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)

Use N=1 for other sections

v: paper web speed (fpm)

Clutch Torque

The torque requirement of the clutch is determined from:

$$Mc = \frac{Pt \cdot 63025}{n} \cdot SF$$

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 ❶

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

Power Requirements of Fourdrinier Machines

Machine Section	NRL
Dual press	
Side rolls only - each	0.020
Side rolls only - each	0.024
Suction pickup	0.010
Suction wringer	0.015
Suction wringer ❸	0.018
Suction felt ❹	0.010 ❷
Transfer	0.030
Smoothing press – marking press pair of rolls	0.007
Size press – pair of rolls	0.020
Dryers: Paper and Felt	
60 inch diam. rolls - each	0.0018
48 inch diam. rolls - each	0.0014
42 inch diam. rolls - each	0.0013
36 inch diam. rolls - each	0.0011
Yankee Dryer	0.05
Doctors (each)	
Metal	0.001
Laminated plastic	0.0015
Fiberglass	0.0017

Machine Section	SF
Fourdrinier	
Couch w/plain bearings	2.2
Couch w/anti-friction bearings	1.8
Press Sections	
Suction press w/plain bearings	2.2
Suction press w/anti-friction bearings	1.8
Plain press w/plain bearings	1.8
Plain press w/anti-friction bearings	1.5
Smoothing press w/plain bearings	1.8
Smoothing press w/anti-friction bearings	1.5
Breaker press w/plain bearings	1.8
Breaker press w/anti-friction bearings	1.5
Size press w/plain bearings	1.8
Size press w/anti-friction bearings	1.5
Transfer press w/anti-friction bearings	1.8
Dryer	
w/plain bearings and helper drive	see text
w/plain bearings and no helper drive	
w/anti-friction bearings and helper drive	2
w/anti-friction bearings and no helper drive	2
Yankee Dryer	2.5
Calendar	
w/plain bearings	4.5
w/anti-friction bearings	3.5

*TAPPI NRL = Technical Association of the Pulp and Paper Industry Normal Running Load.

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Notes:

❶ For machines of 90 inch minimum width.

❷ Recommended Drive Constant

❸ For nip pressures up to 100 lb/in.

❹ 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:

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

A: clutch friction area (in^2)

Wk^2: inertia of dryer section ($lb \cdot ft^2$)

D: dryer roll diameter (in)

If the Wk^2 of the section is not known, it can be estimated from:

$Wk^2 = N \cdot L \cdot K$

Wk^2: estimated Wk^2 of section ($lb \cdot ft^2$)

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:

$$M_a = 0.74 \cdot \left[\frac{Wk^2 \cdot v}{D^2 \cdot n} \right]$$

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:

$$M_f = 0.48 \cdot \left[\frac{Wt \cdot d \cdot v}{D \cdot n} \right]$$

M_f: breakaway torque (lb·in)

Wt: total weight of dryers, gears and one-half of felt and feeney dryers*

d: journal bearing diameter (in)

SF: service factor from following table:

Service Factors for dryers equipped with journal bearings

Paper Speed fpm	Without Helper Drive	With Helper Drive
0 to 500	3.0	1.5
500 to 750	3.5	2.0
750 to 1000	4.0	2.5
1000 to 1500	4.5	3.0
1500 to 1800	5.0	3.5

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

$Wt = N \cdot [K_1 \cdot L + K_2]$

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_c, M_a and M_f with the available applied air pressures. If not specified, selections should be based on 40 psi.

Dryer Constants

Dryer Roll Dia. in	Shell Thickness in	K	K_1	K_2
24	0.50	12	16.5	1000
36	0.63	51	24	1600
42	0.75	97	29	2150
48	0.81	157	34	2500
48	1.00	197	40	2500
60	1.00	378	48	6000
60	1.25	467	60	6000
60	1.38	518		
72	1.44	936		
72	1.50	966		

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

$$P_T = \frac{N \cdot NRL \cdot L \cdot v}{100} = \frac{5 \cdot 0.0011 \cdot 188 \cdot 2500}{100}$$

$$P_T = 26 \text{ HP}$$

$$M_c = \frac{P_T \cdot 63025}{n} \cdot SF = \frac{26 \cdot 63025}{1000} \cdot 2$$

$$= 3260 \text{ lb·in}$$

$$W_k^2 = N \cdot L \cdot K = 5 \cdot 188 \cdot 51 = 48000 \text{ lb·ft}^2$$

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

$$= 0.74 \cdot \left[\frac{48000 \cdot 2500}{36^2 \cdot n} \right] \cdot 50$$

$$= 3430 \text{ lb·in}$$

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

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

$$= 191 \text{ in}^2$$

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

Friction couple velocity = 14·1000·0.262 = 3670 fpm.

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

Example

Determine the clutch torque required for the transfer press for the paper machine given in the first example.

$$NRL = 0.030$$

$$P_T = \frac{N \cdot NRL \cdot L \cdot v}{100} = \frac{0.030 \cdot 188 \cdot 2500}{100}$$

$$= 141HP$$

$$M_c = \frac{P_T \cdot 63025}{n} \cdot SF$$

$$= \frac{141 \cdot 63025}{1000} \cdot 1.8$$

$$= 16000 \text{ lb·in}$$