**General**

Selections for all paper machine sections are based upon TAPPI NRL* power requirements, the clutch shaft speed and a service factor. Because of the large inertia associated with dryer sections, additional calculations are required to determine if the selected clutch has sufficient thermal capacity and breakaway and acceleration torque.

### TAPPI NRL Power Constants

The normal running load (NRL) constants given in the table are indicative of the power required to run the section under normal conditions. The units used are horsepower per inch of width per 100 feet per minute (HP/in width/100 fpm). The power is calculated from:

\[
P_t = \frac{N \cdot NRL \cdot L \cdot v}{100}
\]

- **P_t**: TAPPI HP
- **N**: Number of dryers
- **L**: width of web (in)
- **v**: paper web speed (fpm)

### Clutch Torque

The torque requirement of the clutch is determined from:

\[
M_c = \frac{Pt \cdot 63025}{n} \cdot SF
\]

- **M_c**: clutch torque (lb-in)
- **n**: clutch shaft speed (rpm)
- **SF**: service factor from following table

Clutch selections are made by choosing a size which provides a torque greater than or equal to the required torque. Clutch types CB and VC are recommended for all but the dryer sections. Because of the thermal load, only type VC is recommended for the dryer. Follow the selection procedure given in Section B to determine the clutch size to use. Limit the maximum friction couple velocity to 4500 fpm (22 mps).

### Power Requirements of Fourdrinier Machines

<table>
<thead>
<tr>
<th>Machine Section</th>
<th>NRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fourdrinier (total power)</td>
<td>0.043</td>
</tr>
<tr>
<td>A. Toweling and light wrapping</td>
<td>0.064</td>
</tr>
<tr>
<td>B. Glassine and bond</td>
<td>0.064</td>
</tr>
<tr>
<td>C. News, kraft, and book under 1200 fpm with Millspaugh rolls</td>
<td>0.086</td>
</tr>
<tr>
<td>D. News, kraft, and book 1200-2000 fpm</td>
<td>0.086</td>
</tr>
<tr>
<td>E. News, kraft and book above 2000 fpm</td>
<td>0.086</td>
</tr>
<tr>
<td>F. Kraft board</td>
<td>0.09</td>
</tr>
</tbody>
</table>

**Fourdrinier Driven Rolls**

- Wire return: 0.0012
- Lumpbreaker: 0.001

**Calender Stacks (eight and nine Rolls)**

- Up to 70 lb paper: 0.035
- 70 to 90 lb paper: 0.056
- 90 to 130 lb paper: 0.056
- 130 lb and above: 0.056

**Reel**

- Up to 125 lb - except kraft: 0.008
- Above 125 lb - except kraft: 0.008
- All kraft paper: 0.008

**Presses**

- Main press: (plain or suction) pair of main rolls: 0.024

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**Notes:**

1. For machines of 90 inch minimum width.
2. Recommended Drive Constant
3. For nip pressures up to 100 lb/in.
4. For nip pressures over 100 lb/in.
Dryer Sections

Normally dryer clutch sizing is determined by thermal capacity and the resulting clutch selection will have torque capacities that exceed those indicated by the above calculations. Energy capacities are primarily a function of friction area. The recommended clutch friction area is determined from:

\[ A = \frac{W_k^2 \cdot v^2}{D^2 \cdot 1.21 \times 10^6} \]

- \( A \): clutch friction area (in²)
- \( W_k^2 \): inertia of dryer section (lb•ft²)
- \( D \): dryer roll diameter (in)

If the \( W_k^2 \) of the section is not known, it can be estimated from:

\[ W_k^2 = N \cdot L \cdot K \]

- \( W_k^2 \): estimated \( W_k^2 \) of section (lb•ft²)
- \( N \): number of dryer rolls
- \( K \): factor from dryer constants table

For sections having a large number of dryer rolls and the paper speed is high, an air cooled clutch may not be suitable. A special VC water-cooled unit, having a different friction couple, can be furnished. The friction area required for water-cooling is 1/6 of that required for an air-cooled clutch; however, the clutch torque rating must be reduced by 40%.

The clutch must also be capable of accelerating the dryer in a reasonable time. The acceleration torque can be calculated from:

\[ M_a = 0.74 \cdot \frac{W_k^2 \cdot v}{D^2 \cdot n} \]

- \( M_a \): acceleration torque (lb•in)
- \( Z \): acceleration rate (fpm/sec)

Use 50 to 60 fpm/sec if the acceleration rate is not specified.

For dryer sections having plain journal bearings, the clutch must be capable of overcoming the breakaway torque of the bearings. This torque can be estimated from:

\[ M_f = 0.48 \cdot 10^6 \frac{W_t \cdot d \cdot v}{D \cdot n} \]

- \( M_f \): breakaway torque (lb-in)
- \( W_t \): total weight of dryers, gears and one-half of felt and feeney dryers
- \( d \): journal bearing diameter (in)
- \( SF \): service factor from following table:

<table>
<thead>
<tr>
<th>Paper Speed</th>
<th>Without Helper Drive</th>
<th>With Helper Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 500</td>
<td>3.0</td>
<td>1.5</td>
</tr>
<tr>
<td>500 to 750</td>
<td>3.5</td>
<td>2.0</td>
</tr>
<tr>
<td>750 to 1000</td>
<td>4.0</td>
<td>2.5</td>
</tr>
<tr>
<td>1000 to 1500</td>
<td>4.5</td>
<td>3.0</td>
</tr>
<tr>
<td>1500 to 1800</td>
<td>5.0</td>
<td>3.5</td>
</tr>
</tbody>
</table>

*If total weight is not known, it can be estimated from:

\[ W_t = N \cdot [K_1 \cdot L + K_2] \]

- \( K_1 \) & \( K_2 \): factors from dryer constant table

In general, a clutch selection for a dryer section is usually based upon the required friction area \( A \). The selection is then checked to determine if its torque capacity is capable of torques \( M_a \), \( M_f \) and \( M_t \) with the available applied air pressures. If not specified, selections should be based on 40 psi.

**Service Factors for dryers equipped with journal bearings**

**Dryer Constants**
**Example**

A clutch is required for the third dryer section of a paper machine which operates under the following conditions:

- **Web L**: 188 inch
- **Speed v**: 2500 fpm
- **Dryer diameter D**: 36 inch
- **No. of dryers N**: 5
- **Clutch speed n**: 1000
- **Anti-friction bearings**

\[
P_{T} = \frac{N \cdot \text{NRL} \cdot L \cdot v}{100} = \frac{5 \cdot 0.030 \cdot 188 \cdot 2500}{100} = 141 \text{HP}
\]

\[
M_{t} = \frac{Pr \cdot 63025}{n} \cdot \text{SF} = \frac{26 \cdot 63025}{1000} \cdot 2 = 3260 \text{ lb•in}
\]

\[
W_{k}^{2} = N \cdot L \cdot K = 5 \cdot 188 \cdot 51 = 48000 \text{ lb•ft}^{2}
\]

\[
M_{a} = 0.74 \cdot \left[ \frac{Wk^{2} \cdot v}{D^{2} \cdot n} \right] \cdot Z
\]

\[
= 0.74 \cdot \left[ \frac{48000 \cdot 2500}{36^{2} \cdot 1.21E+06} \right] \cdot 50
\]

\[
= 3430 \text{ lb•in}
\]

\[
A = \frac{Wk^{2} \cdot v^{2}}{D^{2} \cdot 1.21E+06}
\]

\[
= \frac{48000 \cdot 2500^{2}}{36^{2} \cdot 1.21E+06}
\]

\[
= 191 \text{ in}^{2}
\]

Clutch selection is made from friction area required. Select 14VC500.

Friction couple velocity = \(14 \cdot 1000 \cdot 0.262 = 3670 \text{ fpm}\).

The 14VC500 element meets all the requirements. Operating pressure would be approximately 40 psi.