WATER USE AND REDUCTION

Water use and its reduction has become a major focal point for pulp and paper mills around the world. This adoption of environmental laws such as Environmental Protection Agency’s (EPA) Duster Rules in the United States and the European mills needing to comply with Integrated Pollution Prevention and Control Directive (IPPC) Directive has driven many pulp and paper mills around the world to reduce plant water usage and effluent streams. Water use on rotating equipment is often high and with today’s advanced sealing systems can be dramatically reduced. By reducing water usage and leakage from rotating equipment, mills can make significant reductions in the amount of effluent treatment. Along with environmental concerns, various economic concerns with water are also driving water conservation in the pulp and paper industry. The cost of water ranges widely depending on access, region and accounting practices. Biological effluent treatment, advanced effluent treatment, limited water supply or municipal water use results in charges range from as low as € 0.02/m³ to € 0.25/m³. In pulp mills using black liquor as fuel, 1 l/min of water dilution can cost over € 406 per year to evaporate. An area often neglected is the rehandling cost incurred when diluting an elevated temperature process such as stock. Flush water rehandling costs can easily reach over € 75 to € 200 per year for each liter per minute of flush water injected into an elevated temperature processing system. Reducing flush water use on rotating equipment can result in significant savings as long as considerable attention is given on selecting the best available sealing device technology. The high flush water flow rates actually mask any inadequacies in a mechanical seal or mechanical packing being used. The design criteria of a mechanical seal or mechanical packing becomes much more critical when flush flow rates are reduced or eliminated. Plants today continue to use what is referred to as flush/reflux flow through a seal or mechanical packing. This practice is considered a huge waste of flush water, since the water is piped to the floor or the nearest drain where it eventually ends up going to the wastewater facility. A controlled amount going directly to the seal or mechanical packing is the best way to reduce overall flush water consumption.

New braided packing fibers and construction allow for reduced water consumption. Use of a SpiralTrac™ centrifugal device as an ancillary device will reduce water usage even further. New single mechanical seals technology has been developed to run flush-free in stock service up to 4%. The use of single or split mechanical seals with a SpiralTrac™ offers reduced or zero water consumption in a variety of mill applications. New technology dual mechanical seals with proper environmental controls offer water conservation in more severe services. Some pulp and paper mills have the opinion that the water is free for them, for example, “We are taking the water from underground quells, which is free…” or “We have the river next to the mill and we are just taking the water out from the river…” By Bob Martin and Zoltan Homoky, A.W. Chesterton International

REDUCE FLUSH WATER USAGE AND INCREASE PLANT PROFITABILITY

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## Reduction of Water Usage and Increase of Plant Profitability

Bob Martin, global business development manager

### Table 1: Achievable flush water reductions

<table>
<thead>
<tr>
<th>Equipment Name</th>
<th>Water Usage (litres per minute)</th>
<th>Current - Savings</th>
<th>Reduction</th>
<th>Water Treatment</th>
<th>Savings (l/min)</th>
<th>Annual Water Costs (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Sumps</td>
<td>14</td>
<td>6.43</td>
<td>52% - 100%</td>
<td>NA</td>
<td>NA</td>
<td>1,156,072</td>
</tr>
<tr>
<td>Piping Systems</td>
<td>9</td>
<td>3.51</td>
<td>39%</td>
<td>NA</td>
<td>NA</td>
<td>1,156,072</td>
</tr>
<tr>
<td>Mechanical Sumps</td>
<td>24</td>
<td>12.33</td>
<td>33% - 34%</td>
<td>NA</td>
<td>NA</td>
<td>1,156,072</td>
</tr>
<tr>
<td>Mechanical Sumps</td>
<td>5</td>
<td>2.55</td>
<td>72% - 90%</td>
<td>NA</td>
<td>NA</td>
<td>1,156,072</td>
</tr>
</tbody>
</table>

### Table 2: Make Up Liquor Pumps reheat savings

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Current - Recommended</th>
<th>Savings (l/min)</th>
<th>Total Water Costs (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agitators</td>
<td>60.33</td>
<td>20.00</td>
<td>8,827</td>
</tr>
<tr>
<td>Pumps</td>
<td>28.63</td>
<td>15.00</td>
<td>10,827</td>
</tr>
<tr>
<td>Mechanical Seal</td>
<td>1.50</td>
<td>0.75</td>
<td>1,156,072</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>95.00</td>
<td>145,245</td>
</tr>
</tbody>
</table>

### Figure 1: Economic Value Added calculation scheme

Water use and its reduction has become a major focal point for pulp and paper mills around the world. This adoption of environmental laws such as Environmental Protection Agency’s (EPA) Duster Rules in the United States and the European mills needing to comply with Integrated Pollution Prevention and Control Directive (IPPC) Directive has driven many pulp and paper mills around the world to reduce plant water usage and effluent streams. Water use on rotating equipment is often high and with today’s advanced sealing systems can be dramatically reduced. By reducing water usage and leakage from rotating equipment, mills can make significant reductions in the amount of effluent treatment. Along with environmental concerns, various economic concerns with water are also driving water conservation in the pulp and paper industry. The cost of water ranges widely depending on access, region and accounting practices. Biological effluent treatment, advanced effluent treatment, limited water supply or municipal water use results in charges range from as low as € 0.02/m³ to € 0.25/m³. In pulp mills using black liquor as fuel, 1 l/min of water dilution can cost over € 406 per year to evaporate. An area often neglected is the rehandling cost incurred when diluting an elevated temperature process such as stock. Flush water rehandling costs can easily reach over € 75 to € 200 per year for each liter per minute of flush water injected into an elevated temperature processing system. Reducing flush water use on rotating equipment can result in significant savings as long as considerable attention is given on selecting the best available sealing device technology.
Reduce flush water usage and increase plant profitability

By Bob Martin and Zoltan Homoky, A.W. Chesterton International

Water use and its reduction has become a major focal point for pulp and paper mills around the world. The adoption of environmental laws such as Environmental Protection Agency’s (EPA’s) Cluster Rules in the United States and the European mills needing to comply with Integrated Pollution Prevention and Control Directive (IPPC-Directive) has driven many pulp and paper mills around the world to reduce plant water usage and effluent streams. Water use on rotating equipment is often high and with today’s advanced sealing systems can be dramatically reduced. By reducing water usage and leakage from rotating equipment, mills can realize significant reductions in the amount of effluent treatment. Along with environmental concerns, various economic concerns with water are also driving water conservation in the pulp and paper industry. The cost of water ranges widely depending on access, region and accounting practices. Biological effluent treatment, advanced effluent treatment, limited water supply or municipal water use results in charges range from as low as €0.02/m³ to €2.5/m³. In pulp mills using black liquor as the fuel, 1 liter of water dilution can cost over €2565 per year to evaporate. An area often neglected is the reheating cost incurred when diluting an elevated temperature process such as stock. Flush water reheating costs can easily reach over €75 to €220 per year for each liter per minute of flush water injected into an elevated temperature process. Reducing flush water use on rotating equipment can result in significant savings as long as considerable attention is given on selecting the best available sealing device technology. The high flush flow rates actually mask any inadequacies in a mechanical seal or mechanical packing being used. The design criteria of a mechanical seal or mechanical packing becomes much more critical when flush flow rates are reduced or eliminated. Plants today continue to use what is referred to as flush rinse wash out through a seal or mechanical packing. This practice is considered a huge waste of flush water, seeing as the water is piped to the floor or the nearest drain where it eventually ends up going to the wastewater facility. A controlled amount going directly to the seal or mechanical packing is the best way to reduce overall flush water consumption.

New braided packing fibers and construction allow for reduced water consumption. Use of a SpiralTrac™ centrifugal device as an ancillary device will reduce water usage even further. New single mechanical seals technology has been developed to run flush free in stock service up to 4%. The use of single or split mechanical seals with a Spiralis™ offers reduced or zero water consumption in a variety of mill applications. New technology dual mechanical seals with proper environmental controls offer water conservation in more severe services. Table 1 references achievable flush water reductions with today’s advanced sealing systems; the use of new technologies within the frame of a cost reduction programmes can contribute to mill wide savings well in excess of €100,000 annually. Table 2 is a typical example of a Make Up Liquor Pumps reheating savings at a mill.

Table 1: Acheivable flush water reductions

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Water Usage (liters per minute)</th>
<th>Current</th>
<th>Recommended - Savings</th>
<th>To Drain</th>
<th>Water Treatment</th>
<th>Area</th>
<th>Water Code €/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps in Digestor Area</td>
<td>Current - Reconstructed</td>
<td>30.00</td>
<td>0.00</td>
<td>1.50</td>
<td>NA</td>
<td>NA</td>
<td>≤ 150,072 ≤ 150,072</td>
</tr>
<tr>
<td>Pumps in Digestor Area</td>
<td>Recommended</td>
<td>2.00</td>
<td>0.00</td>
<td>0.00</td>
<td>NA</td>
<td>NA</td>
<td>≤ 10,827 ≤ 10,827</td>
</tr>
<tr>
<td>Savings</td>
<td>28.00</td>
<td>0.00</td>
<td>1.50</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>≤ 145,245 ≤ 145,245</td>
</tr>
</tbody>
</table>

Table 2: Make Up Liquor Pumps reheating savings

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Water Usage (liters per minute)</th>
<th>Current</th>
<th>Recommended - Savings</th>
<th>Area</th>
<th>Water Code €/L</th>
</tr>
</thead>
</table>
| Water and Energy Savings and their Financial Perspective

Today’s pulp and paper industry is facing challenging times due to the world financial crisis. Major pulp and paper corporations are making painful decisions especially at pulp production. There are sometimes evaporation losses at the evaporators in chemical pulp lines. There are sometimes heat losses especially at pulp production. There are sometimes evaporation losses at the evaporators in chemical pulp lines.

Figure 1 Economic Value Added calculation scheme

Cost of raw materials: The saving potential is relatively limited as the raw material prices are driven by the world market prices.

Taxes: In some countries the local government is supporting those companies who are paying high attention to environmentally safe and pollution reduction programmes with documented results, but this is based on the local governments and their own rules.

Conversion costs: The conversion costs are the only place for significant saving potential for mills to reduce their total operating cost reduction goals. The conversion cost element has different factors as it is shown in the EVA figure. Let’s investigate the water related cost factors from the water saving point of view:

Safety and environmental: The water in the pulp and paper process is present everywhere. Water leakage that is collected to the drain channel has a potential risk for safety, eg. slippery surfaces. The environmental perspective is the less water going to the drain, less water having to be cleaned and filtered which means automatic water and cost savings.

Operations, maintenance, utilities, electricity and water:

Being able to reduce flush water and service water to rotating equipment can result in significant fresh water and effluent treatment cost savings. So the financial perspective is that if we are able to pump less water for rotating equipment, the result is less electricity and energy output.

The free water subject:

Some pulp and paper mills have the opinion that the water is free for them for example, “We are taking the water from underground quells, which is free…”

Even this looks simple and easy, but is not 100% true, so let’s look at the water related cost and the water loop (Fig. 2). There are always flush water costs like pumping the water from the original source, filtration to make water qualify available for the process. There are always treatment costs like waste water treatment, treatment and cooling of recycled water.

There are sometimes heat losses especially at pulp production. There are sometimes evaporation losses at the evaporators in chemical pulp lines.

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PULP AND PAPERS OPERATING COSTS AND ENVIRONMENTAL CHALLENGES

Operating costs and environmental pressures are making an impact on the way we approach sealing pumps and
rotating equipment today. This means sealing methods are required to lower costs and comply with local regulators by addressing the following cost concerns (fig. 3):

Whether the equipment is sealed with packing or mechanical seals, the percentages vary but maintenance cost and sealing water cost are the two primary cost drivers.

To improve on this and to help you to drastically lower the operational costs for sealing your rotating equipment, Chesterton has developed the Mill Wide Sealing Program. This program focuses on reducing the two primary cost drivers, maintenance cost and sealing water costs, with standardised system solutions that improve reliability while reducing or eliminating the need for external sealing water.

Before we look at the system solutions, let’s first look at what are the sealing issues for mechanical seals in mills and look at ways to resolve these. Let’s take a standard open stuffing box, equipped with a common single mechanical seal. What happens in this stuffing box when the pump is started?

1. Axial flow is introduced into the stuffing box that drives the paper stock along the bore towards the end of the stuffing box.
2. The net axial flow is towards the end of the stuffing box and as a result the papers stock collects at the seal faces. The heat generation of the faces and the presence of air in the paper stock will dry out the stock and the end result is excessive heat generation causing the seal to leak. This leakage will get progressively worse and lead to seal failure as shown below in fig. 4.

The most common fix to make mechanical seals work in paper stock applications is by using a flush. The external flush fluid is injected through the seal at higher pressure than the process and keeps the paper stock away from the faces.

Flushing takes away the source of the problem and is therefore very effective. Yet, it is only as reliable as the external supply system for flush water. In many mills, the flush water supply system is used for a variety of services including equipment house down. This can easily lead to pressure drops and unreliable flush!

The facts are that the two largest contributors to the operational costs for sealing pumps and rotating equipment in mills today are maintenance costs and sealing water costs (both being controllable).

Effluent treatment Dilution Water Consumption Evaporation Energy Pollution

Figure 2

<table>
<thead>
<tr>
<th>Cost concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effluent treatment</td>
</tr>
<tr>
<td>Dilution</td>
</tr>
<tr>
<td>Return</td>
</tr>
<tr>
<td>Disposal</td>
</tr>
</tbody>
</table>

The water loop

Figure 3

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drops in other areas of the supply system and can cause the flush water to backflow, causing chugging. In addition, the clean external water needs to be supplied, heated and eventually evaporated out and treated which all adds operational costs.

When we review the way a stock pump operates and with the facts the industry has been using commonly (Fig. 5), we believe that flushing and quenching is not a very reliable and cost effective way of operating your pumps.

- The reliability of the system is determined only by the reliability of its external support systems: the flush water supply
- The water required for flushing and quenching seals is expensive, especially if treatment and re-heating costs are taken into account
- Lastly, flushing or quenching is certainly not in line with the principles of ISO-14000 that suggests the 4-R principle of Reduce, Re-use, Recover and Recycle.

Let’s look at a different way to operate your stock pumps that is cost effective and does give you extended reliability. First of all, let’s start by using the right seal designs:

- As the two primary reasons of failure are drying out and abrasion, we need to use seal designs that are able to survive in the actual conditions found in mills.
- Drying out can be avoided by using low-heat generation seal designs such as balanced seals with monolithic seal faces. At the same time we need to make sure that heat is dissipated effectively by using the right environmental control such as the SpiralTrac™ device.

Replacing a sleeved shaft by a solid shaft already gives a big improvement and greatly helps to make seals and bearings run more reliable for extended periods of time.

![Figure 5: Most Common Fix](image)

**FLUSH WATER REDUCTION**

**Figure 6: Best practice for fibreline pumps**
- Improve shaft slenderness ratio
- Utilise third generation cartridge seals
- Install SpiralTrac™
  - No flush required
  - Low limited flush over 3% or when there are other sources of an entrainment

**Figure 7: Best Practice For Liquor Pumps**
- Improve shaft slenderness ratio to handle cavitations that may be present in some of the liquor pumps, such as in the evaporation area.
- First, improve the shaft slenderness ratio to handle cavitations that may be present in some of the liquor pumps, such as in the evaporation area.
- Then use third generation dual seals to promote circulation in the stuffing box. As the SpiralTrac™ promotes circulation in the stuffing box, it is also very effective in preventing crystallisation and removing black liquor solids from the seal faces.
- For agitators, the key issue is difficulty and cost of installation. Some of this equipment, such as fan pumps are critical to the operation of the paper machine and cannot be taken out of service. In those cases, packing is often used as repacking can be done without equipment disassembly.
- The second step is to utilise third generation seals that allow lowest heat generation and lowest susceptibility to abrasives.
- The final element that completes the enhanced sealing system is the SpiralTrac™, bushing that actively removes the abrasives from the stuffing box and provides additional cooling to the seal. The SpiralTrac™ requires no flush to function unless the consistency is over 3%. At these higher consistencies, the entrained air in the process becomes more problematic and a small flush is used to cool the air prior to exiting the stuffing box.
- The SpiralTrac™ however only requires very small amounts of flush to do so and saves 70-90% on water in most applications.
- The best practice for liquor pumps is following the same concept.
- First, improve the shaft slenderness ratio to handle cavitations that may be present in some of the liquor pumps, such as in the evaporation area.
- Then use third generation dual seals to promote circulation in the stuffing box. As the SpiralTrac™ promotes circulation in the stuffing box, it is also very effective in preventing crystallisation and removing black liquor solids from the seal faces.
- For agitators, the key issue is difficulty and cost of installation. Some of this equipment, such as fan pumps are critical to the operation of the paper machine and cannot be taken out of service. In those cases, packing is often used as repacking can be done without equipment disassembly.
- The split seal technology overcomes this problem and allows using installation of mechanical seals without equipment disassembly. Together with a split version of the SpiralTrac™ this gives a fully split and reliable sealing system for larger pieces of equipment such as fan pumps and chest agitators as well as some of the larger stock pumps. The split sealing system is a low flush solution and typically gives 90% reduction in flush water usage. It’s recommended to use a self-cleaning flow meter to control these low flush rates.

**ENVIRONMENTAL CONTROL SYSTEMS**

In addition to the seals, we offer all the needed environmental control systems to support the mechanical seals. These environmental control systems are designed for use in mills, taking into consideration the typical operating conditions and maintenance practices that exist in mills. From self-cleaning flow meters that won’t clog to dual seal support tanks that automatically maintain fluid level and require no regulator controls.

The SpiralTrac™ Environmental Control is a bushing that is fixed at the bottom of the seal chamber that features a spiral groove on its inside diameter. This groove collects abrasive particles and expels them from the stuffing box.

- The result is a clean seal cavity, free from abrasion which prolongs the life of the mechanical seal. There’s no need to flush or the flush can be reduced by 90% compared to a conventional sealed seal chamber, the SpiralTrac™ works purely on the rotation of the shaft and actively removes abrasives every time the pump is started.

In addition, the SpiralTrac™ vents the seal chamber to remove any trapped air in the stuffing box that could cause drying out or dry-running. It also improves circulation inside the
drops in other areas of the supply system and can cause the flush water to backflow, causing chugging. In addition, the clean external water needs to be supplied, treated, and eventually evaporated out and treated which all adds operational costs. When we review the way a stock pump operates and with the few the industry has been using commonly (Fig. 5), we believe that flushing and quenching is not a very reliable and cost effective way of operating your pump.

- The reliability of the system is determined only by the reliability of its external support systems: the flush water supply.
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Let’s look at a different way to operate your stock pumps that is cost effective and gives you extended reliability. First of all, let’s start by using the right seal designs:

The primary reasons of failures are drying out and abrasives wear, we need to use seal designs that are able to survive in the actual conditions found in mills. Drying out can be avoided by using low-heat generation seal designs such as balanced seals with monolithic seal faces. At the same time we need to make sure that heat is dissipated effectively by using the right environmental control such as the SpiralTrac™ device. Abrasive wear can be drastically reduced by using hard, monolithic faces that remain flat and parallel in service and do not deflect or distort as is common with shrink-fitted seal faces. Furthermore, abrasives should be removed from the stuffing box by using a low controlled flush or a SpiralTrac™ device that eliminates external flushing completely.

Balanced seals that feature monolithic seal face designs and have springs outside the fluid are commonly known as third generation seals. Third generation seals offer the latest in advanced sealing technology and the best guarantee for extended reliability.

This brings us to the best practice for fibreline pumps. Best practice is to improve shaft slenderness ratio to reduce any vibrations and misalignment that affects the seal due to off-curve operation, start-stop operation and system upsets such as plugs in the piping. Many pumps used today have relatively slower shafts that offer no contribution to extended seal and bearing life.

Replacing a sleeved shaft by a solid shaft already gives a big improvement and greatly helps to make seals and bearings run more reliably for extended periods of time.

- Improve shaft slenderness ratio
- Utilize third generation cartridge seals
- Install SpiralTrac™
  - No flush required
  - Low limited flush over 3% or when there are other sources of an entrainment

Figure 6: Best Practice for fibreline pumps

- Improve shaft slenderness ratio to handle common cavitations in evaporation.
- Utilize third generation cartridge seals.
- Weak liquors may use single seals.
- Install SpiralTrac™ to prevent crystallisation and remove black liquor solids.
- With the use of closed loop water systems, water can be eliminated to the drain.

The split sealing system is a low flush solution and typically gives 90% reduction in flush water usage. We recommend using a self-cleaning flow meter to control these low flush rates.

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flushing box allowing more efficient cooling and prevents crystallisation with liquor pumps.

Now that we have looked at best practices for mechanical seals, let’s look at what can be improved on regular packed stuffing boxes.

Mechanical packing has traditionally been the common method of sealing rotating equipment. Many mills have adopted mechanical seals to some degree, some more than others. Still today, many mills use packing for some applications where a mechanical seal does not work or where costs are just too high.

FACTORS INFLUENCING THE LIFE OF PACKING

There are many factors that influence the life of packing, some to do with the design, others with the way they are used and maintained. Many of these factors can be influenced and improved upon by just simply looking at a different or enhanced method to install packing.

With a conventional flushed packing system there are a number of issues:

- The distribution of the gland load transfer to radial load between each packing ring is very inefficient after the first three rings.
- The amount of sealing (radial load) reduces dramatically as the compressive load decreases.
- The last two rings have a minimal radial load causing pulp to leak between the packing and sleeve causing sleeve and packing damage.
- After a few adjustments the lubricants are washed out of these last two rings and lose volume. This requires gland adjustments to maintain proper loading.
- Increasing gland load to maintain adequate compressive load on the bottom rings creates higher radial loads on the top rings causing sleeve damage and packing glazing or burning.
- In addition the lantern ring dislocates and may even obstruct the flush flow completely.

This way of installing packing is maintenance intensive and leads to short life, heavy sleeve wear (as seen below), and uncontrolled leakage.

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- Increasing gland load to maintain adequate compressive load on the bottom rings creates higher radial loads on the top rings causing sleeve damage and packing glazing or burning.
- In addition the lantern ring dislocates and may even obstruct the flush flow completely.

This way of installing packing is maintenance intensive and leads to short life, heavy sleeve wear (as seen below), and uncontrolled leakage.

- The distribution of the gland load transfer to radial load between each packing ring is very inefficient after the first three rings.
- The amount of sealing (radial load) reduces dramatically as the compressive load decreases.
- The last two rings have a minimal radial load causing pulp to leak between the packing and sleeve causing sleeve and packing damage.
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By utilizing the SpiralTrac™ Environmental Controller and Chesterton’s advanced mechanical packing technology, it has been proven that only three rings of packing are optimal for sealing mixers, pumps, agitators, and other critical equipment. The patented SpiralTrac™ design removes abrasive particulates from the stuffing box, replaces the bottom two rings of packing (in a standard configuration), and extends packing life. Figure 13 below shows an example of the SpiralTrac™ Version P and three rings of Chesterton packing (The SuperSet).

Consult your local Chesterton Specialist for assistance specifying the correct packing style and quantity as well as a SpiralTrac™ Environmental Controller for your most challenging applications today.