

K-28 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. The scantling calculations that follow are for reference purposes only and may not be representative of the final weight estimate of the vessel.



FOR REFERENCE ONLY

Project:	K-28 15 sqm		Date:	08/22/10					
As =	16.05	m ²							
Bc =	1.630	m							
Bh =	1.832	m							
Bwl =	1.596	m							
Lh =	8.500	m							
Lwl =	6.200	m							
V =	5.88	knots							
mldc =	1500	kg	5*Lwl ³ =	1192					
beta 0.4	25.7	deg							
D=	0.909	m							
Materials:									
FRP:									
			2408	1808	E-LM 1810				
Ultimate flexural strength	359	328	441	N/mm ² per manufacturer					
Thickness per ply	1.372	1.168	1.245	mm per manufacturer					
Roving	0.813	0.608	0.627	kg/m ²					
Mat	0.275	0.275	0.305	kg/m ²					
Fiber content	0.415	0.404	0.401	from Annex C table C.2					
w =	1.088	0.883	0.932	kg/m ²					
t/w=	1.568	1.620	1.635	from Annex C equation C.1					
t =	1.706	1.431	1.524	mm/ply per Annex C					
Ultimate flexural strength	193	189		N/mm ² per Annex C table C.4					
	155	151		N/mm ² at 80% per C1.4					
Tensile strength	141	135	338	N/mm ² per Annex C table C.4					
	113	108	270	N/mm ² at 80% per C1.4					
Compressive strength	134	133	290	N/mm ² per Annex C table C.4					
	107	106	232	N/mm ² at 80% per C1.4					
Shear strength	71	70	50	N/mm ² per Annex C table C.4					
	57	56	40	N/mm ² at 80% per C1.4					
Modulus of elasticity	10751	10350	17635	N/mm ² per Annex C table C.4					
	8601	8280	14108	N/mm ² at 80% per C1.4					
Core Cell A550: (linear PVC)									
Density	103	kg/m ³							
Shear Strength	1.112	N/mm ² per table D.1							
Compressive modulus	67.5	N/mm ² per table D.1							
Shear modulus	24.6	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)							
Modulus of Elasticity Perp	3850	N/mm ² per table E.3 (on edge, kn = 0.5)							
Flexural Strength Parallel	42	N/mm ² per table E.2 (5 plies)							
Flexural Strength Perp	26	N/mm ² per table E.2 (5 plies)							
Shear Strength	10	N/mm ² per table E.3 (on edge)							

Design Category =	A									
Kdc =	1.0									
Mode:	Displacement									
ncg =	3.00									
Hull Plating:				Bulkheads:						
Location (x)	4.700	2.700	0.700	Location (x)	-0.300	3.700	5.700			
kL =	1.000	0.863	0.595	h =	0.500	0.923	0.700			
kR =	1.183	1.121	1.093	hb =	0.333	0.615	0.467			
l =	2000	2000	2000							
b =	1057	1263	1357	Pwb =	2.333	4.307	3.267	kN/m ²		
Ad =	2.114	2.526	2.714							
kAR =	0.283	0.254	0.250							
h =	0.000	0.000	0.000							
Z =	0.562	0.546	0.531							
kZ =	1.000	1.000	1.000							
Deck Plating:				Cabin Top Plating:						
Location (x)	4.700	2.700	0.700	Location (x)	2.700					
kL =	1.000	0.863	0.595	kL =	0.863					
kR =	1.083	0.956	1.093	kR =	1.256					
l =	2000	2000	2000	l =	1500					
b =	1389	1813	1357	b =	814					
Ad =	2.778	3.626	2.714	Ad =	1.221					
kAR =	0.250	0.250	0.250	kAR =	0.354					
				kSUP =	0.500					
Bottom Frames:				Topside Frames:						
Location (x)	2.700			Location (x)	2.700					
kL =	0.863			kL =	0.863					
kR =	0.782			kR =	0.782					
lu =	1091			lu =	1091					
s =	500			s =	500					
Ad =	0.393			Ad =	0.393					
kAR =	0.310			kAR =	0.310					
				h =	0.490					
				Z =	0.546					
				kZ =	0.103					
Design Pressures (Sail):										
Location (x)	4.700	2.700	0.700							
Pbs base =	40.34	40.34	40.34	kN/m ²						
Pbs min =	12.59	12.59	12.59	kN/m ²						
Pbs plt =	11.42	8.86	6.00	kN/m ²						
Pbs frame =	0.00	10.79	0.00	kN/m ²						
Pds base =	17.59	17.59	17.59	kN/m ²						
Pss min =	8.68	8.68	8.68	kN/m ²						
Pss plt =	11.42	8.86	6.00	kN/m ²						
Pss frame =	0.00	5.33	0.00	kN/m ²						
Pds min =	5.00	5.00	5.00	kN/m ²						
Pds =	4.40	3.79	2.62	kN/m ²						
Psup =	0.00	3.11	0.00	kN/m ²						

Bottom Plate: (Single Skin)				Bottom Plate at keel: (Single Skin)			
Location (x)	4.700	2.700	0.700	Location (x)	4.700	2.700	0.700
l =	2000	2000	2000	l =		2000	
b =	1057	1263	1357	b =		1263	
k2 =	0.493	0.466	0.449	k2 =		0.466	
c =	199	250	647	c =		250	
kc =	0.500	0.500	0.500	kc =		0.500	
dsn stress =	77	77	77	dsn stress =		77	
P =	12.59	12.59	12.59	P =		22.66	
t =	4.7	5.5	5.8	t =		7.4	
plies =	3	4	4	plies =		6	
thickness =	5.1	6.8	6.8	thickness =		10.2	
weight =	7.87	10.50	10.50	weight =		15.75	
wmin =	1.44	1.44	1.44				
Deck Plate: (Sandwich)				Cabin Plate: (Sandwich)			
Location (x)	4.700	2.700	0.700	Location (x)		2.700	
k1 =	0.017	0.017	0.017	k1 =		0.017	
l =	2000	2000	2000	l =		1500	
b =	1389	1813	1357	b =		814	
k2 =	0.443	0.351	0.449	k2 =		0.490	
k3 =	0.023	0.017	0.024	k3 =		0.027	
c =	58	75	56	c =		72	
kc =	0.961	0.962	0.963	kc =		0.805	
S outer =	54	54	54	S outer =		54	
S inner =	53	53	53	S inner =		53	
P =	5.00	5.00	5.00	P =		3.11	
S _{Mo} =	0.122	0.164	0.118	S _{Mo} =		0.020	
S _{Mi} =	0.124	0.168	0.120	S _{Mi} =		0.021	
I =	0.165	0.262	0.158	I =		0.014	
kSHC =	0.416	0.360	0.420				
sheer strs =	0.723	0.723	0.723				
ts min =	3.92	4.43	3.87				
wos =	0.54	0.54	0.54				
wis =	0.38	0.38	0.38				
Bulkheads:							
Location (x)	-0.300	3.700	5.700				
b =	500	923	700				
k2 =	0.500	0.500	0.500				
dsn stress =	13	13	13				
P =	2.33	4.31	3.27				
t =	4.8	11.9	7.9				
bonding =	1.1	2.8	1.9				
plies =	1	2	2				

Bottom Frames:			Topside Frames:		
Location (x)	0.000	2.700	Location (x)	0.000	2.700
lu =		1091	lu =		1091
s =		500	s =		500
cu =		250	cu =		250
kcs =		0.500	kcs =		0.500
ksa =		5.0	ksa =		5.0
St =		54	St =		54
Sc =		53	Sc =		53
Shr stress =		28	Shr stress =		28
P =		12.59	P =		8.68
Aw =		1.22	Aw =		0.84
SM plt =		5.8	SM plt =		4.0
SM flg =		5.9	SM flg =		4.1
I =		1.82	I =		1.25
Keel Floors:	ABS ORY	8.1.3			
n		3			
N		0.759			
Wk		4240			
Yk		0.600			
SMk plt =		11.9			
SMk flg =		12.1			
SM plt =		17.7			
SM flg =		18.0			
At Gunwhale:					
N		0.500			
SMk plt =		7.8			
SMk flg =		8.0			
SM plt =		11.8			
SM flg =		12.1			

ABS OFFSHORE RACING YACHTS			K-28	08/29/10			
RUDDER STOCK							
l =	36.3	cm	U =	63400	N/cm ²	Silicon Bronze (Everdur)	
xl =	4.1	cm	Y =	37900	N/cm ²		
h =	88.9	cm	Sa =	36229	N/cm ²		
hb =	94.9	cm					
hc =	38.6	cm	k =	984			
A =	0.303	m ²	C =	1.5			
			N =	1.000			
lc =	7.9	cm	LWL =	6.2	m		
Mn =	123667	N*cm	DISP =	1.496	tonnes		
Tn =	21847	N*cm					
P =	2773	N					
Solid Stock dia =	3.3	cm	1.8	cm	at tiller head		
	1.298	in	0.721	in			
Weld Shear =	13255	N					
Allow Stress =	73	MPa					
Weld Area =	181.7	mm ²					
Weld Size =	5	mm					
Weld Length =	51	mm					
Tip to bottom of stock =	49.6	cm					
	Mn =	68998	N*cm				
	Tn =	12189	N*cm				
Dia at bottom of stock =	2.7	cm					
Allowable rudder stress =	5400	N/cm ²	1808 =	1.431	mm thick		
	Section modulus =	13.2	cm ³				
	Actual SM =	16.07	cm ³	(1)	layer at -450 WL		

ABS OFFSHORE RACING YACHTS			K-28	08/29/10			
GROUNDING LOADS:							
DISP =	1496 kg		Material Properties:		E-LTM 1808		
	14676 N						
Grounding Loads:				Tensile Strength =	108 MPa		
				Shear Strength =	56 MPa		
F and A	22014 N			Allowable Tensile Stress =	38 MPa		
Upwards	22014 N			Allowable Shear Stress =	20 MPa		
Keel Lever Arm =	0.793 m						
Floor Lever Arm =	1.000 m						
Keel BM =	17457 N*m						
Floor Load =	17457 N						
Floor Span =	0.391 m						
Floor BM =	853 N*m with fully supported ends						
Required Floor Web Area =	5.62 cm ²						
Total Floor Web Area =	9.67 cm ² at lower tangent						
Required Floor SM =	22.57 cm ³						
Actual Floor SM =	24.05 cm ³ at bottom frame connection						
Note:	This algorithm assumes vertical grounding load is taken by the keel floor webs (double shear). Fore and aft grounding load is taken by fwd and aft keel floors.						