

K-5m Scantling Calculation Notes

1. Hull and deck scantlings are from ISO 12215-5:

Small craft — Hull Construction and Scantlings

Part 5: Design pressures for monohulls, design stresses, scantlings determination

2. Keel attachment and rudder scantlings are from:

American Bureau of Shipping

Guide for Building and Classing Offshore Racing Yachts

1994

3. Entries in blue are entered values. Entries in black are spreadsheet calculated values. The spreadsheet formulas used for the scantling calculations are proprietary and not available to the public.

4. Keel bending loads in half-frames are taken by hull planking between heavy frames.

5. The scantling calculations that follow are for reference purposes only and may not be representative of the final structural arrangement of the vessel.



FOR REFERENCE ONLY

ISO 12215-5
SCANTLINGS

Project:	K 5m			Date:	12/09/10		
As =	23.28	m ²					
Bc =	1.400	m					
Bh =	1.830	m					
Bwl =	1.595	m					
Lh =	8.500	m					
Lwl =	5.810	m					
V =	5.69	knots					
mldc =	2100	kg		5*Lwl ³ =	981		
beta 0.4	30.0	deg					
D=	1.240	m					
Materials:							
FRP:							
			1208	10 oz	E-LM 1810		
Ultimate flexural strength					441	N/mm ² per manufacturer	
Thickness per ply					1.245	mm per manufacturer	
Roving	0.404		0.340		0.627	kg/m ²	
Mat	0.275		0.000		0.305	kg/m ²	
Fiber content	0.387		0.460		0.401	from Annex C table C.2	
w =	0.679		0.340		0.932	kg/m ²	
t/w=	1.710		1.369		1.635	from Annex C equation C.1	
t =	1.161		0.465		1.524	mm/ply per Annex C	
density =	1511		1588			kg/m ³	
Weight per ply =	1.754		0.739			kg/m ²	
Ultimate flexural strength		182	213			N/mm ² per Annex C table C.	
		146	171			N/mm ² at 80% per C1.4	
Tensile strength		126	169		338	N/mm ² per Annex C table C.	
		101	136		270	N/mm ² at 80% per C1.4	
Compressive strength		130	141		290	N/mm ² per Annex C table C.	
		104	113		232	N/mm ² at 80% per C1.4	
Shear strength		69	75		50	N/mm ² per Annex C table C.	
		55	60		40	N/mm ² at 80% per C1.4	
Modulus of elasticity		9710	12480		17635	N/mm ² per Annex C table C.	
		7768	9984		14108	N/mm ² at 80% per C1.4	
Core Cell A500: (linear PVC)							
Density	92	kg/m ³					
Shear Strength	0.958	N/mm ² per table D.1					
Compressive modulus	58.3	N/mm ² per table D.1					
Shear modulus	21.4	N/mm ² per table D.1					
Okume Plywood:							
Specific Gravity	0.500						
Density	500	kg/m ³					
Weight per mm	0.50	kg					
Tensile Strength Parallel	29	N/mm ² per table E.3 (on edge)					
Tensile Strength Perp	29	N/mm ² per table E.3 (on edge)					
Modulus of Elasticity Par	3850	N/mm ² per table E.3 (on edge, kn = 0.5)					

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Design Category =	A													
Kdc =	1.0													
Mode:	Displacement													
ncg =	3.00													
Hull Plating:					Bulkheads:									
Location (x)	1.310	2.810	5.185		Location (x)	1.810	3.810	4.810						
kL =	0.689	0.903	1.000		h =	1.142	1.163	0.960						
kR =	1.200	1.350	1.275		hb =	0.761	0.775	0.640						
l =	1321	1534	1038											
s =	1000	500	750		Pwb =	5.329	5.427	4.480	kN/m ²					
Ad =	1.321	0.625	0.779											
kAR =	0.348	0.490	0.433											
h =	-0.085	-0.174	0.144											
Z =	0.587	0.611	0.681											
kZ =	1.000	1.000	0.789											
draft =	0.431	0.625	0.199											
Deck Plating and Beams:					Keelson:									
Location (x)	1.310	2.810	4.310	5.580	Location (x)			2.810						
kL =	0.689	0.903	1.000	1.000	kL =			0.903						
kR =	1.350	1.350	1.350	1.275	kR =			1.090						
l =	610	1682	1415	570	l =			2000						
s =	500	500	500	750	s =			1368						
Ad =	0.305	0.625	0.625	0.428	Ad =			2.736						
kAR =	0.607	0.490	0.490	0.518	kAR =			0.254						
Hull Frames:					Cheer Clamp:									
Location (x)	-0.190	2.810	4.310	5.560	Location (x)			2.810						
kL =	0.474	0.903	1.000	1.000	kL =			0.903						
kR =	0.814	0.782	0.737	0.821	kR =			1.295						
lu =	930	1092	1314	897	l =			2000						
s =	1000	500	500	750	s =			684						
Ad =	0.285	0.394	0.570	0.266	Ad =			1.170						
kAR =	0.374	0.326	0.275	0.385	kAR =			0.389						
h =	0.208	-0.174	-0.026	0.230	h =			0.531						
Z =	0.594	0.611	0.652	0.694	Z =			0.611						
kZ =	0.650	1.000	1.000	0.669	kZ =			0.131						
draft =	-0.061	0.625	0.430	0.082										
Design Pressures (Sail):														
Location (x)														
Pbs base =	42.97	42.97	42.97	42.97	kN/m ²									
Pbs min =	12.50	12.50	12.50	12.50	kN/m ²									
Pbs plt =	10.29	19.00	18.60	0.00	kN/m ²									
Pbs frame =	7.60	12.64	11.81	16.53	kN/m ²									
Pbs keel =		9.85			kN/m ²									
Pds base =	18.24	18.24	18.24	18.24	kN/m ²									
Pss min =	8.13	8.13	8.13	8.13	kN/m ²									
Pss plt =	10.29	19.00	16.34	0.00	kN/m ²									
Pss frame =	6.07	12.64	11.81	13.38	kN/m ²									
Pss clamp =		7.55			kN/m ²									
Pds min =	5.00	5.00	5.00	5.00	kN/m ²									
Pds =	7.63	8.07	8.93	9.45	kN/m ²									
Psup =	0.00	12.67	0.00	0.00	kN/m ²									

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Deck Plate: (Plywood)				Hull Planking: (Douglas Fir)			
Location (x)	2.810		5.580	Location (x)	1.310	2.810	5.185
l =	1682		570	l =	1321	1534	1038
b =	500		750	s =	1000	500	750
aspect ratio	3.364		1.316	aspect ratio	1.321	3.068	1.384
k2 =	0.500		0.500	k2 =	0.500	0.500	0.500
c =	38		4	c =	0	0	0
kc =	0.847		1.000	kc =	1.000	1.000	1.000
dsn stress =	21		21	dsn stress =	16	16	16
P =	8.07		9.45	Bottom P =	12.50	19.00	18.60
t =	5.9		11.3	Side P =	10.29	19.00	16.34
thickness =	6.0		12.0	% Bottom =	42%	51%	23%
weight =	3.00		6.00	Design P =	11.23	19.00	16.85
				t =	18.9	12.3	17.4
Bulkheads:				thickness =	19.0	13.0	18.0
Location (x)	1.810	3.810	4.810	weight =	9.88	6.76	9.36
b =	1142	1163	960				
k2 =	0.500	0.500	0.500	Keel load =		76.1	N per cm
dsn stress =	13	13	13	Keel bending mom =		4.8	N*m per cm
P =	5.33	5.43	4.48	Hull bending mom =		4.0	N*m per cm
t =	16.4	16.9	12.6	Rqd plate SM =		0.6	cm^3 per cm
bonding =	3.1	3.2	2.4	min t =		1.8	mm
plies =	7	7	6				
tb =	8.0	8.1	6.7				

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Hull Frames (Fir):					Deck Beams (Fir):				
Location (x)	-0.190	2.810	4.310	5.560	Location (x)	1.310	2.810	4.310	5.580
lu =	930	1092	1314	897	lu =	610	1682	1415	570
s =	1000	500	500	750	s =	500	500	500	750
cu =	500	200	253	253	cu =	0	38	25	4
kcs =	0.500	0.500	0.500	0.500	kcs =	1.000	1.000	1.000	1.000
ksa =	5.0	5.0	5.0	5.0	ksa =	5.0	5.0	5.0	5.0
Dsn Stress =	13	33	33	33	St =	33	33	33	33
Shr stress =	5	4	4	4	Shr stress =	4	4	4	4
Bottom P =	12.50	12.64	12.50	16.53	P =	7.63	8.07	8.93	9.45
Side P =	8.13	12.64	11.81	13.38	Aw =	2.90	8.47	7.89	5.05
% Bottom =	0%	51%	40%	11%	SM =	3.6	28.6	22.4	5.8
Design P =	8.13	12.64	12.09	13.71	I =	0.45	10.00	6.59	0.68
Aw =	8.41	8.62	9.91	11.52	Siding =	19	55	40	40
SM =	22.6	9.4	13.1	10.4	Molding =	34	56	58	30
I =	1.20	1.52	2.52	1.37					
Siding =	18	50	40	40					
Molding =	87	34	45	40					
Keel Floors:	ABS ORY 8.1.3				Keelson:				Sheer Clamp:
n		6			Location (x)	2.810	Location (x)	2.810	
N		1.000			lu =	2000	lu =	2000	
Wk		11115			s =	684	s =	684	
Yk		0.530			cu =	85	cu =	55	
SMk =		29.5			kcs =	0.958	kcs =	1.000	
SM =		38.9			ksa =	5.0	ksa =	5.0	
Siding =		55			St =	33	St =	33	
Molding =		66			Shr stress =	4	Shr stress =	4	
At Bottom Frame:					P =	12.50	P =	8.13	
N		0.767			Aw =	21.35	Aw =	13.89	
SMk =		22.6			SM =	82.0	SM =	55.7	
SM =		32.0			I =	33.44	I =	23.18	
Siding =		55							
Molding =		60							

ABS OFFSHORE RACING YACHTS
KEEL AND RUDDER SCANTLINGS

ABS OFFSHORE RACING YACHTS			K 5m		12/09/10		
RUDDER STOCK							
l =	38.6	cm	U =	63400	N/cm ²	Silicon Bronze (Everdur)	
xl =	3.4	cm	Y =	37900	N/cm ²		
h =	95.5	cm	Sa =	36229	N/cm ²		
hb =	101.5	cm					
hc =	40.6	cm	k =	984			
A =	0.340	m ²	C =	1.5			
			N =	1.000			
lc =	9.3	cm	LWL =	5.810	m		
Mn =	135871	N*cm	DISP =	2.100	tonnes		
Tn =	27227	N*cm					
P =	2916	N					
Solid Stock dia =	3.4	cm	2.0	cm	at tiller head		
	1.343	in	0.776	in			
Weld Shear =	15965	N					
Allow Stress =	73	MPa					
Weld Area =	218.9	mm ²					
Weld Size =	5	mm					
Weld Length =	62	mm					
Tip to bottom of stock =	58.0	cm					
	Mn =	82519	N*cm				
	Tn =	16536	N*cm				
Dia at bottom of stock =	2.9	cm					
Allowable rudder stress =	13500	N/cm ²	E-LM 1810 =	1.24	mm thick		
Section modulus =	6.3	cm ³					
Actual SM =	15.04	cm ³	(1) layer				
Keelson Length =	1.055	m					
Rudder Location =	0.574	m					
Keelson Width =	12.0	cm					
Keelson Depth =	6.0	cm					
Rudder Tube OD =	7.3	cm					
Side SM =	120.8	cm ³					
Side Bending Moment =	379	N*m					
Side Bending Stress =	3.1	Mpa					
Side Shear Force =	1650	N					
Side Shear Stress =	0.2	MPa					

ABS OFFSHORE RACING YACHTS
KEEL AND RUDDER SCANTLINGS

ABS OFFSHORE RACING YACHTS			K 5m		12/09/10
KEEL BOLTS:					
			Bolt Material is Silicon Bronze		
Wk =	11115	N	Strength =	380	MPa
Yk =	530	mm	Yield Strength =	172	MPa
Sa =	172	MPa	Shear Strength =	219	MPa
Sum li =	453	mm	Shear SF =	2.0	
dk =	13.9	mm at bottom of thread			
d =	17	mm			