Tall oil soap is a mixture of the sodium salts of rosin acids, fatty acids and neutrals that separates from kraft black liquor.

### Composition of Crude Tall Oil

<table>
<thead>
<tr>
<th></th>
<th>Southern USA</th>
<th>Northern USA &amp; Canada</th>
<th>Scandinavia</th>
<th>New Zealand &amp; Chile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Number</td>
<td>165</td>
<td>135</td>
<td>132</td>
<td>158</td>
</tr>
<tr>
<td>Resin Acids %</td>
<td>41</td>
<td>30</td>
<td>23</td>
<td>43</td>
</tr>
<tr>
<td>Fatty Acids %</td>
<td>51</td>
<td>55</td>
<td>57</td>
<td>40</td>
</tr>
<tr>
<td>Neutrals %</td>
<td>8</td>
<td>15</td>
<td>20</td>
<td>14</td>
</tr>
</tbody>
</table>
How Much Tall Oil Can Be Recovered?

<table>
<thead>
<tr>
<th>Region</th>
<th>Tall Oil kg/1000 kg OD Wood</th>
<th>Tall Oil lb/ ODT Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piedmont</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Coastal</td>
<td>26</td>
<td>52</td>
</tr>
<tr>
<td>Canada</td>
<td>11.5</td>
<td>23</td>
</tr>
<tr>
<td>Southwestern</td>
<td>31.5</td>
<td>63</td>
</tr>
<tr>
<td>West of Cascades</td>
<td>7.5</td>
<td>15</td>
</tr>
<tr>
<td>NZ &amp; Chile</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Finland</td>
<td>18.5</td>
<td>37</td>
</tr>
<tr>
<td>Sweden</td>
<td>25</td>
<td>50</td>
</tr>
</tbody>
</table>

Why Should Tall Oil Soap Be Recovered?

- To improve pulp and paper mill operations
- To reduce the toxicity of pulp mill effluents,
- To reduce accidents due to slips and falls.
- To increase mill revenue
Tall Oil Soap Should Be Recovered To Improve Pulp and Paper Mill Operations:

1. Reduce evaporator fouling,
2. Increase evaporator uptime,
3. Increase recovery boiler solids burning capacity, reduction efficiency
4. Reduce paper machine foaming,
5. Reduce bleaching costs,

Impact of Improved Soap Removal on Evaporator Overall Heat Transfer

Heat Transfer Coefficient (of Initial Maximum)

Hours Running

No Soap Recovery  Poor Soap Recovery  Good Soap Recovery

Influence of Skimmer Outlet Residual on:

Evaporator Time On-Line

Evaporation Rate

Skimmer Outlet Soap Residual (% CTO on a Solids Basis)

Availability

Fraction of Maximum Evaporation Rate

80% 82% 84% 86% 88% 90% 92% 94% 96% 98% 100%

0.5 0.7 0.9 1.1 1.3 1.5 1.7 1.9 2.1

Skimmer Outlet Soap Residual (% CTO on a Solids Basis)
How Soap Skimming Affects Evaporator Performance Overall

<table>
<thead>
<tr>
<th>Good Skimming</th>
<th>Poor Skimming</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skimmer Residual (%)</td>
<td>0.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Downtime (hr./month)</td>
<td>45</td>
<td>75</td>
</tr>
<tr>
<td>Evaporation Rate (Mkg/hr)</td>
<td>323</td>
<td>315</td>
</tr>
<tr>
<td>Production (Tonnes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unbleached</td>
<td>34500</td>
<td>32100</td>
</tr>
<tr>
<td>Bleached</td>
<td>24700</td>
<td>23000</td>
</tr>
</tbody>
</table>

Tall Oil Soap Should Be Recovered To Reduce Pulp Mill Effluent Toxicity

1. Fatty Acids, Resin Acids and Phenols affect both the toxicity to fish and the taste and color of fish.
2. Sodium soaps of resin acids account for 80% of the effluent toxicity.
3. Sodium soaps of unsaturated fatty acids account for 20% of the effluent toxicity.
4. Toxicity is independent of oxygen demand.
What causes soap to separate from black liquor?

- Increased liquor solids,
- Decreased liquor temperature,
- Residual effective alkali above 6 gpl,
- Increased fatty acid to resin acid ratio
- Decreased hardwood liquor content.

At washer filtrate temperatures, soap begins to come out of solution at about 8% solids. Minimum solubility occurs at 25 – 30% solids.
1. Minimum solubility occurs at 6 - 8 gpl REA. 
2. Increasing the fatty acid : resin acid ratio will reduce soap solubility. 
3. The fatty acid : resin acid ratio is determined by the wood species used.

**The Effect of Residual Effective Alkalinity and Soap Composition on Soap Solubility**

**Influence of Hardwood Content on Tall Oil Soap Solubility**
Where does soap separate from black liquor?

1. Washer filtrate tanks
2. Weak liquor storage tanks
3. Evaporator soap skimmers
4. (Heavy liquor storage tanks)

Why Soap Should be Removed from Weak Liquor Storage Tanks

- Soap acts as a surfactant that stabilizes foams and increases evaporator liquor carryover.
- At weak liquor solids levels greater than 14%, soap accumulates rapidly, reducing weak liquor storage significantly.
- Weak liquor skimming increases overall soap removal by reducing the load on the evaporator soap skimmers.
Foam liquor carryover will occur if the height of a column of foam is taller than the height of the vapor space in the evaporator.

Foam Height = \( \frac{\text{Volumetric Evap. Rate} \times \text{Bubble Life}}{\text{Foam Column Area}} \)

- The bubble life is increased by lower temperatures, smaller bubble diameter and increased soap content.
- Removal of the soap before evaporation will reduce the bubble life and reduce liquor carryover.

Common Configurations for Manual Weak Liquor Soap Skimming

**Advantage**
Simple and inexpensive to install

**Disadvantages**
Requires much operator attention
Can result in significant liquor carryover.
Weak Liquor Floating Soap Skimmers

Advantages
• Reduces the risk of soap surges to the evaporators
• Increases the effective liquor storage capacity

Disadvantages
• Higher capital cost

Advantages
• (Inlet Soap - Outlet Soap) = (3.0% - 0.6%)
• (Inlet Soap - Soap Solubility) = (3.0% - 0.45%)
• Good skimming greater than 85% efficiency
Skimmer Baffling to Prevent Soap ShortCircuiting

Baffles
Liquor Path

Poor Baffling
Liquor Path

Good Baffling
Liquor Path

Soap To Storage
Soapy Liquor to Skimmer

Soap Bed

Skimmed Liquor

Circular Soap Skimmer Layout

Baffle
Soap Scraper
Liquor In

Soap Scraper Rotation

Liquor Out

Soap Collection Trough

Soap Pump

Liquor Out

Soap Collection Trough
How Skimmer Dimensions Affect Skimmer Efficiency

Soap will not separate if the soap particle rise rate is less than the liquor downdraft. (Superficial Liquor Velocity)

Effect of Superficial Liquor Velocity on Skimmer Efficiency

Feed Rate 2000 gpm (7580 lpm)

How Skimmer Dimensions Affect Skimmer Efficiency

Efficiency 75%
- Residence time: 155 min
- Superficial Liquor Velocity: 13 fph (4 mph)

Efficiency 90%
- Residence time: 158 min
- Superficial Liquor Velocity: 6 fph (2 mph)

Feed Rate 2000 gpm (7580 lpm)
Skimmer Level Control

Soap To Storage

Soapy Liquor to Skimmer

Soap Bed

Liquor Overflow Standpipe

A = X *Dl/(Dl-Ds)

Ds - Density of Soap
DL - Density of Liquor

A = 4 *1.13/(1.13-0.94)

= 24

Soap Skimmer Efficiency Improvement

▲Stabilize skimmer level control.
▲Soap bed depth < 2 ft. (0.6 m)
▲Remove solids buildup
▲Ensure that the inlet is well isolated from the outlet
▲Evaluate air injection to the suction of the skimmer feed pump.
▲Evaluate chemical additives
How Air Addition Affects Soap and Liquor Bed Depth at a Fixed Skimmer Level Set-Point

Liquor sp.gr. 1.14   Soap sp.gr. 0.12   Soap sp.gr. 0.54   Soap sp.gr. 0.96

Depth

High Air Addition  Moderate Air Addition  No Air Addition

Soap Pumping, Piping

- Ensure that the pump suction is not restricted or reduced,
- Minimize the length of the pump suction
- Use positive closure ball valves
- Isolate spare soap pumps by ball valves, never use check valves
- Use positive displacement pumps
- Provide steam clean-out lines
- See also http://www.pumpschool.com
Positive displacement pump flow rate is relatively independent of viscosity

Positive Displacement Pumps Produce Essentially Constant Flow That Is Almost Independent Of Pressure
Positive displacement pump flow rate is relatively independent of viscosity

Positive Displacement Pumps Produce Essentially Constant Flow That Is Almost Independent Of Pressure
Soap Pumping Problems

- Ensure that the pump suction is not restricted or reduced,
- Check the pump rotation
- Positive displacement pumps:
  - Set the internal pressure relief valve 50 – 100% above the Normal system pressure
- Check Gear pumps for wear
- Too much Liquor – Lower the skimmer level ~ 1%
- Low Soap Density ( < 0.23 sp. Gravity)
  - Reduce air addition to soap skimmer
  - Use soap Concentrators

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Slide 27

Mill Soap Fiber Content

![Graph showing soap fiber content over time]
Summary

▲ Tall oil soap is a mixture of the sodium salts of rosin acids & fatty acids that separates from black liquor.

▲ Depending on wood species, good soap recovery is about 45 Kg soap / ODt wood.

▲ Good soap recovery reduces evaporator fouling, recovery boiler loading & effluent toxicity.

Summary

▲ Soap solubility is minimized at 30% black liquor solids and 6 - 10 gpl residual effective alkali.

▲ Soap separates in the washer filtrate tanks, weak liquor storage, evaporator soap skimmers.

▲ Soap is best removed in tanks that have a downdraft less than 2 m/h, are well baffled & have stable level control.

▲ Improve soap skimming by isolating the inlet and outlet liquor, controlling the soap bed depth at 0.6 m, injecting 7.5 lpm air /m³ feed liquor.