dropped from this system because they leaked it would add another 7 gallons per minute to the needed capacity if we fix them, bringing the total to 172 gallons per minute. We found some drawings done by Paperchine in 2006 that show 7 basement felt rolls in the 5th dryer sections. If those were added **that would bring our grand total of required flow to approximately 175 gallons per minute. This is about twice the capacity of the existing oil system that lubricates the five main dryer sections. The existing oil system is not able to supply the amount of oil this machine needs today or in the future.**

The capacity of the system's **oil reservoir** completely full is approximately 2,800 gallons. However, at the time of our inspection the reservoir was running about half full when the machine was running. When the machine was down on Wednesday we saw there was approximately 33 inches of oil in the 48" high reservoir. That would mean there is about 1,980 gallons of oil available to the machine. If the oil pumps can pump 90 gallons of oil as we expect the system has only 22 minutes of retention time with that amount of oil in the reservoir.

Older oil reservoirs of this design were typically built to provide 30 minutes of retention time. This was for the oil to rest and give up any water and dirt that might be mixed in it before being pumped back to the paper machine. For instance, if a paper machine needed 100 gallons of oil per minute for all its bearings and gears, the oil reservoir would be designed to hold approximately 3000 gallons and have some excess room for air above the oil plus room for internal parts like baffles and heaters. This reservoir does not have any baffles to help with water and air separation. See the next picture. It only has some supporting steel braces and steam heating coils at the bottom.

At the current flow rates and pumping capacity the reservoir with the maximum of about 2,500 gallons of oil in it will provide approximately 27 minutes of retention which would be fairly good. However, if the reservoir oil level is allowed to drop down to where it only has 33 inches of oil in it the retention time is reduced to 22 minutes. If this machine was receiving the 175 gallons of oil per minute that it needs, this reservoir would provide only 14 minutes retention provided it is kept at the maximum working level with 2500 gallons of oil in the system.

The present oil reservoir is large enough for the oil flow the machine gets today provided the level if kept up. However, the existing oil reservoir will not be large enough when oil flow rates are at their recommended levels. If this reservoir remains in use it should be retrofitted with new internal baffles to improve its ability to remove water and air.

It is very important to have a reliable source of heat in the reservoir to keep the oil warm, between 125 and 140 when the paper machine and its oil system are shut down. During our visit it appeared that the attached vacuum dehydrator was being used to do that as best it could along with one electric heater. The original steam coils that were supplied in the reservoir when it was new are still there but we were told those are not used any more because they leak condensate into the oil.

This reservoir, if re-used, should be retrofitted with several low-watt density electric heaters, in stainless steel sleeves so any one heater could be removed for service without draining the oil from the reservoir. In most cases, we try to keep the watt density of electric heaters at or below 5 watts per square inch to avoid burning the oil. A new or rebuilt reservoir should have several heaters, maybe 8 or more in a reservoir this size. The length of the electric heaters can be almost as long as the reservoir is wide. That alone helps reduce the watt density.

HOT (150 degree F) oil at start-up can help reduce oil leaks due to bearing flooding during machine start up.

The two pictures below show some rusting on the inside of the walls of the reservoir and there were some similar signs on the underside of the reservoirs top. In these pictures one can see excess foaming on top of the oil indicating too much air is getting into the oil. We will comment on this in the section regarding pressure control. Also note the black material on the sides of the reservoir. We could not safely reach a sample but it appeared that it could have metal in it. Perhaps from the gear wear we heard about.

We did not see much condensation inside this reservoir during our inspection but we did see rusting. A new oil reservoir or an upgrade of this existing one should include a method of removing moisture laden air and replacing it with clean dry air. Large amounts of condensation can build up on the inside of the reservoir's top metal plate due to the difference between the oil temperature inside the reservoir and the air temperature outside it. The condensation then drips off the underside of the top plate and into the oil. It can amount to a

large amount of water per day that will get into the oil system. There are closed loop air dryers available for this application.

The picture below is of the inspection cover in the top of the main part of the reservoir. It is made of wood; it is not tight fitting and has a piece of screen material in it. Fine dust, water and other liquids can enter the oil through this mesh.

This cover should be replaced with one that fits tightly. A good air breather that will filter fresh air going into the reservoir and keep out water and other liquids should be added.

This system has a Beloit oil filter assembly on top of the main reservoir. This was part of the original equipment. The oil returns from the paper machine into this device that is called a roll filter assembly. The returning oil once had to pass through the filter blanket before it could drain into the main reservoir below. See the next picture. The roll filter assembly sets on top of the main reservoir and now is mostly covered with plastic. Inside there is still a used filter blanket – see second picture. This should be removed if the mill is no longer going to use and maintain it. These devices filtered in the 40 to 50 micron range, taking out larger particles that might return in the oil from the paper machine. These were used before there were good filters that could be put into the pressure side of the system to filter before the bearings, not after.

If the mill does not plan to repair and maintain the filter blanket the whole assembly including the metal tank should be removed. This will make room for a second inspection cover in the tank top if this reservoir continues to be used. These filter assemblies are just another place for contaminants to enter the oil if they are not properly sealed and maintained.

The **oil pumps** in this system are Roper 2F 75. They are driven by 10 HP **electric motors** turning 1170 rpm. The oil used in this system to lubricate all the points in the five dryer sections is Chevron Clarity PM ISO 220. At this speed the Roper pumps when in perfect condition pumping this oil at 140 degrees Fahrenheit will supply approximately

88 GPM oil. The arrangement around the two oil pumps can be seen in the next picture. Each has an internal safety relief valve. We could not determine what pressure they were set to relieve at but that pressure should be at least 150 PSI. We noted that these pumps do not have an external pressure relief or safety valve between the pump and first manual shutoff valve. That is a safety requirement by most standards to have the safety dumping back into the oil reservoir.

This system should have two safety relief valves installed. One for each pump. These should be piped to relieve oil back into the oil reservoir somewhere away from the pump suction. The dump line from the safety valves should include a flow sight glass with a flapper to indicate when oil is flowing or starts to flow through either valve. This is a good trouble-shooting tool and helps when field setting relief pressures. Typically these valves would be set to crack at 150 PSI.

The suction pipe between the pumps and the oil reservoir is 3 inch for each. These are connected to a common 3 inch pipe that is attached to the reservoir as normal. However the suction and the oil return are very near each other in the same end of the reservoir. Because there are no baffles inside the oil reservoir the oil short circuits from the return direct to the pump suction. There is very little time for larger particles or water to drop out of the oil prior to it getting pumped back to the paper machine's bearings and gears.

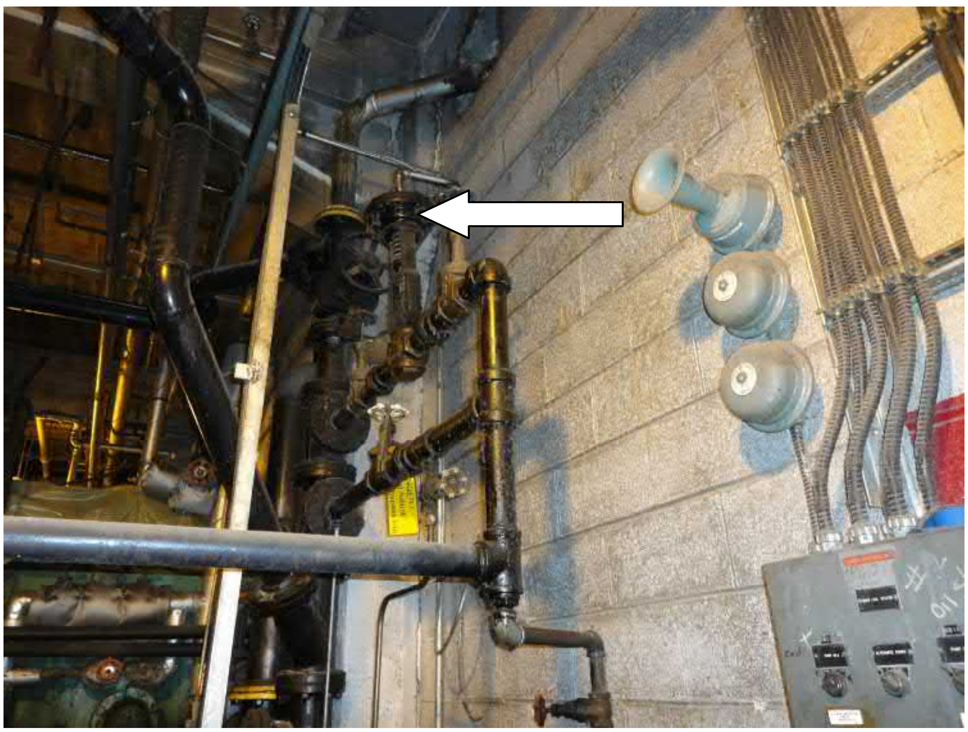
If this pump and reservoir arrangement continue to be used for an extend period of time a baffle should be installed down the length of the reservoir so the oil has to flow down one half of the reservoir and back before getting to the pump suction.

The system was running at 35 PSI pump discharge pressure when we conducted the audit. The mill's lube technicians reported that was normal and they change oil filters when the system reaches approximately 10 pounds of pressure differential across the filters. That would mean that the pump pressure will go up to 45 PSI normally.

The Oil Filters are being changed at a very low pressure differential. The pressure drop across clean filters is normally at least 5 psi. Many filters used in this type of application today are made to stand as much as 50 psi differential. **The oil filters are being changed before they have come close to reaching their full dirt holding potential. If at some point, the oil pumps on this system are replaced with ones that will supply at least 175 gallons of oil per minute the drive motors for the selected pumps must be able to drive them to achieve up to 150 - 175 PSI system pressure. Many new systems today use variable speed drives on the oil pumps. This feature allows many**

system options not possible with fixed speed motors. One of the nice features is that the flow in the system can be increased over time as other components are improved and implemented. It also allows for a smoother start-up of the system after a machine shutdown.

The **Systems pressure control valve** is piped so it discharges excess oil into the oil reservoir very near the pump suction. This keeps the oil foamed up, full of air in this area. The arrow in the picture below is pointing to the systems pressure control valve.



We were told by the lube technician that the systems pressure control valve does not work properly so the lube technicians manipulate the manual bypass valve around the automated pressure control to control pressure. As the oil filters get dirty they close the manual valve so less oil can recalculate and this increases system pressure. The manual bypass valve can be seen just below the automated pressure control valve in the previous picture.

The automated pressure control valve may be the original in the system. It could be 50 plus years old. The ability to maintain a stable, consistent pressure is one of the most important features an oil circulation system must have. Without it, pressure will fluctuate up and down and so will the oil flow to the bearings and gears. The working pressure of this system will need to be increased when the system is improved or replaced. This valve will not be sufficient for the systems future needs. Pressure control can be improved with the use of a pressure transmitter and automated valve with actuator and controller.

The discharge or dump line from the system's pressure control valve should include a flow sight glass with a flapper to indicate when oil is flowing or starts to flow through the valve and back to the oil reservoir. This is a good trouble-shooting tool. We might have learned more about this system if it had one.

For trouble shooting and some machine startup situations it is good to incorporate a manual valve that can be used to allow oil to go directly back to the oil reservoir. It should be lockable and checked whenever low system pressure is a problem.

The lube technicians should not have to manipulate a manual valve to control pressure.

The fact that this oil is relieving through the systems pressure control valve tells us that the machine is not getting or using the full 88 gallon capacity of the pumps. **At this time the paper machine is not getting all the oil available to it.**

The next major components in the system are the **oil filters**. In the next picture there is an assembly of four filters. These four filters are the ones that filter the oil before it goes back to the bearings and gears on the machine. The oil flows through two of them at any given time while the other two are in standby or are being serviced.

The lube technicians told us they get about a month out of a set of filters unless the oil has a lot of water in it. **It should be possible to increase this if the system had the capacity to generate more oil pressure and there was less water getting into the system.**

We were told the filter elements the mill is using in these filter housings is supplied by Pall and that they filter to the 6 micron range.

This unit with two filters per side is large enough to handle the 88 gallon per minute oil flow the system produces now. These filter housings <u>will not</u> be large enough for the future flow requirements of 175 gallons. The existing filter housing assembly will need to increased so it has at least three filter housings and elements per side. Filter life can be improved if the system, rebuilt or new can provide enough pump discharge pressure so the system can reach 22 or 50 pounds of differential pressure across the filters and have enough pressure left to overcome other system pressure losses and provide the proper flows to all bearings and gears.

The oil piping that connects all the main components we have been reviewing is of several sizes but appears to be suitable for this. **It will need to be improved, enlarged or replaced when the system capacity is increased to 175 gallons per minute.**

As the oil flows through these pipes there is only one pressure gauge and no oil temperature gauges to help us know what the system is doing. This is not enough.

Good control of system temperature and pressure are critical for an oil circulation system. If either temperature or pressure is not well controlled the oil flow to all the machine's lube points will not be consistent. The flow will increase or decrease depending on what the system pressure and temperature are doing.

Usually the more pressure and temperature gauges a system has the better. These are tools to help the operator / lube technician understand what may be going on within the system. As the system is improved new pressure and temperature transmitters should be added to improve pressure and temperature control and improve the system remote alarming ability. These transmitters should include local digital read-out that can be easily viewed by those working around the system.

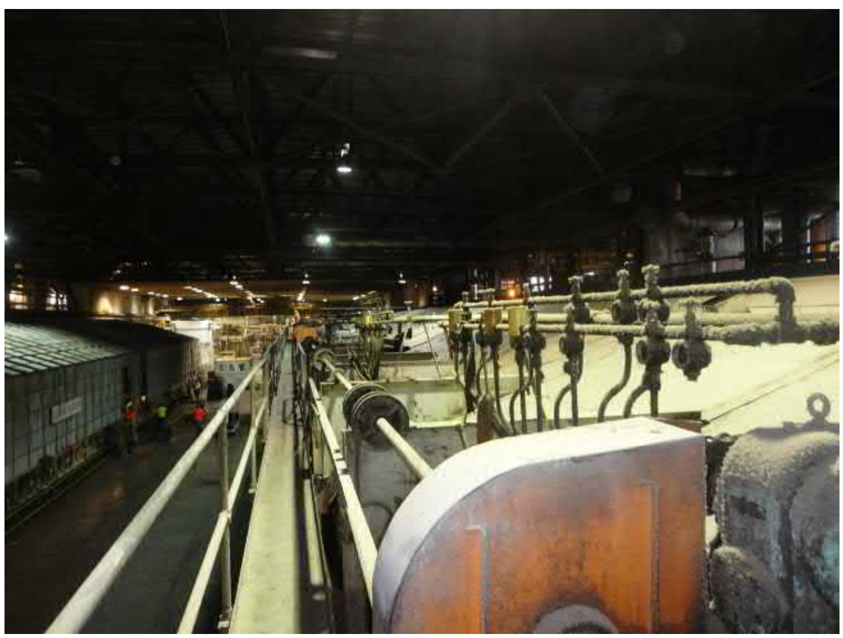
The next major component in the system after the oil filters is the **system oil cooler or heat exchanger** as some people refer to it. This system has two that can be run together or separately. If clean and working properly these heat exchanges should be sufficient for the existing system capacity. However the lube technicians again told us they have to manipulate the water flow through the heat exchanger by using a manual valve. They told us that there is no automated cooling water valve in the system. To get the flow so it can be controlled they have installed a ½ inch ball valve which they try to adjust day by day.

We explained earlier about the need to correctly regulate pressure and temperature. This system needs an automated valve that will properly control water flow through the coolers based on exit oil temperature to the paper machine. The oil coolers should be cleaned and inspected. They are large enough for the systems capacity today but will not be in the future if they had to supply all the oil the machine needs. SKF has found that plate and frame heat exchangers are more efficient and compact in this type of operation.

Previously in this report we discussed the need for electric heaters to keep the oil warm when the machine was not running or just starting up from a shutdown. When the machine is up and running with steam in the dryer cylinders the oil will return to the system reservoir hotter than we want to send it back to the lube points on the paper machine. The hotter the oil the less protection it will give the bearings and gears as far as keeping their moving parts separated. At the time of our visit with the machine running we saw 160 degree oil in the reservoir and oil going to the machine between 130 and 140 degrees F. We feel 125 to 130 is a good oil temperature for this machine. At the present time the mill may run with it hotter so the oil will drain from the bearings and gear cases better. While this improves oil drainage it does not improve lubrication of the bearings.

After leaving the heat exchanger the oil flows through the main supply header to the oil sight glasses. The oil supply headers are constructed of carbon steel pipe. The header for the drive side meters which are located on the mezzanine is about level with the top of the machine hood and runs outside of the dryer hood. See the next picture. The arrow is pointing to the supply header on the drive side. Each group of meters is connected to this header by more carbon steel pipe with threaded fittings. Each group can be isolated with a shut off valve.

In three places carbon steel lines branch off the drive side header and cross the machine over the hood to supply oil to the tending side of the machine. The sight glasses for the front side lube points are located above the hood on the tending side and are accessed from a cat walk that runs the length of the machine. See the second picture on the next page.



The supply headers are large enough for the system today but the system should be run at a higher pressure in the future. This will be explained further in the report covering the individual lines between each sight glass and lube point. New systems today are designed using 304 or 316 pipe materials. Connections to the groups of meters should come out the top of the supply headers rather than the bottom or side as they do now. See the next picture. The arrow shows the connection of the supply to the sight glasses comes out the side of the main header pipe. Any heavy particles moving with the oil inside this header have more chance to go directly down and into the sight glasses and perhaps the bearing if the sight glass does not plug. New systems are designed with the oil meter feed line connected to the top of the supply headers and pipes are sized to avoid large pressure differentials in the piping to insure that every group of sight glasses has approximately the same inlet pressure.

After the oil leaves the main supply piping and the branch piping feeding the groups of sight glasses the oil enters the sight glasses themselves. With the exception of a few in the after dryer section all the sight glasses are Beloit C-Shurs. This type of flow control was provided with many Beloit machines built between 1950 and 1985. The Beloit sight glasses are old technology for regulating oil flow to bearings and gears on a paper machine. These are being replaced on most machines by devices that can be accurately calibrated for the different oil flows and oil viscosities required by these machines as they have improved over the years.

The Beloit C-Shurs are operated by someone opening or closing the valve handle at the top of the sight glass. This opens or closes a needle valve to increase or decrease oil flow. However, there are no markings or other indication on the C-Shur to tell a person the amount of oil that is flowing through the sight glass. All the lube technician can do is look at the size of the flow stream itself. Judging how much oil that is flowing is very subjective. One person may feel that the size of the stream indicates four pints per minute while someone else might think that the flow was only one pint per minute.

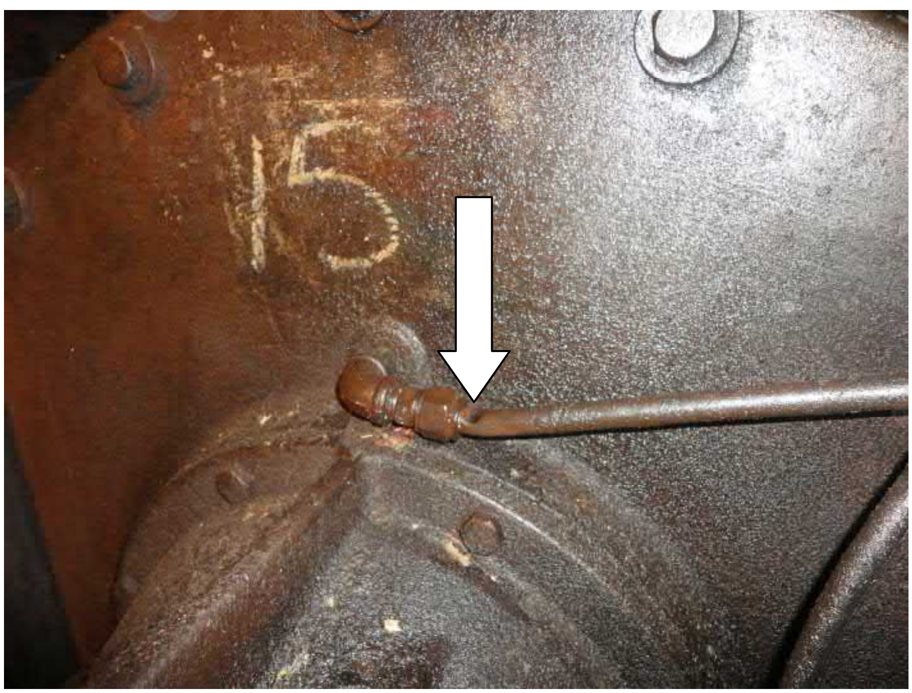
We noted that the size of the flow streams in the sight glass on this machine did not appear that much different for a dryer bearing than for a felt roll bearing. The lube technicians indicated they did not have a good estimate for the amount of oil the different bearings and gears should have. They are basically doing what they were shown to do when they took over the job. They pointed out they feel the lube points are not well labeled and they often do not know if they are adjusting the flow to a dryer bearing, a drive gear or a felt roll.

The majority of the meters on this machine were not leaking as badly as we frequently see them in other mills.

The Beloit C-Shurs on this machine should be replaced with a flowmeter that can be accurately calibrated for the various flows this paper machine requires for it many lube points. If you will look at the flow rates suggested for this machine on page 8 you will see there are several. The lube technicians told us they try to check the machine at least once per day. If a problem with one or more meters occurs it could be 24 hours or more before the problem is known to the machine operators. In that time a bearing could fail or be well on it's way to failure. The mill should consider low flow alarms to protect the machine when the lube technicians are not on duty or tied up with other functions.

The existing locations of the C-Shurs is less than ideal but new meters and alarms could be mounted in the same or nearby positions if they must. Some of these locations on the drive side could be improved on but going to slightly different locations or combining some groups of meters. When groups are moved or combined some new tubing will be necessary.

After the oil moves through the meters it enters the **smaller oil supply lines** which carry the oil to each lubrication point. There are approximately 538 active lubrications points, each with a supply tube and several discontinued tubes that are still in the machine. The majority of the tubes are 5/8" steel tubes with a few ½" stainless steel tubes. It appears that the stainless steel was used when the old steel tubes have been replaced. In some cases the old tubes have been crimped or damaged. See the next two pictures. We believe that the steel tubing is the original and is the source of some of the oil leaks on this machine.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Cracking and pitting of the steel tube is likely to form in areas closest to the wet end of the machine and in places where wash up water and chemicals can lie in the tube bundles. The problem will be worse if the tubes are not well supported and can vibrate. Leaks in the tubes are often very difficult to find and in some cases almost impossible to fix because of the way the tubes are clamped in bundles.

After the mill has selected the locations for new oil flowmeters they should start a program to replace the carbon steel tubes with stainless and only the best grades of stainless should be used in the first dryer section which will be the closest to the wet end.

As new tubes are installed they should have spacing between them and the hot parts of the machine frame they may be clamped to. Some engineering must be done to select the best locations and the correct size of the tubes to help avoid high pressure drops and keep the oil temperature more uniform to as many lube points as possible.

After the oil travels through the supply tubes it reaches the different bearings and gears. Please see the following picture of the tending side of the machine. This pictures shows **dryer bearings and felt roll bearings on the tending side of the machine.**

The gear case collects most of the oil on the drive side. Dryer bearings, intermediate gear bearings, gear nip lubrication and some of the felt rolls drain into the gear cases. The drains from the drive side gear case are 1.5”. Most drains are connected from the inside of the case but a few drain from the outside. See the next picture. Those on the inside use an identical drain port but it is on the back side of the case, closer to the dryer cylinders.

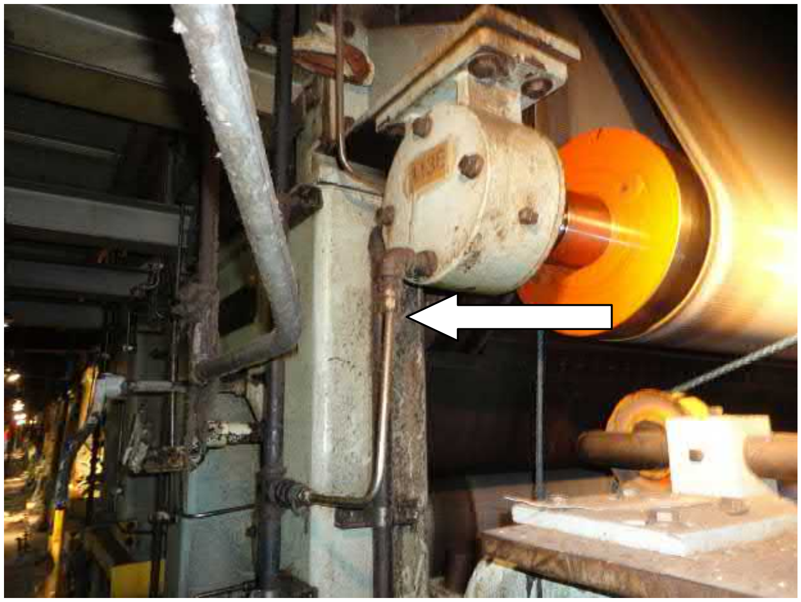
The next two pictures are of typical front side dryer bearing housing with a 1” drain line from the inner side of the housing. Theses bearings should receive 4.0 pints of oil per minute.

Most of the individual drain lines from bearings and gear cases are steel pipe with threaded fittings. On several felt rolls we found steel tubing and some hoses.

The picture above shows a typical front side dryer bearings housing with 1" pipe connected to the inner drain port of the bearing housing. Note is the next picture there is an unused drain port in the outside of the housing. The next picture is typical of all front side dryer bearings where the inner drain port has been used. See the next picture. The arrow is pointing to the unused port in the bearing.

To properly flow 4 pints per minute a combination of the two drains should to be used in the front side bearings. This has been done on many paper machines to improve the oil flow rates and make the drains work properly.

In the next picture you can see felt roll bearing drain that has been bushed down from ¾ pipe to ½ tube. Maybe it was a temporary repair but this will keep that bearing from draining the proper flow. This may have been a quick repair one time or another but until this machine can have a new drain system designed and installed **the full size of any existing drain ports should be utilized.**



The felt roll bearing in the next picture will not drain the proper amount of oil because another bearing above it is draining into it's drain. This can case oil to back up in the lower bearing.

The felt roll bearings should have an oil flow of 1 pint per minute and to achieve that flow need at least a ¾" drain port. As well as lines that are two small we found some with hoses that had low spots creating sump pockets and some with street elbows at the bearing. Hoses and street elbows typically have smaller internal diameters then pipe and should be avoided unless properly thought out. The next picture shows one case where red rubber hose has been used as a temporary fix for front side dryer bearing drains. This should be replaced when possible.

The drive side gear cases leak and like many machines of this style and age, the leaks are very difficult to find or reach to make a repair.

This style of machine with sections of gear cases bolted together and having many bolted covers, combined with the wear and tear of many years of running 24 hours a day often leak.

This oil will normally make its way into the mills waste collection system where a lot of money can be spent to remove it. The mill reported that they added approximately 8,000 gallons of oil so far this year. Part of this was due to oil leaks around felt rolls and gear cases but some because of condensate contamination. The condensate would normally get into the system because of leaking steam joints.

A systematic overhaul of the gear case joints and covers by installing new gaskets or gasket material where possible should be started. New bolts properly torqued and re-torqued when the machine has run awhile will be required. Loctite or similar products should be used to keep the bolts from loosening. In most cases this is an ongoing process that people are assigned to each shutdown. The payback will be fewer oil leaks, improved safety and environmental issues but also the people involved in this type of work, if properly motivated will pick up other potential problems before they become serious.

We were told by mechanics working on the machines drive gears and intermediate bearing that they have found the drive side gear cases will sometimes have dirt and sludge blocking the drain ports. All the gear cases should be cleaned. The correct oil flows will help keep the cases flushed out. Low oil flows will result in carbon and sludge build up.

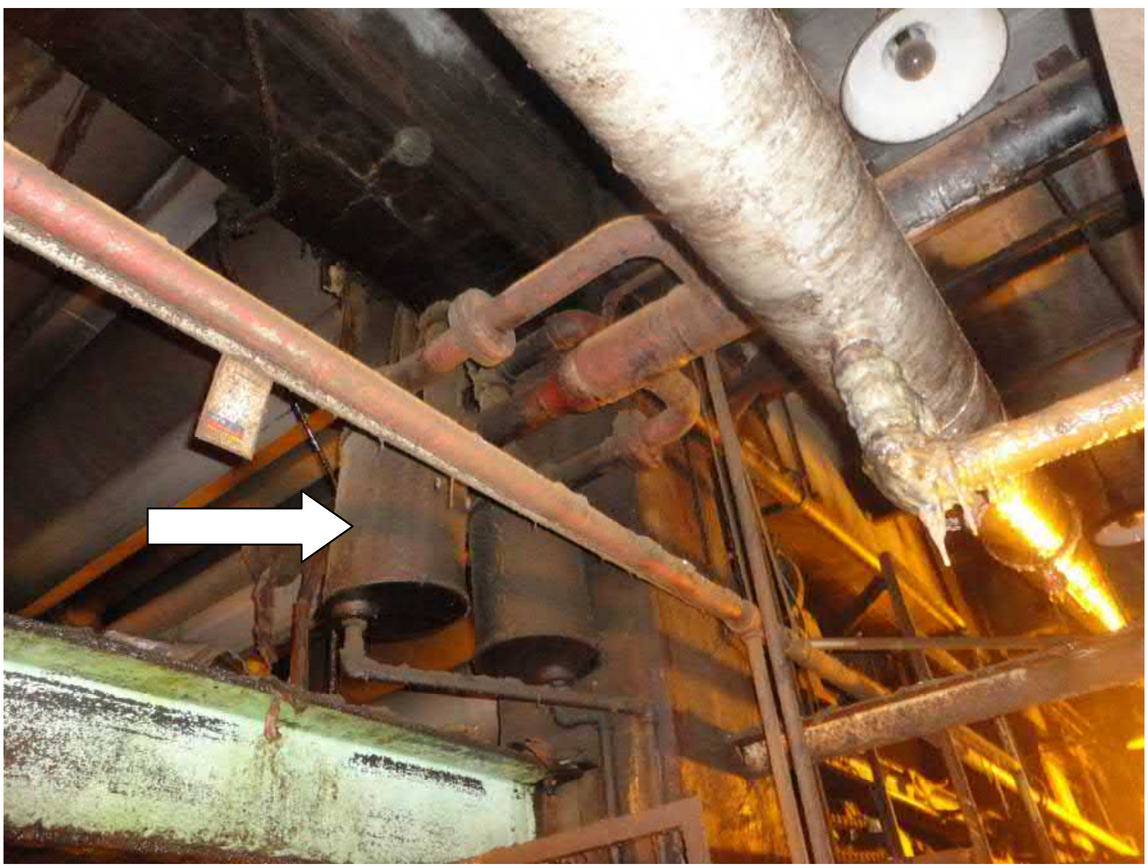
When the oil exits the bearings and gear cases it drains through the smaller pipes, tubes and hoses of various size that we have already discussed. These pipes, tubes, and hoses direct the oil into larger pipes that make up the **main drain header system**. Together the smaller diameter items and the larger main drain pipes make up the total oil drain system. Most of the main drain pipes are carbon steel. We were not able to learn much about their internal condition. It would not be unusual to find that they are partially blocked with corrosion and sludge after all these years. The arrow in the next picture is pointing to some of the larger of the drain pipes under the paper machine.

New oil drain systems installed today are typically built with stainless steel materials. Often the main drain headers which are designed to run approximately half full of oil will be attacked from the inside due to water and other chemicals that sometimes get into the oil.

With the exception of the forth and fifth dryer sections the main drains on this machine are generally large enough for the oil flows used today. However, they will not be large enough for the flows this machine should have. A new system of drains should be engineered and installed with proper venting before oil flows are fully increased to all lube points. The new system should be built of stainless steel, using welded

connections as much as possible. It should have a minimum of screwed fittings. The existing system will leak worse if the flow rates are increased before improvements are made to the drains and gear cases.

The existing main drain system has four Beloit style water collection pots in it. Two are on the tending side and two on the drive side. See the next two pictures. The first picture shows the two on the tending side and the second picture shows the two on the drive side. These should be checked and the drained off every day. These can be used as an early warning of water problems.



Water contamination of the oil is a major factor in bearing failures on most paper machines. Presently the oil reservoir in this system is to small to be of much use in water removal. The oil is kept so agitated inside that little water has a chance to settle out. We are told and also observed that there is no way to drain free water off the bottom of this reservoir. Due to the way oil enters and is pumped back out we know not much water will settle out in the existing reservoir. This makes the water traps and the one vacuum dehydrator attached to the system very important. See the next picture of the vacuum dehydrator. This unit should be well maintained and kept

running as much as possible. The unit in this picture is connected to the main lube unit on both PM 14 and PM 13. Each machine should have a dedicated dehydrator.

New oil should always be filtered as it is being added to any oil reservoir or gearbox.

As mentioned before this paper machine has bottom felting in the first four dryer sections and there may be plans to add it to the fifth dryer section. The elevation of these rolls makes them too low in the machine to use the main drain headers to collect the oil that lubricates them. When this machine was installed it came with ten sump systems. Two for each dryer section with one being installed on each side of the machine in that one dryer sections. See a typical sump reservoir and it's oil pumps in the next picture.

Oil collects in the sump's reservoir until the oil level reaches a point sufficient to trigger a level switch. This starts one of the pumps and provided that pump works well the oil is pumped out and into the larger main drain system above.

The piping system that carries oil from the basement felt rolls and into these sump reservoirs is not correctly sized or sloped

in many cases. The drain system for the basement felts rolls needs to be included in the re-design of the oil drain system. The basement felt roll bearings are a common source of oil leaks in this type of machine and special attention must be given to their drain system. The sumps need additional attention like cleaning and normal PM inspections to see that pumps and back-up pumps start and run as they should.

The systems **instrumentation, electrical logic controls and alarm outputs** appear to be very basic and limited in the information that machine operators or the lube technicians can receive.

When and if this system is rebuilt or replaced the electrical logic must be reviewed and instruments added where needed. Existing or new instruments must be wired so that system logic is correct to control pressure and temperature correctly and that the necessary remote alarms are taken to the machine control room. Additional training for the operators and lube technicians regarding the correct operation of the system may be needed. The next picture shows the very basic controls in this system now.

The picture below shows some of the old electrical switches in the system. The arrow is pointing to an air over oil type accumulator that Beloit put in many of their low pressure systems built in the 1950's. This device and associated switches should be replaced with a modern control pressure control and alarm system as part of the overall update of the system if it continues to be used to lubricate this paper machine.

<u>Other oil circulation systems:</u>

The dryer section oil circulation system was the main focus of our visit but we also did a quick inspection of the After Dryer and differential drive lube systems. **The next two pictures are of the oil system that supplies the two calendar stacks and the After Dryers** and the gears that drive those dryers. The picture on the left is the systems oil reservoir and the one on the right is of the systems pump, motors, one oil filter and system controls. The pumps are Roper 2F 10 series 27 and the drive motors are 3 HP 1725 RPM.

This systems pumps and motors can supply approximately 11.5 gallons of oil per minute at 100 psi. ISO 220 oil is used in this system.

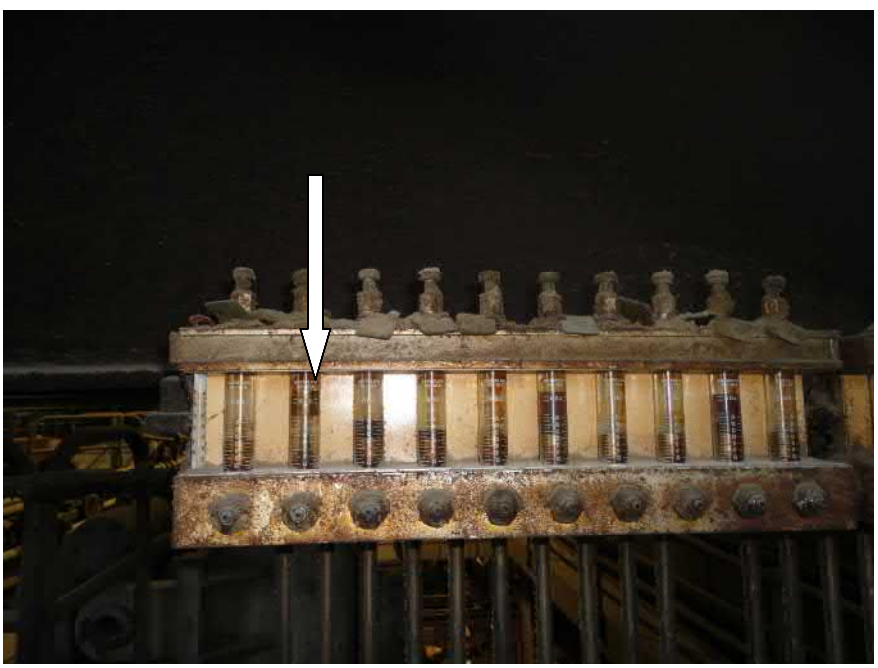
This flow is marginal if all bearings were to get the SKF recommended flows. The pumps in this system are designed so they could be turned at 3600 RPM is necessary. It might require a 7 HP motor at that speed but the pumps on this system can supply more oil if we want them to.

The system on has one oil filter. If becomes dirty when the machine is running it is bypass and changed on the run or the mill must wait for an outage before changing it. A second filter housing and filter should be added to this system so the dirty filter can be changed with the machine running.

The oil flowmeters on the tending side of the calendar stacks and After Dryers are Beloit C-Shurs just like those in the five main dryer sections and have all the same problems. The lube points on the drive side of this section of the machine are serviced by Safematic (Now SKF) model SF flowmeters. See the next two pictures. The first picture below shows two banks of 10 meters, each meter being the size SF10. These are an excellent meter for paper machines when used properly. One problem we found was that all 20 meters (only 19 were in use) were set for approximately the same flow rates. That means that a calendar stack roll that needs approximately 1.5 pints per minute is getting the same flow as a bearing on the King, Queen or dryer cans. **This is not correct and the flows should be adjusted according to the needs of each bearing or gear.**

These meters have been installed with stainless steel tube connecting them to the lube points. This is the way we would like to see the whole machine done. However, as long as this machine lube system runs at low oil pressures the size and length of those tubes is very important. Tube to small or to long will take require more pressure than the system might be able to provide.

One of the features of the SKF model SF meter that makes it user-friendly is the fact that a person can walk by them and quickly check to see that all the metal floats inside the tubes are the proper ADJ Position or Adjusted Position. If flow decreases in one meter it's float will be out of the Adjust Position and will be very evident to the person checking. But, this good feature also means it is important that the floats never stick in the up position when there is no flow.



The arrow in the previous picture is pointing to a float that was stuck when we did our inspection. One day when the machine was down and the oil shut off we checked and found two metal floats stuck in the up position. One in each bank of meters. This can happen if the oil gets varnished and the varnish builds up on the float and tube thus reducing the clearance between the two parts. **These meters need to be taken apart and the glass tube and float cleaned. New o'rings should be used when the parts are reinstalled. These meters require special viton seals. The meters should be checked for stuck floats whenever the oil system is turned off.**

Differential Drive Lube System. This system is used to lubricate the differential drive gear boxes, transfer cases and PIV units associated with the line shaft on this machine. See the next picture.

The differential drive lube unit is very much the same as the Calendar and After Dryer Lube System with the exception that the pumps on the differential drive lube unit are Roper 2F 20 Type 27 lube pumps. ISO 220 oil is also used in this system. These pumps are driven by 2 HP motors turning 1725 rpm. These pumps will supply approximately 22 gallons of oil per minute when turning 1725 RPM. This flow could be doubled if the pumps were turned at 3600 RPM.

There are approximately 60 lubrication points this system is supplying oil to. Each point is monitored with a Beloit C-Shur. See the next picture. The arrow is pointing to a group of the C-Shurs.

Statement of the Survey Team:

The most immediate problem with the oil lubrication of the five main dryer sections is that the majority of the bearings and gears are not getting enough oil. This is especially true for the dryer bearings and gear nip lube points. There are several reasons for this.

1. The lube technicians do not try to adjust the Beloit C-Shur oil sight glasses to get a larger flow of oil for the dryer bearings and gear nips. They only monitor to see that there is some oil flowing to all points. The problem with doing it this way is that the flow could be the same to a felt roll bearing as it is a dryer bearing, and that is wrong. The felt roll bearing only needs about 1 pint per minute while the dryer bearing may need 6 pints per minute. The lube technicians also feel the C-Shurs are not properly tagged or not tagged at all to indicate the bearing or gear they service.
2. The C-Shur sight glasses do not indicate how much oil is flowing. Only the size of the oil stream seen in the sight glass gives any indication of the amount of flow and one person's opinion of that flow amount can be very different from another person. Also there are no low or high flow electronic alarms on these meters. At present these meters are visually checked only once or twice in a 24 hour period. Maybe not at all on week ends. Between those inspections oil flow to a bearing could stop and not be realized until the next visual inspection or until something fails.
3. The oil circulation system that supplies the oil does not have sufficient capacity for this machine. To add to that the problem we found that the full capacity of the existing system is not being utilized. The capacity of the existing system is approximately 90 gallons per minute. It is our estimate that 65 or 70 gallons per minute of that is being used on a regular basis. The machine's five main dryer sections should have approximately 175 gallon per minute capacity.

Adding new oil flow meters with good flow indication and alarms is very important to maximize the oil flow the existing system can provide. This will help avoid putting too much oil to some points like felt rolls and intermediate gear bearings while getting the most possible for the dryer bearings and gear nips. In the process of installing new meters and alarms it is important that the meters be tagged correctly to indicate the lube point each supplies.

There are things that can be done to make the existing oil system work better. The oil temperature and oil pressure is not controlled as well as it should be. The system's operating pressure is lower than necessary so the life of the oil filters is short because of it. There should be improvements to the oil reservoir including baffles, water drain and additional electric heaters. These items are possible to correct without a huge cost.

Before the machine can use more than 90 gallons of oil per minute its oil drain piping needs to be replaced with larger pipes. A new system of drains should be engineered and installed as a second priority after installing new oil flowmeters and making some of the important corrections to the existing oil circulation system.

The machine needs more oil; almost twice as much as its existing systems capacity. This could be accomplished with one new replacement system or by adding a second system to lubricate the fourth and fifth sections of the machine. If a new system were installed for those sections it would be possible to add the after dryer section and Calandars and do away with the special after dryer lube system.

The after dryers and the differential drive system do not have the immediate problems as the five main dryer sections but they also use the Beloit C-Shurs for most of their lube points. These C-Shurs have the same problems as those in the main dryer sections. A longer term plan should be to replace those as well.