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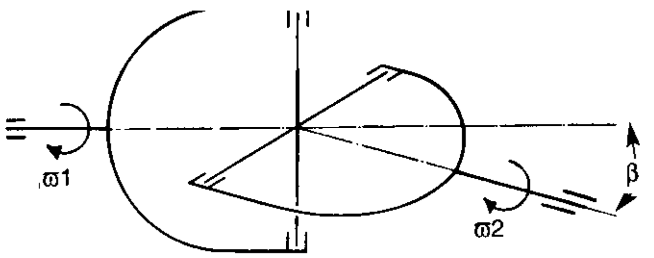
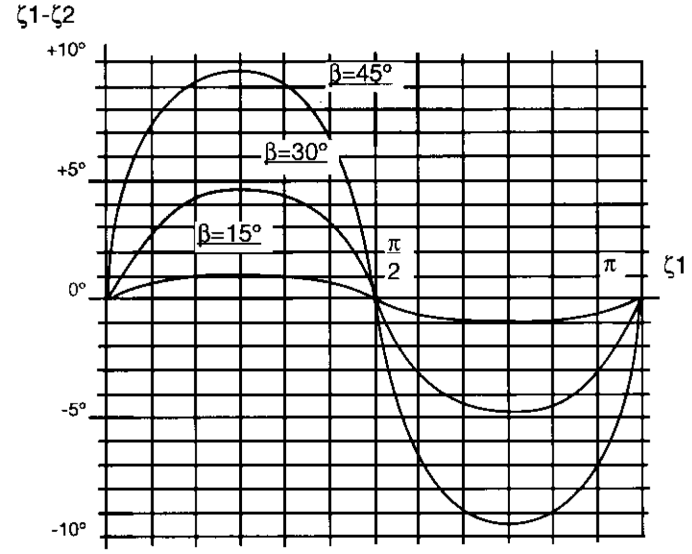
The Universal Joint also known as the Cardan or Hooke's Joint consists of a Journal (or spider) and four Bearings. Its purpose is to transmit torque from one inclined Shaft to another and the use of this construction can be traced back more than 700 years.

The uniform rotation ϖ1 of a single Universal Joint deflected at a certain angle β will result in a non-uniform rotation of the output side of the Joint.

Shaft 1



Shaft 2



This irregularity is called Cardan error and results in a sine like oscillation of the angular velocity ϖ2 and a phase difference of Shaft 2 rotation angle ζ with the amplitude of plus or minus ζ1-ζ2.

The non-constant velocity can be compensated by a second Joint provided that they are both in phase.

i.e. The Yokes (1) of the intermediate Shafts must be situated in the same plane. Marking arrows (2) must be noted.

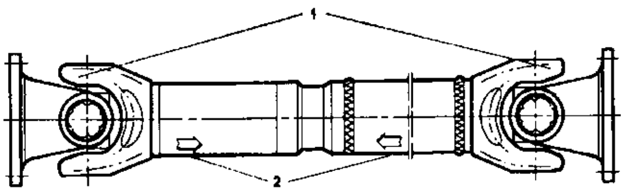
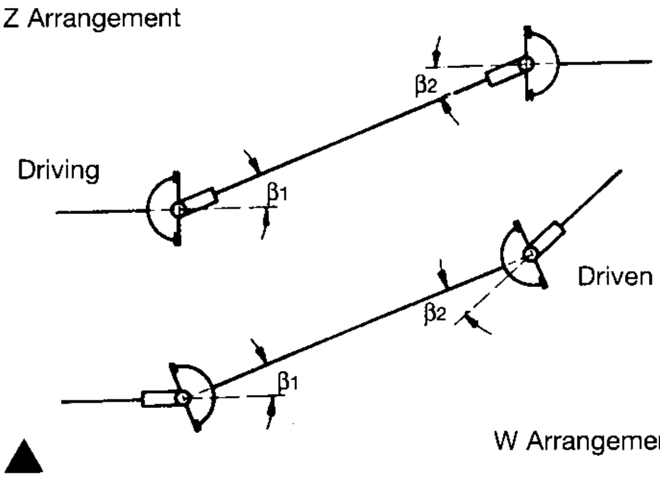


Diagram 1.

Diagram 2.



The Joint angles β1 and β2 must be equal. Two common methods of achieving this are the W and Z arrangements.

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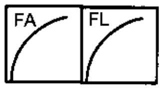
How to select a Driveshaft

Selection of the correct Universal Driveshaft for an application is dependent on the service life required, this is based on the following criteria.

Step 1	Calculate **torque** using formula.	$T = \frac{9545 \times P}{n}$ (Nm) **Page 3**
Step 2	Use life and angle requirements in conjunction with diagrams to determine **Angle Factor (FA) and Life Factor (FL)**.	 **Page 3**
Step 3	Using formula determine **corrected torque** and make provisional selection using diagram.	TC = T x FA x FL (Nm) **Page 3**  **Page 4**
Step 4	Using table determine the **service factor K** which is dependent upon application.	e.g. Service Factor K Paper machines 2 **Page 5**
Step 5	Using formula determine **maximum torque.**	Tmax = T x K (Nm) **Page 5**
Step 6	Using the range data tables on pages 9-26, check Tmax does not exceed the **short duration torque (Tsd)** for the selected series of Driveshaft.	 **Page 9 to 26**
Step 7	Check **angle to speed relationship** for the series selected as shown on diagram. Angle and speed must intersect below the series line.	 **Page 6**
Step 8	Check to ensure that the **working angle** does not exceed maximum stated angle for the series selected using the range data tables (note: compound angles must be calculated using formula). Again the resultant angle must not exceed the maximum angle stated.	 $\tan\beta = \sqrt{\tan^2\beta H + \tan^2\beta V}$ **Page 6**
Step 9	Check **critical speed** of the selected series does not exceed that in diagram. For Driveshafts with non-standard Tube dimensions, determine critical speed using formula.	 $n(crit) = 1.22 \times 10^7 \times \frac{\sqrt{D^2 + d^2}}{L^2}$ (r.p.m.) **Page 7**

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Selection of the correct Driveshaft for an application is dependent on the service life required which is based on the following criteria.

1) Torque
2) Joint Angles
3) Joint Life
4) Application Data; e.g. Shocks, Vibration, Cycle
5) Critical Speed

TORQUE

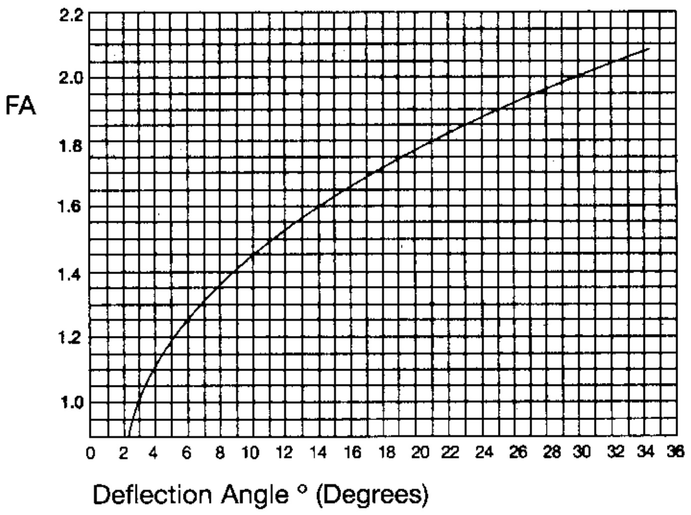
Torque is calculated using formula:

$$T = \frac{9545 \times P}{n} \text{ (Nm)}$$

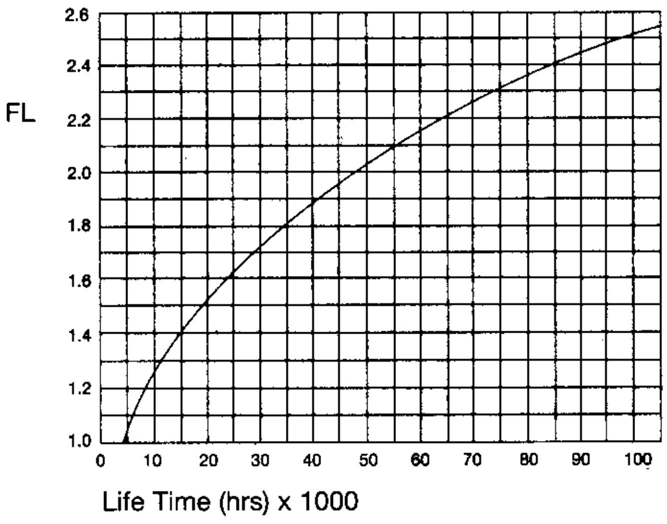
Where
T = Torque in Nm
P = Power in kW (1 hp = 0.7457 kW)
n = Speed in rpm

ANGLE AND LIFE FACTOR

Angle Factor



Life Factor



CORRECTED TORQUE

Corrected torque is calculated using formula: **TC = T x FA x FL (Nm)**

Where
TC = Corrected torque
T = Torque
FA = Angle factor
FL = Life Factor

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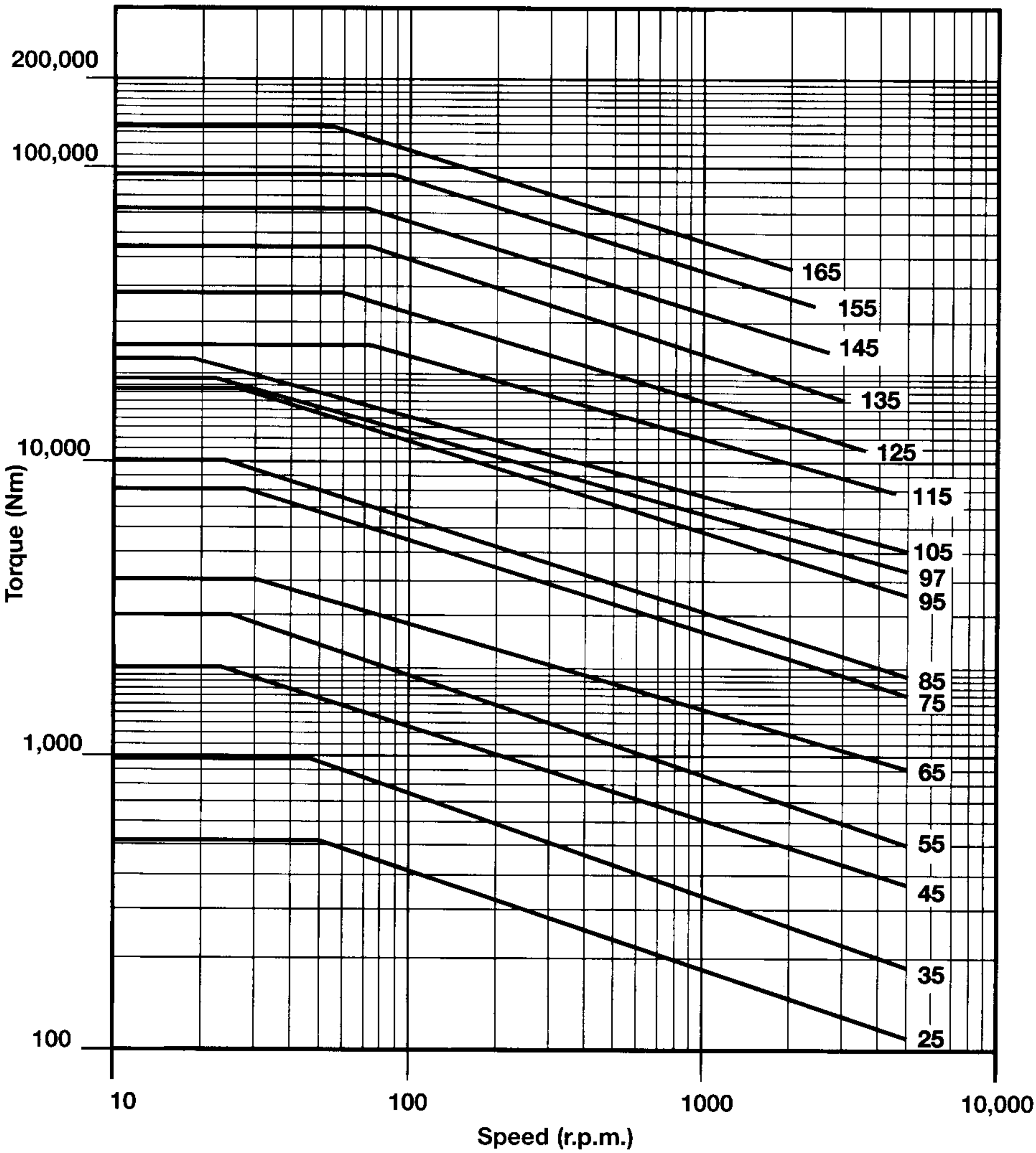
PROVISIONAL SELECTION

Standard Joint life calculation graph based on operation for **5000 hours at 3°.**



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SERVICE FACTOR K

Load condition Driven machine	Service factor K
Continuous load	**1,2 - 1,5**
Centrifugal Pumps	
Generators (continuous)	
Conveyors (continuous)	
Small Ventilators	
Light shock load	**1,5 - 2**
Diesel Engines	
Petrol Engines	
Centrifugal Pumps	
Generators (not continuous)	
Conveyors (not continuous)	
Medium Ventilators	
Machine Tools	
Printing Machines	
Wood Handling Machines	
Small Paper and Textile Machines	
Medium shock load	**2,5**
Pumps (multi cylinder)	
Compressors (multi cylinder)	
Large Ventilators	
Marine Transmissions	
Calendars	
Transport Roller Tables	
Rod and Bar Mills	
Small Pinch Rolls	
Small Tube Mills	
Locomotive Primary Drives	
Heavy Paper and Textile Machines	

Load condition Driven Machine	Service factor K
Heavy shock load	**3**
Compressors (single cylinder)	
Pumps (single cylinder)	
Mixers	
Crane Travel Drives	
Bucket Wheel Reclaimers	
Presses	
Rotary Drilling Machines	
Locomotive Secondary Drives	
Continuous Working Roller Tables	
Medium Section Mills	
Continuous Slabbing and Blooming Mills	
Continuous Heavy Tube Mills	
Extreme shock load	**4 - 6**
Breast Roller Drives	
Wrapper Roll Drives	
Reversing Working Tables	
Reversing Slabbing and Blooming Mills	
Scale Breakers	
Vibration Conveyors	

MAXIMUM TORQUE

Shock and vibrations are dependant on the application. These must be taken into consideration by using Service Factor K when calculating the maximum torque.

Maximum torque is calculated by using formula: **$T_{max} = T \times K$ (Nm)**

Where T_{max} = maximum torque
T = Torque
K = Service factor

Maximum torque calculated by this method should not exceed the short duration torque rating (Tsd) of the selected Driveshaft series i.e. $T_{max} \leq T_{sd}$ (short duration torque). The short duration torque capacity is used as the 'rating' of the Driveshafts.

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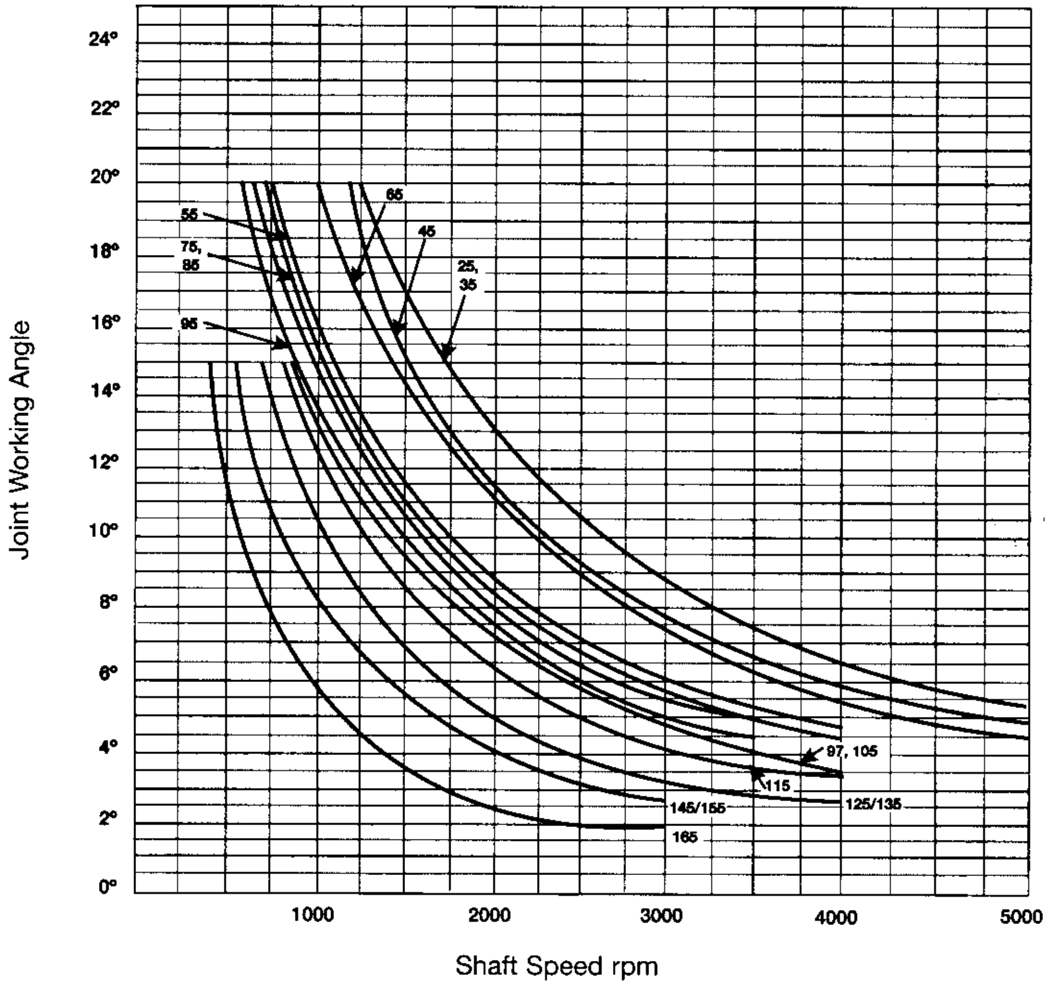
ANGLE TO SPEED RELATIONSHIP

Angle and speed are governed by a relationship for each Joint size as shown below. Angle and speed must intersect below the series line.



Angles are also governed by the maximum working angles as listed in the catalogue for each series - Flange combination.

COMPOUND ANGLES

To determine the compound Joint angle when a Driveshaft is deflected in the two planes (V vertical, H horizontal).

The compound Joint angle is calculated using formula: $\mathbf{\tan\beta = \sqrt{\tan^2\beta H + \tan^2\beta V}}$

Where βH = Working angle horizontal plane

βV = Working angle vertical plane

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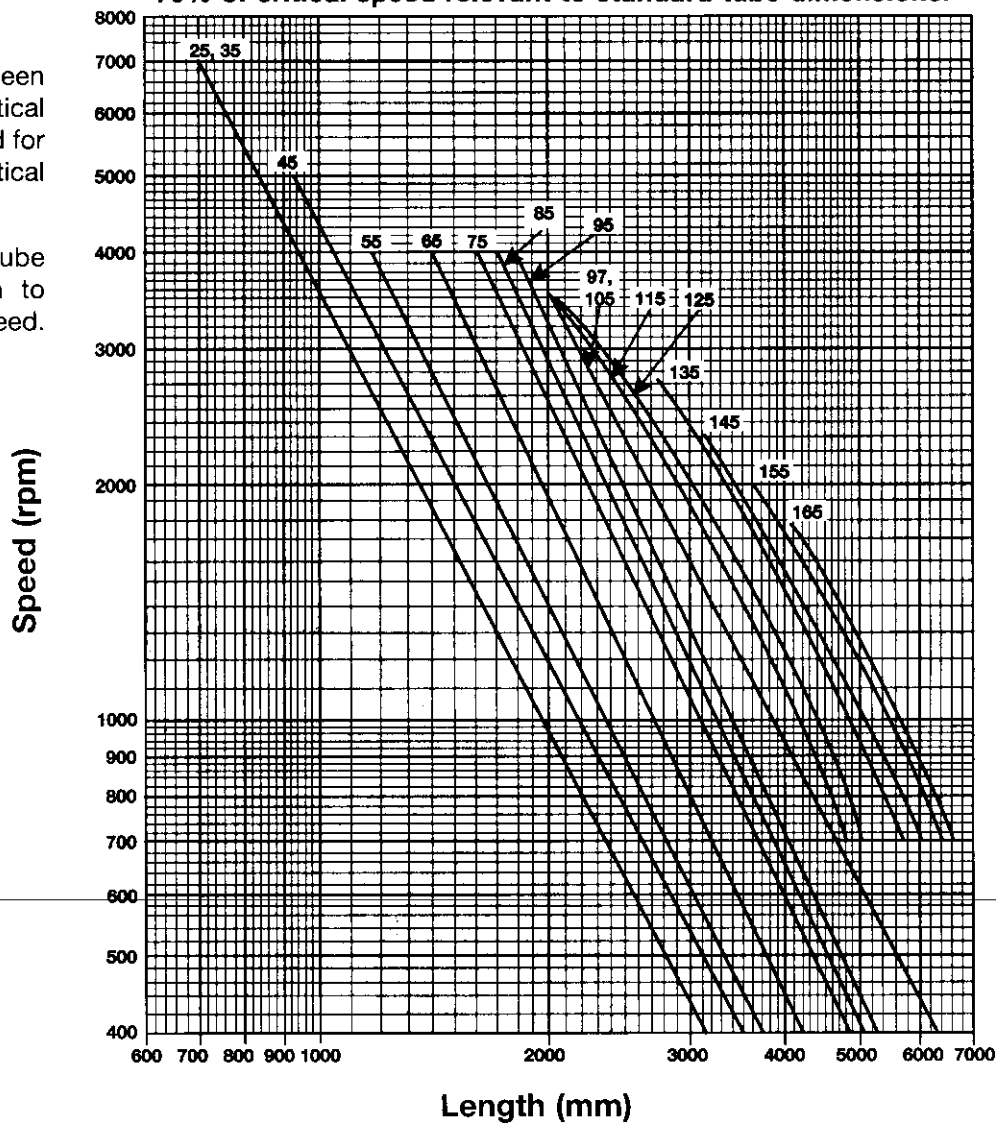
CRITICAL SPEED

Another relationship is that between speed and length, referred to as critical speed. The maximum working speed for safety reasons is taken at 70% of critical speed relevant to tube dimensions.

For Driveshafts with **standard** tube dimensions use the graph shown to determine the maximum working speed.

70% of critical speed relevant to standard tube dimensions.



For Driveshafts with **non-standard** tube dimensions critical speed is calculated using formula :

$$n(crit.) = 1.22 \times 10^7 \times \frac{\sqrt{D^2 + d^2}}{L^2} \quad (rpm)$$

Where
n = Critical speed in rpm
D = Tube outside diameter (cm)
d = Tube inside diameter (cm)
L = Length of Driveshaft (cm)

Again the maximum working speed should be limited to 70% of the calculated critical speed.

CRITICAL LENGTH

Critical length can be calculated using formula : $L(crit.) = \sqrt{\frac{1.22 \times 10^7 \times \sqrt{D^2 + d^2}}{n}} \quad (cm)$

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Range	Size	Torque Rating (Nm)	Flange Sizes Available SAE	Flange Sizes Available DIN	Types Available	Dimensions Page
Light Duty	25	570	1140	90	A, Y, M	9 to 11
	35	990	1310	100		
	45	2050	1410	120		
	55	3120	1510	150		
Meduim Duty	65	4000	1510	120	A, Y, M, B	12 to 15
				150		
	75	8000	1600	150		
			1700	165		
			1800	180		
	85	10000	1800	150		
				180		
	95	17500	1800	180		
			1900	225		
	97	19000		180		
				225		
				250		
Heavy Duty	105	18000		225	A, Y, B	16 to 18
	115	25000		250		
	125	37000		285		
	135	52000		315		
	145	72000		350		
	155	94000		390		
	165	136000		435		
Heavy Duty With Dowel Pins	106	33000		225	A, Y,	19 to 20
	116	40000		250		
	126	47000		285		
	136	70000		315		
	146	102000		350		
	156	145000		390		
	166	195000		435		
Heavy Duty With Face Key	107	44000		225	A, Y	21 to 22
	117	64000		250		
	127	98000		285		
	137	140000		315		
	147	190000		350		
	157	260000		390		
Extra Heavy Duty With Dowel Pins	205	45000		225	A, Y	23 to 24
	215	48000		250		
	225	66000		285		
	235	98000		315		
	245	140000		350		
	255	190000		390		
	265	260000		435		
Extra Heavy Duty With Face Key	206	54000		225	A, Y	25 to 26
	216	80000		250		
	226	117000		285		
	236	165000		315		
	246	225000		350		
	256	270000		390		