Airflex® Product Application by Industry

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Airflex® Engine Clutches

Section X

General

Power rating capability is determined by engine design. Combined capability and durability of all engine components determine how much power can be produced in a particular application.

The power output of a basic engine model can be varied within its design ranges by changing the engine fuel setting or speed setting. Both of these settings affect the engine's maximum fuel rate and the power output capability.

Some of the application conditions considered by an engine manufacturer in determining a rating for an application are:

- Load factor
- Duty cycle
- Operating hours
- Historical experience

The same basic engine model can have different ratings for different industries and applications. Usually, they are grouped into the following categories:

- Industrial
- Truck
- Off-highway
- Power generation
- Petroleum
- Marine

Also, within these groupings, are ratings for continuous and intermittent service. Continuous ratings are for continuous use without interruption or load cycling. Intermittent ratings apply to about one hour operation followed by one hour operation at or below the continuous rating.

Engine Clutches

The CB element is usually recommended for engine clutch applications. Selections are based on the horsepower transmitted by the clutch. In some cases, it may be much lower than the engine's horsepower rating due to other engine driven auxiliary loads. Extra loads imposed by a cooling fan, alternator, air compressor or hydraulic pumps may represent a significant proportion of total engine power available.

Selections for Engines Without Torque Converters

Clutch selection is based upon the power transmitted, clutch rpm, the appropriate service factor, 110 psi (7,6 bar) actuating air pressure and clutch engagement at engine idle.

Recommended Engine Clutch Service Factors

Drive	SF
Compound -Drilling Rig	1.8
Generator	1.5
Metal Shredder	2.2
Rotary Table -Drilling Rig	1.5

Torque loss due to centrifugal effect must be taken into account. Follow procedure given in Section B. The peripheral speed of our spiders and drums should not exceed the limits shown in the below table.

Standard Cast spiders, Drums and Hubs (MTL 1-4): 8500 fpm

High Speed Cast spiders (MTL 1-6): 12,100 fpm

High Speed Cast Drums and Hubs (MTL 1-5): 11,000 fpm

The use of ductile iron components allows for the higher speed limits.

If speed exceeds above limits, a dual element should be considered. Single elements are preferred because of smaller overhung loads and ease of alignment.

Selections for Engines With Torque Converters

The selection procedure for engines with torque converters is the same as that discussed above for direct drives, but with one other major consideration. Under the stall conditions, i.e. converter output shaft at zero speed, the clutch must be able to transmit the torque multiplication of the converter.

The Power Capacity Table can be used to make a selection for single CB clutch elements having a 1.8 service factor and an operating pressure of 110 psi (7,6 bar). Find the horsepower value that is equal or greater than that which must be transmitted in the appropriate rpm line and read the clutch size in the column heading. For dual elements, double the power values in the table.

Airflex® Engine Clutches

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rpm	HP CapacityTable (110 psi and 1.8 SF) for Clutch Sizes:										
	12CB350	14CB400	16CB500	18CB500	20CB500	22CB500	24CB500	26CB525	28CB525	30CB525	32CB525
1000	147	216	362	440	520	587	688	803	884	967	1054
1050	153	223	371	449	529	595	693	804	879	954	1033
1100	158	229	379	456	536	599	695	798	866	932	
1150	163	235	385	462	539	600	693	787	846		
1200	167	241	390	465	540	597	685	769			
1250	171	245	394	466	538	591	674	744			
1300	175	249	395	465	533	581	657				
1350	179	253	395	462	525	567	635				
1400	182	256	394	456	514	549	607				
1450	185	258	390	448	499	527					
1500	187	259	385	437	481						
1550	189	259	378	423	459						
1600	191	259	369	407							
1650	192	258	358	388							
1700	193	256	345								
1750	193	253	329								
1800	193	249	312								
1850	192	245									
1900	191	239									
1950	189	232									
2000	187	225									
2050	184	216									
2100	181	206									
2150	177	195									

rpm	kW CapacityTable (7,6 bar and 1,8 SF) for Clutch Sizes:										
	12CB350	14CB400	16CB500	18CB500	20CB500	22CB500	24CB500	26CB525	28CB525	30CB525	32CB525
1000	110	161	270	328	388	438	512	599	659	721	786
1050	114	166	277	335	394	443	517	599	655	711	770
1100	118	171	283	340	399	446	518	595	645	695	
1150	121	175	287	344	402	447	516	586	630		
1200	125	179	291	346	402	445	511	573			
1250	128	183	293	347	401	441	502	555			
1300	131	186	295	347	397	433	489				
1350	133	188	295	344	391	423	473				
1400	136	190	293	340	383	409	452				
1450	138	192	291	334	372	392					
1500	139	193	287	326	358						
1550	141	193	282	315	342						
1600	142	193	275	303							
1650	143	192	267	289							
1700	143	191	257								
1750	144	189	245								
1800	144	186	232								
1850	143	182									
1900	142	178									
1950	141	173									
2000	139	167									
2050	137	161									
2100	135	154									
2150	132	146									

Airflex® Engine Clutches

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Engine Clutch Arrangements

For direct engine drive applications, the standard arrangement (Forms CB408 and CB427) uses an external flange drum mounted to the engine flywheel. The clutch element and its spider are fastened to a separate bearing supported jackshaft as shown in the figure.

When the clutch mounts on an engine stub shaft or on the output shaft of a torque converter, then the standard gap mounting arrangements (Forms CB406 and CB407) are used.

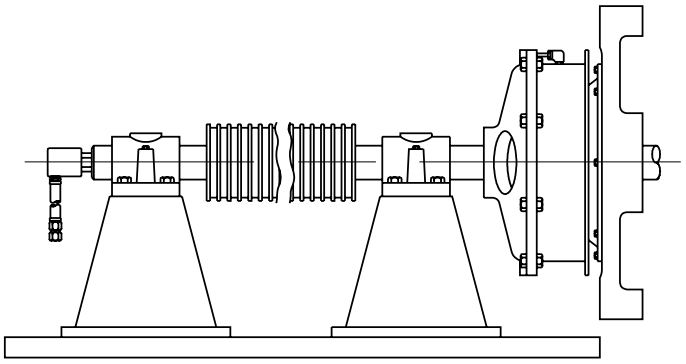
Clutch Engagement Speed

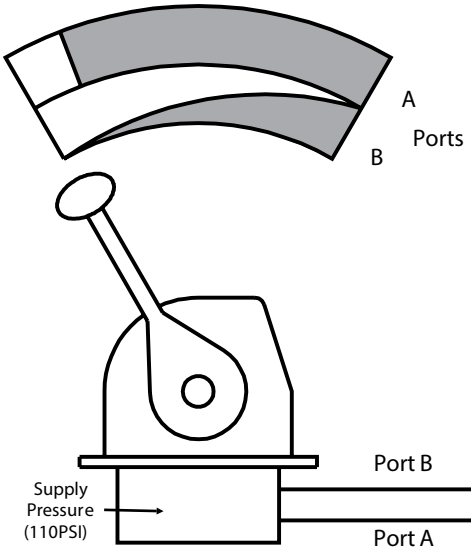
The recommended clutch engagement speed is 4500 fpm (22.8 mps) at the friction couple. If the speed at engine idle exceeds this value, then the idle speed should be changed.

Engine Clutch Control

To ensure clutch engagement at engine idle, the control shown below is recommended.

Typical Spider Engine-Mounted Application





Relay Valve

snap acting sequencing

passes air only when pilot pressure exceeds a set pressure (100 PSI)

Pneumatically Controlled Engine Governor/Throttle

Pilot connection should be located as close to the clutch as possible

Pilot

Control Valve

2 port compound

Port A: instant on/off

Port B: modulated pressure with lever position

This control system prevents the engine speed from increasing before the pressure in the clutch reaches a preset value.

CB Clutch

Example

A 200 HP, 1200 rpm engine is required to drive a generator.

A clutch is required to connect the engine to the generator.

$$M_c = \frac{HP.63025}{n} \cdot S\,F$$

$$= \frac{200 \cdot 63025}{1200}$$

$$= 15750\ lb \cdot in$$

Try 12CB350 rated 13300 lb·in at 75 psi.

$$M_e = \frac{p_0 - p_p - p_c}{75} \cdot M_r$$

P_P=2 psi (Page B-92)
$P_C = C_S.N^2$=17 psi

$$= \frac{110 - 2 - 17}{75} \cdot 13300$$

$$= 16140\ lb \cdot in$$

Spider peripheral speed

$$v = 0.262 \cdot N \cdot D$$

$$= 0.262 \cdot 1200 \cdot 18$$

$$= 5660\ fpm < 8500\ fpm...OK$$

Engagement Speed

V = 0.262.N.D

= 0.262.1200.12

= 3772.8 fpm < 4500 fpm...Good

Therefore, the 12CB350 selection is suitable.

Example

A 332 HP, 1200 rpm engine is used as a direct drive in a compound. What size clutch is required?

For the Power Capacity Table, running across the 1200 rpm line, a 16CB500 clutch is selected.

Example

A torque converter is being considered for the application in second example. The converter will have a torque multiplication factor of 3. Operating within its efficiency range, the maximum horsepower output is 332 and the maximum output speed is 1000 rpm. What size clutch is required?

Stall torque at converter output shaft

$$= \frac{332.63025}{1200 \cdot 3}$$

$$= 52300\ lb \cdot in$$

A 16CB500 element at 110 psi is capable of:

$$\frac{(110 - 2)}{75}\ X\ 35200 = 50{,}688\ lb.in$$

The 16CB500 torque is light, therefore, try an 18CB500.

Referring to the Engine Selection Guide, the 18CB500 element at 1000 rpm is capable of 445 HP.

The clutch selection would be an 18CB500

Airflex® Grinding Mills

Section X

General

The function of a grinding mill is to reduce the particle size of a material to a size necessary for a given process. The grinding is accomplished by rotating a large cylinder that is partially filled with the material to be ground and grinding media. As the cylinder rotates, its contents is lifted until it falls or tumbles over itself back down to the bottom of the cylinder. The impact of the grinding media and the tumbling action crush and grind the material down to the desired particle size.

Grinding mills are classified by the media used for grinding. The more common types of mills are:

Ball mills - These mills use forged steel balls up to 5 inches (127 mm) in diameter to crush and grind the material. Mill length is two or more times its diameter.

Rod mills - Steel rods up to 4.5 inches (114 mm) in diameter and slightly shorter then the mill length are used for the grinding process. Mill length is two or more times its diameter.

Pebble mills - These mills use small cylinders, balls, or other chunks of silica, porcelain, aluminum or zirconium oxides for grinding. This type of mill is used when the product must be free of metallic contamination.

Autogenous mills - These mills use coarse ore particles of the material to grind itself. Grinding is by attrition. An autogenous mill's diameter is larger compared to its length.

Semi-Autogenous mills - Forged steel balls in addition to the coarse ore perform the grinding. Mill diameter is larger compared to mill length.

Use of a clutch permits the mill motor or motor and reducer to be started in the unloaded condition, keeping current demand and power factor within limits agreed upon with local utilities. The result is a substantial savings on power costs. The following amperage curves compare peak current demands of high torque - direct drive systems and drive systems using standard torque motors with Airflex clutches which replaced them.

Because of the large thermal loads associated with mill start-up, the use of VC clutches are recommended.

Clutch Selection

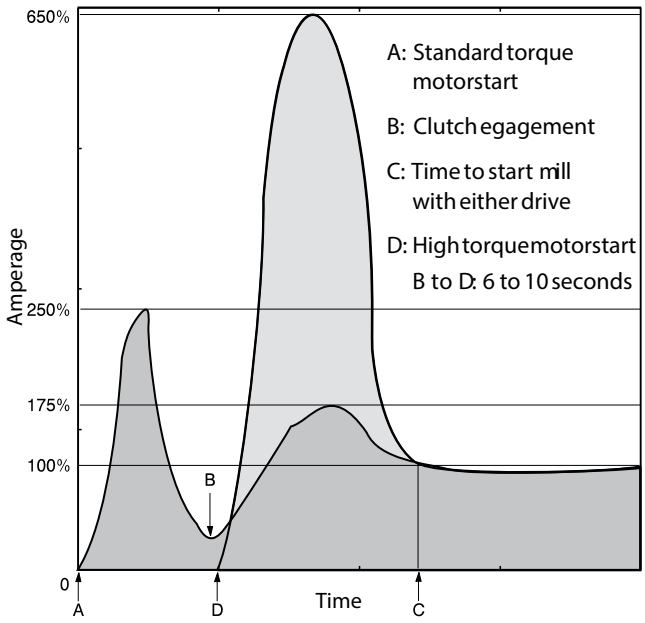
The required clutch torque is calculated from the power rating of the mill motor, clutch shaft rpm and an appropriate service factor.

$$M_c = \frac{P_p \cdot 63025}{n} \cdot S_F (lb \cdot in)$$

$$M_c = \frac{P_p \cdot 9550}{n} \cdot S_F (N \cdot m)$$

Type of Mill	SF
Ball and Rod	2
Pebble and Semi-Autogenous	2.5
Autogenous	3.0

Mill Motor Current Demand



A type VC clutch element or use an Airflex auxiliary hydraulic inching drive is selected using the procedure outlined in Section B. For good friction lining life, it is desirable to limit the maximum clutch engagement speed to 4500 fpm (22,8 mps). If the clutch is used for inching of the mill, engagement speed should not exceed 3500 fpm (17,8 mps). Gap mounted arrangements, Forms VC506 thru VC510, are recommended.

A preliminary clutch selection guide is given on the following pages. The selections are valid for the operating parameters stated on the guide.

Airflex® Grinding Mills

Section X

For motor ratings up to 3000 HP (2240 kW) and clutch shaft speeds up to 277 rpm, the clutch element selected should have sufficient thermal capacity and in most cases can be used for inching or spotting of the mill.

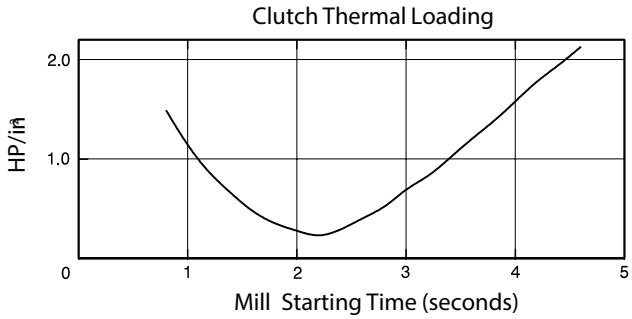
For larger power motors and higher clutch shaft speeds a more thorough analysis of the mill is required. Various mill starts can be simulated by computer modeling to determine the proper clutch size and starting time. The various starts are obtained by changing the rate of pressure build-up, and hence the rate of torque build-up in the clutch.

For a given clutch size, the mill starting times are plotted against the resulting clutch thermal load. A typical overview of the starts are shown below. The preferred starting time is when the peak loading is at a minimum.

For any given starting time, the entire clutch profile can be projected for the complete start. By comparing the profile to the rated capacity, the clutch's suitability for the drive can be determined.

The information required for simulation must include:

- Type of mill
- Mill inertia
- Mill rpm
- Inside diameter of shell liners
- Total weight or mass of charge including grinding media
- Normal percent mill fill
- Material cascade angle
- Method of material discharge (overflow, grate or batch)
- Motor power rating
- Motor pullout torque
- Clutch shaft rpm
- Maximum air pressure available
- Mounting style - FWD/ REV
- Hydraulic lifters - YES/NO

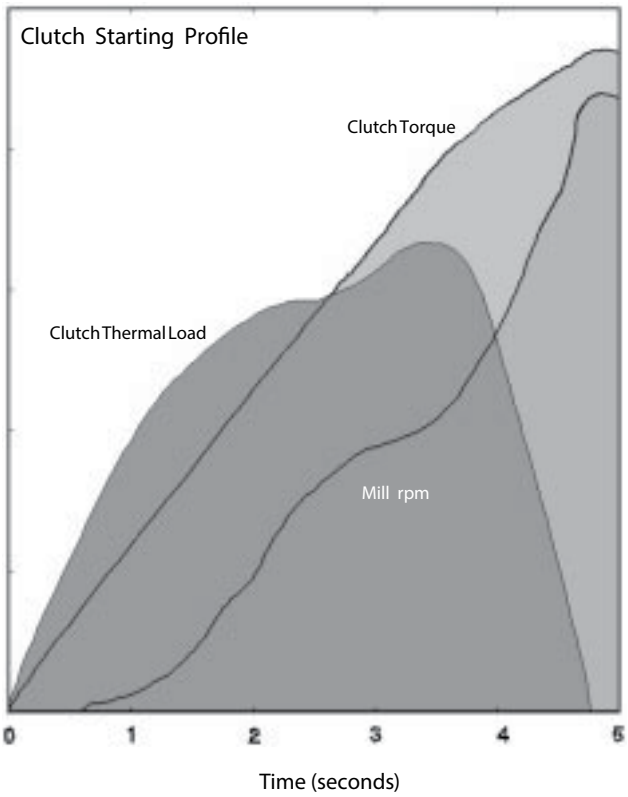


Clutch Control

Normal mill starting procedure is to bring the motor up to operating speed and then engage the clutch to accelerate the mill. Airflex offers several types of reliable systems for clutch control. The systems consists of two parts: the pneumatic and electrical portions. Refer to Airflex catalog A-191 or Section B of this catalog for more information.

The pneumatic portion is basically that shown in Section Y, with the addition of a three-way normally closed solenoid valve, a manually adjusted flow control valve and pressure switch, all plumbed in the air line to the clutch. The pressure switch in the clutch air line prevents motor starting if the clutch is pressurized. The pressure switch on the air tank insures that sufficient air volume and pressure is available before a start can be made. Rate of clutch torque build-up and mill acceleration is determined by the flow control valve setting.

The pressure switches are tied in electrically to the motor and clutch control circuits. The electrical clutch control furnished by Airflex regulates the electrical signal to the solenoid valve. The standard control permits starting, stopping and where applicable, inching of the mill.



Airflex® Grinding Mills
Preliminary Clutch Selection Guide
Section X

Motor Horse Power

Clutch Shaft RPM (60 Hz. Synchronous speeds)

	100	125	150	175	200	250	300	350	400	450	500	600	700	800	900	1000	1250	1500	1650	1750	2000	2200	2250	2500	2750
120					F											PP									
124		E						N	FF		P														UU
129					L	M			H						S								TT		
133							EE																		
138	D								N																
144						F				H	FF						T								
150							M							R											
157				E						N		P								RR			SS		
164						L					H						S								
172									EE									T							
180							F				N	FF	P												
190																									
200							L					H		P						T					
212	C							F				N													
225				D						M					P									RR	
240								L	F			EE	H							S	T				
257													N			P							T		
277										F	M			H	FF			R				PP			
300								E			F			N										T	
327										L		M			N		P							PP	T
360				C								F				N							S		PP
400		B										L		M			FF				R				
450								D			E		F					P							PP
514													L	F		EE	N			P		GG			
600													CC	L	M		EE	FF			MM				
720							C						K	CC	L	M			LL						
900		A									BB	X		K		KK									
1200								AA																	

Selection Guide Parameters:

Minimum Torque Service Factor - 2

Minimum Operating Air Pressure - 100 psig

Maximum Contact Velocity - 4,500 fpm

Inching with clutch permitted at 3500 FPM or less (unshaded area).

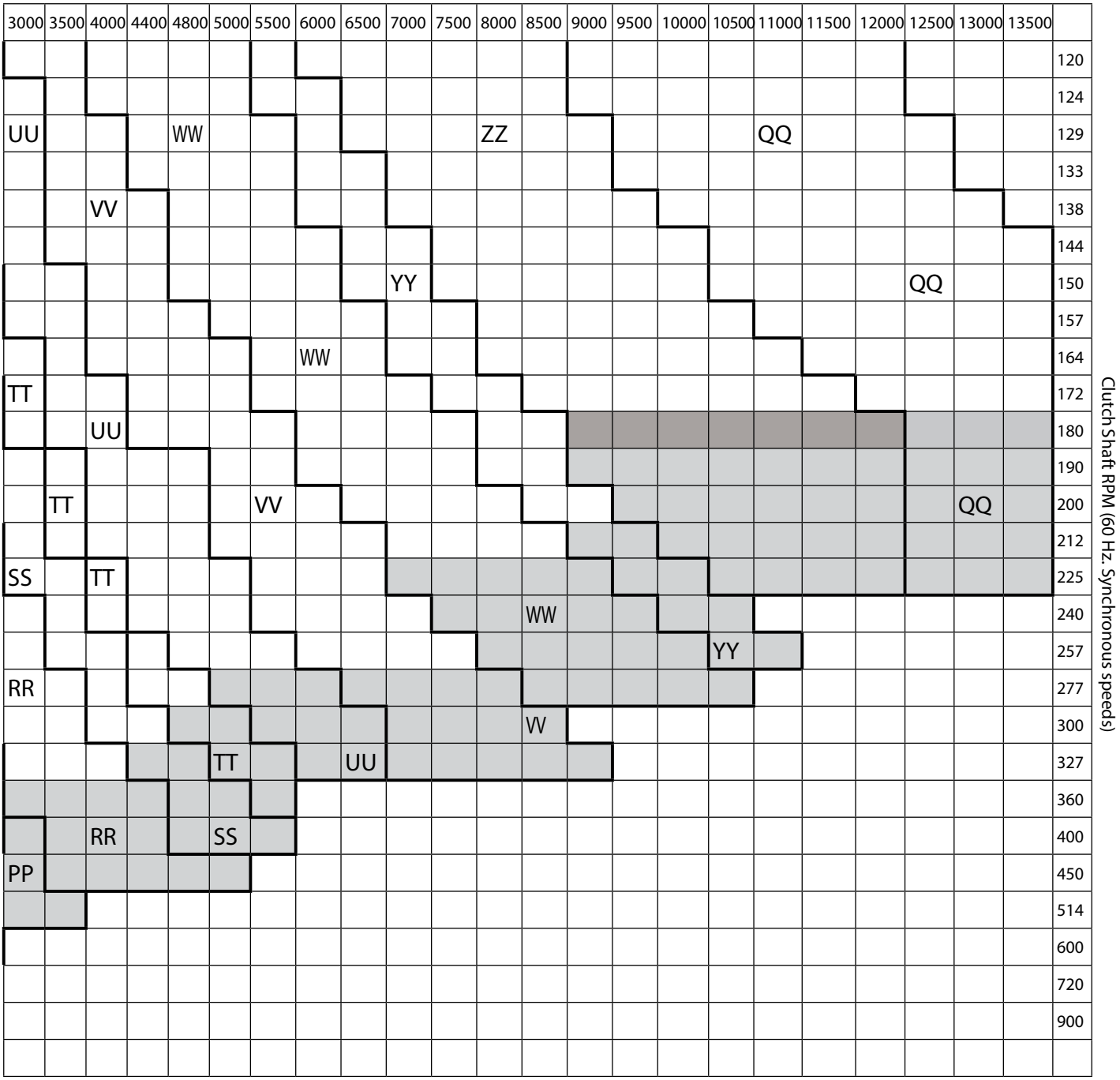
Consult factory for applications which exceed these specifications.

For motor ratings up to 3000 hp (2250 kW) and clutch shaft speeds up to 277 rpm, the clutch element selected from this chart should have sufficient thermal capacity and in most cases can be used for inching and spotting of the mill.

For larger power motors and higher clutch shaft speeds a more thorough analysis of the mill is required. Various mill starts can be simulated by computer modeling to determine the proper clutch size and starting time. The various starts are obtained by changing the rate of pressure build-up, hence the rate of torque build-up in the clutch.

Airflex® Grinding Mills

Section X



A	11.5VC500	J	42VC650	T	46VC1200
B	14VC500	X	14VC1000	U	52VC1200
C	16VC600	K	16VC1000	V	51VC1600
D	20VC600	L	20VC1000	W	60VC1600
E	24VC650	M	24VC1000	Y	66VC1600
F	28VC650	N	28VC1000	Z	76VC1600
G	33VC650	P	32VC1000	Q	76VC2000
H	37VC650	R	38VC1200	Double letters indicate dual elements	
		S	42VC1200		

This guide is based on minimum data only.

Final clutch selection must be approved by the Airflex ® Division's Application Engr. Dept. in Cleveland, Ohio.

Airflex® Marine Drives

Section X

General

Airflex marine clutches are readily adaptable to the wide variety of drive arrangements found in the marine industry. They have been used for main propulsion, bow thrusters, reverse-reduction gears and Z-drives.

The type VC element can be easily combined with a torsional coupling for the main propulsion drive or it can be furnished in quill shaft mountings required for reverse-reduction gear drives. The more common VC marine clutch arrangements appear on the following pages.

Type CM elements are used primarily for connecting the engine to in-line reverse reduction gears.

Selection Procedure

Clutch selection is based upon the torque requirement calculated from the maximum power to be transmitted, clutch shaft rpm and an appropriate service factor. For drives utilizing a controllable pitch propeller, the service factor is 1.5; for a fixed pitch propeller 1.7.

Maximum recommended operating air pressure for reversing clutch application is 125 psi (8,6 bar). For reversing applications employing a propeller shaft brake or disconnect applications having a controllable pitch propeller, maximum operating air pressure is 150 psi (10,3 bar).

Follow the selection procedure outlined in Section B for VC and CM elements. Horsepower capacities for VC elements at various speeds appear on the following pages. The elements shown have sufficient thermal capacity to handle crash stops. For maneuvering (slipping the clutch to obtain propeller speeds below engine idle), contact the factory.

Clutch Power Capacities — Reversing Applications — 125 psi (8,6 bar) Fixed-Pitch Propeller

Clutch Shaft rpm	11.5VC500		14VC500		16VC500		20VC600		24VC650		28VC650		33VC650		37VC650		42VC650	
	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW
200	91	68	133	99	220	164	313	234	453	338	609	455	849	633	1060	791	1256	937
250	114	85	165	123	273	204	389	290	561	419	753	562	1046	781	1302	971	1542	1150
300	136	101	197	147	326	243	462	345	666	497	892	665	1234	920	1529	1140	1808	1349
350	158	118	228	170	377	281	533	398	766	572	1023	763	1409	1051	1737	1296	2051	1530
400	179	133	258	192	427	318	601	449	862	643	1147	856	1570	1171	1924	1436	2268	1692
450	199	149	287	214	475	354	666	497	952	710	1262	941	1716	1280	2087	1557	2454	1831
515	225	168	323	241	535	399	746	556	1059	790	1396	1042	1878	1401	2258	1684	2644	1973
550	239	178	342	255	566	422	786	586	1112	829	1461	1090	1951	1455	2328	1736	2720	2029
600	258	192	368	274	608	454	839	626	1181	881	1542	1150	2036	1519	2399	1790	2791	2082
650	275	205	392	293	648	483	888	662	1241	926	1610	1201	2098	1565	2434	1816	2817	2101
720	299	223	424	316	699	522	947	706	1311	978	1681	1254	2140	1596	2416	1802	2769	2065
750	309	230	436	326	720	537	969	723	1334	995	1701	1269	2141	1597	2382	1777	2716	2026
810	327	244	460	343	757	565	1007	751	1370	1022	1725	1287	2111	1574	2265	1689	2547	1900
850	338	252	474	353	780	582	1027	766	1385	1033	1726	1287	2065	1540	2147	1602	2385	1779
900	351	262	489	365	805	600	1046	780	1393	1039	1710	1276	1976	1474				
950	363	271	503	375	826	616	1058	789	1389	1036	1674	1249						
1000	373	278	514	384	843	629	1062	793	1371	1023	1617	1206						
1050	382	285	523	390	857	639	1059	790	1339	999								
1100	390	291	530	395	866	646	1047	781										
1225	403	301	535	399	870	649												
1300	407	303	530	395														
1400	405	302	512	382														
1500	396	295	481	359														
1600	378	282	436	325														
1700	353	263	377	281														
1800	316	236																

Clutch Power Capacities — Reversing Applications — 125 psi (8,6 bar) Fixed-Pitch Propeller

Clutch Shaft rpm	14VC1000		16VC1000		20VC1000		24VC1000		28VC1000		32VC1000	
	HP	KW	HP	KW	HP	KW	HP	KW	HP	KW	HP	KW
200	286	213	382	285	538	401	730	544	984	733	1375	1025
250	356	265	476	355	668	498	904	674	1217	907	1698	1266
300	424	317	567	423	795	593	1073	800	1441	1074	2007	1497
350	492	367	657	490	918	684	1236	922	1655	1234	2299	1715
400	559	417	744	555	1036	773	1391	1037	1857	1385	2572	1918
450	623	465	829	618	1149	857	1538	1147	2045	1525	2823	2105
515	705	526	935	698	1288	961	1714	1278	2266	1690	3111	2320
550	747	557	990	738	1359	1013	1801	1343	2373	1770	3247	2421
600	806	601	1066	795	1453	1083	1916	1429	2510	1872	3414	2546
650	863	643	1137	848	1540	1148	2017	1504	2626	1958	3548	2646
720	937	699	1230	917	1647	1229	2136	1593	2750	2051	3674	2740
750	968	722	1267	945	1688	1259	2178	1624	2789	2079	3705	2763
810	1025	764	1336	997	1759	1312	2244	1673	2838	2116	3720	2774
850	1061	791	1378	1028	1799	1341	2274	1696	2848	2124	3695	2755
900	1102	822	1426	1063	1838	1371	2296	1712	2835	2114	3620	2700
950	1141	851	1468	1094	1866	1392	2298	1713	2791	2081	3496	2607
1000	1175	876	1503	1121	1882	1404	2279	1700	2714	2024	3319	2475
1050	1205	899	1533	1143	1886	1406	2240	1670	2602	1940		
1100	1231	918	1555	1160	1876	1399	2178	1624	2455	1830		
1225	1277	953	1580	1178	1789	1334	1917	1430				
1300	1291	963	1572	1172	1691	1261						
1400	1290	962	1532	1142								
1500	1268	945	1456	1086								
1600	1221	911										
1700	1150	857										
1800	1051	784										

Clutch Power Capacities — Reversing Applications With Propeller Shaft Brake, and Disconnect Applications with Controllable Pitch Propeller — 150 psi (10,3 bar)

Clutch Shaft rpm	14VC1000		16VC1000		20VC1000		24VC1000		28VC1000		32VC1000	
	HP	KW	HP	KW	HP	KW	HP	KW	HP	KW	HP	KW
200	346	258	463	345	652	486	884	659	1192	889	1668	1244
250	430	321	576	430	810	604	1097	818	1477	1102	2064	1539
300	514	384	688	513	965	720	1305	973	1754	1308	2446	1824
350	597	445	798	595	1116	832	1506	1123	2020	1507	2812	2097
400	678	506	905	675	1263	942	1700	1268	2274	1696	3158	2355
450	758	565	1010	753	1405	1048	1885	1406	2515	1875	3482	2596
515	859	641	1142	852	1581	1179	2112	1575	2804	2091	3865	2882
550	912	680	1211	903	1671	1246	2226	1660	2947	2198	4051	3021
600	986	735	1307	974	1794	1337	2379	1774	3136	2339	4292	3201
650	1057	789	1398	1043	1909	1423	2519	1879	3304	2464	4499	3355
720	1153	860	1520	1133	2056	1533	2692	2007	3501	2611	4728	3526
750	1192	889	1569	1170	2114	1576	2757	2056	3571	2663	4802	3581
810	1268	945	1662	1239	2219	1655	2869	2140	3683	2746	4905	3658
850	1316	981	1720	1283	2281	1701	2930	2185	3735	2785	4939	3683
900	1372	1023	1788	1333	2349	1752	2991	2230	3774	2814	4937	3682
950	1425	1063	1849	1379	2406	1794	3031	2260	3782	2820	4886	3644
1000	1475	1100	1905	1421	2450	1827	3052	2276	3757	2802	4782	3566
1050	1520	1133	1955	1458	2482	1851	3051	2275	3698	2758		
1100	1561	1164	1997	1489	2500	1865	3027	2257	3603	2686		

Clutch Shaft rpm	14VC1000		16VC1000		20VC1000		24VC1000		28VC1000		32VC1000	
	HP	KW	HP	KW	HP	KW	HP	KW	HP	KW	HP	KW
1225	1645	1226	2073	1546	2485	1853	2863	2135				
1300	1680	1253	2095	1562	2429	1812						
1400	1710	1275	2095	1562								
1500	1717	1281	2059	1535								
1600	1701	1268										
1700	1676	1250										
1800	1609	1200										

Clutch Power Capacities — Fixed Pitch Propeller — 125 psi (8,6 bar)

Clutch Shaft rpm	38VC1200		42VC1200		46VC1200		52VC1200		51VC1600		60VC1600		66VC1600	
	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW
80	816	608	982	733	1138	849	1454	1085	1927	1437	2610	1947	3340	2491
100	1017	759	1224	913	1418	1058	1810	1351	2399	1790	3248	2423	4151	3097
120	1217	908	1465	1093	1695	1264	2162	1613	2866	2138	3876	2892	4947	3691
180	1803	1345	2169	1618	2500	1865	3181	2373	4218	3146	5687	4243	7211	5380
200	1992	1486	2396	1788	2759	2058	3505	2615	4648	3468	6259	4669	7914	5904
250	2451	1829	2946	2198	3377	2519	4274	3188	5669	4229	7602	5671	9528	7108
300	2884	2152	3463	2583	3947	2944	4970	3708	6597	4921	8798	6563	10899	8130
350	3286	2452	3941	2940	4459	3327	5580	4163	7411	5529	9816	7323	11978	8936
400	3652	2724	4372	3261	4905	3659	6089	4543	8094	6038	10627	7928	12717	9487
450	3975	2966	4751	3544	5274	3934	6483	4836	8627	6436	11203	8357		
515	4325	3227	5154	3845	5623	4195	6799	5072	9064	6762				
550	4477	3340	5324	3972	5743	4285	6868	5123						
600	4645	3465	5506	4108	5825	4345								
650	4750	3543	5609	4184										

Clutch Shaft rpm	Dual 32VC1000		Dual 38VC1200		Dual 42VC1200		Dual 46VC1200		Dual 52VC1200		Dual 51VC1600		Dual 60VC1600		Dual 66VC1600	
	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW
80	997	743	1631	1217	1964	1465	2276	1698	2908	2169	3853	2875	5219	3893	6680	4983
100	1243	927	2034	1517	2449	1827	2835	2115	3621	2701	4799	3580	6495	4846	8303	6194
120	1489	1110	2433	1815	2929	2185	3389	2528	4324	3226	5732	4276	7753	5784	9895	7382
180	2212	1650	3605	2689	4337	3236	5001	3731	6362	4746	8435	6293	11374	8485	14422	10759
200	2448	1826	3985	2973	4793	3575	5518	4116	7011	5230	9297	6935	12518	9339	15828	11808
250	3023	2255	4903	3658	5892	4396	6753	5038	8548	6376	11339	8459	15205	11343	19056	14215
300	3574	2666	5769	4304	6926	5167	7893	5889	9940	7415	13193	9842	17596	13126	21797	16261
350	4095	3055	6573	4903	7881	5879	8919	6653	11160	8325	14823	11058	19632	14646	23956	17871
400	4583	3419	7303	5448	8744	6523	9810	7318	12178	9085	16189	12077	21255	15856	25434	18974
450	5031	3753	7951	5931	9502	7088	10547	7868	12966	9673	17254	12872	22405	16714		
515	5548	4139	8651	6454	10308	7690	11246	8390	13598	10144	18129	13524				
550	5791	4320	8954	6680	10649	7944	11487	8569	13735	10246						
600	6093	4546	9290	6930	11012	8215	11650	8691								
650	6337	4727	9500	7087	11218	8368										
720	6570	4901	9565	7135												
750	6628	4945														
800	6667	4973														
900	6504	4852														
950	6294	4695														

Airflex® Marine Drives

Section X

Clutch Power Capacities —

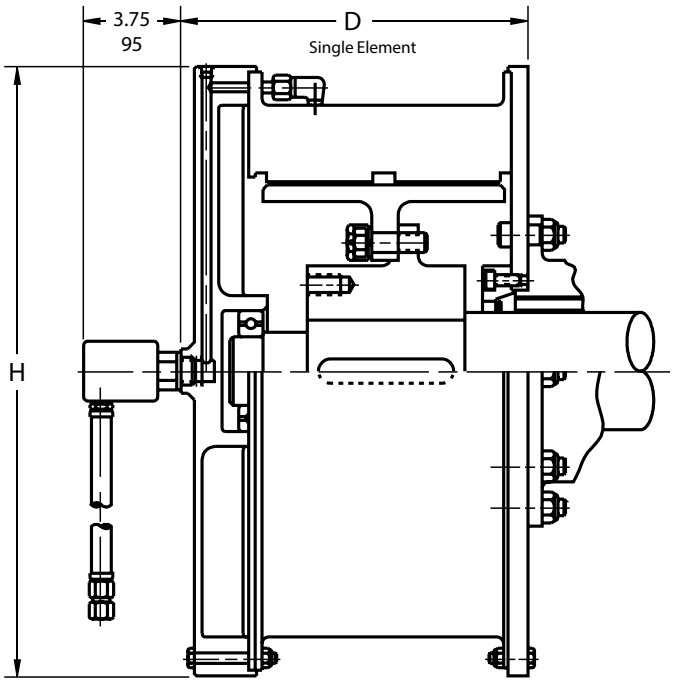
Controllable Pitch Propeller — 125 psi (8,6 bar)

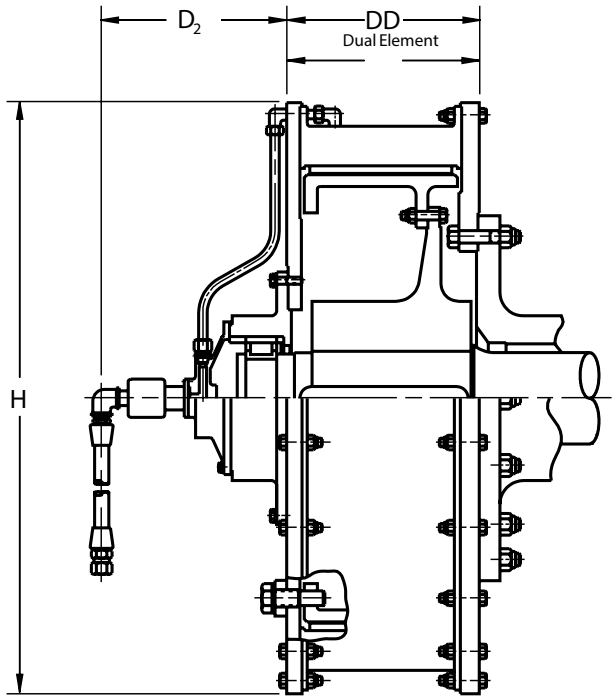
Clutch Shaft rpm	38VC1200		42VC1200		46VC1200		52VC1200		51VC1600		60VC1600		66VC1600	
	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW
80	924	690	1113	830	1290	962	1648	1229	2184	1629	2957	2206	3785	2824
100	1153	860	1388	1035	1607	1199	2052	1531	2719	2028	3681	2746	4705	3510
120	1379	1029	1660	1238	1920	1433	2451	1828	3248	2423	4393	3277	5607	4183
180	2043	1524	2458	1834	2834	2114	3605	2690	4780	3566	6445	4808	8173	6097
200	2258	1684	2716	2026	3127	2333	3973	2964	5268	3930	7094	5292	8969	6691
250	2778	2073	3339	2491	3827	2855	4844	3613	6425	4793	8616	6428	10798	8055
300	3269	2439	3925	2928	4473	3337	5633	4202	7476	5577	9971	7438	12352	9214
350	3724	2778	4466	3332	5054	3770	6324	4718	8399	6266	11125	8299	13575	10127
400	4139	3087	4955	3696	5559	4147	6901	5148	9174	6844	12044	8985	14412	10752
450	4505	3361	5384	4017	5977	4459	7347	5481	9778	7294	12696	9471		
515	4902	3657	5841	4357	6373	4754	7706	5748	10273	7664				
550	5074	3785	6034	4502	6509	4856	7783	5806						
600	5264	3927	6240	4655	6602	4925								
650	5383	4016	6357	4742										

Clutch Shaft rpm	Dual 32VC1000		Dual 38VC1200		Dual 42VC1200		Dual 46VC1200		Dual 52VC1200		Dual 51VC1600		Dual 60VC1600		Dual 66VC1600	
	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW	HP	kW
80	1129	843	1849	1379	2226	1661	2579	1924	3295	2458	4367	3258	5915	4413	7570	5647
100	1409	1051	2305	1720	2775	2070	3214	2397	4103	3061	5438	4057	7362	5492	9410	7020
120	1687	1258	2758	2057	3320	2477	3841	2865	4901	3656	6496	4846	8787	6555	11214	8366
180	2507	1870	4086	3048	4916	3667	5668	4228	7211	5379	9560	7132	12891	9616	16345	12194
200	2774	2069	4516	3369	5432	4052	6253	4665	7946	5927	10536	7860	14187	10584	17938	13382
250	3426	2556	5557	4145	6678	4982	7654	5710	9687	7227	12851	9587	17232	12855	21596	16111
300	4050	3021	6538	4877	7850	5856	8946	6674	11266	8404	14953	11155	19942	14877	24704	18429
350	4641	3462	7449	5557	8932	6663	10108	7540	12648	9435	16799	12532	22250	16598	27150	20254
400	5194	3875	8277	6175	9910	7393	11118	8294	13802	10296	18347	13687	24089	17970	28825	21503
450	5702	4254	9011	6722	10769	8033	11954	8918	14695	10962	19555	14588	25392	18943		
515	6287	4690	9804	7314	11682	8715	12746	9508	15411	11497	20546	15327				
550	6563	4896	10148	7571	12069	9003	13018	9712	15567	11613						
600	6906	5152	10528	7854	12481	9311	13203	9850								
650	7182	5357	10766	8032	12714	9484										
720	7446	5555	10840	8087												
750	7512	5604														
800	7556	5636														
900	7372	5499														
950	7133	5321														

Airflex® Marine Drives

Section X





Capacities to 4900 HP (3680 kW)

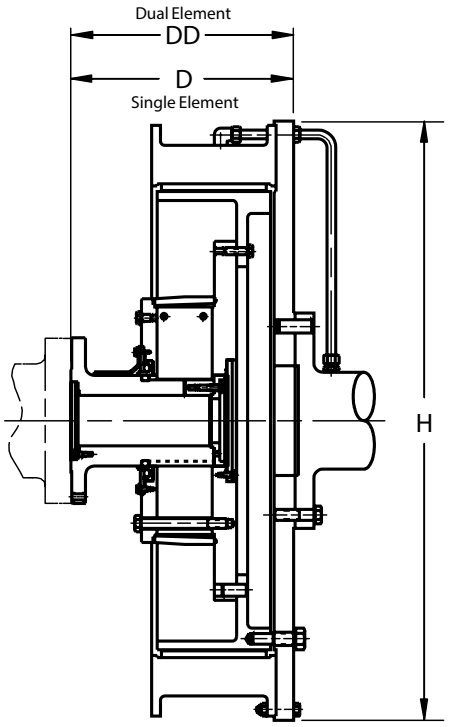
Size	Dimensions in inches		Dimensions in millimeters	
	D	H	D	H
14VC1000	14.69	24.00	373	610
16VC1000	14.44	26.00	368	660
20VC1000	14.81	30.00	376	762
24VC1000	14.81	34.50	376	876
28VC1000	14.94	38.50	379	978
32VC1000	15.88	44.25	403	1124

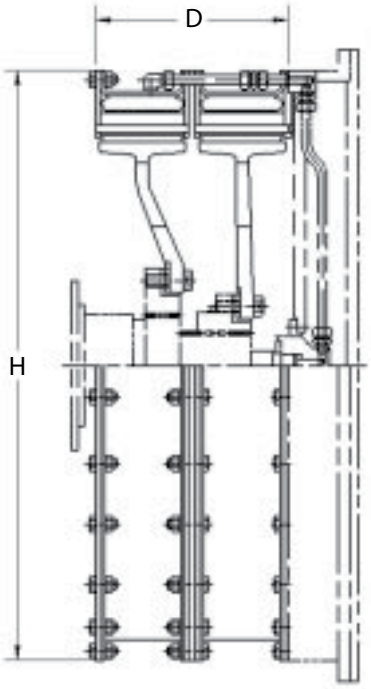
Capacities to 29000 HP (21600 kW)

English	Dimensions in inches			
38VC1200	19.75	33.50	17.00	49.88
42VC1200	19.75	33.50	17.00	54.13
46VC1200	20.25	34.00	17.00	60.75
52VC1200	20.75	35.00	18.00	67.50
51VC1600	24.25	42.50	18.00	67.50
60VC1600	24.25	43.00	18.00	76.50
66VC1600	24.25	43.00	18.00	83.50
Size				
Single or Dual	D	DD	D2	H
38VC1200	502	851	432	1267
42VC1200	502	851	432	1375
46VC1200	514	863	432	1543
52VC1200	527	889	457	1715
51VC1600	616	1080	457	1715
60VC1600	616	1092	457	1943
66VC1600	616	1092	457	2120
SI		Dimensions in millimeters		

Airflex® Marine Drives

Section X





Capacities to 29000 HP (21600 kW)

Size Single or Dual	Dimensions in inches			Dimensions in millimeters		
	D	DD	H	D	DD	H
38VC1200	17.00	34.50	49.88	432	876	1267
42VC1200	19.50	34.50	54.13	495	876	1375
46VC1200	20.00	37.75	60.75	508	959	1543
52VC1200	21.00	38.75	67.50	533	984	1715
51VC1600	25.50	40.75	67.50	648	1035	1715
60VC1600	27.50	45.75	76.50	699	1162	1943
66VC1600	29.75	48.00	83.50	756	1219	2121

Capacities to 2820 HP (2100 kW)

Size	Dimensions in inches		Dimensions in millimeters	
	D	H	D	H
11.5VC500	12.25	19.63	311	498
14VC500	12.25	23.50	311	597
16VC600	14.75	25.50	375	648
20VC600	14.75	29.50	375	749
24VC650	15.38	34.50	391	876
28VC650	15.38	38.00	391	965
33VC650	15.38	44.63	391	1134
37VC650	15.38	48.63	391	1235
42VC650	15.38	53.63	391	1362

General dimension of typical VC clutches for marine applica - tion are shown in the above drawings. Construction details vary slightly in clutches of different sizes. For example, clutch design may include a one-piece or two-piece drum and hub.

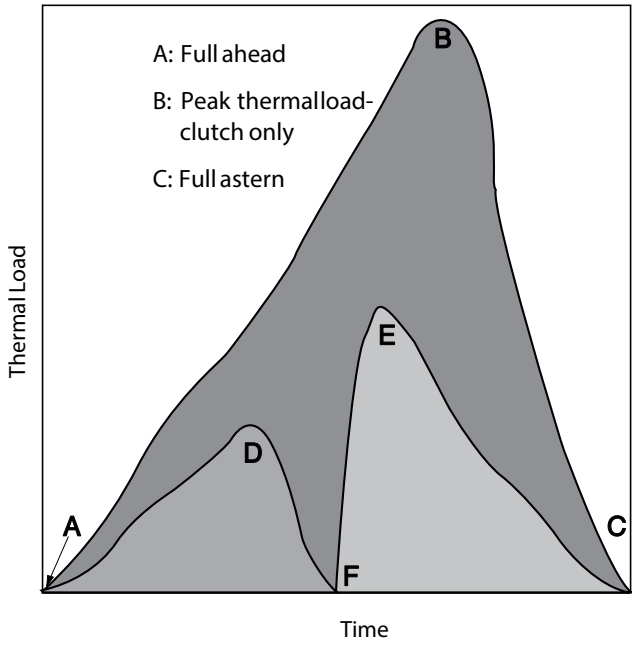
Propeller Shaft Brakes

General

Propeller shaft brakes are used to improve vessel maneuver ability by stopping the propeller shaft as fast as possible, to prevent engine stalling during hard reversing maneuvers and to reduce the thermal load on the reversing clutch. In addition, the brake reduces the shock loads on the major components of the propulsion system and prevents freewheeling of the propeller in heavy currents.

The chart below compares the thermal load imposed on a reversing clutch through a "crash astern maneuver" and a brake and reverse clutch through the same maneuver. Clutch thermal load is much less when the brake/clutch combination is used, prolonging clutch life.

Airflex element types VC, CH and calipers are recommended for use as propeller shaft brakes.



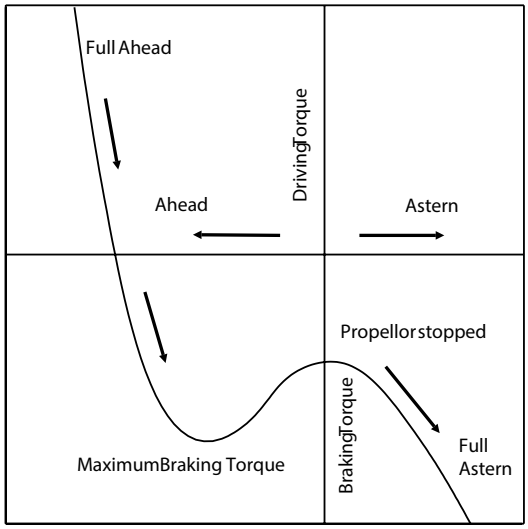
Brake Selection Procedure

A characteristic propeller shaft reversing torque curve at maximum speed ahead is shown below. This generally is the operating speed requiring the greatest stopping torque. The characteristic curve is dependent upon ship design and varies somewhat with the type of vessel.

The propeller shaft brake must have sufficient torque to reduce propeller speed to the maximum brake torque point. This torque rarely exceeds 70% of full power torque except for vessels with high performance hulls and/or twin propellers. Use 100% of full power torque for these vessels. (Full power torque does not include service factor). Brake torque at various speeds for different types of vessels are given in the following table:

Brake Torque
as a Percentage of Full Propulsive Power

Ship Speed	Towing Barge, Tug & Fishing Boats	High Performance Hulls & Twin propellers	All other vessels
Full	100	100	100
3/4	50	100	70
1/2	25	50	35
1/4	20	45	25



After the propeller is stopped, the reversing clutch is engaged and the propeller speed increased in the astern direction to stop the vessel.

A tentative brake selection is made using the torque calculated from the percentage of full propulsive power. The selected brake's thermal capacity is then compared to the stopping thermal load. The thermal load is calculated from the component inertias to be stopped and the wind milling propeller torque resulting from water flow through the propeller.

Airflex® Paper Machine Drives

Section X

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 deter - mine 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 sec - tions. Because of the thermal load, only type VC is recom - mended 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
Transfer	0.030
Smoothing press – marking press pair of rolls	0.007
Size press – pair of rolls	0.020
Dryers: Paper and Fel t	
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

❷

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
w/plain bearings and no helper drive	text
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 mini - mum 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:

$$A = \frac{W\,k^2 \cdot v^2}{D^2 \cdot 1.21E\ +0\,6}$$

A: clutch friction area (in ^{2})

Wk ^{2}: inertia of dryer section (lb·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·L·K

Wk ^{2}: estimated Wk ^{2} of section (lb·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:

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

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·[K_1· 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 ma - chine 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

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

$P_T = 26$ HP

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

$= 3260$ lb·in

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

$$M\,a = 0.74 \cdot \left[\frac{W\,k^2 \cdot v}{D^2 \cdot n}\right] \cdot Z$$

$$= 0.74 \cdot \left[\frac{48000 \cdot 2500}{3\,6^2 \cdot n}\right] \cdot 5\,0$$

$= 3430$ lb·in

$$A = \frac{W\,k^2 \cdot v^2}{D^2 \cdot 1.21E\ +0\,6}$$

$$= \frac{48000 \cdot 2500^2}{3\,6^2 \cdot 1.21E\ +0\,6}$$

$= 191$ 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

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

$= 141$HP

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

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

$= 16000$ lb·in

Airflex® Power Presses, Brakes and Shears

Section X

General

Power presses are used for punching or stamping, forming or drawing and embossing operations. Press brakes are used for bending operations. Shears are used to cut material to size. In most cases, the material being worked is steel.

These machines usually utilize a slider-crank linkage to transfer kinetic energy from a rotating flywheel to a recipro - cating ram. They are rated by the force Fr, the ram can exert at a given distance d above the bottom of the stroke. This distance is called the drive capacity. The product of the drive capacity and rated force determines the maximum energy which should be removed from the flywheel to perform the necessary work.

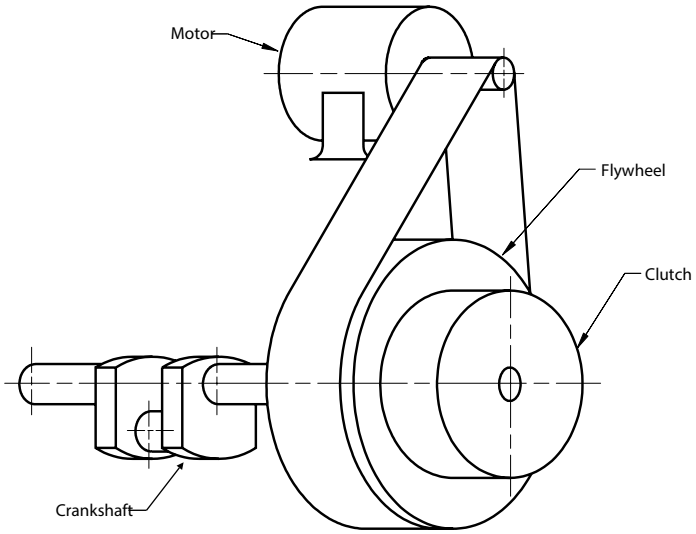
As energy is removed from the flywheel, and work is per - formed, the flywheel slows down. The machine's motor replaces the expended flywheel energy before the next work stroke by bringing the flywheel back up to its operating speed.

A clutch and brake is usually required for one or all of the fol - lowing reasons:

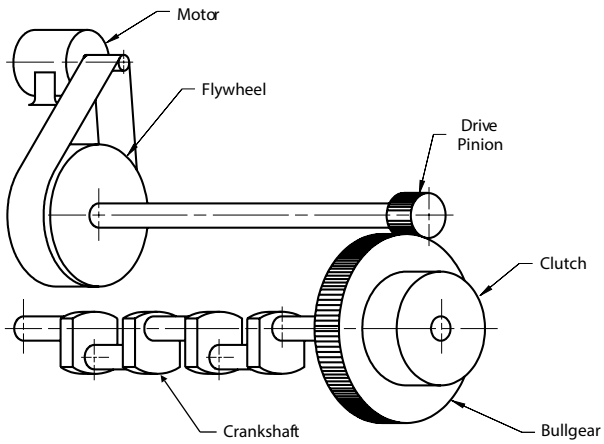
- For die or blade setup.
- For feeding and removing work pieces from the machine.
- For emergency stopping.

Because these machines are inherently dangerous, the brakes are spring-set, pressure released types.

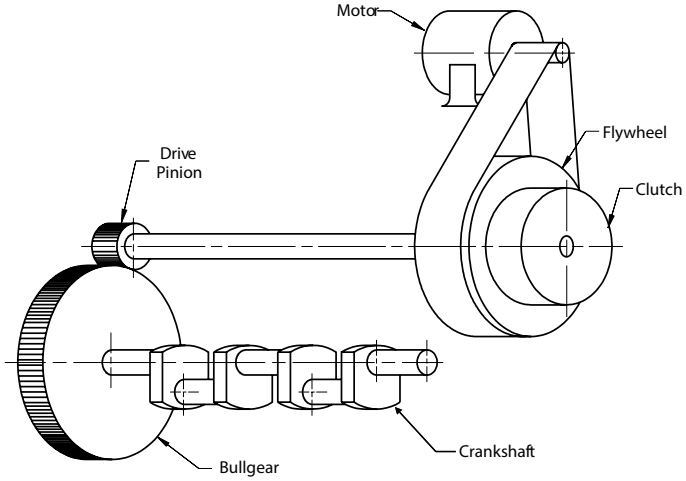
Crankshaft mounted flywheel



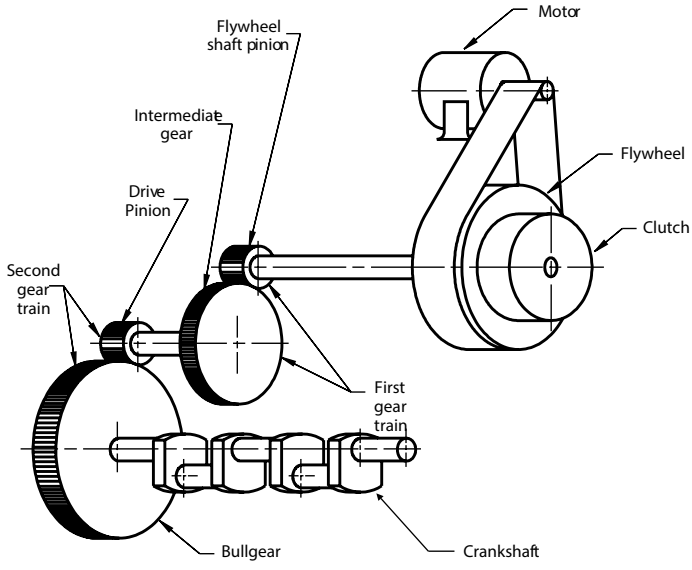
Single geared, single drive clutch mounted on bullgear



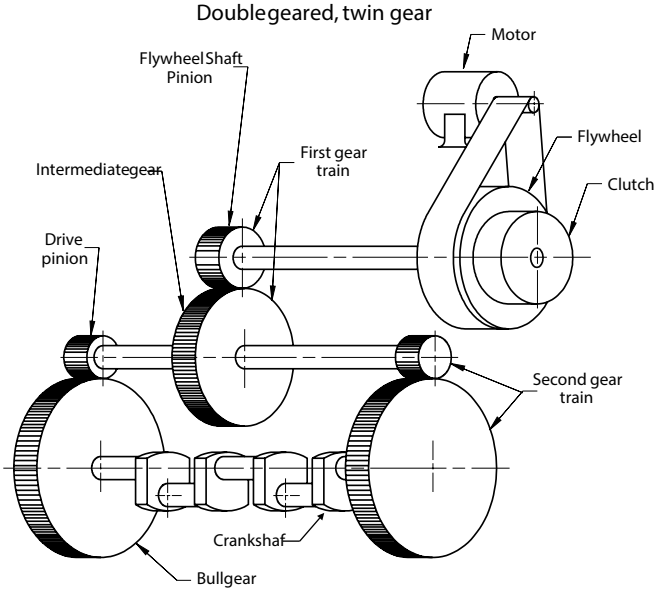
Single geared, single drive clutch mounted on flywheel



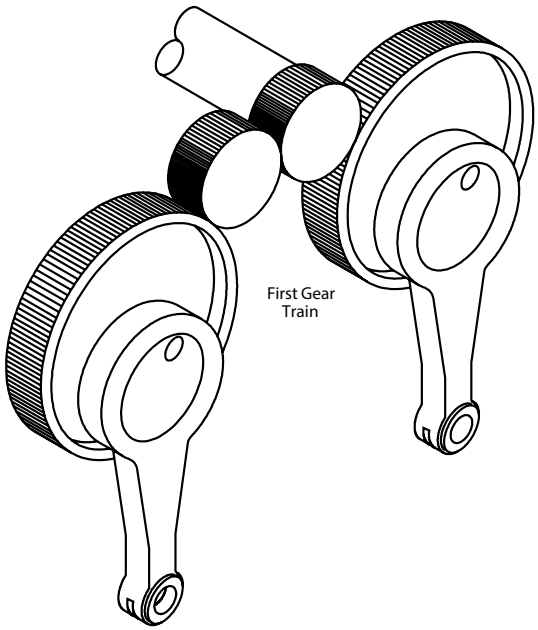
Double geared, single drive



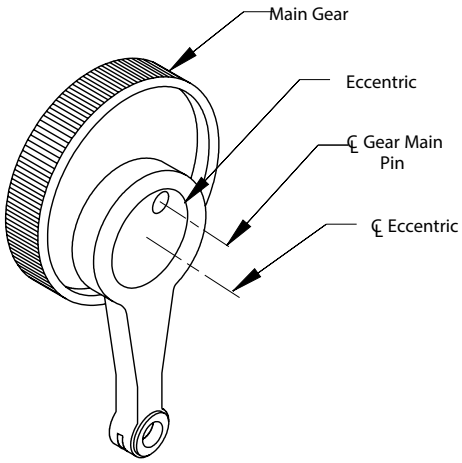
Double geared, twin gear



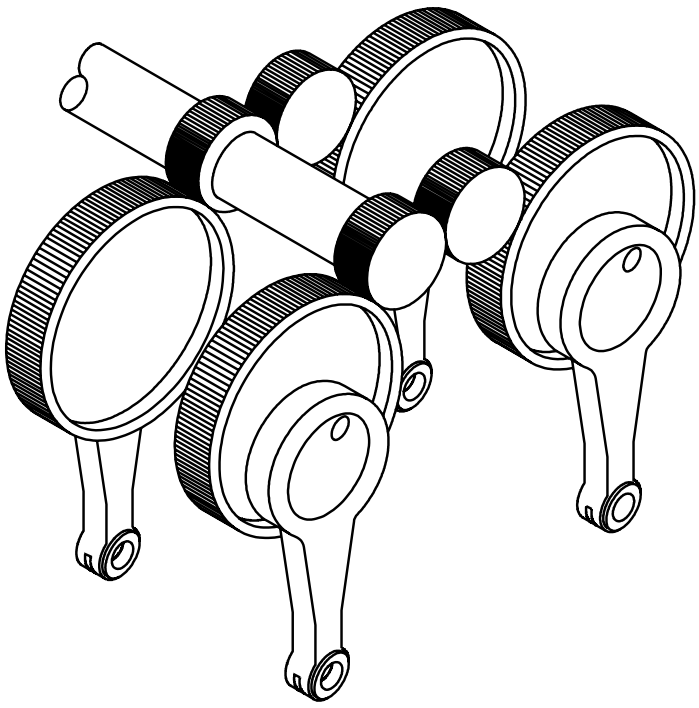
Eccentric, two point



Eccentric, single point



Eccentric, four point



Drive Capacities

Power presses

Mechanically, the drive capacity is dependent upon the drive train between the crank and flywheel shafts. Commonly used drive trains are illustrated on the preceding pages. The dis - tance is a minimum for crankshaft mounted flywheels and a maximum for twin geared drives. If not specifically stated, the values given in the following table may be used.

Drive Capacities d

for Open Back Inclinable (OBI) and Horn Presses

Rated Tonnage	c/s Flywheel Drive	Geared Drive
32 and less	0.03 in (0,8 mm)	0.13 in (3,3 mm)
over 32 to 110	0.06 in (1,5 mm)	0.25 in (6,4 mm)
over 110		0.25 in (6,4 mm)

For Single-Action, Single and Multiple Point Geared Presses

Single drive	0.25 in (6,4 mm)
Eccentric drive	0.50 in (13 mm)
Twin drive	0.50 in (13 mm)

Press brakes

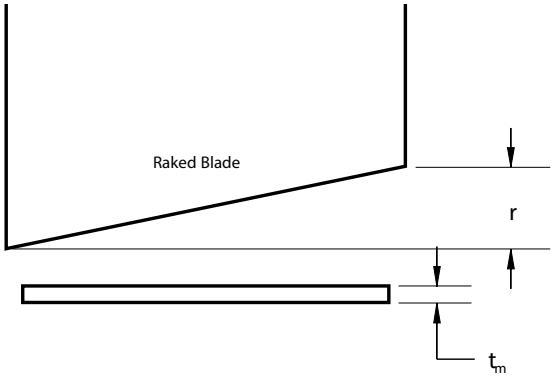
The drive capacity for short stroke machines, if not specified, can be approximated from the width V of the vee die opening. Use the following approximations:

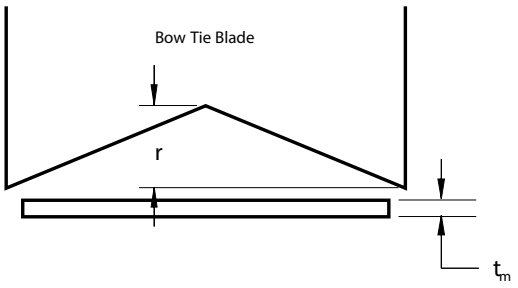
For stroke less than 3 in (76 mm) d = 0.28V

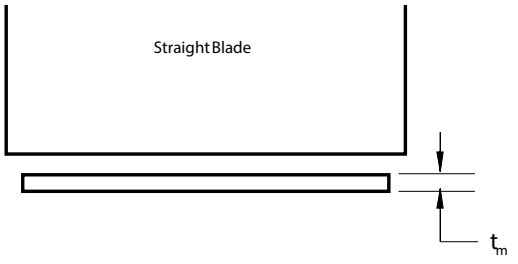
For larger strokes d = 1 in (25 mm)

Shears

The tonnage and drive capacity needed to cut a given material depends upon the type of blade used. The diagrams illustrate the differences between straight, raked and bow tie blades and gives the drive capacities. Usually, the shear blade is allowed to over travel the work piece thickness t_m by a small distance e to provide a clean cut.

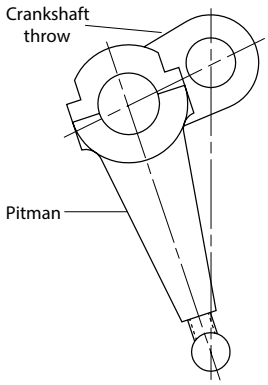


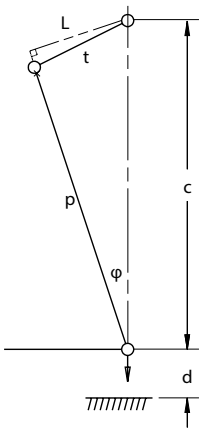




Crankshaft Torque

The slider-crank linkage is shown below.





The crank link t length is equal to the crankshaft throw (one-half of the stroke distance) or in the case of an eccentric drive, the eccentric offset. The link p connecting the crank shaft throw to the ram is called the pitman.

Knowing the lengths of the throw and pitman, the pitman angle Ø can be calculated at any point in the stroke from:

$$\cos \varnothing = \frac{p^2 + c^2 - t^2}{2 \cdot p \cdot c}$$

$$c = p + t - d$$

The torque lever arm L varies throughout the stroke of the machine. At any point in the stroke, the lever arm can be calculated from:

$$L = c \cdot \sin \varnothing$$

The force F_p which the pitman must transmit can be calculated from:

$$F_p = F_r / \cos \varnothing$$

F_r = 2000 · Rated Tonnage of Press

The crankshaft torque M is:

$$M = F_p \cdot L = Fr \cdot c \cdot \tan \varnothing$$

The torque required at the machine's drive capacity is used in the clutch selection procedure.

Clutch Torque

Clutch torque M_c calculations can be simplified by the use of the effective lever arm L_e graphs and the following formula. The graphs assume the pitman length is twice the stroke. Longer pitmans will slightly reduce the effective lever arm.

$$M_c = \frac{F_r \cdot L_e}{R} \cdot SF$$

R: reduction between clutch shaft and crankshaft.

SF: service factor from following table.

Brake Capacity

Type of Drive	SF
Crankshaft mounted flywheel	0.8
Single drive, single reduction	1.0
Single drive, double reduction, single throw	1.1
Single drive, double reduction, double throw	1.2
Twin drive, single reduction	1.3
Twin drive, double reduction	1.5

The selected brake must satisfy the following conditions:

It must have sufficient torque to stop the ram within a given crankshaft angle.

It must have sufficient torque to hold the ram and die on the back stroke.

It must have sufficient thermal capacity to handle the single stroke rate of the machine.

Formulas are given in Section Y which allow calculation of brake torque Mb knowing the stopping angle, inertia to be stopped and the brake shaft speed n. A brake selection is made using Mb.

Holding torque Mh is calculated from:

$Mh = F \cdot t/R$

F: total weight or mass of ram including attached tooling.

The reverse torque of the brake selected is compared to Mh to determine if it has sufficient capacity.

Cyclic thermal power Pc is calculated from formula 23, Section Y. The allowable thermal loading on the friction area of Airflex types CS, CTE and DB brakes is 0.012 HP/in^2 (0.0014 kW/cm^2).

Example

Press rating - 60 tons

Type of drive - crankshaft mounting

Drive capacity d - 0.06 in

Stroke - 3 in

Pitman length p - 8 in

Crankshaft speed - 100 rpm

Single stroke rate - 30 cpm

Ram and die weight F - 200 pounds

Wk^2 less clutch and brake - 10 lb·ft^2

Stopping angle θ_d - 15^0

Flywheel Wk^2 - 900 lb·ft^2

Calculations

$c = t+p-d = 0.5 \cdot 3 + 8 - 0.06 = 9.44$ in

$$\cos f = \frac{p^2 + c^2 - t^2}{2 \cdot p \cdot c} = \frac{8^2 + 9.44^2 - 1.5^2}{2 \cdot 8 \cdot 9.44}$$

$= 0.9988$

$\varnothing = 2.78^0$

$L = 9.44 \cdot \sin \varnothing = 0.46$ in

$M = F_r \cdot c \cdot \tan \varnothing$

$= 60 \cdot 2000 \cdot 9.44 \cdot \tan 2.78$

$= 55000$ lb·in

$M_c = 55000 \cdot 0.8 = 44000$ lb·in

Select FSPA109 (20CB500 clutch and 15CS300 brake):

clutch torque = 53600 lb·in

forward brake torque = 22000 lb·in

reverse brake torque = 3500 lb·in

flywheel Wk^2 = 942 lb·ft^2

Wk^2 drum and hub = 61 lb·ft^2

Total Wk^2 to be stopped = 10 + 61 = 71 lb·ft^2

Stopping Time:

$$t_d = \frac{Wk^2 \cdot n}{25.58 \cdot M_b} = \frac{71.100}{25.58 \cdot 22000}$$

$= 0.012$ sec

Stopping Angle:

$f_d = 3 \cdot n \cdot td = 3 \cdot 100 \cdot 0.012$

$= 3.6^0$

$M_h = F \cdot t$

$= 200 \cdot 1.5$

$= 300$ lb·in

$$W_r = \frac{Wk^2 \cdot n}{5873} = \frac{71.100^2}{5873} = 121 \text{ft} \cdot \text{lb}$$

$$P_c = \frac{W_r \cdot cpm}{33000} = \frac{121.30}{33000} = 0.11 \text{HP}$$

$$\frac{P\,c}{A} = \frac{0.11}{89} = 0.0012 \text{ HP/in}^2$$

Both thermal capacity and holding torque requirements are within the 15CS300 parameters.

Airflex® Tensioning, Winding and Unwinding

Section X

General

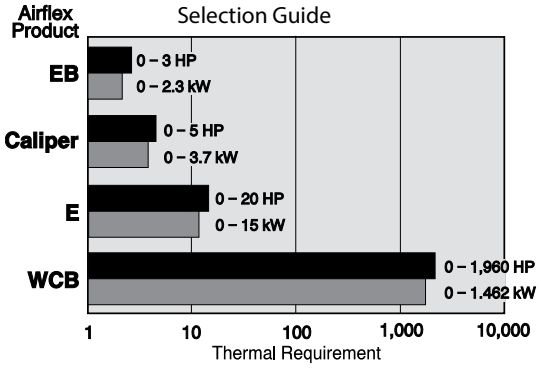
Winding is the process of taking up a web or a strand of a long length of material onto a beam, a cone, a core, a drum or a spool; primarily for handling convenience for end use or reprocessing. Depending upon the industry, the process is also called coiling or spooling. Examples are a roll of paper toweling and a coil of steel providing material in a stamping operation.

Unwinding is the process of controlled payoff of material which has previously been wound, coiled or spooled.

In both processes it is important to maintain a constant tension or pull on the material. Improper tensioning during winding results in roll dishing or telescoping and improper roll density. Improper tensioning during unwinding can cause web distortion and flutter, affecting the reprocessing operation. Material tension can be controlled electrically, hydraulically or mechanically. Airflex products recommended for mechanical (friction) control include the types E, EB, WCB and caliper ele ments. See selection guide, below.

Material Tension

As indicated, correct tension is important; however, most users are unaware of the material tension required. Tension values may vary considerably from plant to plant and from machine to machine; operator preference as to tightness of web and desired roll densities are also factors. To assist in this matter, the tension charts shown are intended to serve only as a guide.



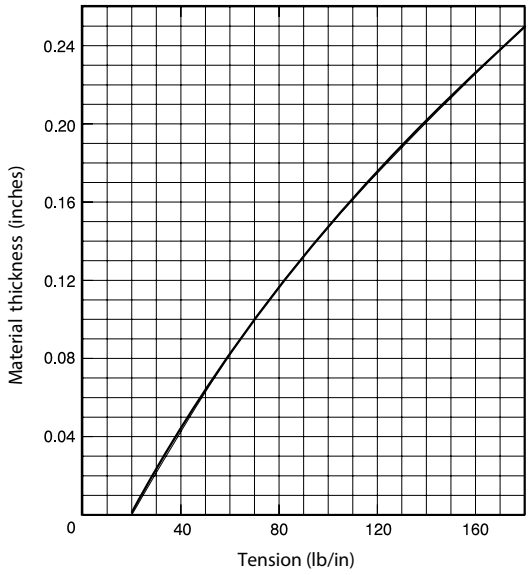
Metal Tension Guide

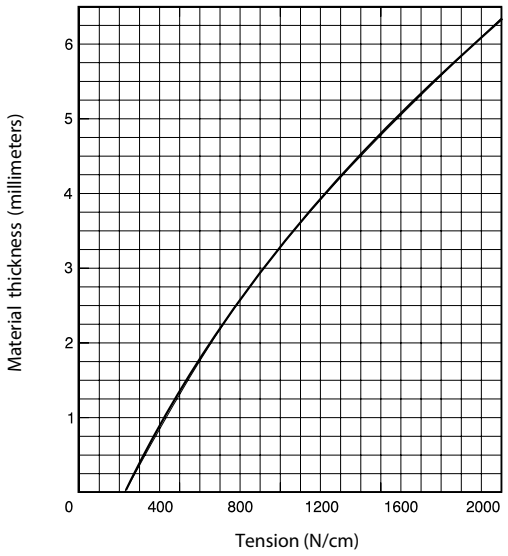
Depending upon material, multiply the graph tension by the following factors:

Aluminum, full hardness	1.00
Aluminum, half hardness	0.75
Brass, full hardness	1.00
Brass, half hardness	0.75

Steel:

Carbon, full hardness	2.25
Mild	1.00
Nickel	2.50
Silicon	1.20
Stainless, cold drawn	4.25



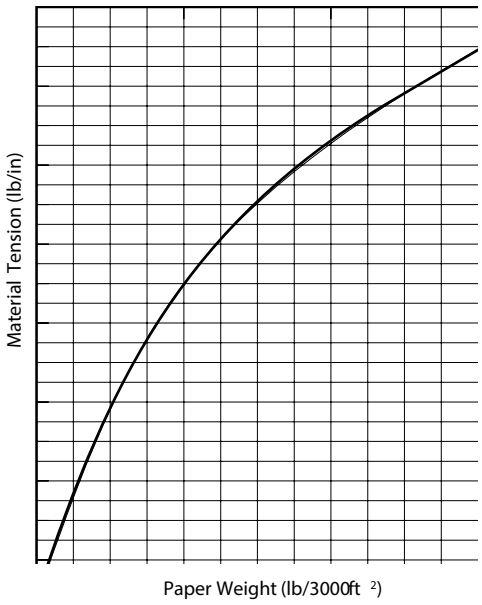


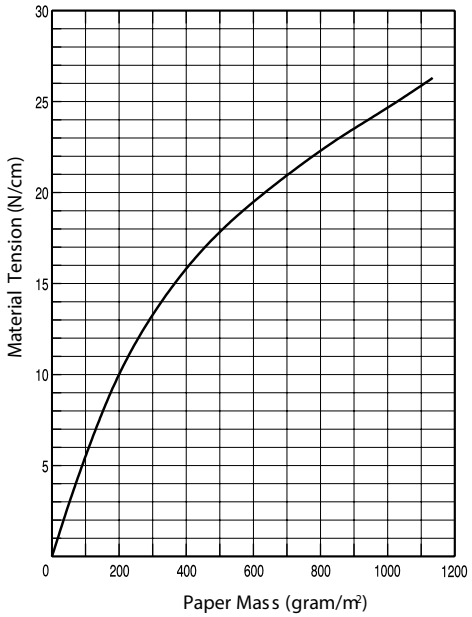
Airflex® Tensioning, Winding and Unwinding

Section X

Paper and Board Tension Guide

The paper and board chart is for 3000 ft ^{2} (279 m ^{2}) of material which is the equivalent of 500 sheets (Ream) 24 in x 36 in (0.62 x 0.91 m). Various papers and board stocks with different basic weight and size designations should be adjusted to 3000 ft ^{2} for direct reading from the chart. For example, if a board is designated 120 lbs per 1000 ft ^{2}, multiply 120 by 3 to bring it to 3000 ft ^{2}. If board weight is in points, multiply by 10 (i.e., 50 point board x 10 = 500 lbs per 3000 ft ^{2}). For chip board multiply the point designation by 8.5.





Slip Clutches and Tension Brakes

In most winding and unwinding applications, in addition to a constant tension, the material processing procedure requires a constant web speed that is usually controlled by the processing machine's main drive. During unwinding, as the roll diameter decreases, the roll rpm increases and the tension or drag brake torque requirement decreases.

When winding, as the roll diameter increases, the roll rpm decreases and the slip clutch torque requirement increases.

Both clutch and brake torque is adjusted by regulation of the applied pressure during the winding and unwinding procedure.

Selection Procedure

In many cases, the winding and unwinding machines are required to handle different types of materials and/or operate under different parameters. It is important to determine the maximum and minimum operating ranges The following parameters are necessary to determine proper clutch and brake sizes (see Section Y for units):

Material

T_{max}: maximum material tension

T_{min}: minimum material tension

or

F_{max}: maximum material pull

F_{min}: minimum material pull

D: maximum roll diameter

d: minimum roll or core diameter

w_{max}: maximum web width

w_{min}: minimum web width

v_{max}: maximum web speed

v_{min}: minimum web speed

R: reduction between clutch or brake shaft and roll shaft

Using the parameters, the following calculations are made:

$$F_{max} = T_{max} \cdot w_{max}$$

$$F_{min} = T_{min} \cdot w_{min}$$

$$M_{max} = F_{max} \cdot 0.5\ D/R$$

$$M_{min} = F_{min} \cdot 0.5\ d/R$$

English Units

$$N_{max} = \frac{V_{max} \cdot R}{0.262 \cdot d}$$

$$N_{min} = \frac{V_{min} \cdot R}{0.262 \cdot D}$$

SI Units

$$n_{max} = \frac{V_{max} \cdot R}{5{,}236\ E\text{-}05 \cdot d}$$

$$n_{min} = \frac{V_{min} \cdot R}{5{,}236\ E\text{-}05 \cdot D}$$

For a tension or drag brake on an unwind stand, the thermal power to be dissipated P_{tb} is

$$P_{tb} = \frac{F_{max} \cdot V_{max}}{33000} (HP)$$

$$P_{tb} = \frac{F_{max} \cdot V_{max}}{60000} (kW)$$

For a slip clutch on a winding stand, it is desirable to have the driving side of the clutch rotating at a slightly faster speed than the driven side to prevent clutch lockup and a slip-grab situation. The recommended driving speed is 10% greater than the driven speed for speeds under 100 rpm and 5% greater for speeds over 100 rpm. Slip clutch thermal power to be dissipated P_{tc} is:

$$P_{tc} = \frac{M_{max} \cdot n_s}{63025} (HP)$$

$$P_{tc} = \frac{M_{max} \cdot n_s}{9550} (kW)$$

n_s: slip rpm = (1.10 or 1.05) $\cdot n_{max} - n_{min}$

The calculated torques, thermal power and speeds must fall within the capacities given in the appropriate product catalog section.

Type E slip clutch arrangements are shown in Section C on catalog Forms E605 through E607. Air-cooled tension brake arrangements are shown on catalog Forms E608 and E609; water-cooled arrangement on Form E610.

The caliper tension brake arrangement is shown in Section H, Form CA1003.

Water-cooled WCB tension brakes are shown in Section I.

Application examples appear on the following page.

Example

A slip clutch is required for a rewind stand operating under the following conditions:

Material pull F_{max}: 125 lb

Maximum coil diameter D: 20 in

Minimum core diameter d: 12 in

Web speed v_{max}: 1000 fpm

Reduction R: 1:1

$M_{max} = F_{max} \cdot 0.5 \cdot D = 125 \cdot 0.5 \cdot 20$

$= 1250$ lb·in

$M_{min} = F_{max} \cdot 0.5 \cdot d = 125 \cdot 0.5 \cdot 12$

$= 750$ lb·in

$$n_{max} = \frac{v_{max}}{0.262 \cdot d} = \frac{1000}{0.262 \cdot 12} = 318 \text{ rpm}$$

recommended driving speed=1.05 · 318=334 rpm

$$n_{min} = \frac{v_{min}}{0.262 \cdot D} = \frac{1000}{0.262 \cdot 20} = 190 \text{rpm}$$

$n_s = 334 - 190 = 144$ rpm

$$P_t = \frac{v_{max} \cdot n_s}{63025} = \frac{1250 \cdot 144}{63025} = 2.9 \text{ HP}$$

From P_t curves for 3 HP @ 334 rpm select 14E475

Approximate operating pressure = $\frac{1250}{16000} \cdot 75 \sim 6$ psi

Example

A tension brake is required to handle the following require - ment:

Material tension T_{max}: 18 lb/in

Material tension T_{min}: 18 lb/in

Maximum roll diameter D: 108 in

Core diameter d: 16 in

Maximum web width w_{max}: 216 in

Minimum web width w_{min}: 216 in

Maximum web speed v_{max}: 4100 fpm

Minimum web speed v_{min}: 4100 fpm

Reduction R: 1:1

$F_{max} = F_{min} = T_{max} \cdot W_{max} = 18 \cdot 216 = 3890$ lb

$M_{max} = F_{max} \cdot 0.5 \cdot D = 3890 \cdot 0.5 \cdot 108$

$= 210000$ lb·in

$M_{min} = F_{min} \cdot 0.5 \cdot d = 3890 \cdot 0.5 \cdot 16$

$= 31100$ lb·in

$$n_{max} = \frac{V_{max}}{0.262 \cdot d} = \frac{4100}{0.262 \cdot 16} = 978 \text{ rpm}$$

$$n_{min} = \frac{V_{min}}{0.262 \cdot D} = \frac{4100}{0.262 \cdot 108} = 145 \text{ rpm}$$

$$P_{tb} = \frac{Fmax \cdot v_{max}}{33000} = \frac{3890 \cdot 4100}{33000} = 483 \text{ HP}$$

Select 324 WCB

Operating pressure:

$$P_{max} = \frac{M_{max}}{M_r} \text{ x } P_r + P_p \text{ (Page I-13, } P_p)$$

$$= \frac{210000}{300000} \text{ x } 80 + 5$$

$= 61$ psi

$$P_{min} = \frac{M_{min}}{M_r} \text{ x } P_r + P_p \text{ (Page I-13, } P_p)$$

$$= \frac{31100}{300000} \text{ x } 80 + 5$$

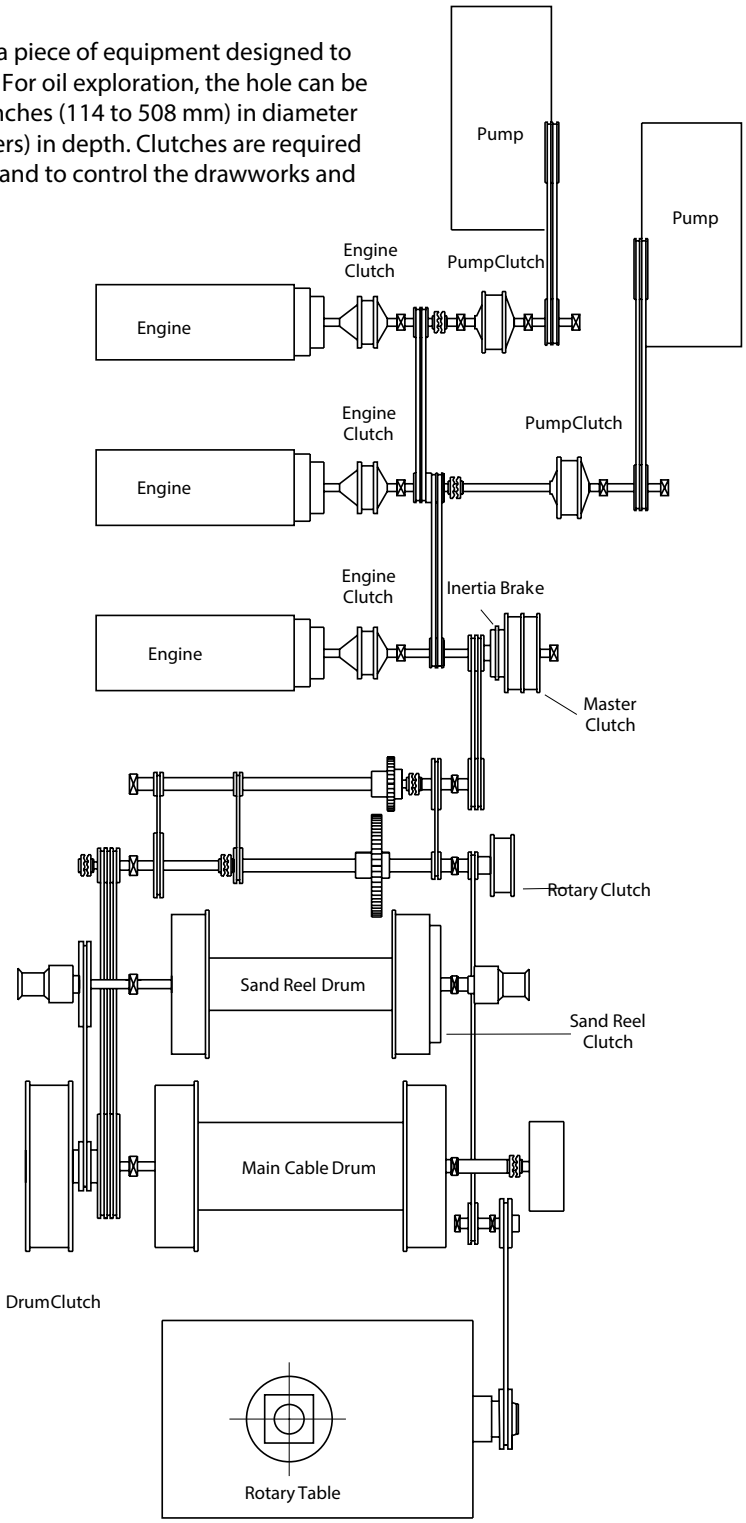
$= 13$ psi

Airflex® Well Drilling

Section X

General

A rotary well drilling rig is a piece of equipment designed to bore a hole into the earth. For oil exploration, the hole can be anywhere from 4.5 to 20 inches (114 to 508 mm) in diameter and 30000 feet (9140 meters) in depth. Clutches are required for the rig's prime movers and to control the drawworks and rotary table functions.



Engine Clutches

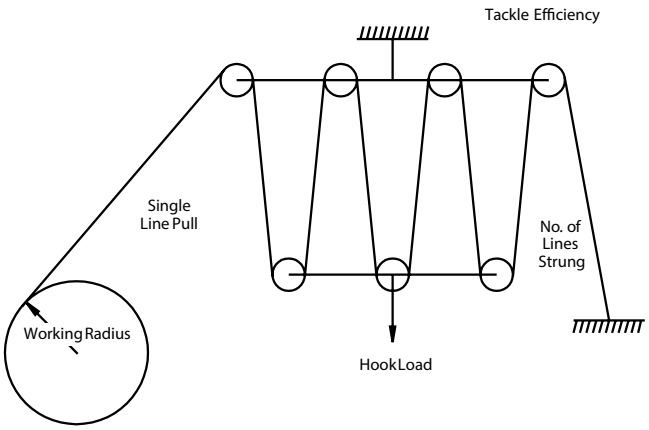
On the majority of rigs, three or more diesel engines supply power to run all the machinery necessary to bore the hole. The engines are arranged so that they may be put in operation as the need arises. For instance, at the start of drilling, one engine may provide all the power necessary. As the hole becomes deeper, the second and then the third engine can be brought on-line. This arrangement is called a compound and CB clutches are used to engage and disengage the engines.

During the drilling operation, pumps are used to circulate a mud slurry to clean the bottom of the hole, to cool and lubricate the tools and to maintain the walls of the well. Hereto, CB elements are used to connect and disconnect the pumps as required.

A selection procedure for engine clutches is given in Section X. Use the procedure for clutch sizing.

Drawworks Clutches

Sections of pipe are used to connect the drilling bit to the rotary table. After the bit has bored a pipe length depth, the operation is stopped and a new pipe section added. The drilling bits wear and must be replaced several times when drilling a well. This means the drill string (the bit and all the pipe sections) must be withdrawn from the hole, the bit replaced and the drill string re-assembled. Raising and lowering of the string is the function of the drawworks.



A drawworks is basically a hoist which raises or lowers heavy loads by means of wire rope (line) wound on a drum. The drawwork's transmission allows a number of drum speeds. The deeper drilling rigs have a low and high speed drum clutch which further increases the number of possible drum speeds. The drill string weight (hook load) determines which clutch is used.

Low speed clutch

The low speed drum clutch torque requirement M_L is determined by the single line pull F and the working drum radius r. Usually, the maximum hook load H is given instead of single line pull. Single line pull is calculated from:

$$F = \frac{H}{N \cdot E}$$

N: number of lines strung

E: Tackle efficiency

Good design practice limits the line pull to one-half of the line breaking strength.

N Number of lines strung	E Tackle Efficiency
4	0.908
6	0.874
8	0.842
10	0.811
12	0.782
14	0.755
16	0.728
18	0.703

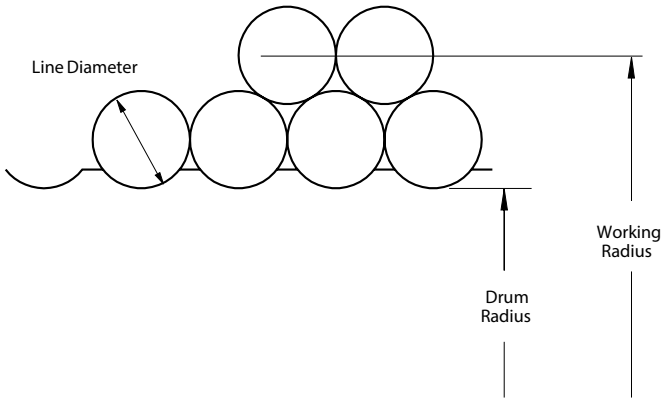
The following figure illustrates the working drum radius. Usually, the drawworks is rated on the second line wrap on the drum. The working radius can be calculated from:

$r = 0.5\ D + 0.866\ \cdot d \cdot w - 0.366\ \cdot d$

D: drum diameter

d: line or wire rope diameter

w: number of wraps



Low speed clutch torque can then be calculated from:

$M_L = F \cdot r$

No service factor is used because this is the maximum torque required and only occurs at the maximum hole depth. Applying a service factor results in too large a clutch torque for the range of speeds and a overstressed line.

Using the calculated low drum torque and the lowest drum rpm N_L, the power required for hoisting P_h is calculated from:

$$P_h = \frac{M_L \cdot n_L}{63025} (HP)$$

$$P_h = \frac{M_L \cdot n_L}{9550} (kW)$$

High speed clutch

High speed clutch torque M_H is calculated from the hoist power and the lowest high speed drum rpm N_H. A service factor is applied because of abuse from higher engagement speeds and shock loading due to breaking the drill string free of the rotary table slips.

$$M_H = \frac{P_h \cdot 63025}{n_H} \cdot 1.5 \ (lb \cdot in)$$

$$M_H = \frac{P_h \cdot 9550}{n_H} \cdot 1{,}5 \ (N \cdot m)$$

In many cases, the same size clutch is used for both the high and low speed clutches to keep the number of clutch sizes on a rig to a minimum. Because of the large torque requirement, VC elements are used. Follow the selection procedure given in Section B.

Inertia Brake

This brake is used to stop the rotating transmission components of the drawworks. Its selection is based upon the rotating inertia, the brake shaft speed and the desired stopping time.

Other Drawworks Clutches

All other clutch selections with the exception of the sand reel are based upon the maximum power which the clutch must transmit, the clutch shaft speed and the appropriate service factor from the following table. The sand reel clutch torque depends upon its line pull and drum working radius

Clutch	SF
Master	1.5
Rotary	1.5
Pump	1.8
Sand Reel	1.25

Example

Determine the low and high speed drum clutch torques required for the following conditions:

Maximum hook load H: 500000 lb

Hoist drum dia. D: 20 in

Lines strung N: 8

Line dia. d: 1.125 in

Rated wrap W: 3

Low speed range: 34 to 77 rpm

High speed range: 108 to 254 rpm

$$F = \frac{H}{N \cdot E} = \frac{500000}{8 \cdot 0.842} = 74228 lb$$

$$r = 0.5 \cdot D + 0.866 \cdot d \cdot w - 0.366 \cdot d$$
$$= (0.5 \cdot 20) + (0.866 \cdot 1.125 \cdot 3) - (0.366 \cdot 1.125)$$
$$= 12.51 \text{ in}$$

$$M_L = F \cdot r = 74228 \cdot 12.51$$
$$= 928593 \text{ lb·in}$$

$$P_h = \frac{M_L \cdot n_L}{63025} = \frac{928593 \cdot 34}{63025} = 501 HP$$

$$M_H = \frac{P_h \cdot 63025}{n_H} \cdot 1.5 = \frac{501 \cdot 63025}{108} \cdot 1.5$$

$$= 438550 \text{ lb·in}$$

Airflex® Well Drilling

Section X

Drawworks Auxiliary Brake

This brake is used for fine and precise control of drilling speed of all hook loads at all depths. Airflex WCBD & WCSB units are selected for 100% of maximum rated loads. They will function as retarding and stopping the loads.

WCSB is a combination brake that provides dynamic (tensioning) braking, parking (static holding) and spring applied e-stop braking. The WCSB (combo) is designed for direct mounting and to be used as the sole brake (only mechanical brake) on a drawworks application. (AC, DC or Mechanical).The water cooled portion of the brake offers energy absorption (HP) capacity, while the spring set function accommodates "fail safe" braking (for parking & e-stop). WCSB must be sized with 2 aspects; plenty of torque (spring set) for heaviest loads at "worn condition" and then also plenty of HP (for dynamic braking). However on AC drawworks, the brake may not see full HP, as the motors are doing most of the energy dissipation.

A WCBD is primarily an "auxiliary" brake for all types of drawworks, as it can be coupled, chain driven or direct mounted. HP sizing is the primary concern. If used on an AC drawworks, a fail-safe mechanical brake must be present (spring set bands, spring set calipers, spring set plate brake, etc…)

Airflex has a selection tool for a thorough analysis of the torque and the thermal loading encountered in a drilling operation.

The information required for a selection includes;

1. Empty hook load
2. Maximum full load
3. Number of lines strung
4. Available air pressure
5. Wire rope diameter
6. Hoist drum diameter (Bare)
7. Rated wrap
8. Motor power
9. Number of motors
10. Gear box inertia at brake
11. Cable drum inertia at brake
12. Total number of brakes
13. Hook speed (Empty)
14. Hook speed (Full load)

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