



MANAGING RISK

Nauticus Hull for CSR Tank

Software with unique efficiency and flexibility to support hull design according IACS Common Structural Rule for Oil Tankers



Software offering is part of DNV's commitment to support the industry

1. DNV need to have a production tool for hull approval according to CSR Tank:
 - To give timely response and assistance to owners and yards
 - To provide efficient, professional and smooth hull approval ensuring safe design
2. DNV has a strategy to offer the best Class software support for CSR for the yards:
 - To support yards develop safe hull design in an efficient way
 - To ensure smooth interaction between yard and Class

Nauticus Hull for CSR Tank – available to the industry from January 2006



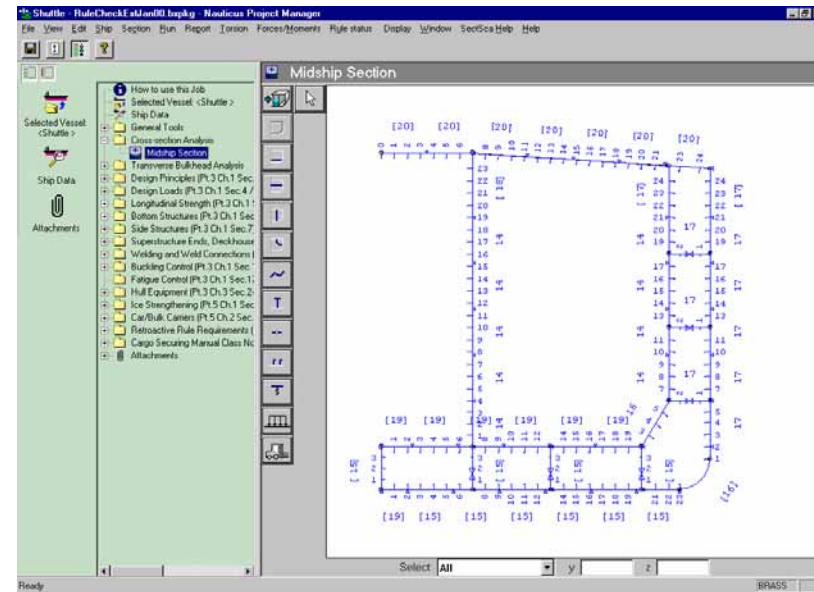
Nauticus Hull for CSR Tank

- Builds on Nauticus Hull since 1996 (PILOT since 1970's)
- Developed in parallel with CSR Tank since 2003
- CSR Tank continuously tested on Nauticus Hull
 - Frequent CSR Tank test releases and patches – one updated version every second month during 2005
 - Official release supporting Final Rules on January 9, 2006 only 3 weeks after Rules adopted by IACS Council
- During April 2006, DNV again made a new release of its Nauticus Hull software available to the industry, this time with an even wider coverage of the latest Rules updates and clarifications.

Section Scantlings

- Market-leader software Section Scantlings has been upgraded to cover CSR Tank :

- Hull girder requirements
- H-ULS (hull girder ultimate capacity)
 - single step
 - multistep
- Yielding
 - Local pressures
- Buckling
 - DIN Standard
- Advanced buckling (PULS)
- Minimum scantlings
- Fatigue



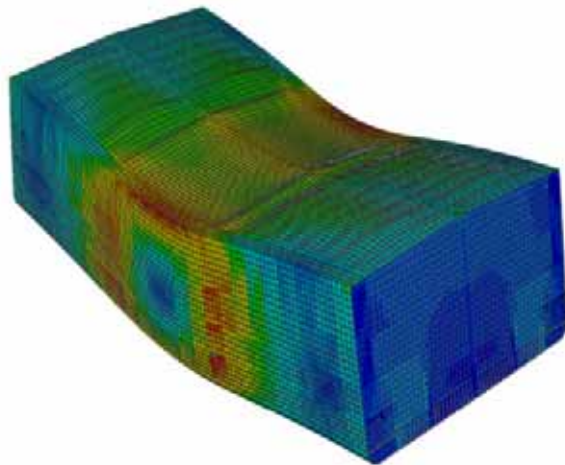
- With the latest CSR Tank enhancements, the program scope is further extended and user-friendliness further improved.

Direct strength analysis - cargo model FE model



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- Support FE analysis for tankers according to CSR Tank
 - Three cargo tanks about midship
 - Co-centric beams
 - Modified boundary cond. and spring calculation
 - New loads (incl. Fatigue)
 - Automatic application of longitudinal bending moment and vertical shear
 - Gravity loads added
- Export to MSC Patran, import from MSC Nastran
- User are in control – no "black-box"!



FE load cases for oil tankers with one centerline longitudinal bulkhead

Seagoing load cases				Head Sea				Beam Sea				Oblique Sea		Harbour load cases						
(P) = Weather side Port	(S) = Weather side SB	Draught [m]	GM [m]	r _{gyr-roll} [m]	Max. VWBM Sagg.	Max. VWSF Hogg.	1	2	3	4	Max Tr. acc.	Max. Vert. acc.	5A(P)	5B(S)	6A(P)	6B(S)	7A(P)	7B(S)	Draught	
B1		0.9Tsc	0.12B	0.35B	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1/3Tsc	<input checked="" type="checkbox"/>
B2		0.9Tsc	0.12B	0.35B	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1/3Tsc	<input checked="" type="checkbox"/>
B3		0.9Tsc	0.12B	0.35B	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	1/3Tsc	<input checked="" type="checkbox"/>
B4		0.6Tsc	0.24B	0.4B	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Tsc	<input checked="" type="checkbox"/>
B5		0.6Tsc	0.24B	0.4B	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
B6		0.6Tsc	0.24B	0.4B	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
B7		0.7Tsc	0.3B	0.45B	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		

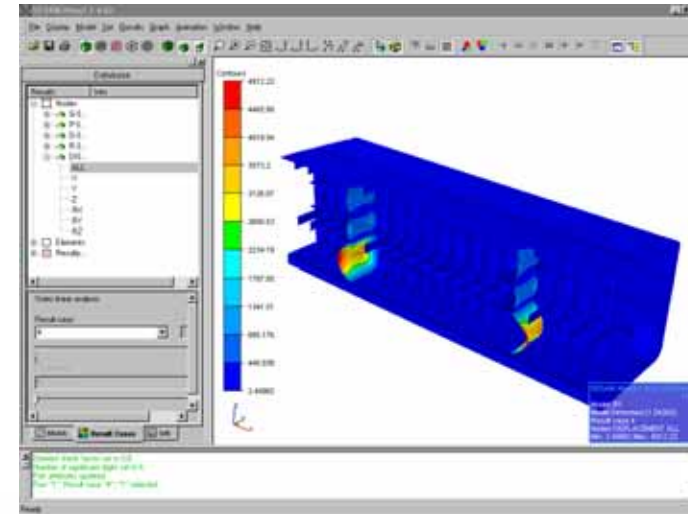
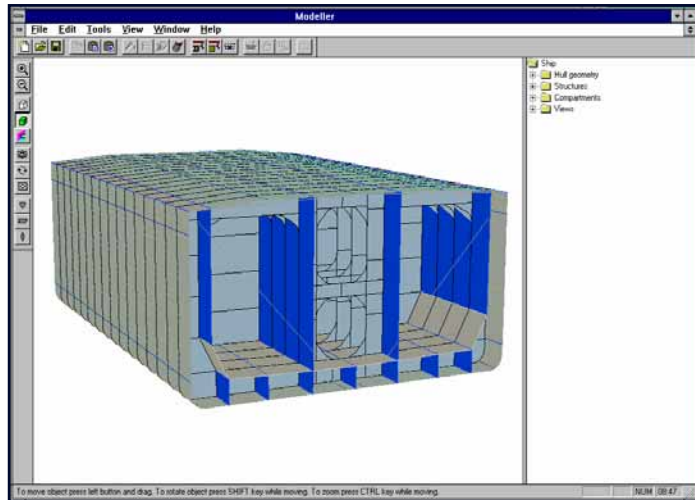
Density: Cargo 1.025 t/m³, Ballast 1.025 t/m³
 Extent of cargo hold analysis model: Aft #59 mm/#, Forward #87 mm/#
 Assessment procedure: Strength assessment (Fwd, Mid, Aft), Hull girder shear strength (checked), Use max combined SFs in Fwd region (checked)

Cargo model FE model - Automated Strength Assessment



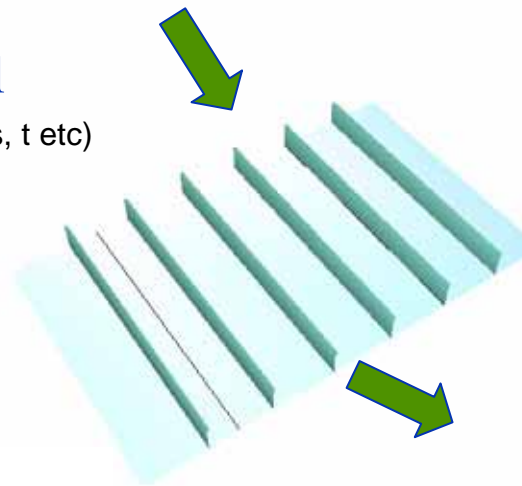
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- Automatic buckling and von-Mises stress control of Cargo Hold model:



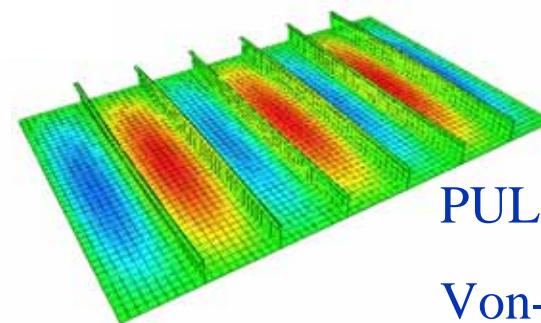
Capacity model

- Geometry (L, B, s, t etc)
- Boundary cond.
- Usage factor
-



FEA Results

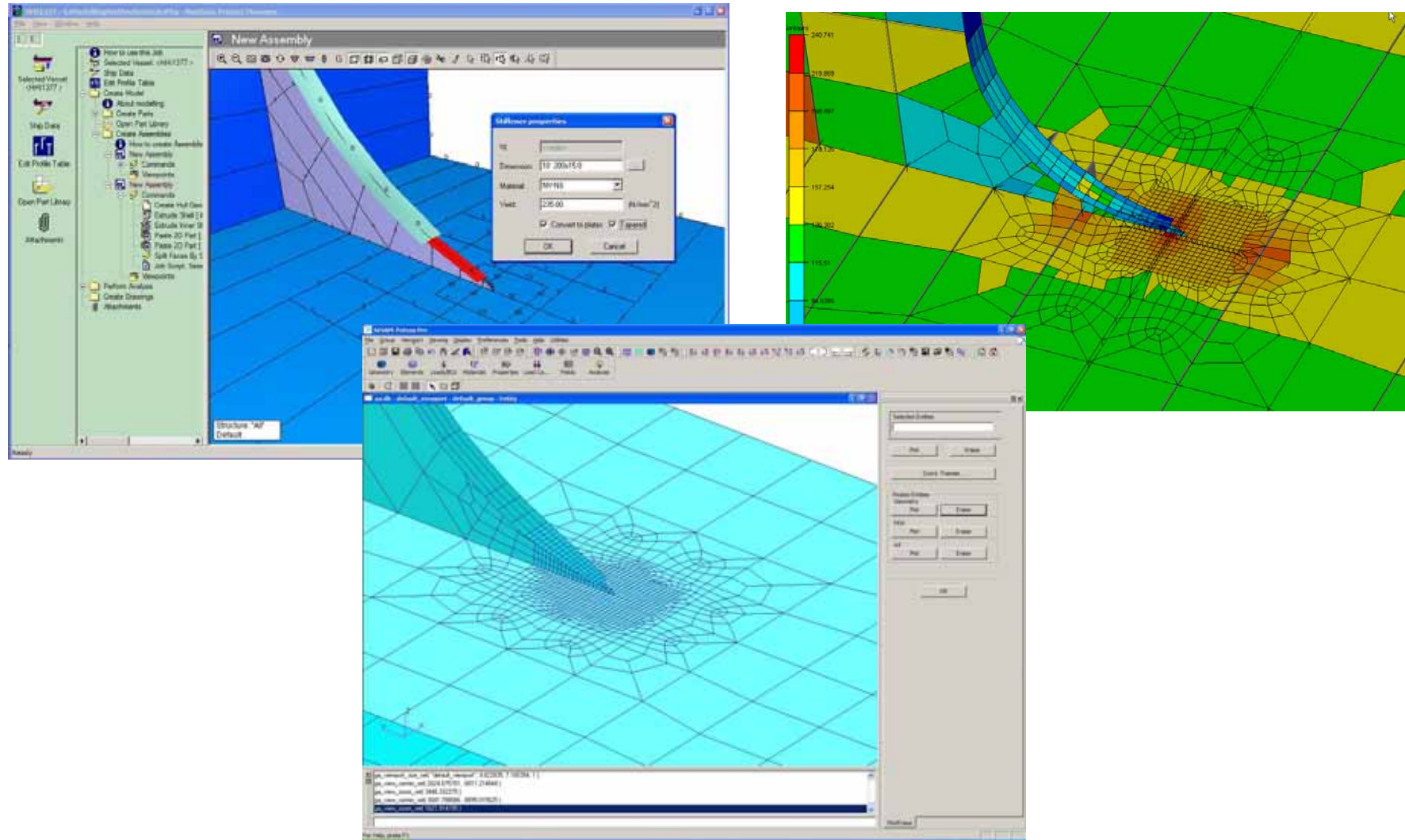
- Stress
- Pressure



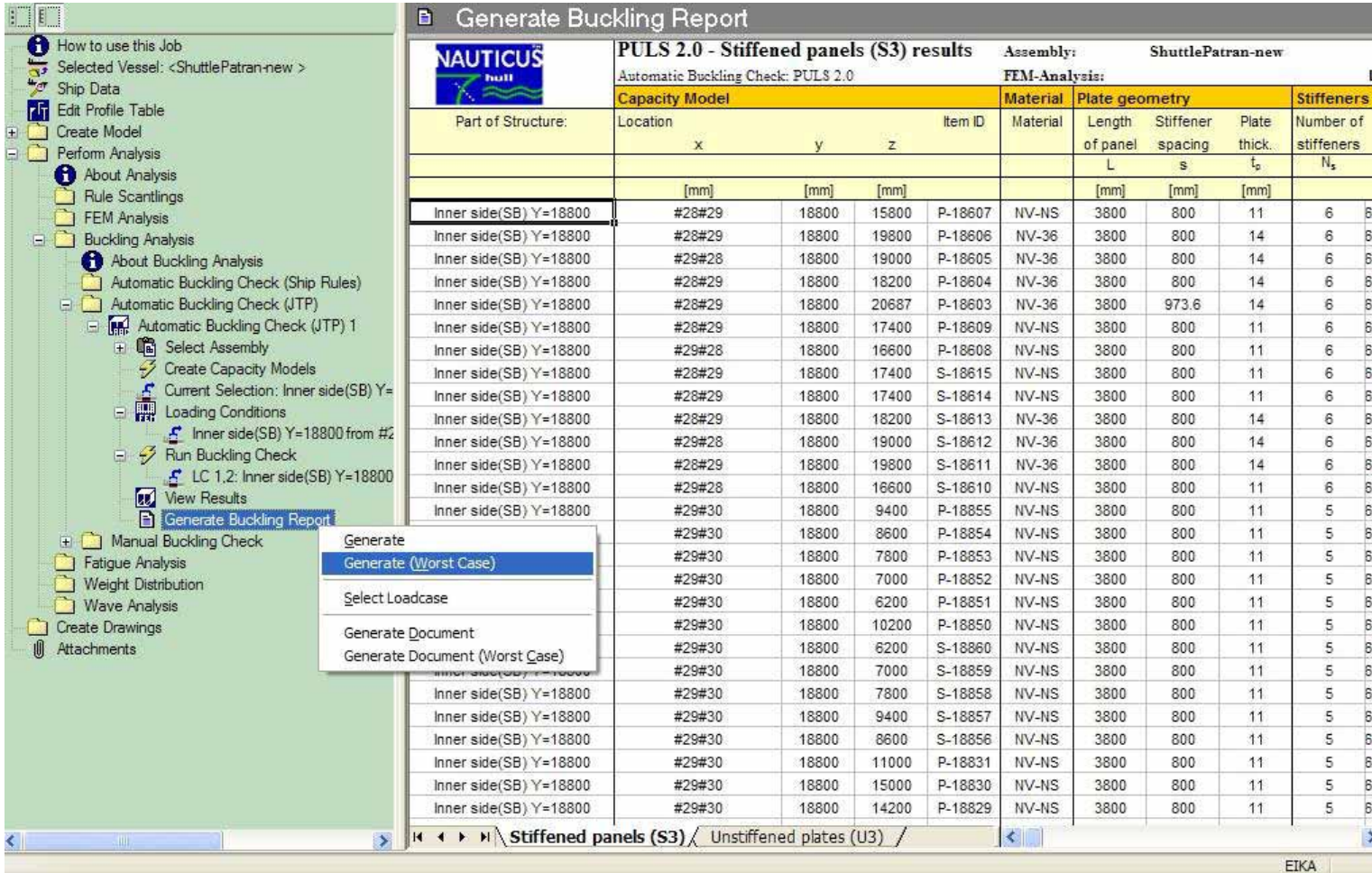
PULS buckling check

Von-Mises stress check

Local fine mesh FE model



Standardises reporting - Excel



Generate Buckling Report

NAUTICUS hull

PULS 2.0 - Stiffened panels (S3) results Assembly: ShuttlePatran-new

Automatic Buckling Check: PULS 2.0 FEM-Analysis: L

Part of Structure:	Capacity Model			Item ID	Material	Plate geometry			Stiffeners
	Location	x	y			z	Length of panel	Stiffener spacing	
		[mm]	[mm]	[mm]		L	s	t _p	N _s
Inner side(SB) Y=18800	#28#29	18800	15800	P-18607	NV-NS	3800	800	11	6
Inner side(SB) Y=18800	#28#29	18800	19800	P-18606	NV-36	3800	800	14	6
Inner side(SB) Y=18800	#29#28	18800	19000	P-18605	NV-36	3800	800	14	6
Inner side(SB) Y=18800	#28#29	18800	18200	P-18604	NV-36	3800	800	14	6
Inner side(SB) Y=18800	#28#29	18800	20687	P-18603	NV-36	3800	973.6	14	6
Inner side(SB) Y=18800	#28#29	18800	17400	P-18609	NV-NS	3800	800	11	6
Inner side(SB) Y=18800	#29#28	18800	16600	P-18608	NV-NS	3800	800	11	6
Inner side(SB) Y=18800	#28#29	18800	17400	S-18615	NV-NS	3800	800	11	6
Inner side(SB) Y=18800	#28#29	18800	17400	S-18614	NV-NS	3800	800	11	6
Inner side(SB) Y=18800	#28#29	18800	18200	S-18613	NV-36	3800	800	14	6
Inner side(SB) Y=18800	#29#28	18800	19000	S-18612	NV-36	3800	800	14	6
Inner side(SB) Y=18800	#28#29	18800	19800	S-18611	NV-36	3800	800	14	6
Inner side(SB) Y=18800	#29#28	18800	16600	S-18610	NV-NS	3800	800	11	6
Inner side(SB) Y=18800	#29#30	18800	9400	P-18855	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	8600	P-18854	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	7800	P-18853	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	7000	P-18852	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	6200	P-18851	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	10200	P-18850	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	6200	S-18860	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	7000	S-18859	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	7800	S-18858	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	9400	S-18857	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	8600	S-18856	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	11000	P-18831	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	15000	P-18830	NV-NS	3800	800	11	5
Inner side(SB) Y=18800	#29#30	18800	14200	P-18829	NV-NS	3800	800	11	5

Stiffened panels (S3) / Unstiffened plates (U3) / EIKA

Standardises reporting – Report Viewer

[Shuttle.REP] - Nauticus Hull Report

ABC-PULS 2.0 Shuttle Tanker Signature: GLCE Shuttle Ref. date: 1998.12.03

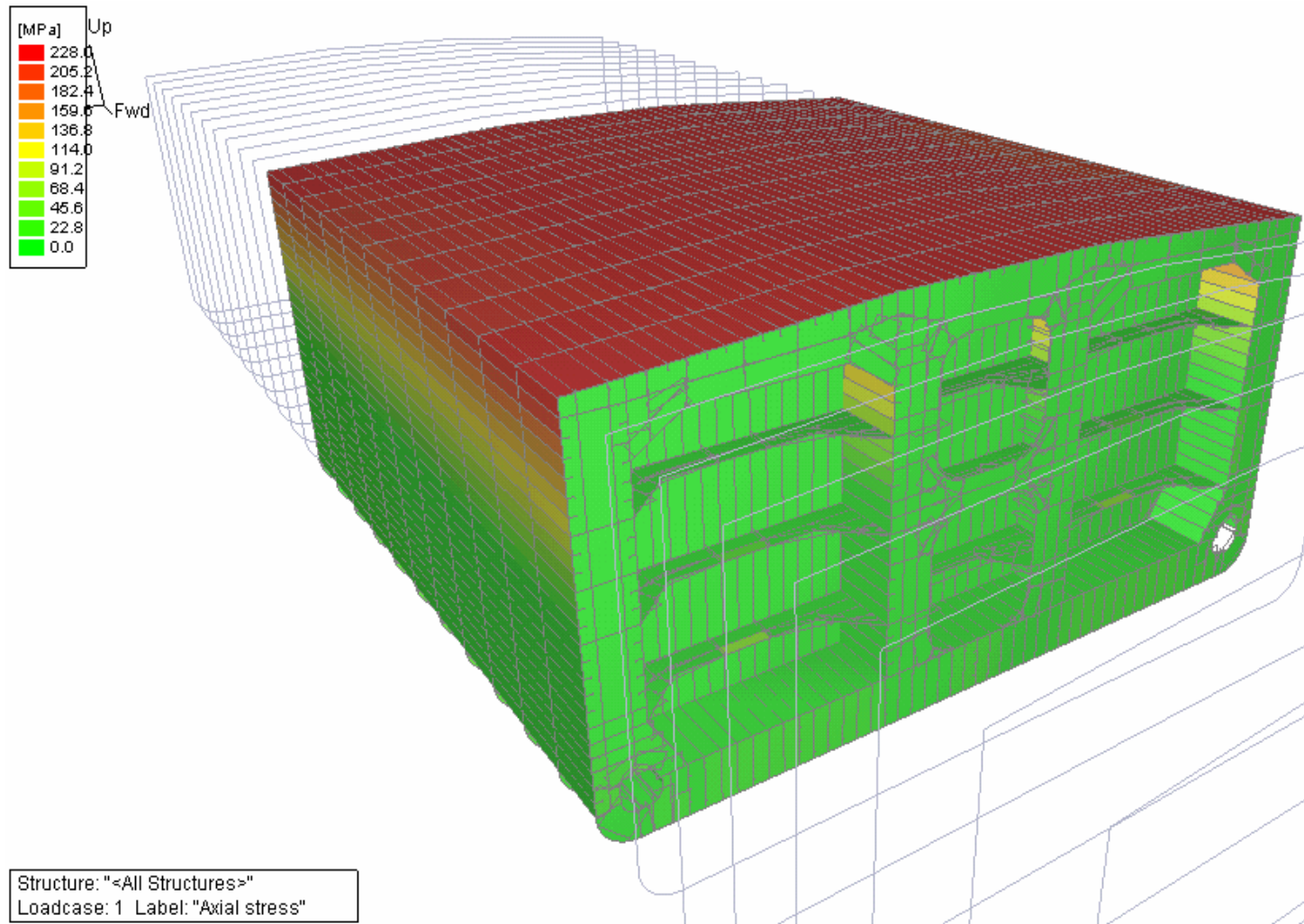
1 PULS 2.0 buckling check, JTP requirements - Stiffened Panels (S3)

Item ID	ACT1 ACT2	Elem. type Long. span mm	Type	h t _{stret} mm	b _y t _{stret} mm	s t _{stret} mm	σ_p σ_n N/mm ²	N _{req} Bth act	t _{corr} ht _{stret} mm	t _{corr} b _y _{stret} mm	t _{corr} st _{stret} mm	Y Z mm
Frame No	Applied Stresses		p Id/Nm ²	σ_{x1} N/mm ²	σ_{x2} N/mm ²	σ_y N/mm ²	s N/mm ²	Bth req	ht _{stret} req	b _y _{stret} req	st _{stret} req	OK?
	Ultimate Capacity			$\sigma_{x1,UC}$ N/mm ²	$\sigma_{x2,UC}$ N/mm ²	$\sigma_{y,UC}$ N/mm ²	τ_{oc} N/mm ²		Crit limit state	η_{oc}	η_{bth}	OK?
LC No	Buckling Strength			$\sigma_{x1,LC}$ N/mm ²	$\sigma_{x2,LC}$ N/mm ²	$\sigma_{y,LC}$ N/mm ²	τ_{bc} N/mm ²		Strength limit	η_{bc}	Elastic buckling	OK?

Inner side(SB) Y=18800

Item ID	ACT1 ACT2	Elem. type Long. span mm	Type	h t _{stret} mm	b _y t _{stret} mm	s t _{stret} mm	σ_p σ_n N/mm ²	N _{req} Bth act	t _{corr} ht _{stret} mm	t _{corr} b _y _{stret} mm	t _{corr} st _{stret} mm	Y Z mm
F-18007	ACT1 ACT2	S3 3800	20 L	340 10.0	62 33.8	800 11.0	236 236	6 0.20	3.0 30.6	3.0 1.7	3.0 72.7	18800 18800
#29#29	Applied Stresses		0.0 s	13	13	7	35	0.25 *	75.0	12.0	90.0	No
	Ultimate Capacity			47	47	25	130		3	0.27	1.00	Yes
2	Buckling Strength			47	47	25	130		UC	0.27	No	N.A.
F-18008	ACT1 ACT2	S3 3800	20 L	340 9.5	62 33.3	800 14.0	355 355	6 0.20	3.5 32.3	3.5 1.7	3.0 87.1	18800 19000
#29#29	Applied Stresses		0.0 s	5	5	4	30	0.25 *	61.0	9.8	73.2	No
	Ultimate Capacity			33	33	27	201		3	0.15	1.00	Yes
2	Buckling Strength			33	33	27	201		UC	0.15	No	N.A.
F-18009	ACT1 ACT2	S3 3800	20 L	340 10.0	62 33.8	800 14.0	355 355	6 0.20	3.0 30.6	3.0 1.7	3.0 87.1	18800 19000
#29#29	Applied Stresses		0.0 s	3	3	5	31	0.25 *	61.0	9.8	73.2	No
	Ultimate Capacity			17	17	32	201		5	0.15	1.00	Yes
2	Buckling Strength			17	17	32	201		UC	0.15	No	N.A.
F-18004	ACT1 ACT2	S3 3800	20 L	340 10.0	62 33.8	800 14.0	355 355	6 0.20	3.0 30.6	3.0 1.7	3.0 87.1	18800 18200
#29#29	Applied Stresses		0.0 s	1	1	5	31	0.25 *	61.0	9.8	73.2	No

Standardises reporting – Graphical Viewer



How Nauticus Hull adds value to the CSR Tank Rules

■ Comprehensive:

- Through Nauticus Hull, DNV deliver extensive software support for the the new Rules (CSR Tank)

■ Effective / support design process:

- The Section Scantlings program fully support optimization and proposing main scantlings based on the CSR Tank requirements.
- Results are not merely shown as "OK" or "not OK" or as utilization factors, instead required scantlings are calculated as an aid to the designer.
- PULS Advanced Viewer provides easy access to 3D graphics of different results like buckling modes, redistributed stress patterns etc. and provides for a thorough understanding of the physical behavior of non-linear buckling response.

How Nauticus Hull adds value to the CSR Tank Rules

■ Efficient:

- Not only focusing on cutting modeling and input time, but rather cutting the total design and approval time.
- Most of the Prescriptive Rules covered by one program, ensuring input only once: Section Scantlings.
- New tools have been developed to make FE analysis more efficient: automated post-processing and code-checking, as well as generation of loads, net scantlings and boundary conditions.
- New tools for automated code-checking according to the new method for buckling check, PULS (Panel Ultimate Limit State).
- Standardised report format ensures easy comparison between Prescriptive Rules and FEA.



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