TECHNICAL REPORT – TR 06-08 r3

Title:	Design of Panel for Fire Testing according to IMO Res MSC45(65)
Date: 2006-03-14	No. of pages: 8

Customer/	LÄSS
Application/	Marine
Country:	Sweden

Department:	TS	Project no:
Prepared by:	Carl-Johan Lindholm Geir Arnestad	Signature:
Approved by:	Björn Abrahamsen	Signature:

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Background
In the LASS project a typical deck panel and bulkhead that has a DNV approved design shall be tested in a fire test according to IMO Res. MSC 45(65). The lay up of the panels are described in this document together with calculations for the DNV approval.

Geometry
Attached drawings:
"Outline dimensions fire test panel.dwg"

Span between supports = 3300 mm, (Total length is 3425 mm)
Spann between stiffeners = 2000 mm (Total width is 3200 mm)

The stiffeners have a height 200 mm and a with (core thickness) of 50 mm.

Load
Deck Panel Static Pressure
Pressure = 350 kg/m^2
Area = 3.3*4=13.2 m^2

Total load =350*13.2=4620 kg
Load for each "load distribution beam" = 4620/2 = 2310 kg

Bulk Head
In the fire test a vertical line load of 700 kg/m will applied on the upper edge.

Since the bulkhead is water tight it also needs to be designed to take a Uniform Load of 13 kN/m^2. This load case is controlled in the calculations.

Temperature
The insulation is designed (se document?) so the panel and the stiffeners will not be exposed to a temperature above 80 C°. Hence the panel shall be designed for a temperature of 80 C° for 1 hour.

Manufacturing Method:
The panels and stiffeners will be manufactured with infusion in one step.

Sandwich Lay Up

The panel is made with Divinycell foam and E-glass fibre/polyester laminates. The thickness values given for the glass fibre laminas in the tables below are approximate values, since the thickness will varies with the actual volume fraction fibre, typical is 44-48 % (64 % by weight) for an infused laminate.

Deck Panel

Table 1. *Lamina in the Deck Panel. *Estimated thickness.*

Material	Weight [g/ m^2]	Thickness* [mm]
GF Biaxial 0/90	1600	1,36
Divinycell H80		50
GF Biaxial 0/90	1200	1,02
Total thickness, mm		**52,38**

Table 2. *Lamina at the sides of the stiffener. *Estimated thickness.*

Material	Weight [g/ m^2]	Thickness* [mm]
GF Biaxial 45/-45	3*800	2,04
Divinycell H80		50
GF Biaxial 45/-45	3*800	2,04
Total thickness, mm		**54,4**

Table 3. *Lamina at the bottom of the stiffener. *Estimated thickness.*

Material	Weight [g/ m^2]	Thickness* [mm]
GF Biaxial 45/-45	800	0,68
GF Uni Directional	600	0,51
GF Biaxial 45/-45	800	0,68
GF Uni Directional	600	0,51
GF Biaxial 45/-45	800	0,68
GF Uni Directional	600	0,51
Total thickness, mm		**3,57**

In the fire test panel, the stiffener shall be reinforced at the four support points. The reinforcement starts at the end of the stiffeners and is 200 mm long. The reinforcement is made by switching the core H80 to H250 and increasing the glass fibre lamina with 2400 g/m^2 Biaxial 0/90 that is wrapped around the edge and all the way up to the panel

Bulkhead

Table 4. *Lamina in the Bulkhead. *Estimated thickness.*

Material	Weight [g/ m^2]	Thickness* [mm]
GF Biaxial 0/90	1200	1,02
Divinycell H80		50
GF Biaxial 0/90	1200	1,02
Total thickness, mm		**52,04**

Material Properties

Table 1. *Estimated Material properties: Divinycell H80* at 80 C.

Material	Density	E-modulus	G-modulus	Shear Strength
H80	80 kg/m³	32.5 MPa	11.5 MPa	0.45 MPa

Table 2. *Estimated Material properties: Glass fibre/Polyester laminates* at 80 C.

Fibre skins

Designation	**Fib/Res Ratio**	**Tens. str.** [MPa]	**Comp. str.** [MPa]	**Tens. mod.** [MPa]	**Comp. mod.** [MPa]	**Flex. mod.** [GPa]	**Th. factor** [mm/kg/m²]
E-Glas Biax (0/90)	1,66	400	320	17000	17000	17	0,85
E-glas D-biax (+/-45)	1,66	400	320	17000	17000	17	0,85
E-glas Uni (0)	1,66	650	350	30000	30000	30	0,85

Deck panel - Static pressure load

SUMMARY OF RESULTS

Design object:	Deck panel "LASS"	**Date:**	06.02.2006
Customer:		**Designer:**	

DESIGN

Resin:	Iso polyester
Process:	Vacuum bagged
Adhesive:	

Designation	**Layer W/T**	**Unit**
E-Glas Biax (0/90)	1600	g/m²
Divinycell H80(min) a 80 gr.	50	mm
E-Glas Biax (0/90)	1200	g/m²

PROPERTIES

Outer skin thickness:	**1,36**	mm
Inner skin thickness:	**1,02**	mm
Total thickness:	**52,38**	mm
Panel weight:	**9,15**	kg/m²
Panel cost:		/m²
Flexural rigidity:	**26,303**	Nm²/mm width

SANDWICH / LAMINATE

PROPERTIES

Laminate thickness	**Outer skin**	**1,36**	mm
	Inner skin	**1,02**	mm
	Total thickness	**52,38**	mm
	Laminate weight	**9,15**	kg/m²
	Flexural rigidity	**26,303**	x10^6 Nmm²/mm width
	Shear stiffness	**0,603**	x10^3 N/mm width
If the outside skin is in compression failure is expected in the outside	**skin at a moment of**	**6,253**	x10^3 Nmm/mm width
If the outside skin is in tension failure is expected in the inside	**skin at a moment of**	**4,753**	x10^3 Nmm/mm width
	Maximum shear load	**23,04**	N/mm width

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PANEL BENDING: SIMPLY SUPPORTED PANEL

Panel length	3200	mm	**Midpanel deflection**	18,55	mm
Panel width	2000	mm	**Shear deflection**	13,4	%
			Bending ratio L/	107,8	
Panel pressure	3,5	kN/m²			
			Safety factor at center of panel	5,2	
			Safety factor at end of panel	N/A	
			Shear stress	0,059	N/mm²
			Safety factor for shear	7,7	

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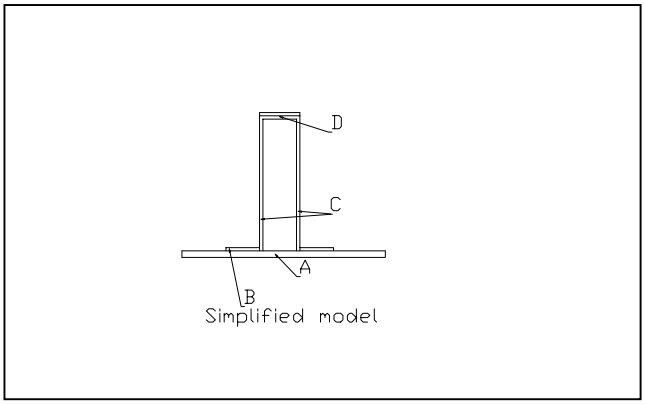
Deck stiffener - Static pressure load

Deck panel, "LASS" , Section modulus requirements for stiffeners

Pt. 3, Ch.4, sec.7-fig.1

Stiffener	Position	Factor C1	p (kN/m2)	l (m)	b (m)	Rules Max M (kNm)	fig. 1 b eff	Sigma ultimate 400 Sigma * 0.3 (Mpa)	Mpa Required Z cm3	Stiffener type
DEKK										
Stiver		8	3,5	3,2	2	9,0	300	120	75	

Calculation of top hat stiffeners;



Ref	Part	t (mm)	b (mm)	A (mm2)	z (mm)	Az (mm3)	Az2 (mm4)	I (mm4)
A	Bottom (eff.)	1,1	300	330	0,55	181,5	100	33
B	In-lamination	2,04	100	204	2,1	432	917	71
C	Web laminate	200	4,08	816	101,1	82497,6	8340507	2720000
D	Flange laminate	3,57	60	214,2	202,885	43457,967	8816970	227
	Summary			**1564,2**		**126570**	**17158494**	**2720332**

Neutral axis from bottom: 80,9 mm (n.a. 1)

Neutralaxis from flange **119,1 mm** **(n.a. 2)**

I	9637264	mm4	963,7	cm4	
Z	**80929**	**mm3**	**80,9**	**cm3**	**(n.a. 2)**
Z	**119101**	**mm3**	**119,1**	**cm3**	**(n.a. 1)**

Bulk Head – Uniform Pressure 13 kN/m^2

Design object:	Bulk head "LASS"	**Date:**	2006-02-06
Customer:		**Designer:**	

DESIGN

Resin:	Iso polyester
Process:	Vacuum bagged
Adhesive:	

Designation	**Layer W/T**	**Unit**
E-Glas Biax (0/90)	1200	g/m²
Divinycell H80	50	mm
E-Glas Biax (0/90)	1200	g/m²

PROPERTIES

Outer skin thickness:	**1,02**	mm
Inner skin thickness:	**1,02**	mm
Total thickness:	**52,04**	mm
Panel weight:	**8,48**	kg/m²
Flexural rigidity:	**23,402**	Nm²/mm width

Shear stiffness	**1,614**	x10^3 N/mm width
If the outside skin is in compression failure is expected in the outside skin at a moment of	**8,879**	x10^3 Nmm/mm width
If the outside skin is in tension failure is expected in the inside skin at a moment of	**8,879**	x10^3 Nmm/mm width
Maximum shear load	**51,02**	N/mm width

PANEL BENDING:
50% FIXED PANEL

OWN WEIGHT NOT INCLUDED

Panel length	2650	mm	**Midpanel deflection**	51,20	mm
Panel width	2440	mm	**Shear deflection**	6,7	%
			Bending ratio L/	47,7	
Panel pressure	13	kN/m²			
			Safety factor at center of panel	3,2	
			Safety factor at end of panel	4,5	
			Shear stress	0,222	N/mm²
			Safety factor for shear	4,5	

Comment:
Room temperature material properties for the core has been used in this calculation.

The safety margin for fibre failure is 3.2 (requirements 3.3), however the difference is very small hence the amount fibre is kept at 1200 g/m^2 which is the minimum requirement. The same discussion applies the L/50 requirement which here is L/47.

The reason for keeping the amount of fibre to 1200 g/m^2 is that the fire test shall be a worst case scenario (which it is due to the quite large panel size) with a smaller panel size the requirements above would have been fulfilled.

Bulk Head – Vertical Load 700 kg/m

A buckling calculation has been made in ESAComp.

Plate buckling and FPF

Laminate : H80 50 mm - 1200 g 0/90 h = 52.04 mm
Plate: a = 2650 mm; b = 2440 mm;

Laminate load : Ny = -7000 N/m

Factor of safety : FoS^v = 1
Stability factors : SF_g = 1, SF_l = 1
Failure crit. (reinf.;core) : Max stress;Von Mises

Buckling load

N_x = 0.00 N/m sig°_x = 0.00 MPa eps°_x = 0.0083 %
N_y = -37240.00 N/m sig°_y = -0.72 MPa eps°_y = -0.0958 %
N_xy = 0.00 N/m tau°_xy = 0.00 MPa gam°_xy = 0.0000 %

Margin to failure

MoS_buckling = 432 %
MoS_buckling/FPF = 432 % Mode: Global buckling Crit. layers: -