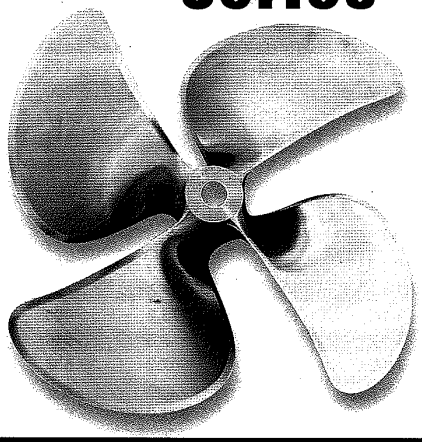
Propeller Series



The Standard series of propellers are designed to function in a non-cavitating to a partially cavitating environment. Cavitation is a water vapor cavity which forms on the surface of the hub or blade as a result of low pressure due to water flow over the blade surface. Stable cavitation is quite common on smaller performance propellers and often results in no adverse effects. Unstable cavitation can result in vibration and noise problems, or in extreme conditions, blade surface erosion. Cavitation is not necessarily bad, but needs to be controlled to avoid problems. A primary effort in sizing is to qualify an application as to the amount of blade loading (pressure in pounds per square inch), and what propeller area ratio is required.

STANDARDS

PROPELLER SERIES	EXPANDED AREA RATIO	BLADE NUMBER	SIZE RANGE, DIAMETER
DJX	0.61	3	Call Humco for available sizes.
DQX	0.735	4	Call Humco for available sizes.
DQX	0.81	4	Call Humco for available sizes.
DYNA-JET	0.56	3	19" - 46"
DYNA-QUAD	0.69	4	19" - 46"
M-500	0.86	5	22" - 46"
DQ SPECIAL	0.76 to 0.91	4	32" - 56"
DURA-QUAD	0.76	4	24" - 36"
PAC-MASTER	0.69	4	20" - 30"
MACHINE PITCH	0.51	3	19" - 60"
MACHINE PITCH	0.47	3	62" - 96"
MAXIMA 3	0.63	3	26" - 50"
MAXIMA 4	0.836	4	26" - 50"
WORK HORSE	0.71	4	24" - 60"
WORK HORSE	0.622	4	62" - 96"
WORK HORSE	0.8875	5	30" - 60"
TRAWLER	0.44	4	40" - 72"
KAPLAN	0.56, 0.76, Custom	4	35" - 95"

Too much blade area can reduce the efficiency of a propulsion system because the more the area, the more drag. There are ranges of loading that will predicate which of the Michigan Propeller configurations could be used. Typically, this ranges from the 3 blade on moderately sized boats through 40'), 4 blade on mid-range to larger (40'-100'), with 5 blade coming into play where there is extreme blade loading and compromise of diameter. There may be over-riding considerations in selecting a 4 or 5 blade over a 3 blade, such as maximizing vibration reduction.

On moderately sized boats, generally speaking, if optimal diameter is possible with adequate tip clearance, a 3 blade will yield the best top end speed. However, the choice of a 4 blade may provide similar cruising speed, and may offer a more comfortable ride, with less vibration. With an increase in blade number, the "blade rate frequency" increases for a given shaft RPM. In general, the higher the blade rate frequency, the less problematic vibration is. On the larger, heavier applications, with higher gear ratios, the loading requires greater area ratios, and 4 or 5 bladed propellers have a better speed potential. Properly matching propeller area ratio to an application will optimize propulsion and reduce the possibility of destructive cavitation erosion.

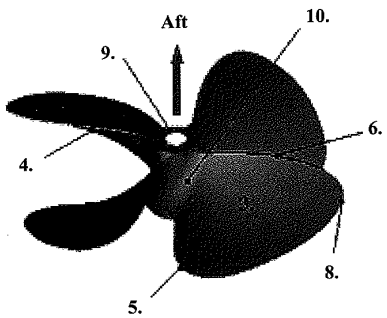
	SPECIFICATIONS
	High Skewed Blade Shape, Standard Thickness
	High Skewed Blade Shape, Standard Thickness
	High Skewed Blade Shape, Standard Thickness
	Skewed Blade Shape, Standard Thickness
	Skewed Blade Shape, Standard Thickness
	Skewed Blade Shape, Standard Thickness
	Skewed Blade Shape, Standard Thickness
	Skewed Blade Shape, Heavy Duty Thickness
	Skewed Blade Shape, Stainless Steel, Heavy Duty Thickness
	Symmetric Blade Shape, Standard and Heavy Duty Thickness
	Symmetric Blade Shape, Standard and Heavy Duty Thickness
	Symmetric Blade Shape, Heavy Duty Thickness
	Symmetric Blade Shape, Heavy Duty Thickness
	Semi-Elliptical Blade Shape, Standard and Heavy Duty Thickness
	Semi-Elliptical Blade Shape, Standard and Heavy Duty Thickness
	Semi-Elliptical Blade Shape, Standard and Heavy Duty Thickness
	Elliptical Blade Shape, Standard Thickness
	Kaplan Shape, Standard Thickness

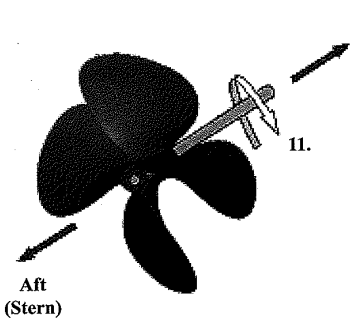
Propeller Terms and Definitions

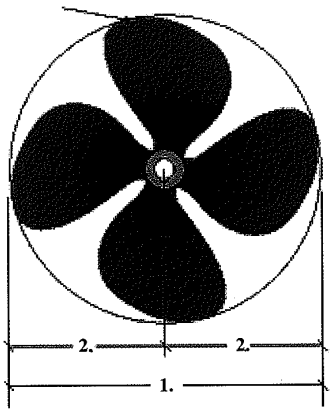
No.	TERM	DEFINITION
1.	Diameter	The diameter of the imaginary circle scribed by the blade tips as the propeller rotates.
2.	Radius	The distance from the axis of rotation to the blade tip. The radius multiplied by two is equal to the diameter.
3.	Blade Face	Pressure Side, Pitch Side. Aft side of the blade (surface facing the stern).
4.	Blade Back	Suction Side. Forward side of the blade (surface facing the bow).
5.	Leading Edge	The edge of the propeller blade adjacent to the forward end of the hub. When viewing the propeller from astern, this edge is furthest away. The leading edge leads into the flow when providing forward thrust.
6.	Trailing Edge	The edge of the propeller adjacent to the aft end of the hub. When viewing the propeller from astern, this edge is closest. The trailing edge retreats from the flow when providing forward thrust.
7.	Blade Number	Equal to the number of blades on the propeller.
8.	Blade Tip	Maximum reach of the blade from the center of the hub. Separates the leading and trailing edges.
9.	Hub	Solid cylinder located at the center of the propeller. Bored to accommodate the engine shaft. Hub shapes include cylindrical, conical, radius, & barreled.
10.	Blade Root	Fillet area. The region of transition from the blade surfaces and edges to the hub periphery. The area where the blade attaches to the hub.
11.	Rotation (Right hand shown here)	When viewed from the stern (facing forward):Right-hand propellers rotate clockwise to provide forward thrust.Left-hand propellers rotate counter-clockwise to provide forward thrust.
12.	Pitch	The linear distance that a propeller would move in one revolution with no slippage.
13.	Cylindrical Section	A cross section of a blade cut by a circular cylinder whose centerline is the propeller axis of rotation.
14.	Pitch Reference Line	Reference line used to establish the geometric pitch angle for the section. This line may pass through the leading and trailing edges of the section and may be equivalent to the chord line.
15.*	Geometric Pitch Angle, a	The angle between the pitch reference line and a line perpendicular to the propeller axis of rotation.
16.*	Controllable Pitch Propeller	The propeller blades mount separately on the hub, each on an axis of rotation, allowing a change of pitch in the blades and thus the propeller.
17.*	Fixed Pitch Propeller	The propeller blades are permanently mounted and do not allow a change in the propeller pitch.
18.*	Constant Pitch Propeller	The propeller blades have the same value of pitch from root to tip and from leading edge to trailing edge.
19.*	Variable Pitch Propeller	The propeller blades have sections designed with varying values of local face pitch on the pitch side or blade face.
20.*	Rake	The fore or aft slant of a blade with respect to a line perpendicular to the propeller axis of rotation.
20a.	Aft Rake	Positive Rake. Blade slant towards aft end of hub.
20b.	Forward Rake	Negative Rake. Blade slant towards forward end of hub.
21.	Track	The absolute difference of the actual individual blade rake distributions to the other blade rake distributions. Always a positive value and represents the spread between individual blade rake distributions.
22.*	Skew	The transverse sweeping of a blade such that viewing the blades from fore or aft shows an asymmetrical shape.
22a.	Aft Skew	Positive Skew. Blade sweep in direction opposite of rotation.
22b.	Forward Skew	Negative Skew. Blade sweep in same direction as rotation.
23.	Cup	Small radius of curvature located on the trailing edge of blade.

* denotes terms that do not have a graphic representation to aid in definition.

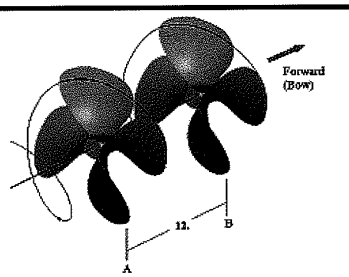
Michigan Wheel Propeller Terms and Definitions

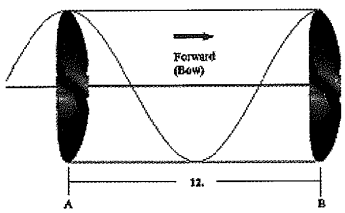


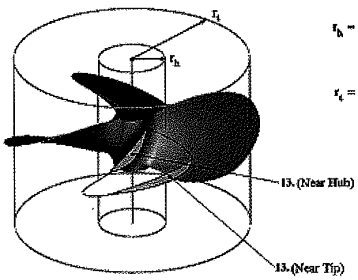




7. Blade Number = 4

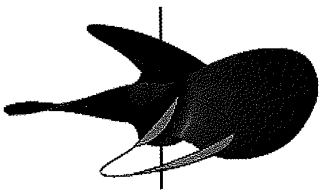


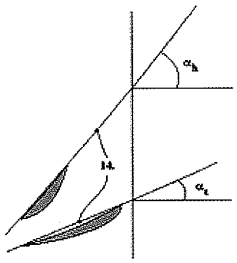


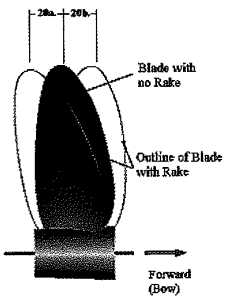


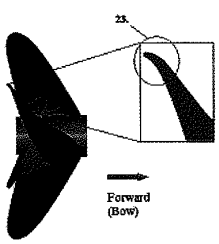
r_h = The radius of a cutting cylinder near the hub. The cylindrical section near the hub is located on the surface of this cylinder.

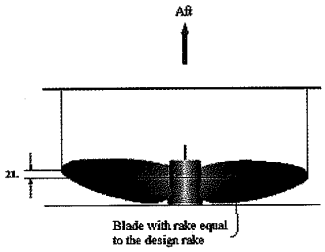
r_t = The radius of a cutting cylinder near the tip. The cylindrical section near the tip is located on the surface of this cylinder.

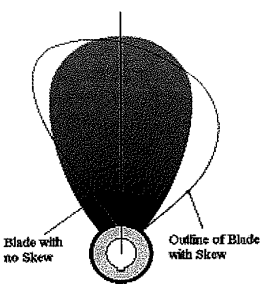


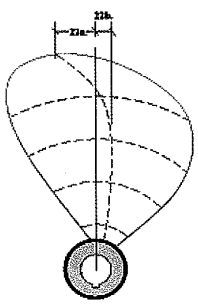












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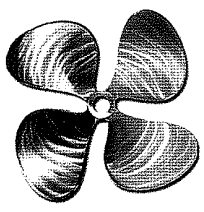
- Primary material - NiBrAl (Nickel, Bronze, Aluminum alloy - ABS 4)
- Alternative material - Manganese Bronze, Stainless Steel
- Compliance with certification agency classifications available.
- All Federal propellers are serialized and have full inspection report record.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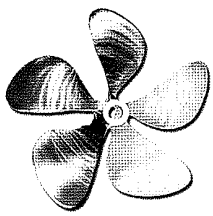
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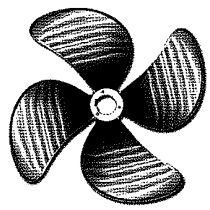
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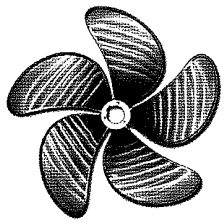
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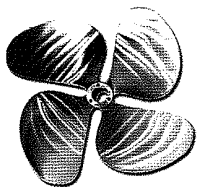
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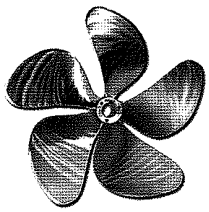
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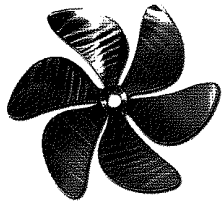
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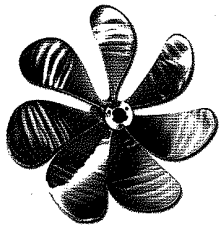
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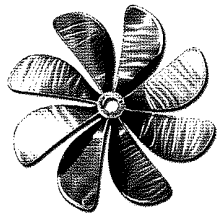
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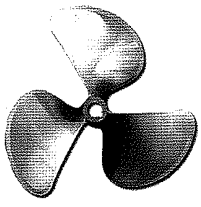
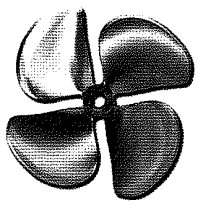

EPY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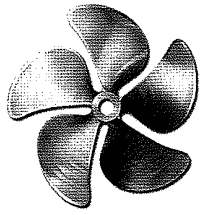
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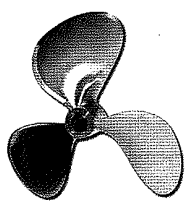
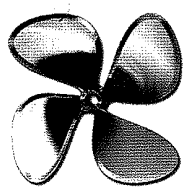
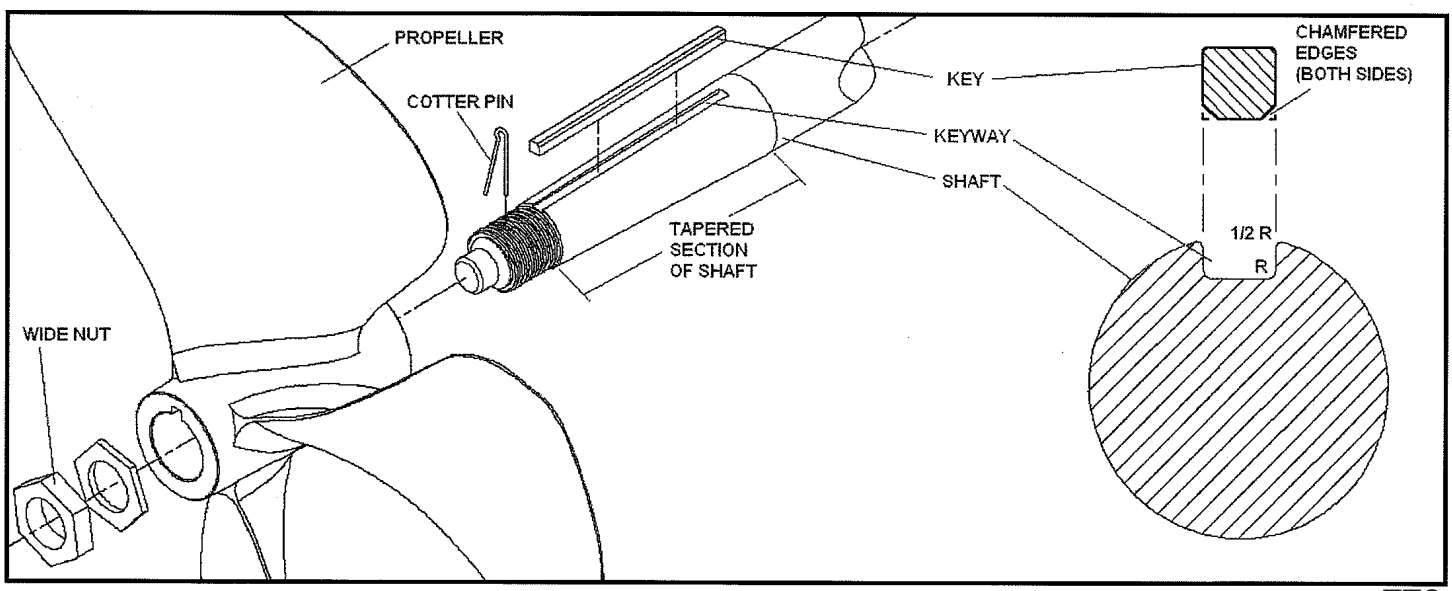

Equi-Poise


Equi-Quad

Propeller Installation Procedures

1. Push propeller snugly onto shaft taper WITHOUT key in either keyway (propeller or shaft).
2. Make sure the propeller is snug and there is no side to side movement by gently moving propeller back and forth.
3. Make a line on the shaft with a non-graphite marker at the forward end of the propeller where it stops up against the shaft taper.
4. Remove Propeller.
5. Put key into keyway on shaft taper with radiused or chamfered corners (down) in shaft keyway (if propeller shaft keyway has radiused corners).
6. Put propeller onto shaft taper.
7. Check to see that the propeller moves back to the forward line made in Step 3. If it does, skip down to Step 8. If not, perform the following:
   a. Remove propeller from shaft.
   b. Place a file on a flat surface area or work bench.
   c. Run opposite end of chamfered key back and forth over file (to remove any burrs) with a downward pressure on key until side being filed is clean.
   d. Install cleaned key in shaft keyway with chamfered corner side down in shaft (the cleaned, filed side up in keyway).
   e. Replace the propeller on the shaft and fit snugly on taper. Check to see if it reaches the line made as in Step 7. If it does not line up then repeat "Steps a. through e.".

   NOTE: A vise can be used to hold key and then filed, but care must be taken not to tighten too much, causing burrs and irregularities on key.
8. When propeller hub moves to correct position, install propeller nut on shaft and torque to seat the propeller. Install the torque jam nut also, if your shaft is so equipped.
9. Install cotter pin at end of the shaft.



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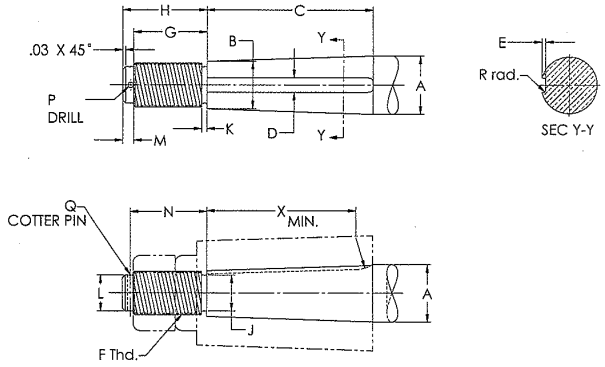
APPROVED S.A.E. STANDARD DIMENSIONS FOR SHAFTS ¾ TO 3 INCHES IN DIAMETER

Nom Shaft Dia.	Diameter Small End B		Taper Length	Keyway Width D			Keyway Side Depth [a] E			Keyway Fillet Radius [b] R	Thread [c] F		End of Taper to End of Thd	Ext. Beyond Taper	Undercut		Dia. of Pin end	Lgth. of Pin end	Cotter-Pin Hole		Cotter-Pin, Q		Nuts [d]			Keyway Length
A	Min.	Max	C	Nom	Min	Max	Nom	Min	Max		Dia.	Tpi	G	H	J	K	L	M	N	(drill) P	Nom dia.	Length	Size	Plain thick, T	Jamb thick, W	X
¾	0.624	0.626	2	3/16	0.1865	0.1875	3/32	0.095	0.097	1/32	½	13	1 1/16	1 5/16	25/64	⅛	⅜	¼	19/64	9/64	⅛	¾	½-13	½	5/16	1½
⅞	0.726	0.728	2⅜	¼	0.249	0.250	⅛	0.125	0.127	1/32	⅝	11	1¼	1½	31/64	⅛	7/16	¼	1 21/64	9/64	⅛	¾	⅝-11	⅝	⅜	1 25/32
1	0.827	0.829	2¾	¼	0.249	0.250	⅛	0.125	0.127	1/32	¾	10	1 7/16	1¾	19/32	⅛	½	5/16	1 33/64	9/64	⅛	1	¾-10	¾	7/16	2⅛
1⅛	0.929	0.931	3⅛	¼	0.249	0.250	⅛	0.125	0.127	1/32	¾	10	1 7/16	1¾	19/32	⅛	½	5/16	1 33/64	9/64	⅛	1	¾-10	¾	7/16	2⅛
1¼	1.030	1.032	3½	5/16	0.3115	0.3125	5/32	0.157	0.160	1/16	⅞	9	1⅝	2	23/32	⅛	⅝	⅜	1 23/32	11/64	5/32	1¼	⅞-9	⅞	½	2 13/16
1⅜	1.132	1.134	3⅞	5/16	0.3115	0.3125	5/32	0.157	0.160	1/16	1	8	1 13/16	2¼	13/16	⅛	¾	7/16	1 29/32	11/64	5/32	1½	1 - 8	1	9/16	3 9/16
1½	1.233	1.235	4¼	⅜	0.374	0.375	3/16	0.189	0.192	1/16	1⅛	7	2	2 7/16	29/32	3/16	⅞	7/16	2 3/32	11/64	5/32	1½	1⅛-7	1⅛	⅝	3½
1¾	1.437	1.439	5	7/16	0.4365	0.4375	7/32	0.219	0.222	1/16	1¼	7	2¼	2¾	1 1/32	3/16	1	½	2 33/64	13/64	3/16	1¾	1¼-7	1¼	¾	4 7/32
2	1.640	1.642	5¾	½	0.499	0.500	¼	0.251	0.254	1/16	1½	6	2⅝	3⅛	1¼	3/16	1¼	½	2 47/64	13/64	3/16	2	1½-6	1½	⅞	4 15/16
2¼	1.843	1.845	6½	9/16	0.5610	0.5625	9/32	0.281	0.284	3/32	1¾	5	3	3½	1⅜	3/16	1⅜	½	3 3/64	17/64	¼	2¼	1¾-5	1¾	1	5⅝
2½	2.046	2.048	7¼	⅝	0.6235	0.625	5/16	0.312	0.315	3/32	1¾	5	3	3½	1 7/16	3/16	1 7/16	½	3 9/64	17/64	¼	2¼	1¾-5	1¾	1	6 3/32
2¾	2.257	2.259	7⅞	⅝	0.6235	0.625	5/16	0.313	0.316	3/32	2	4½	3½	4	1 11/16	¼	1 11/16	½	3 41/64	17/64	¼	2½	2-4½	2	1⅛	6 21/32
3	2.460	2.462	8⅝	¾	0.7485	0.750	3/16	0.311	0.314	3/32	2¼	4½	3⅞	4⅜	1 15/16	¼	1 15/16	½	4 1/64	17/64	¼	3	2¼-4½	2¼	1¼	7 1/32

DIMENSIONS OF SHAFTS FROM 3¼ TO 8 INCHES IN DIAMETER

Nom Shaft Dia.	Diameter Small End B		Taper Length	Keyway Width D			Keyway Side Depth [a] E			Keyway Fillet Radius R	Thread [c] F		End of Taper to End of Thd	Ext. Beyond Taper	Undercut		Dia. of Pin end	Lgth. of Pin end	Cotter-Pin Hole		Cotter-Pin, Q		Nuts [d]			Sleeve Dia. [e] U		Clearance	Keyway Length
A	Min.	Max	C	Nom	Min	Max	Nom	Min	Max		Dia.	Tpi	G	H	J	K	L	M	N	(drill) P	Nom dia.	Length	Size	Plain thick, T	Jamb thick, W	Min	Max	Z	X
3¼	2.663	2.665	9⅜	¾	0.7485	0.750	5/16	0.311	0.314	⅛	2½	4	4⅜	5⅛	2⅛	⅜	2⅛	¾	4 37/64	⅜	⅜	3	2½-4	2½	1½	3.870	3.872	⅜	8½
3½	2.866	2.868	10⅛	⅞	0.8735	0.875	5/16	0.310	0.313	⅛	2½	4	4⅜	5⅛	2⅛	⅜	2⅛	¾	4 37/64	⅜	⅜	3	2½-4	2½	1½	4.120	4.122	⅜	9¼
3¾	3.069	3.071	10⅞	⅞	0.8735	0.875	5/16	0.310	0.313	⅛	2¾	4	4¾	5½	2⅜	⅜	2⅜	¾	4 61/64	⅜	⅜	3½	2¾-4	2¾	1⅝	4.369	4.371	⅜	10
4	3.272	3.274	11⅝	1	0.9985	1.000	5/16	0.309	0.312	⅛	3	4	5⅛	5⅞	2½	⅜	2½	¾	5 21/64	⅜	⅜	3½	3 - 4	3	1¾	4.619	4.621	⅜	10½
4½	3.827	3.829	10¾	1⅛	1.123	1.125	⅜	0.373	0.376	5/32	3¼	4	5⅝	6⅜	2¾	⅜	2¾	¾	—	—	—	—	3½-4	3¼	1⅞	5.243	5.245	½	9⅝
5	4.249	4.251	12	1¼	1.248	1.250	7/16	0.434	0.437	3/16	3¾	4	6⅜	7⅛	3¼	⅜	3¼	¾	—	—	—	—	3¾-4	3¾	2⅛	5.993	5.995	½	10⅞
5½	4.671	4.673	13¼	1¼	1.248	1.250	7/16	0.435	0.438	3/16	4	4	6¾	7¾	3½	½	3½	1	—	—	—	—	4 - 4	4	2¼	6.492	6.494	½	12⅛
*6	4.791	4.793	14½	1⅜	1.373	1.375	½	0.493	0.496	7/32	4¼	4	7½	8½	3⅞	½	3⅞	1	—	—	—	—	4¼-4	4¼	2¼	6.992	6.994	½	13¼
*6½	5.187	5.189	15¾	1⅜	1.373	1.375	½	0.494	0.497	7/32	4½	4	8¼	9¼	4⅜	½	4⅜	1	—	—	—	—	4½-4	9½	2½	7.492	7.494	½	14⅜
*7	5.582	5.584	17	1½	1.498	1.500	9/16	0.555	0.558	¼	5	4	9	10	4⅞	½	4⅞	1	—	—	—	—	5 - 4	5	2¾	8.117	8.120	½	15⅝
*7½	5.978	5.980	18¼	1½	1.498	1.500	9/16	0.556	0.559	¼	5½	4	9⅜	10⅜	5⅛	½	5⅛	1	—	—	—	—	5½-4	5½	3	8.616	8.619	½	16⅞
*8	6.374	6.376	19½	1¾	1.748	1.750	9/16	0.553	0.556	¼	5¾	4	9¾	10¾	5⅜	½	5⅜	1	—	—	—	—	5¾-4	5¾	3⅛	9.240	9.243	½	18⅛

* 6" through 8" shaft has 1 inch per foot taper, 1/12" per inch taper. Angle with centerline is 2° 23' 9".
a Keyway shall be cut parallel to taper.
b Fillets are recommended for keyways in shafts through 2" in diameter. fillets are mandatory for shafts above 2" in diameter.
c Threads are Unified and American Standard, Class 3A..
d Nuts are to be semi-finished stock, American Standard B18.2.
e The shaft sleeve shown is recommended practice, but the use of a sleeve is optional.

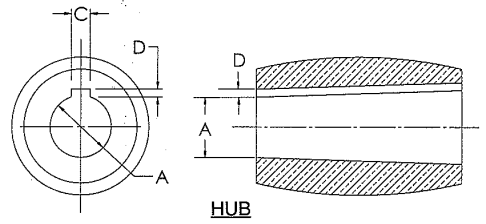


MARINE PROPELLERS HUB BORE DIMENSIONS

Taper: Per Foot = ¾"
Per Inch - 1/16" Angle with centerline = 1° 47' 24"

Std. Taper	Dia. Small End "A"		Keyway Width "C"			Keyway Side Depth "D"		
	Min.	Max.	Nom.	Min.	Max.	Nom.	Min.	Max.
¾	0.608	0.610	3/16	0.1865	0.1875	3/32	0.098	0.100
⅞	0.710	0.712	¼	0.249	0.250	⅛	0.129	0.131
1	0.812	0.814	¼	0.249	0.250	⅛	0.129	0.131
1⅛	0.913	0.915	¼	0.249	0.250	⅛	0.129	0.131
1¼	1.015	1.017	5/16	0.3115	0.3125	5/32	0.162	0.165
1⅜	1.116	1.118	5/16	0.3115	0.3125	5/32	0.161	0.164
1½	1.218	1.220	⅜	0.374	0.375	3/16	0.195	0.198
1¾	1.421	1.423	7/16	0.4365	0.4375	7/32	0.226	0.229
2	1.624	1.626	½	0.499	0.500	¼	0.259	0.262
2¼	1.827	1.829	9/16	0.561	0.5625	9/32	0.291	0.294
2½	2.030	2.032	⅝	0.6235	0.625	5/16	0.322	0.325
2¾	2.233	2.235	⅝	0.6235	0.625	5/16	0.322	0.325
3	2.437	2.439	¾	0.7485	0.750	5/16	0.323	0.326
3¼	2.640	2.642	¾	0.7485	0.750	5/16	0.323	0.326
3½	2.843	2.845	⅞	0.8735	0.875	5/16	0.324	0.327
3¾	3.046	3.048	⅞	0.8735	0.875	5/16	0.324	0.327
4	3.249	3.251	1	0.9985	1.000	5/16	0.326	0.329
4½	3.796	3.798	1⅛	1.123	1.125	⅜	0.388	0.391
5	4.218	4.220	1¼	1.248	1.250	7/16	0.450	0.453
5½	4.640	4.642	1¼	1.248	1.250	7/16	0.450	0.453
*6	4.749	4.751	1⅜	1.373	1.375	½	0.517	0.520
*6½	5.145	5.147	1⅜	1.373	1.375	½	0.516	0.519
*7	5.541	5.543	1½	1.498	1.500	9/16	0.579	0.582
*7½	5.937	5.939	1½	1.498	1.500	9/16	0.579	0.582
*8	6.332	6.334	1¾	1.748	1.750	9/16	0.582	0.585

Overseas specifications on request.



PROPELLER BORING

To insure retention of inherent factory accuracy, order your propeller factory-bored whenever possible. When bored in the field, propellers should be bored to the pilot hole, NOT to the hub or blade edges.

* 6" through 8" shaft has 1 inch per foot taper, 1/12" per inch taper. Angle with centerline is 2° 23' 9".