# Paper Machine Oil: Lubricants suitable for wet and dry systems

Photo credit: Irving Oil Limited

By the Afton Chemical Industrial Team

The processes involved in manufacturing paper range from wood handling to post treating the paper. A complete unit usually includes systems for wood handling, chemical pulping, stock preparation, mechanical pulping, finishing, etc.

Paper machines are extremely large, with the largest systems costing over 600 million Euros or about $721 million. The paper machine section alone can cost up to 100 million Euros ($121 million), depending on the level of automation.

The width of rollers can vary from one meter to 11.5 meters, and paper speed can reach up to 120 km/h on the wider machines. These hardworking machines can put in 15 to 20 years of service while shutting down production only 2-3 days per year for routine maintenance, although some do require rebuilds after five years and major rebuilds after 10 years.

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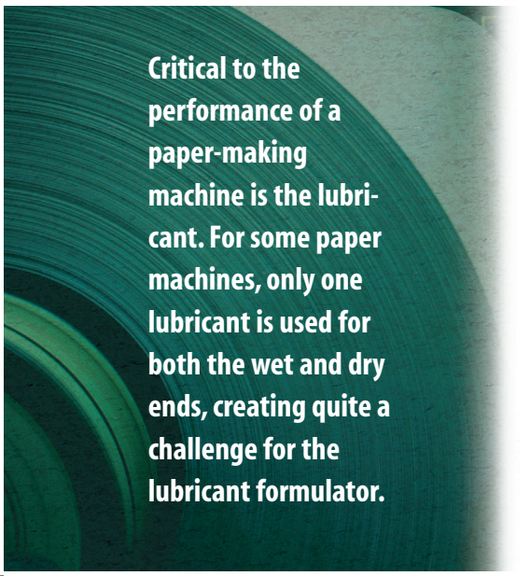
Critical to the performance of a paper-making machine is the lubricant. For some paper machines, only one lubricant is used for both the wet and dry ends, creating quite a challenge for the lubricant formulator.




## General lubrication systems

There are over 500 lubrication points in a paper machine that require oil feed and flow meters. The lubricants used include paper machine oils and hydraulic oils (actuator and roll). The paper machine oil lubricates the bearings and gears of the rollers.

The actuator hydraulic system controls the cylinders, and the roll hydraulic system keeps the rolls straight. For a large machine, the wet end requires up to 25,000 liters of lubricant, and the dry end requires up to 40,000 liters (as the dry end is bigger).

Typical oil change intervals are five years for the dry end and even longer for the wet end, which tends to operate at lower temperatures. Top-offs may be required with older machines that tend to leak.

## Wet end composition and requirements

The wet end contains pulp preparation, paper forming and paper pressing sections and is where the pulp from the pulping plant is formed into sheets. It contains 99% water and 1% pulp in the head and forming sections. After the pressing section, there may be only 50% water left in the paper. The sheet is then squeezed between rollers to remove as much water as possible before moving to the dryer section or dry end.

Paper machines are designed to have a maximum operating temperature of around 75 C for wet end bearings. Due to heavy loading, some OEMs have four-ball weld load requirements for lubricants which can require the use of mild EP additives in the lubricant formulation. In addition, different viscosity grades often are required, depending on the application.

Paper machines typically use ISO 220VG fluid. Roll hydraulics use ISO 100VG fluid, which may also lubricate the drive gear of the roll and roller bearing. Actuator hydraulics use ISO 46VG fluids.

### Table 1. Wet end lubricant performance requirements

- Filterability (wet & dry).
- Water separation/removal.
- Air release (mainly hydraulic oil issue, sump sizes are getting smaller).
- Antiwear/mild EP -Weld performance required due to high loads and contamination.
- Anticorrosion and antirust.
- Compatibility with process chemicals used which appear as contaminants in water. (In severe cases, pH of 2.5 have been measured on water sampled from the system)
- Improved conductivity for roll hydraulic fluids. (Use of ashless hydraulic technology and plastic filters have shown some problems in the field)

## Table 2. Dry end lubricant performance requirements

**Drying/normal calendar**

- Oxidation stability/thermal stability-resistance to sludge formation.
- Filterability (wet & dry).
- Water separation.
- Air release (mainly hydraulic oil issue).
- Foam formation (mainly hydraulic oil issue).
- Antiwear/very mild EP anticorrosion and antirust at higher temperatures.

**Latest calendar section**

- Excellent oxidation/thermal stability.
- Deposit control.
- Additive stability up to 200 C.
- Filterability (wet & dry).
- Water separation.
- Air release (hydraulic oil issue).
- Antiwear.
- Anticorrosion.
- Low volatility.

## Dry end composition and requirements

The dry end contains cylinder and calendar sections. The paper sheet from the wet end is fed into the dry end where it is pressed between heated rollers to remove the remainder of the water. Steam temperatures vary from 120 C to 190 C through the rolls.

Newer machines can use natural gas in place of steam at temperatures up to 600 C. Bearing temperatures normally run around 90 C but can be up to 130 C if insulation is not possible. For temperatures higher than 100 C, synthetic oils are recommended.

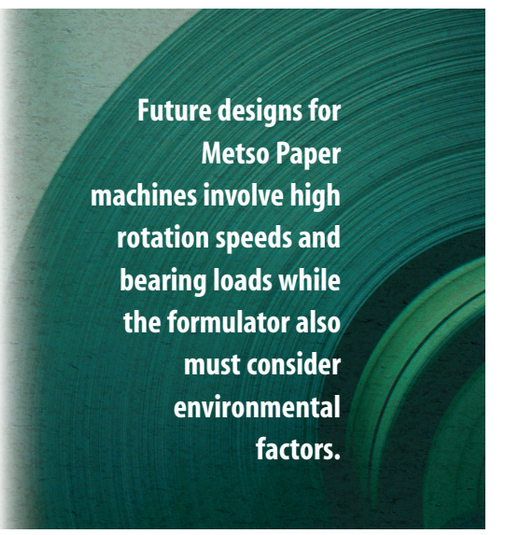
High temperatures in this section means the oil has to be very oxidatively stable, even in the presence of yellow metals which often are used in the bearings. Potential corrosion of these metals by the oil has to be taken into consideration. Also, due to the higher temperatures, more viscous fluids are required.

The dry end of the paper machine typically uses ISO 220 or ISO 320VG fluid, while roll hydraulic may use ISO 100VG or 220VG fluid and actuator hydraulic uses ISO 68VG fluid. After the cylinder section, the paper moves into the calendar section containing 1% water.

The calendar section is the hottest part of the paper machine with a paper skin temperature of up to 200 C. A heat transfer fluid is used to heat rollers when temperatures get as high as 230 C to 280 C. It is recommended that a separate synthetic fluid be used to lubricate these bearings (ISO 1000VG). In general, there is a move toward synthetic or Group III-based fluids for higher performance.

## OEMs: Paper machines

Two of the top paper machine manufacturers are Metso Paper (formerly Valmet) and Voith Paper (formerly Voith Sulzer). Both of these manufacturers serve the global market.



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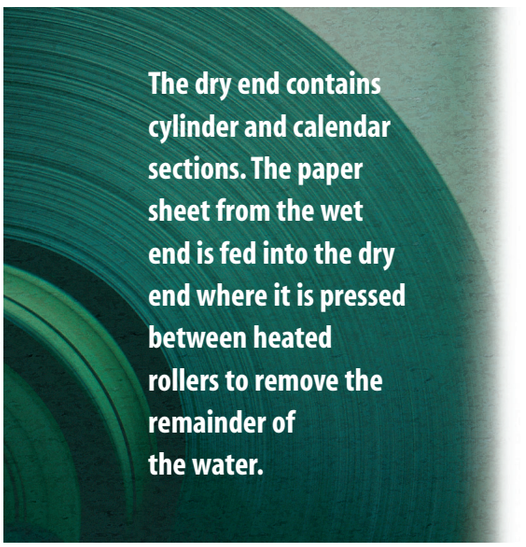
## Metso Paper

Metso Paper has recommended specifications for oils used in the wet end and oils used in the dry end of the paper machine. Both specifications require a four-ball weld test. They do not recommend or approve oils but will advise users. This allows paper mills to have supply agreements with oil companies. Major oil marketers include ExxonMobil, ChevronTexaco (now Chevron), Shell and Neste.

The main lubricant system covers both the wet and dry ends using different viscosity grades: wet end ISO 220VG; dry end ISO 220/320VG. Oil life is typically five years. However, with older machines, topping off can be as much as 300 liters per week to replace fluid which has leaked.



The dry end contains cylinder and calendar sections. The paper sheet from the wet end is fed into the dry end where it is pressed between heated rollers to remove the remainder of the water.

This topping off has the added benefit of providing an additive replenishment to the system which newer machines do not benefit from.

Most lubricant-related problems pertain to individual mills rather than being general to all installations. There is a trend within the industry for ashless (zinc-free) paper machine oils, which is driven by the negative interactions seen between zinc dialkyldithiophosphate (ZDDP) in the zinc-based fluids and paper-making chemicals and with water.

Two other lubricant concerns include air release and foam performance, which can lead to the possibility of cavitation in the system. Air compressed into the oil in hydraulic systems can also lead to oil oxidation which is further compounded by the use of smaller sump sizes.

Demulsibility also can be a problem in older machines where the water content easily can exceed the levels seen in newer machines. Newer machines will tend to see 350 ppm of water or less. The newer machines have the benefit of water separators that are activated when needed.

More recently, the use of low viscosity ashless technology and plastic filters has been reported to cause an issue with electrostatic discharge in the wet end. This phenomenon is not fully understood and appears to be influenced by the design of the filters.

Future designs for Metso Paper machines involve high rotation speeds and bearing loads while the formulator also must consider environmental factors. Rotation speeds and load on bearings are increasing, giving rise to revised bearing lifetime calculations from FAG and SKF: 190,000 hours dry end bearing; 120,000 hours wet end bearing are typical lives for these bearings. Bearing life also is influenced with larger bearings where the sliding contact at high speed can lead to wear issues.

Bearing manufacturers such as SKF have introduced EP tests such as the FZG test into their specifications in an attempt to address this problem. The use of hydrostatic bearings is an alternate resolution, although expensive.

With regard to environmental factors, recycling of water can lead to increased levels of treatment chemicals in the water system. This can lead to a greater chance of compatibility problems with the lubricant following any contamination.

## Voith Paper

Voith Paper machine designs consist of three main lubrication systems: (1.) wet end (typical oil volume 20,000 liters), (2.) dry end (typical oil volume 20,000 liters) and (3.) calendar rolls (high temperature and load, usually synthetic ISO 1000VG product). The wet and dry ends usually use the same lubricant with a typical oil life of five years with oil analysis programs.

The oil circulation system may include a centrifuge for water removal and a filtration system. In the Voith systems, bearings tend to operate under high-speed conditions and are fed with increased oil circulation, which imparts lubrication and cooling. These increased bearing speeds are regard-

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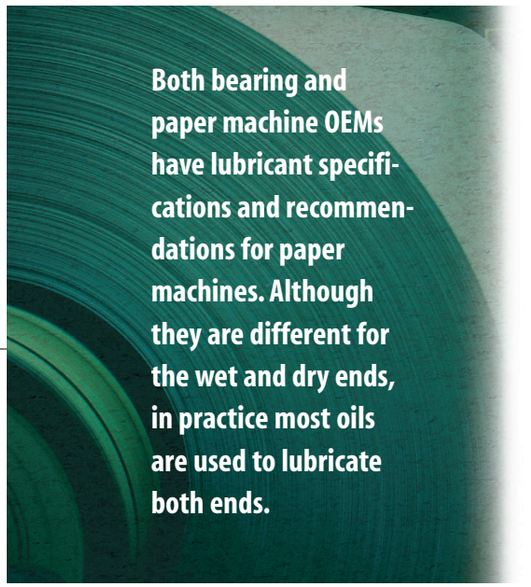
ed by Voith as beneficial to lubrication due to the improved hydrodynamics.

Voith Paper does not operate a lubricant approval system. They do, however, provide a set of standards titled, "Recommendations and Minimum Requirements." These requirements are based on DIN and ISO specifications (current version dated October 2004).

At the top of the list of tests is the DIN 51517 Part III specification air release and demulsibility, which are stressed as key requirements along with FXG performance. Although synthetic oils are used in Voith systems, the equipment is designed for use with mineral oil.




## OEMs: Bearing manufacturers

Bearing suppliers play an important role in the design of the lubrication system and oil specifications used in paper machines. Two key players, FAG and SKF, delivered a technical presentation at this year's STLE Annual Meeting in Las Vegas.

## FAG

FAG has a specification for paper machine oils that includes the FAG PM test. This specification is now covered by the Voith requirements. FAG Dynamic PM Test (DIN 51819-3) runs for 500 hours at 750 rpm with an axial load of 20 KN.

The oil runs through a preheated container set at 120 C where water is added to the oil to get water-in-oil content through the system of 50 PPM. The oil goes through a 10-micron filter after coming out of the oven. There is reason to believe that this test cannot be passed if using strong EP additives.

## SKF

SKF has published requirements for the dry end sections of paper machines, but not for the wet end. SKF would like to avoid use of EP additives but admits that weld performance is required so the use of "mild" EP additives is necessary. The Metso specification is based on SKF requirements.

## Conclusion

Both bearing and paper machine OEMs have lubricant specifications and recommendations for paper machines. Although they are different for the wet and dry ends, in practice most oils are used to lubricate both ends. This means that the oil not only has to have good rust and oxidation performance but also good water tolerance. It also needs some antiwear and mild EP performance. These varied requirements present a challenge to the lubricant formulator which can be met by combining ashless antiwear hydraulic technology with mild extreme pressure additives.

## Acknowledgments

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