VVD - Visual Vessel Design

Version 18.0 (2018)

Read Me File

Version 18.0 – (2018) Updates to latest code amendment

Version 18.0 includes a number of improvements and additions. This version is also in compliance with:

- ASME VIII Div.1: 2017 Edition
- EN13445:2014 Issue 4:2017
- PD5500:2015+A3:2017
- EN13480:2017 Issue 1:2017
- AD2000:2017

The material libraries have been expanded and updated to be in compliance with the latest edition of the following material standards:

- ASME II Part D : 2017 Edition
- EN 10028-2:2017
- EN 10028-3:2017
- EN 10028-4:2017
- EN 10028-5:2017
- EN 10028-6:2017
- EN 10213:2016
- EN 10222:2017

Updated the wind and seismic codes to ASCE 7:2016.

Added a new feature to the EN13445 module that will check the difference in thickness between elements adjoined by welding, and make reference to Table A in EN13445-3 Annex A when special provision is required.

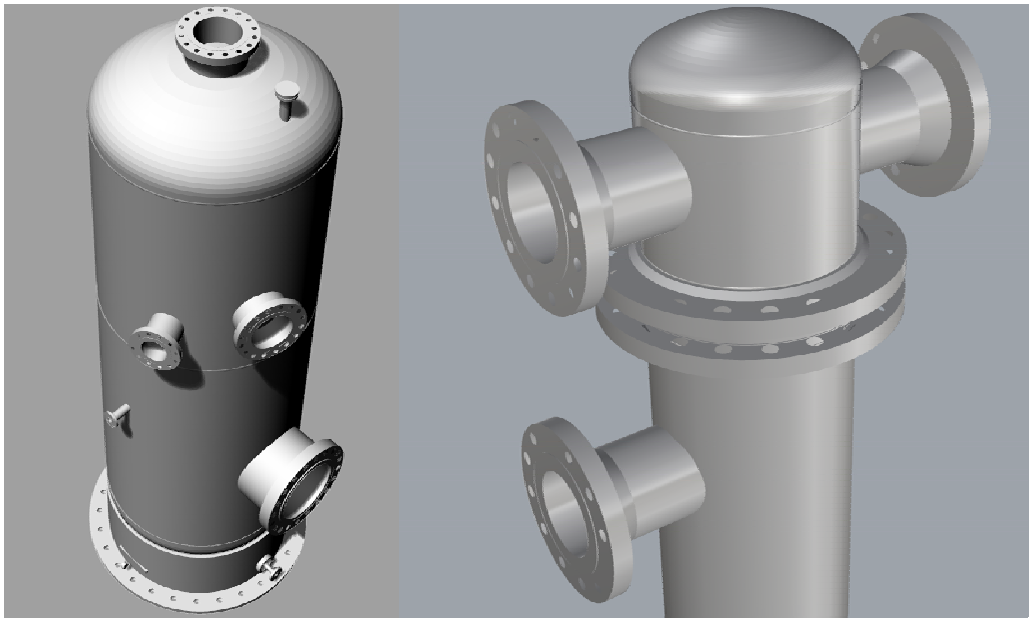
Added a new option to include reinforcement plates on nozzles located in flat ends and blind flanges for design according to ASME VIII Div.1.

Added straight bar reinforcement ribs to the design of flat plates.

Added calculation of deflection for flat plates with or without reinforcement ribs.

Added calculation of non-circular flat ends to AD2000 section B5.

The STEP file converter has been significantly improved, this tool allows export of the 3D drawing generated in the VVD software to a STEP file format. Most 3D CAD systems supports the STEP file format, hence allows the end user to import the 3D drawing from the VVD software into their 3D CAD modeller.



If the VVD software was forced to close while minimized, it remained minimized when VVD was re-started. This problem has now been corrected.

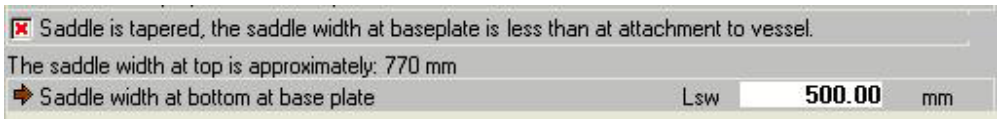
Added a new option so the end user may specify the stress concentration factor when calculating the number of cycles for bellows to EN13445-3 section 18.

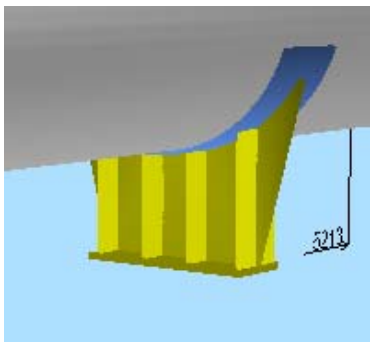
The maximum number of tubes handled by the tube-layout module was extended from a maximum of 17 000 tubes to a maximum of 40 000 tubes.

Corrected a problem related overflow when designing large diameter tubesheets to the alternative tubesheet design method in EN13445-3 Annex J.

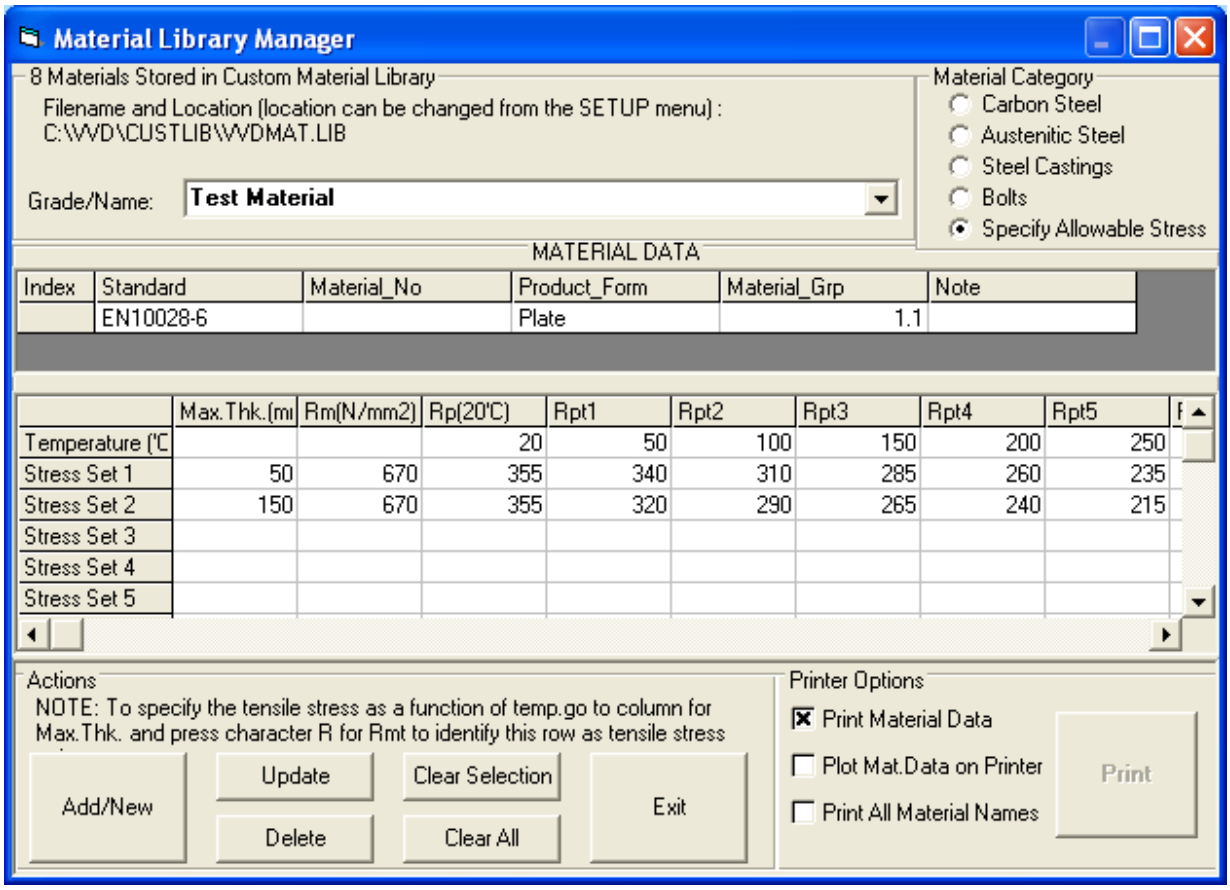
In case the external pressure is larger than the internal pressure the external pressure is used instead as internal pressure according to EN13445-3 section 8.4.1 for internal pressure calculations with a weld joint coefficient of 1.0. In VVD however for conical shells the weld joint coefficient z could in some cases remain less than 1.0 resulting in over conservative design, this problem has now been corrected.

Added a new option to design tapered saddle support, so the saddle width at the bottom at the base plate can be less than at top, at the attachment to the vessel. This new saddle option will reduce material and fabrication costs.



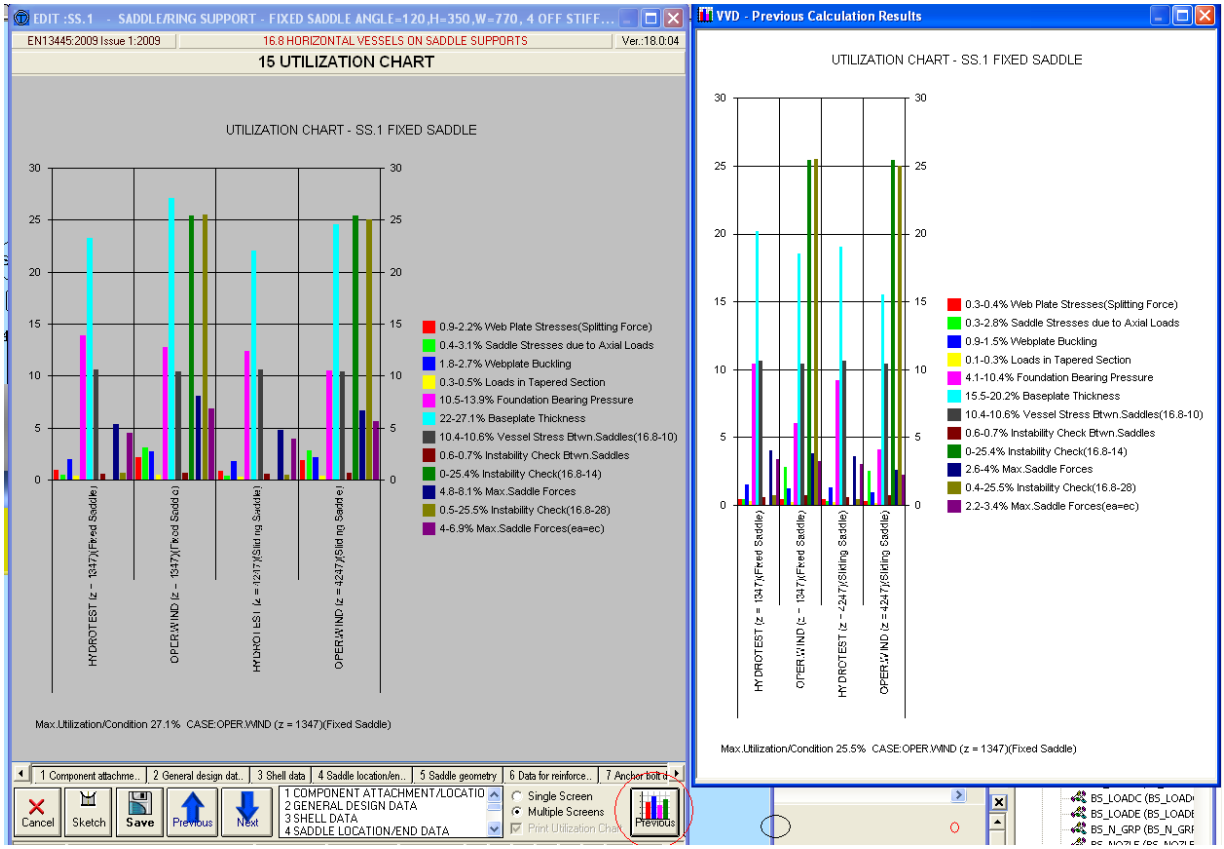


A new feature was added to the Material Library Manager to enable the user to specify the allowable stress as a function of temperature instead of yield stresses and material category when adding new materials to the custom material library.



The maximum pressure for the central ring in a flat plate radial reinforced by ribs was incorrectly calculated according to equation 21.8-1 in EN13445-3, this has now been corrected.

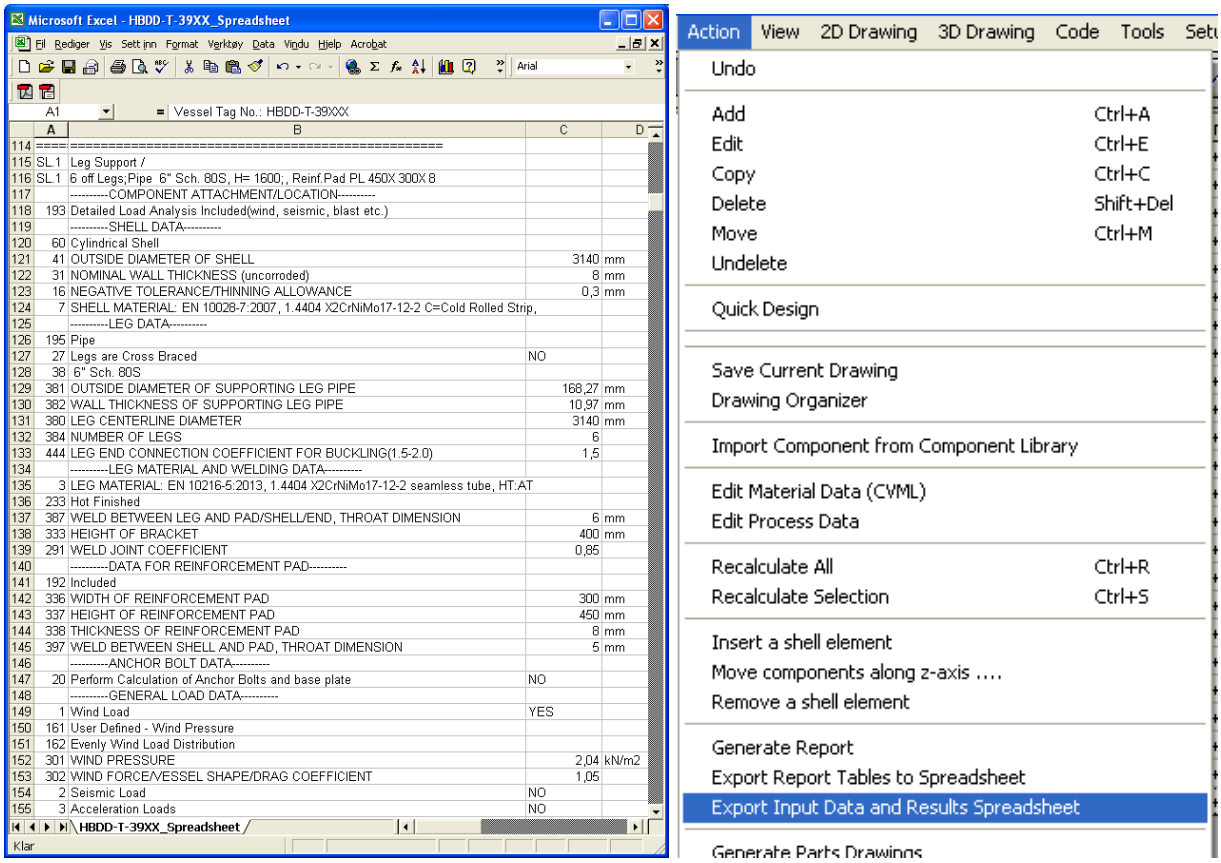
Added a new feature that allows easy comparison with previous calculation results. The impact of any changes can easily be seen as the results from the previous run can be shown simultaneously together with the results from the new run, see below:



Use the new command ‘Previous’ as shown encircled in red above to display the results from the previous run.

Corrected some problems with the German translation.

A new feature was added that allows all input data and result summary to be exported to MS-Excel spreadsheets. The name and location of the MS-Excel file will be the same as the vessel file name including a name extension of ‘spreadsheet’. To use this feature, go to the pull down menu ‘Action’ and select ‘Export Input Data and Results to Spreadsheet’, see below:



	A	B	C	D
114	====	==========		
115	SL1	Leg Support /		
116	SL1	6 off Legs;Pipe 6" Sch. 80S, H= 1600;, Reinf.Pad PL 450X 300X 8		
117		----------COMPONENT ATTACHMENT/LOCATION----------		
118	193	Detailed Load Analysis Included(wind, seismic, blast etc.)		
119		----------SHELL DATA----------		
120	60	Cylindrical Shell		
121	41	OUTSIDE DIAMETER OF SHELL	3140	mm
122	31	NOMINAL WALL THICKNESS (uncorroded)	8	mm
123	16	NEGATIVE TOLERANCE/THINNING ALLOWANCE	0,3	mm
124	7	SHELL MATERIAL: EN 10028-7:2007, 1.4404 X2CrNiMo17-12-2 C=Cold Rolled Strip,		
125		----------LEG DATA----------		
126	195	Pipe		
127	27	Legs are Cross Braced	NO	
128	38	6" Sch. 80S		
129	381	OUTSIDE DIAMETER OF SUPPORTING LEG PIPE	168,27	mm
130	382	WALL THICKNESS OF SUPPORTING LEG PIPE	10,97	mm
131	380	LEG CENTERLINE DIAMETER	3140	mm
132	384	NUMBER OF LEGS	6	
133	444	LEG END CONNECTION COEFFICIENT FOR BUCKLING(1.5-2.0)	1,5	
134		----------LEG MATERIAL AND WELDING DATA----------		
135	3	LEG MATERIAL: EN 10216-5:2013, 1.4404 X2CrNiMo17-12-2 seamless tube, HT:AT		
136	233	Hot Finished		
137	387	WELD BETWEEN LEG AND PAD/SHELL/END, THROAT DIMENSION	6	mm
138	333	HEIGHT OF BRACKET	400	mm
139	291	WELD JOINT COEFFICIENT	0,85	
140		----------DATA FOR REINFORCEMENT PAD----------		
141	192	Included		
142	336	WIDTH OF REINFORCEMENT PAD	300	mm
143	337	HEIGHT OF REINFORCEMENT PAD	450	mm
144	338	THICKNESS OF REINFORCEMENT PAD	8	mm
145	397	WELD BETWEEN SHELL AND PAD, THROAT DIMENSION	5	mm
146		----------ANCHOR BOLT DATA----------		
147	20	Perform Calculation of Anchor Bolts and base plate	NO	
148		----------GENERAL LOAD DATA----------		
149	1	Wind Load	YES	
150	161	User Defined - Wind Pressure		
151	162	Evenly Wind Load Distribution		
152	301	WIND PRESSURE	2,04	kN/m2
153	302	WIND FORCE/VESSEL SHAPE/DRAG COEFFICIENT	1,05	
154	2	Seismic Load	NO	
155	3	Acceleration Loads	NO	

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Version 17.0 – (2017) Updates to latest code amendment

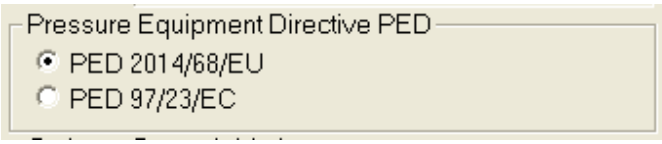
Version 17.0 includes a number of improvements and additions. This version is also in compliance with:

- EN 13445:2014 Issue 2
- EN 13445:2014 Issue 3
- EN 13480:2012 Issue 4
- PD5500:2015+A2:2016

The material libraries have been expanded and updated to be in compliance with the latest edition of the following material standards:

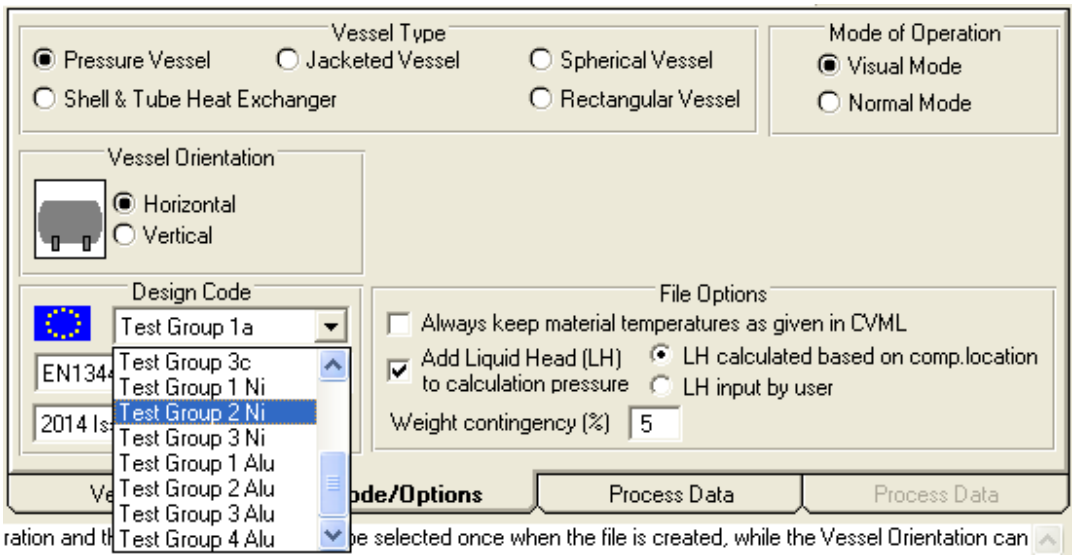
- EN 10028-7:2016
- EN 10272:2016
- EN 10273:2016

The PED classification tool was updated to reflect the latest requirements to PED 2014/68/EU. The user must now select the edition of PED to be applied:

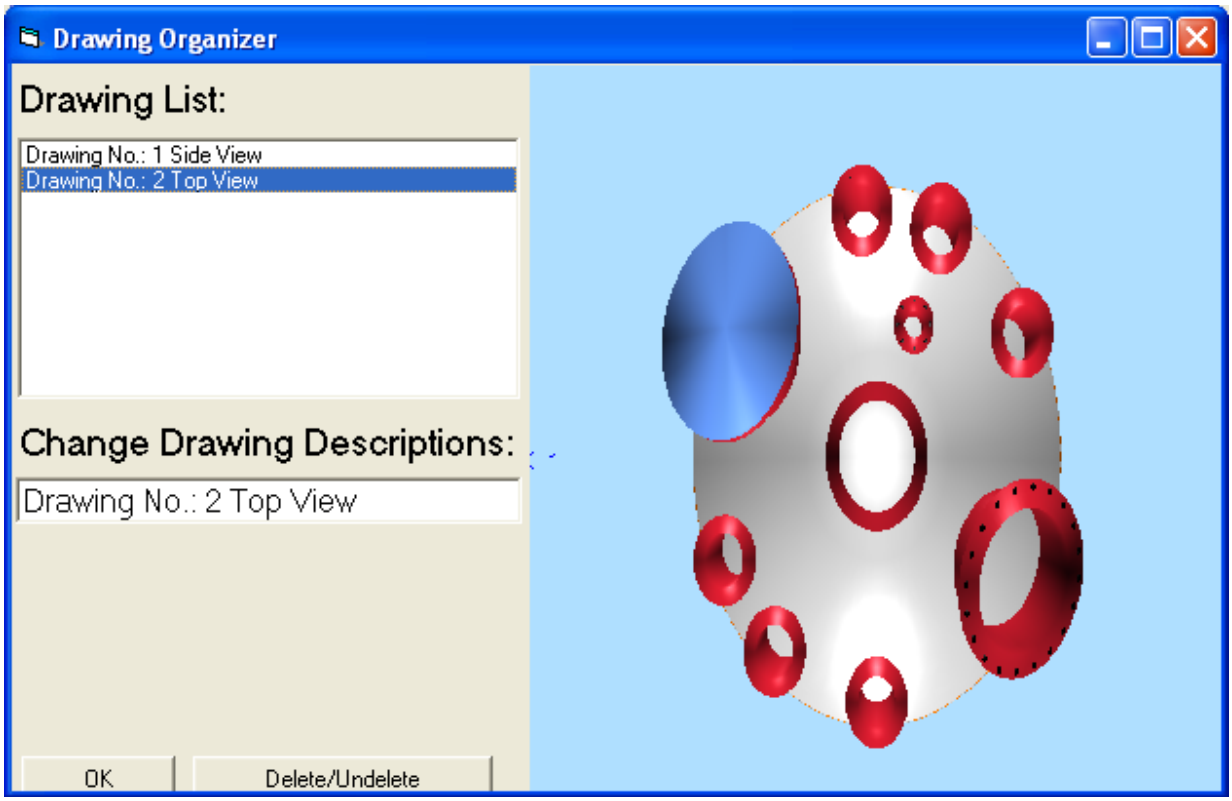


Added - EN 13445:2014 Part 10, Additional requirements for pressure vessels made of nickel and nickel alloys. Added the Nickel material in Table A.2 to the VVD material library. VVD modifications was implemented to accommodate the new requirements related to calculating allowable stresses to Table 6.2-1, Fatigue design to section 6.5, testing groups to Table 8.2-1, NDT requirements to Table 8.3-1 etc.

To perform an analysis to Part 10, select Nickel or Nickel alloy materials and use test groups (TG) 1 Ni, 2 Ni or 3 Ni, as shown below:



Added a new feature so that multiple drawings/sketches can be included in the design report. Any drawing/sketch shown on the screen can now be saved and included in the design report. To save a drawing go to ‘Action’ and ‘Save Current Drawing’. Added a drawing organizer that allows the user to change the description of the drawing and delete/undelete any drawings. Up to ten different drawings can be inserted into the report.



Added a new option so that a standard blind flange can be attached to a standard flange without performing calculations. The flange/blind flange design is then only based on the applicable pressure/temperature rating curves in the standard.

Added - EN 13445:2014 Part 8, Additional requirements for pressure vessels made of aluminium and aluminium alloys. Added the aluminium materials to the VVD material library. VVD modifications was implemented to accommodate the new requirements related to calculating allowable stresses to Table 6.3-1, testing groups to Table 8.2-1, NDT requirements to Table 8.3-1 etc. Applicable test groups (TG) are 1 Alu, 2 Alu, 3 Alu and 4 Alu. To perform an analysis to Part 8, select aluminium materials and applicable test groups (TG) 1 Alu, 2 Alu, 3 Alu or 4 Alu.

Added a new option so that the user can select not to check the minimum thickness to ASME VIII Div.1 UG-16, for special type of components/application.

Corrected a functionality problem when importing components from an existing file, the user was in some cases unable to specify the filename of the file to import from.

Corrected a functionality problem related to calculation of reversed full faced flanges to PD5500, sometime the calculation would stop and not be completed when calculating the maximum test pressure.

Corrected a problem for calculation of blind flanges to PD5500, after re-calculation the thickness of the blind flange could in some cases be changed to the same thickness as the mating flange.

In some cases an incorrect warning message could be displayed for the AD2000 module when generating a report for hydro-testing.

Corrected a problem for calculation of MAWP for conical transitions to the standard EN13480, the MAWP value could in some cases be underestimated.

Corrected a problem when using the standard ASME VIII Div. 1:2013 edition, for some materials the yield stress could become zero when obtained from the material database. This problem was only related to the 2013 edition in the new VVD version 2016.

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Version 16.0 – (2016) Updates to latest code amendment

Version 16.0 includes a number of improvements and additions. This version is also in compliance with:

- ASME VIII Div. 1: 2015 Edition (A validation document to ASME PTB-4 is also available upon request).
- ASME II Part D : 2015 Edition
- EN13445:2014 Issue 1

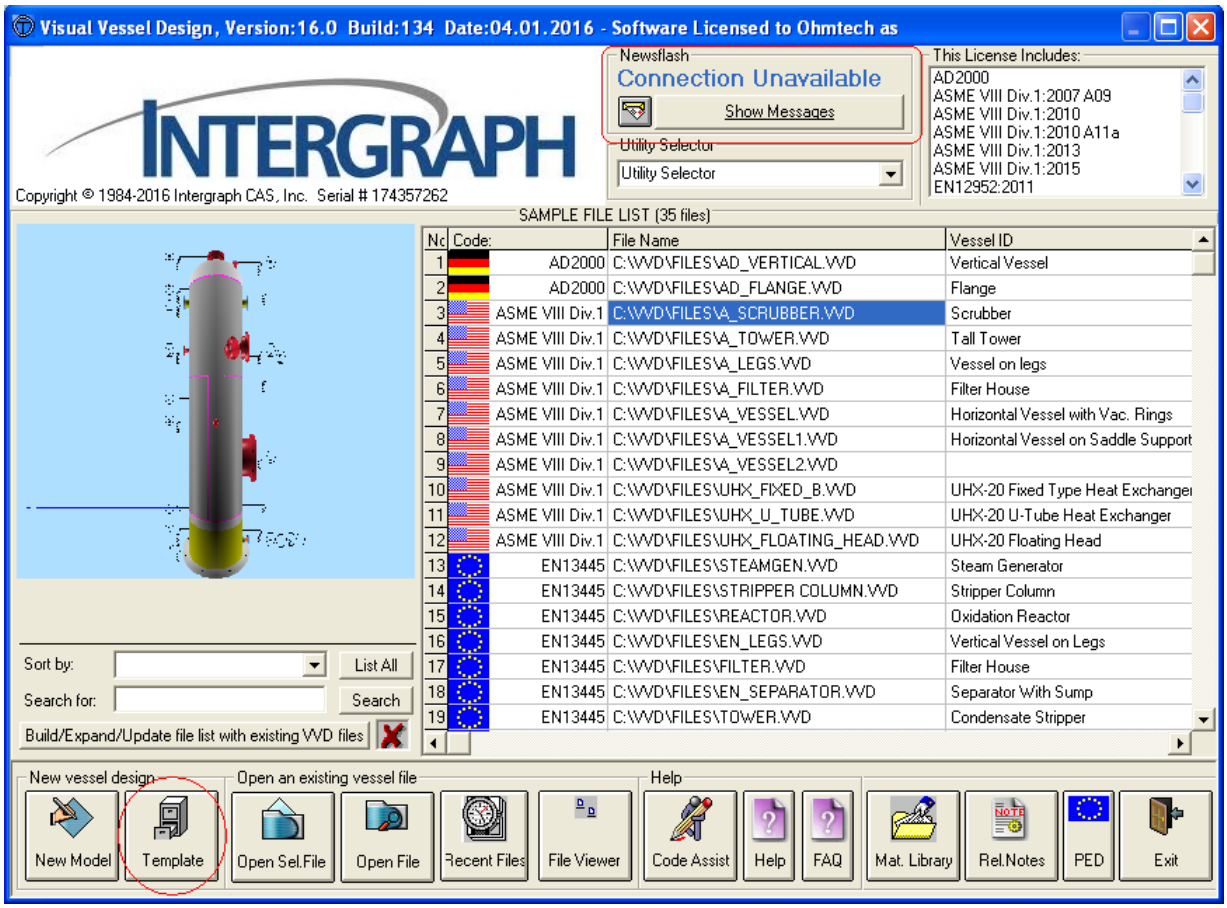
- PD5500:2015+A1:2015
- EN13480:2012 issue 3

The new licensing model has now been adopted for the VVD software. The software is no longer sold as separate modules, but now includes all available modules. With this version all users are given access to all modules/standards and full capabilities.

Below is a brief summary of additions and enhancements:

- A new option has been included to allow the use of any existing file as a template for new design. The end user can select an existing file and easily change the design code, process conditions, materials, and/or any major dimensions. This will in many cases give a significant time saving compared to starting a vessel design from scratch. To re-use any file, click on the file name in the list of files and then click on the command ‘Template’ (see sketch below).

- Newsflash - Direct communication with end users. Newsflash allows a direct communication with end users. Information can very quickly be transmitted to the end user. Newsflash will automatically update after a few days as long as the PC is kept online, however in case the PC is offline the text box will show ‘Connection Unavailable’. This information channel will be used to better inform the end users of new modules available, new features, discovered/solved problems, changes to standards, testing of new modules, available courses and general information.

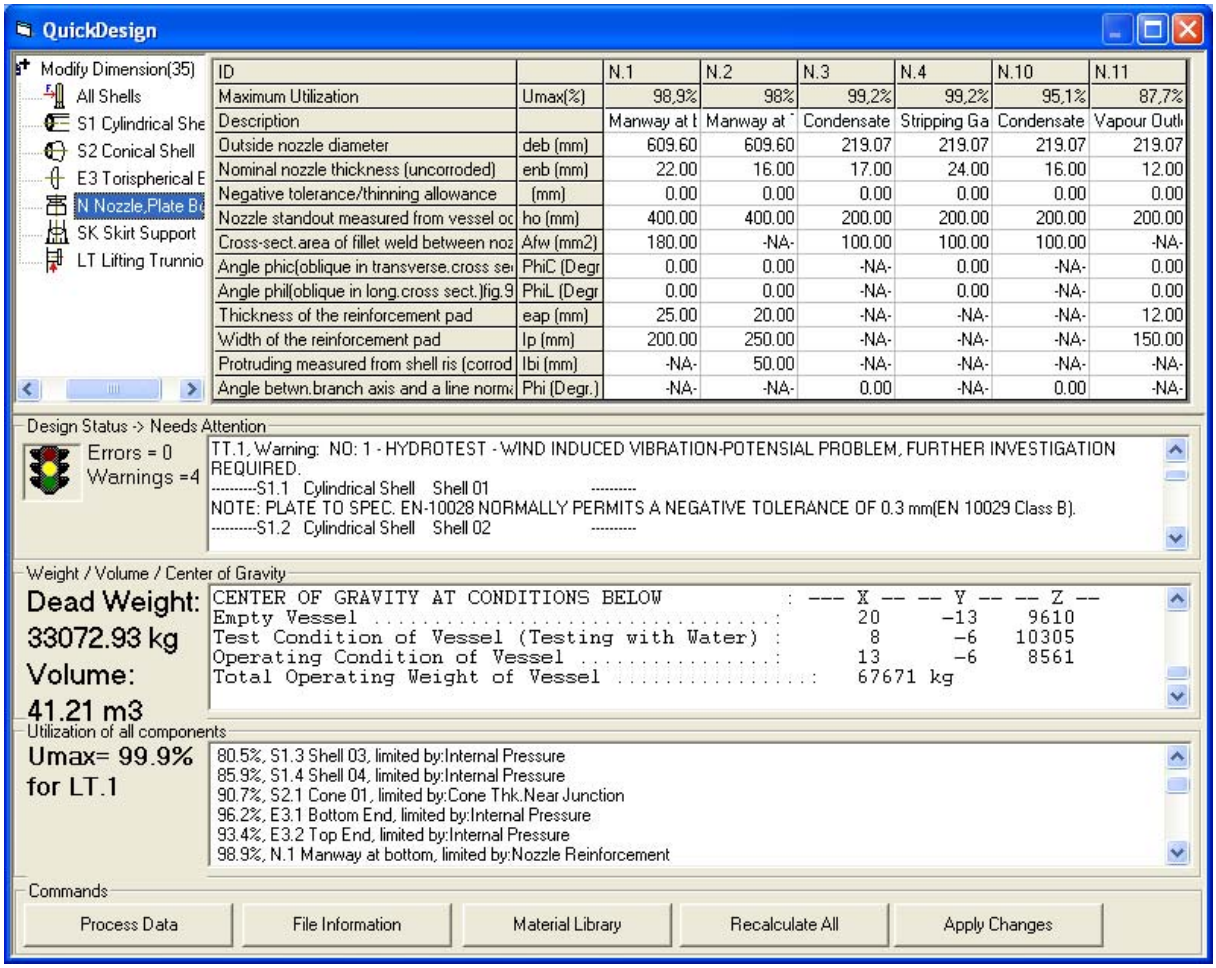


- The unit conversion option has been significantly improved.

- The STEP file converter has been significantly improved, this tool allows export of the 3D drawing generated in the VVD software to a STEP file format. Most 3D CAD systems supports the STEP file format, hence allows the end user to import the 3D drawing from the VVD software into their 3D CAD modeller.

- Updated the material library to latest editions of the material standards.

- Added a new feature named QuickDesign that allows the end user to modify the input of multiple components at the same time. The input data is shown in a matrix for multiple components as shown below. This allows a much more rapid design and modification to existing components. QuickDesign also shows essential information like error and warning messages, weight and CG of vessel, maximum utilization for each components etc. To activate QuickDesign go to the scroll down menu and click on ‘Action’ > ‘QuickDesign’. When using the command ‘Apply Changes’, all the modified components will be recalculated. It is however advised to use the ‘Recalculate All’ function after all modifications have been completed.



Shown above is the QuickDesign window.

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Version 15.1 – (2015)

The new licensing model has now been adopted for the VVD software. The software is no longer sold as separate modules, but now includes all available modules. With this version all users are given access to all modules/standards and full capabilities.

Corrected a problem with the error handler, in case of an incorrect input the error handler could terminate the software instead of displaying the equation generating the problem allowing the input to be corrected by the user.

Added a new option in tubesheet design for automatic calculation of the thermal expansion coefficients in case of multiple load cases and with different calculation temperatures.

Added calculation for deformation of conical shells and torispherical dished ends due to forming to EN13445-4 section 9.

This version is now in compliance with EN13480:2012 issue 3.

Updated the material library to latest editions of material standards.

Improved the error handling for the external loads module.

Corrected a problem that after recalculation could reset/alter the load weighing factors back to the default setting.

When calculating a tubesheet, the user may now select any material design temperatures that is not directly linked to the process data.

When calculating a tubesheet with extended flange to EN13445-3 section 13 configuration d2 (threads in extended flange), the user may now specify two different bolt loads.

Corrected a problem related to selecting the pressure rating for ASME flanges, in some cases the selecting box could be overwritten by another selection box.

Corrected a problem when adding a flange calculation, in some cases the VVD software could incorrectly report an error: File Missing

Corrected a problem related to nozzle locations in dished ends to the PD5500 module, the software could in some cases incorrectly display a warning message related to the limit L>= D/10 according to Figure 3.5-8.

For the alternative flange method to EN13445-3 Annex G and EN1591 the criteria for non-uniformity of gasket stress was altered from generating an error message to generating a warning message, since this criteria deals with potential leakage and is not related to an overstressed flange.

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Version 15.0 – (2015) Updates to latest code amendment

Version 15.0 includes a number of improvements and additions. This version is also in compliance with:

- EN13445:2014
- PD5500:2012+A3:2014

Below is a brief summary of additions and enhancements:

- Added new commonly used materials to the VVD material library. Updated the

material library to latest edition of the following material standards:

EN10216-1:2013
EN10216-2:2013
EN10216-3:2013
EN10216-4:2013
EN10216-5:2013
EN10217-7:2014
EN10269:2013

- Additions to the EN13445 standard includes:

New section EN13445-3:2014 Section 22, Static Analysis of Tall Vertical Vessels.

This new section provides all necessary design rules to perform a complete analysis of a tall vertical vessels/columns, with the definition of columns as vessels with a total height h < 10 m and with a ratio of total height to outside diameter $h/d \geq 6{,}5$, and vessels with $h \geq 10$ m and with a ratio $h/d > 4$.

The new sections of the standard gives requirements for dead loads, live loads, wind loads, seismic loads, loads from external piping at nozzles, load cases, load weighing factors, safety factor for anchor bolts, recommended minimum torque for anchor bolts, considerations for foundation loads, and detailed design of skirt base including base ring, gussets, chairs and top ring.

EN13445:3 Table 22-1: New Load Combinations for columns. The load cases and load weighing factors as given in table below are now the default values suggested by the external loads module for vertical vessels. The user may however delete or add additional load cases, and change the load weighing factors as applicable.

Table 22-1: Load Combinations for columns

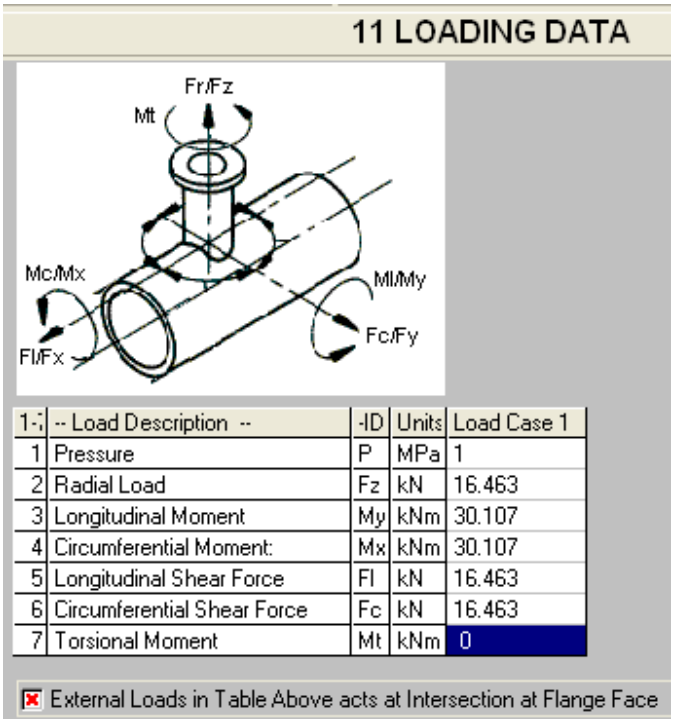
Load Case	Types of load included	Load combination including weighting factors	Allowable tensile stress for shells	Allowable compressive stress for shells	Allowable tensile stress for anchor bolts	Explanations
LC1	P_i, D_{max}, L, F, W	$0{,}9 \cdot P_i$ & D_{max} &L&F & $1{,}1 \cdot W$	f_d	$\sigma_{0,all}$	$f_{B,op}$	Operation with internal pressure and
LC2	P_e, D_{max}, L, F, W	P_e & D_{max} & L & F & $1{,}1 \cdot W$	f_d	$\sigma_{0,all}$	$f_{B,op}$	Operation with external pressure and
LC3	D_{max}, L, F, W	D_{max} & L & F & $1{,}1 \cdot W$	f_d	$\sigma_{0,all}$	$f_{B,op}$	Operation without pressure but with
LC4	D_{corr}, W	D_{corr} & $1{,}1 \cdot W$	f_d	$\sigma_{0,all}$	$f_{B,op}$	Shut down (no pressure, contents and
LC5	D_{min}, W	D_{min} & $0{,}7 \cdot W$	f_d	$\sigma_{0,all}$	$f_{B,op}$	Installation
LC6	P_i, D_{max}, L, E	$0{,}9 \cdot P_i$ & D_{max} & L & E	f_{test}	$\sigma_{0,all,test}$	$1{,}2 \cdot f_{B,op}$	Operation with int.pressure and
LC7	P_e, D_{max}, L, E	P_e & D_{max} & L & E	f_{test}	$\sigma_{0,all,test}$	$1{,}2 \cdot f_{B,op}$	Operation with ext.pressure and
LC8	D_{max}, L, E	D_{max} & L & E	f_{test}	$\sigma_{0,all,test}$	$1{,}2 \cdot f_{B,op}$	Operation without pressure/with
LC9	P_{test}, D_{max}, L_{test}, W	P_{test} & D_{max} & L_{test} & $0{,}6 \cdot W$	f_{test}	$\sigma_{0,all,test}$	$f_{B,op}$	Test with test pressure, test filling and

L = Live Loads, F = Loads from External Piping, W = Wind, E = Earthquake, Dmax = Maximum dead loads, Dcorr = Corroded dead loads, Dmin = Manimum dead loads

The wind load has become more conservative as the wind load for operating conditions with the new rules is multiplied by 1.1 instead of 1.0 previously in VVD (0.6 for hydrotest case while 0.5 previously in VVD). The factor 0,6 is in accordance with EN 1991-1-6 and DIN 1055-4, Table 1 for duration times < 3 days (0,5 × 1,1 = 0,55 ≈ 0,6. The seismic loads allowable stress is however now taken as ftest (less conservative) while previously it was 1.2 * f in VVD, the allowable stress for anchor bolt are however still multiplied by a maximum of 1.2 for exceptional load cases. The factor 0,9 is applied to the internal maximum allowable pressure PS because the internal operating pressure is normally 10% below PS due to the pressure limiting device. For more information reference is made to the relevant sections in the standard and the VVD Code Assistant (technical help section 7.1 External Design Loads).

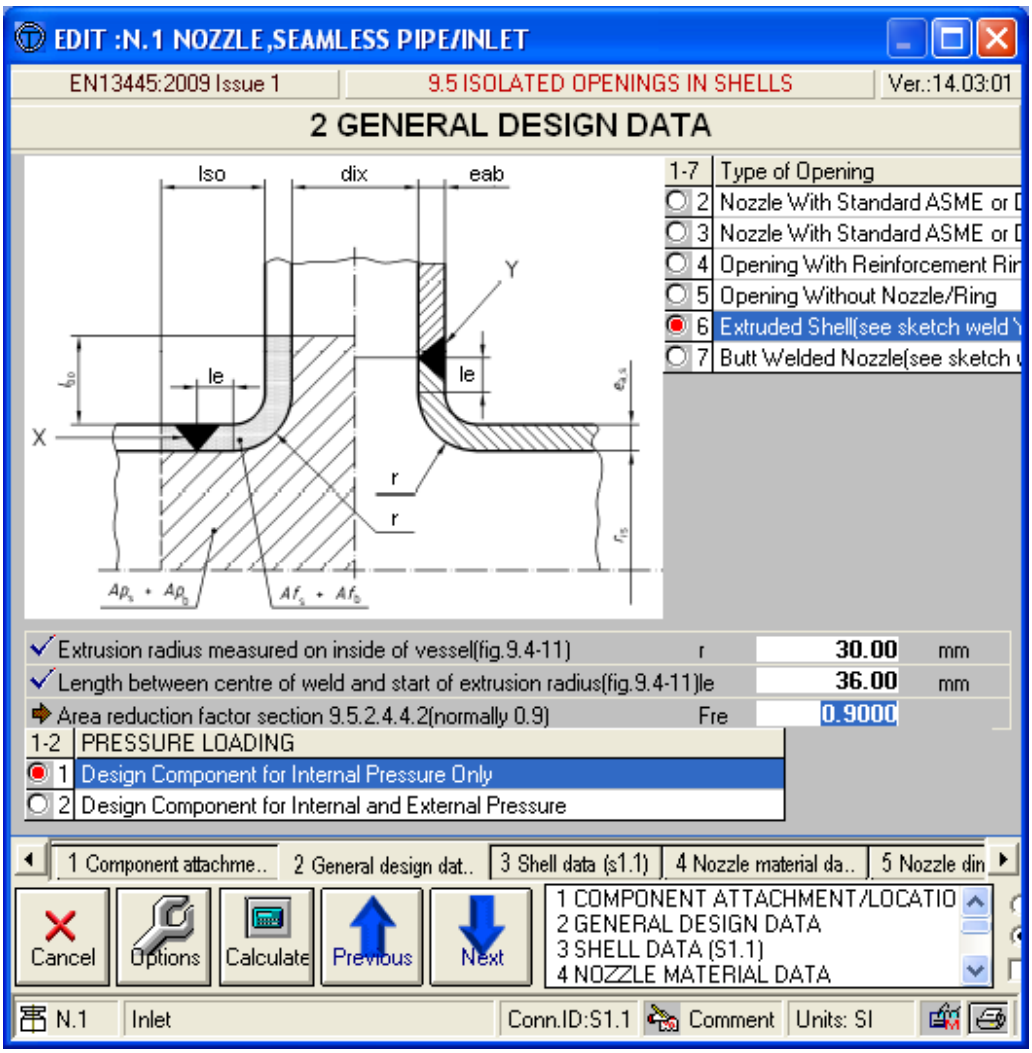
In EN13445-3 Section 16.12, four different methods have been added for complete design of skirt base to one of the following options:

- Type 1: Simple bearing plate
- Type 2: Bearing plate with gussets
- Type 3: Bearing plate with chairs
- Type 4: Bearing plate with top ring plate

- 

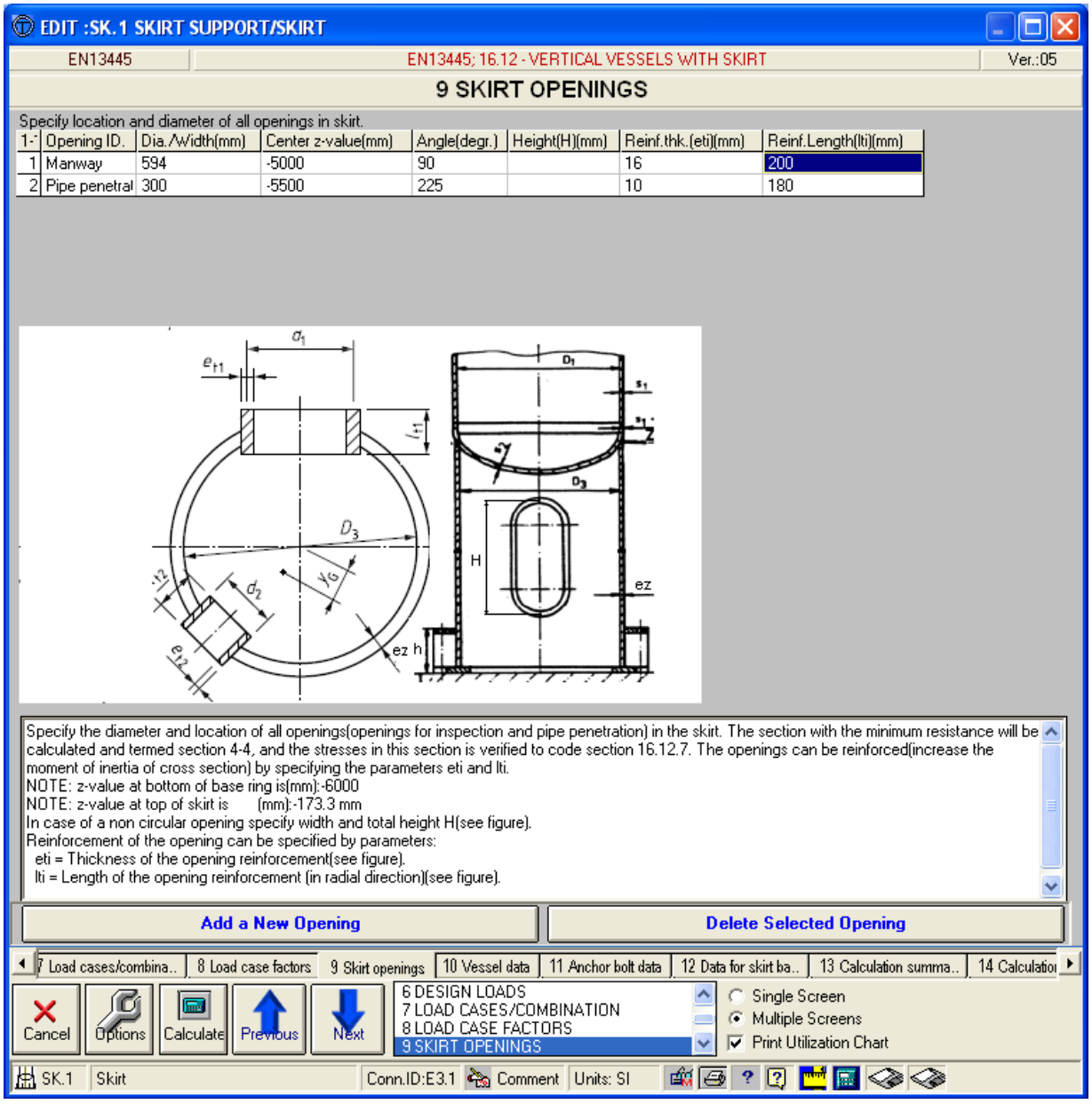
- Added a new option to specify the nozzle loads at the flange face instead of having to always specify the nozzle loads at the nozzle to shell intersection as required by the design methods in the standards. If this option is checked as

shown above, the VVD software will convert the forces and moments acting at the flange facing to forces and moments acting at the nozzle to shell intersection. This new option is particularly helpful for hillside nozzles, and other non-radial nozzles.

- Added a new module for wind loading to ASCE-7-10.
- Added a new module for calculation of pipe bends to ASME B31.3 section 304.
- The minimum thickness due to external pressure is now calculated based on given value for unsupported length when the vessel is subjected to external pressure/vacuum conditions.
- Fixed a problem related to design of conical shells to AD2000, sometimes the results would show 100% utilization, while the actual utilization was less than 100%.
- 

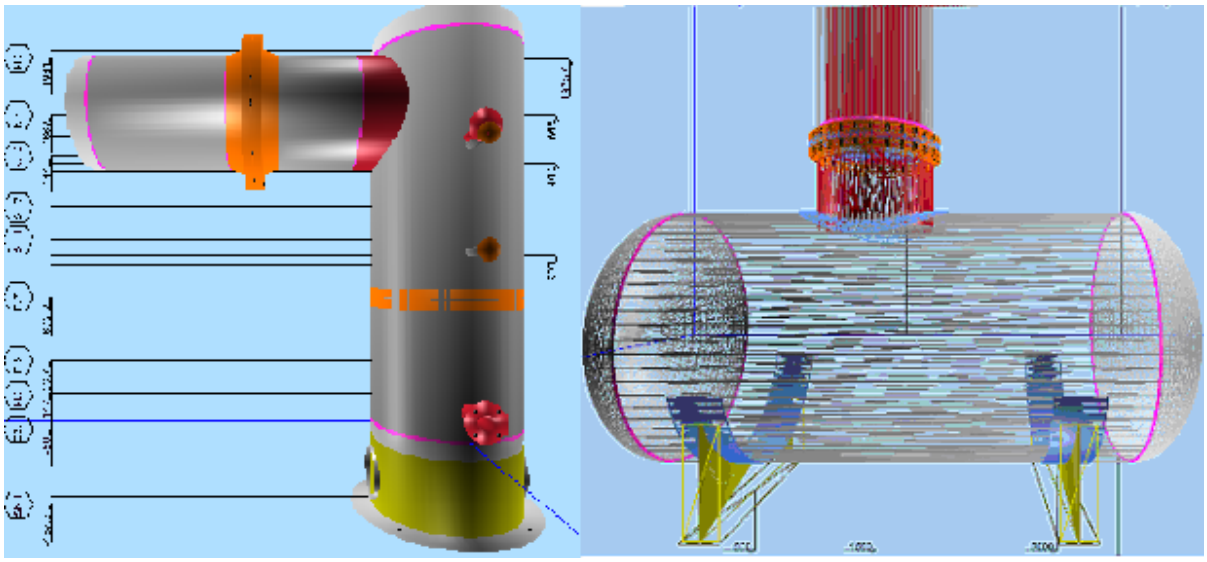
- Added a new module for calculation of extruded shells and butt welded nozzles according to EN13445-3 Section 9.5.

- The calculation for saddle stresses in the web plate due to the splitting force was modified to always include the area of the wrapper plate. Previously the area of the wrapper plate was only included when the conditions in EN13445-3 section 16.8.8 for using a reinforcement plate was met. Furthermore the allowable stress limit for bending stresses due to axial loading was increased from 1.0*f to 1.5*f, due to the stress classification (bending stresses caused by external loading).



- The skirt openings module has been improved and made more flexible, any number of reinforced or un-reinforced openings can now be accommodated. The skirt strength calculation is now performed at all weakened sections in addition to the bottom of the skirt where the largest moment occurs. The moment is adjusted according to the elevation of the weakened section.

- The external loads module has been made more flexible and can now accommodate almost any type of vessel geometry. Below is an example for a vertical vessel with two bolted on horizontal vessels, and an example of a horizontal vessel that includes a vertical shell and tube heat exchanger. The vessels are subjected to wind loads and seismic loading. The VVD software will automatically calculate the wind load, based on the total calculated projected area of all components. Similar for the seismic loading, the weight and centre of gravity of all individual components are included in the seismic analysis.



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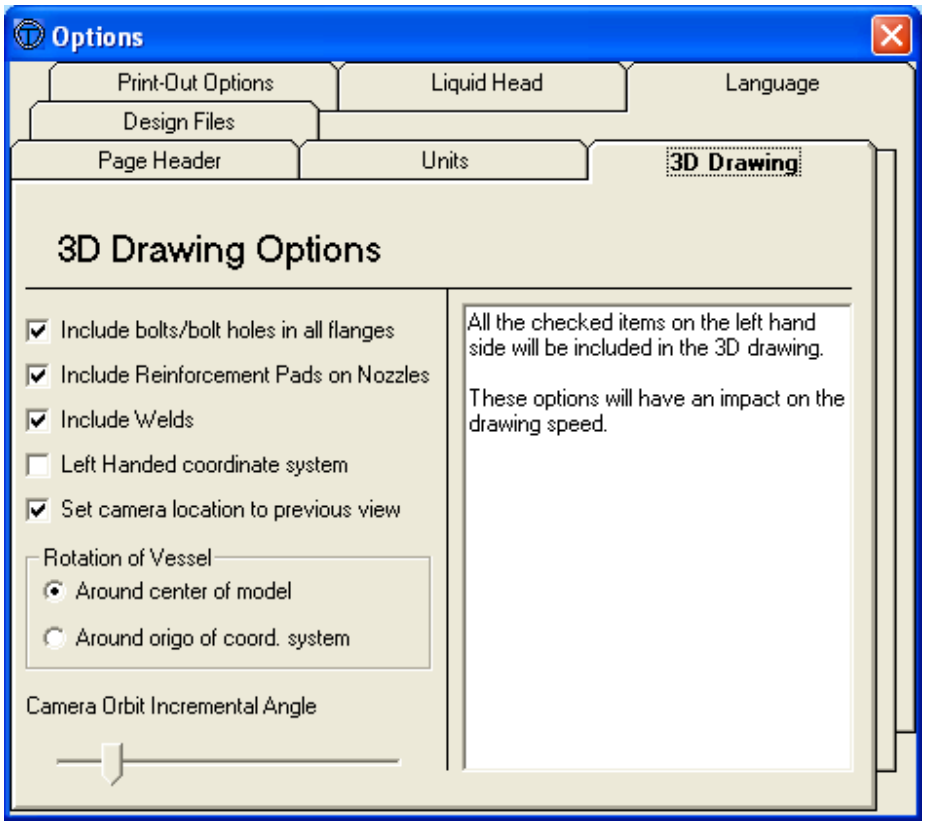
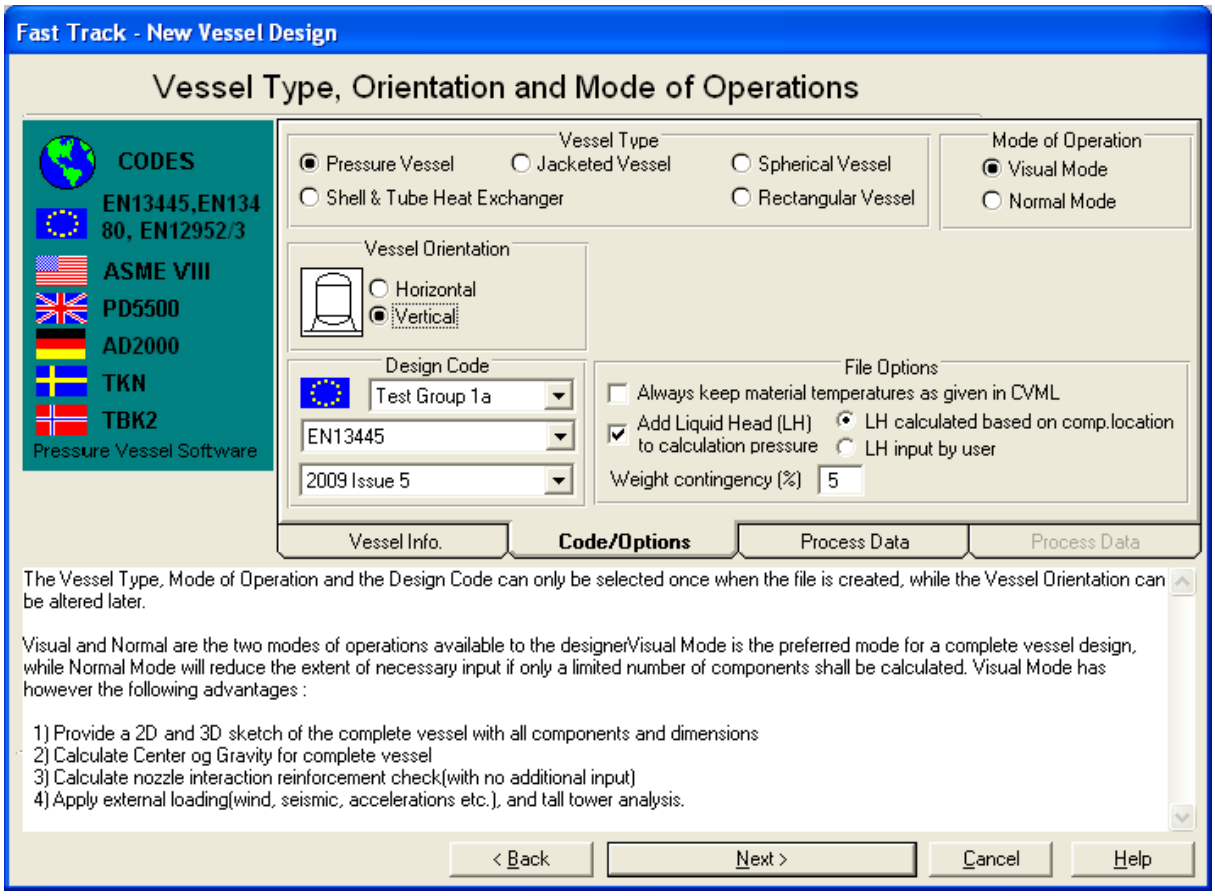
Version 14.02 (Service Pack 2)

A new option has been included for the ASME VIII Div. 1 module to allow nozzle loading to be applied to nozzles that has been designed to Appendix 1-10 instead, previous this option was only available for nozzle designs to UG-37/Appendix 1-7.

A new option in the 3D Drawing options has been included to enable the camera position to revert to the same location as previous view. If the end user zooms in on any parts, makes a modification, the re-drawn vessel will be shown in the same view as previously drawn.



The Liquid Head option has now become part of the VVD file to ensure that the same values for liquid head are applied for the vessel, even if the VVD file is run on a different PC. Previously the Liquid Head option was part of the set-up on each individual PC.



For multi-compartment vessels that uses two or more different design/calculation temperatures the material properties shown in the report section would in some cases show material properties at only a single temperature. This had no impact on the calculation results, however a new option has now been included to freeze the temperatures as specified originally.

A problem could occur with calculation of factor C1 for **welded flat ends** in EN13445-3 section 10, in some cases giving a non-conservative result. This problem was first introduced in version 14.0 and was also included in version 14.01, but has now been resolved.

Corrected a problem related to a single group of nozzles located in dished ends according to ASME VIII Div.1 section UG-42. For a single nozzle group the calculation could in some cases become over-conservative, this problem has now been corrected.

A new option has been included to allow the user to specify the thinning in % (when using a pipe as shell component) instead of mm when designing cylindrical shells.

In some cases the utilization graph was included in the report without left margins, this has now been corrected.

Corrected a problem related to the nozzle list in the report section that could in some cases show a standard flange attachment, even if the nozzle was designed without a standard flange.

Sometime when calculating a welded flat plate according to EN13445, and selecting ‘Stayed Flat Plate to section 20.2’, this option could in some cases be turned off if all components was later re-calculated.

When the nozzle is connected to the nozzle neck of another nozzle, after all components was re-calculated the nozzle could in some cases be re-attached to a different nozzle. If the original attachment was nozzle N.11, after recalculation of all element this nozzle could be re-attached to nozzle N.1. This problem has now been corrected.

Corrected a problem related to page numbering in the report, sometimes two consecutive pages could be given the same page number.

Corrected a problem related to user specified comments in the print-out, sometime the printed text could be repeated.

Corrected a problem when exporting 2D drawings in dxf file format to AutoCAD, an error could show up related to the drawing header and aborting opening of the file.

==========

Version 14.01 (Service Pack 1)

A new option has been included for the ASME VIII Div. 1 module to allow nozzle design to Appendix 1-10 instead of UG-37/Appendix 1-7.

Sketches of all Optional-Type Flanges to Figure 2-4 in ASME VIII Div. 1 Appendix 2 has now been included in the flange calculation module.

Corrected a problem with some of the allowable stress values from ASME II Table 3 bolting material for the 2013 edition, tensile stress and yield stress was however always correct.

Corrected a problem with regards to the AD2000 module related to the classic AD2000 approach for materials in temperature range between 100 to 120 ‘C. For some materials selected from the EN material database the allowable stress could become smaller than allowed by standard resulting in an over conservative design.

Corrected an incorrect warning message related to EN13445 Section 18, detailed analysis of fatigue for unwelded components with a thickness less than 25 mm.

Increased maximum number of permutations for groups of nozzles from 400 to 2000.

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Version 14.0 – (January 2014) Updates to latest code amendment

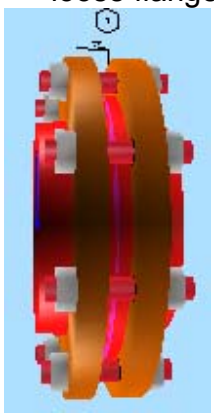
Version 14.0 includes a number of improvements and additions. This version is also in compliance with:

- EN13445:2009 Issue 5
- EN 1591-1:2001+A1:2009/AC:2010
- ASME VIII : 2013 Edition
- ASME II Part D : 2013 Edition
- PD5500:2012+A2:2013

Version 14.0 – General

The new module for flange calculations to EN1591-1:2001+A1:2009/AC:2010 includes many new features:

- Any number of load cases can be included
- Each load case can be given different calculation temperature
- Each load case can be given different external loads, including shear forces and torsional moment
- Each load case can be given different thermal expansion coefficients
- 3D flange drawing significantly improved, it now includes the gasket, bolts & nuts, loose flange and collar.



Several hundred hours have been spent in the verification process of this new module. The module have been subjected to a verification against results from other software packages, Excel spreadsheets and Mathcad applications. A large range of different flange design cases has been investigated in the verification process. Two different Notified Bodies have participated in this verification process.

EN13445 Issue 5 includes a relaxation of restrictions for use of test group TG4, increasing the applicability of TG4. The thickness and temperatures limits have been increased.

EN13445 Issue 5 includes a significant reduction in the extent of NDT requirement, resulting in reduced manufacturing costs. Please find below a copy of EN13445-5 Table 6.6.2.1 with changes shown in red ink, the 'new' values has a red underscore and the 'old' values are shown in the brackets():

EN 13445-5:2009 (E)
Issue 5 (2013-07)

NEW (OLD)

Table 6.6.2-1 — Extent of non-destructive testing

TYPE OF WELD [a, p]			TESTING [b]	EXTENT FOR TESTING GROUP [o]					
				1a	1b	2a [i]	2b [i]	3a	3b
				EXTENT FOR PARENT MATERIALS [l,m,n]					
				1 to 10	1.1, 1.2, 8.1	8.2, 9.1, 9.2, 9.3, 10	1.1, 1.2 8.1	8.2, 9.1, 9.2, 10	1.1, 1.2, 8.1
Full penetration butt weld	1	Longitudinal joints	RT or UT MT or PT	100 % 10 %	100 % 10 % [d]	(100-10) % 10 %	(100-10) % 0 (10)	25 % 0 (10)	10 % 0 (10)
	2a	Circumferential joints on a shell, including circumferential joints between a shell and a non-hemispherical head	RT or UT MT or PT	25 % (100) 10 %	10 % (25) 10 % [d]	(25 -10) % (100) 10 %	(10 - 5) % 0 (25)	10 % 0 (10)	5 % [c] (10) 0 (10)
	2b	Circumferential joints on a shell, including circumferential joints between a shell and a non-hemispherical head, with backing strip [k]	RT or UT MT or PT	NP NP	NA (100) 100 %	NP NP	NA 100 %	NP NP	NA (25) 100 % (10)
	2c	Circumferential joggle joint, including circumferential joints between a shell and a non-hemispherical head [k]	RT or UT MT or PT	NP NP	NA (100) 100 %	NP NP (100)	NA 100 %	NP NP	NA (25) 100 % (10)
	3a	Circumferential joints on a nozzle d_i > 150 mm and e > 16 mm	RT or UT MT or PT	25 % (100) 10 %	10 % (25) 10 % [d]	(25 -10) % 10 %	(10 - 5) % 10 % [d]	10 % 10 %	5 % [c] (10) 10 % [d]
	3b	Circumferential joints on a nozzle d_i > 150 mm and e > 16 mm with backing strip [k]	RT or UT MT or PT	NP NP	NA (100) 100 %	NP NP	NA 10 %	NA 100 %	NA (25) 100 % (10)
	4	Circumferential joints on a nozzle $d_i \leq 150$ mm or $e \leq 16$ mm	RT or UT MT or PT	0 % 25 % (100)	0 % 10 %	0 % (100) (25 -10) %	0 % (10 – 5) %	0 % 10 %	0 % 5 % (10)
	5	All welds in spheres, heads and hemispherical heads to shells	RT or UT MT or PT	100 % 10 %	100 % 10% [d]	(100-10) % 10 %	(100-10) % 0	25 % 0 (10)	10 % 0
	6	Assembly of a conical shell with a cylindrical shell without a knuckle (large end of the cone) [q, r]	RT or UT MT or PT	100 % 100 %	25 % 100 %	(100-10) % 100 %	(25-10) % 100 %	10 % 100 %	10 % 100 %
	7	Assembly of a conical shell with a cylindrical shell without a knuckle (small end of the cone)	RT or UT MT or PT	100 % 10 %	25 % 10 % [d]	(100-10) % 10 %	(25-10) % 10 % [d]	10 % 10 %	10 % 10 % [d]
Circumferential lapped joints [k]	8a	General application shell to head	RT or UT MT or PT	NP NP	NP NP	NP NP	NP NP	NP NP	NP NP
	8b	Bellows to shell $e \leq 8$ mm	RT or UT MT or PT	0 % 100 %	0 % 100 %	0 % 100 %	0 % 25 %	0 % 25 %	0 % 10 %

Table 6.6.2-1 *(continued)*

TYPE OF WELD [a, p]			TESTING [b]	EXTENT FOR TESTING GROUP [o]					
				1a	1b	2a [i]	2b [i]	3a	3b
				EXTENT FOR PARENT MATERIALS [l,m,n]					
				1 to 10	1.1, 1.2, 8.1	8.2, 9.1, 9.2, 9.3, 10	1.1, 1.2 8.1	8.2, 9.1, 9.2, 10	1.1, 1.2, 8.1
Assembly of a flat head or a tubesheet, with a cylindrical shell Assembly of a flange or a collar with a shell	9	With full penetration	RT or UT MT or PT	25 % 10 %	10 % 10 % [d]	(25 - 10) % 10 %	(10 - 5) % 10 % [d]	10 % 10 %	5 % 10 % [d]
	10	With partial penetration if $a > 16$ mm (a as defined in figure 6.6.2-1) [j]	RT or UT MT or PT	NP NP	NA 100 %	NA 100 %	NA 100 %	NA 100 %	NA 10 %
	11	With partial penetration if $a \leq 16$ mm (a as defined in figure 6.6.2-1) [j]	RT or UT MT or PT	NP NP	NA 100 %	NA 100 %	NA 100 %	NA 10 %	NA 10 %
Assembly of a flange or a collar with a nozzle	12	With full penetration	RT or UT MT or PT	25 % 10 %	10 % 10 % [d]	(25 - 10) % 10 %	(10 - 5) % 10 % [d]	10 % 10 %	5 % 10 % [d]
	13	With partial penetration [j]	RT or UT MT or PT	NP NP	NA 100 %	NA 100 %	NA 10 %	NA 100 %	NA 10 %
	14	With full or partial penetration $d_i \leq 150$ mm and $e \leq 16$ mm [j]	RT or UT MT or PT	0 % 10 %	0 % 10 % [d]	0 % 10 %	0 % 10 % [d]	0 % 10 %	0 % 10 %
Nozzle or branch [e]	15	With full penetration $d_i > 150$ mm and $e > 16$ mm	RT or UT MT or PT	25 % 10 %	10 % 10 % [d]	(25 - 10) % 10 %	(10 - 5) % 10 % [d]	10 % 10 %	5 % 10 % [d]
	16	With full penetration $d_i \leq 150$ mm or $e \leq 16$ mm.	RT or UT MT or PT	0 % 100 %	0 % 10 %	0 % (100-10) %	0 % 10 %	0 % 10 %	0 % 10 %
	17	with partial penetration for any d_i $a > 16$ mm (see figure 6.6.2-2)	RT or UT MT or PT [i]	NA 100%	NA 10 %	NA (100-10) %	NA 10 % [d]	NA 10 %	NA 10 % [d]
	18	with partial penetration $d_i > 150$ mm. $a \leq 16$ mm.(see figure 6.6.2-2)	RT or UT MT or PT [i]	NP NP	NP NP	NP NP	NP NP	0 10 %	0 10 %
	19	With partial penetration $d_i \leq 150$ mm. $a \leq 16$ mm.(see figure 6.6.2-2)	RT or UT MT or PT [i]	0 % 100 %	0 % 10 %	0 % (100-10) %	0 % 10 %	0 % 10 %	0 % 10 %
	19i	With reinforcing plate	MT or PT	25 %	10 %	10 %	10 %	10 %	5 %
	19j	Weld joint in reinforcing plate [s]	RT or UT MT or PT	100 % 100 %	100 % 10 %	(100-10) % 10 % [d]	(100-10) % 10 %	25 % 0	10 % 0
Tube ends into tubesheet	20		MT or PT	100 %	100 %	100 %	100 %	25 %	10 %
Permanent attachments [f]	21	With full penetration or partial penetration	MT or PT	10 %	10 %	100 %	10 %	10 %	10 % [d]

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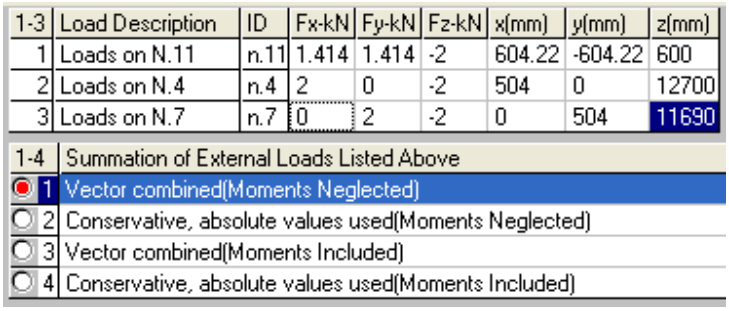
Version 13.2 – General

- The fatigue analysis can now also include the effect from mechanical loading in addition to pressure cycles. If a nozzle load calculation has been performed for the nozzle, suggestive values for the stress range will be suggested when adding these mechanical loads to the fatigue analysis. An option is also included to allow the cycles from pressure loading coincide with the cycles from pressure loading.
- Added a new module for detailed analysis of fatigue to section 18 of EN13445, covering both welded and un-welded components.
- When calculating the flange extension of a tubesheet, the required input data can now be automatically retrieved from the mating flange.
- Seismic loading to EUROCODE 8 can now be applied to horizontal vessels on saddle support.
- Added a new module for seismic loading to ASCE 7.
- Added a new option for seismic loading on vessel located inside building/structures, the user has to select location of vessel if it is ground supported or building/structure mounted.
- Added a new option for wind loading to EN 1991-1-4 for calculation of the structural factor cscd according to Annex C, procedure 2 as this method may be alternatively used by some national annexes.
- Added new options for adding external loads to vessels. The user may select any

of the four alternatives below:



1-3	Load Description	ID	Fx-kN	Fy-kN	Fz-kN	x(mm)	y(mm)	z(mm)
1	Loads on N.11	n.11	1.414	1.414	-2	604.22	-604.22	600
2	Loads on N.4	n.4	2	0	-2	504	0	12700
3	Loads on N.7	n.7	0	2	-2	0	504	11690

1-4	Summation of External Loads Listed Above
1	Vector combined(Moments Neglected)
2	Conservative, absolute values used(Moments Neglected)
3	Vector combined(Moments Included)
4	Conservative, absolute values used(Moments Included)

The summations of absolute values ensures a conservative design, while vector combination is the recommended method in section 16 of the EN13445 standard. The inclusion of external moments from nozzles may according to standard in most cases be neglected, however in some special cases when the nozzle diameter is large compared to the shell diameter it can be included.

- The buckling calculation for vertical vessels supported by legs have now been modified so that a buckling analysis is performed for all legs and all load cases. Previously this analysis was only performed using conservative load values, resulting in some cases in a over-conservative design. The results are however still conservative as in the EUROCODE EN 1993-1 fY is the yield point, but in the VVD calculations fY is taken as the nominal design stress since no partial load factor has been included.
- A standard flange ASME B16.5, DIN or EN1092-1 can now be attached to all relevant components without performing detailed calculations. Previously this was only possible for attachment to nozzles.
- Corrected a problem with regards to movement of the ref. datum line for tall vertical vessels. In some cases the ref. datum line would move without operator instructions, this problem has now been corrected. The command Set/Move Ref. Datum Line, to move the datum line along the z-axis has also been improved.
- Corrected a problem with regards to material temperature changes of multi-chamber vessels. When changing the temperature in the process card and requesting an update of the related material properties, the software could in some cases also update materials not belonging to the selected process card, this problem has now been corrected.

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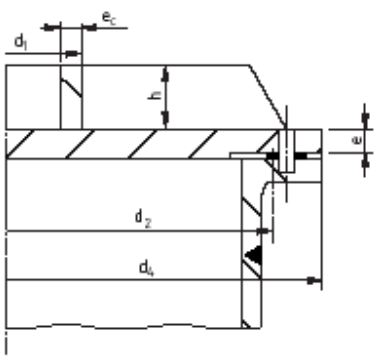
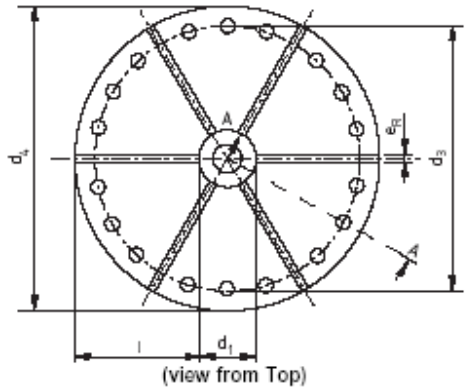
Version 13.1 – General

- Added calculation of circular flat ends with radial reinforcement ribs to EN13445 section 21. This section applies to both bolted and welded ends.



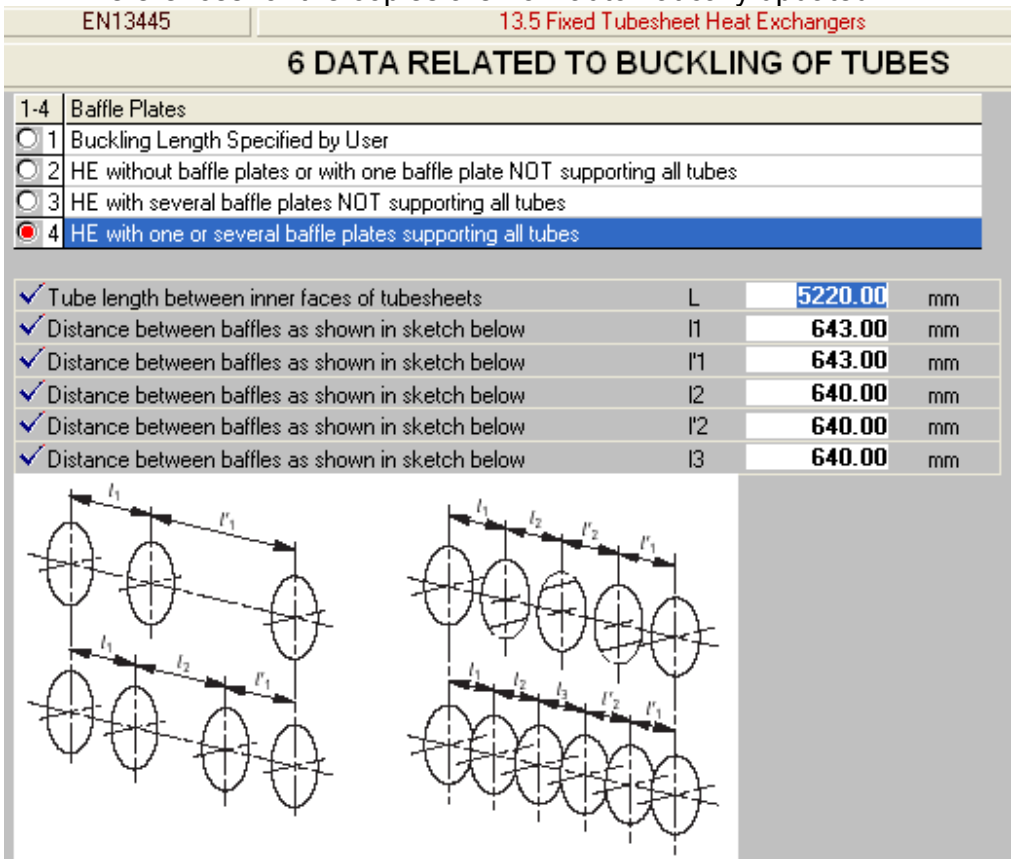
(section AA)



(view from Top)

- Added a new feature for fatigue analysis of multiple chamber vessels, the selection of components can now be related to the connected process card.
- Added a new option to apply the fatigue analysis method in EN13445 section 17 to vessels/components designed with the ASME VIII Div.1 module. By using the method given in EN13445 section 17, the maximum number of cycles can be determined for all components.
- Added deflection check of covers to TEMA RCB-9-21 for multipass units.
- Corrected a problem for calculation of untubed area in the tube layout module, in case of multi pass layout and switching to a single pass layout the untubed area could sometimes remain non zero from the multi pass calculation.
- Included a new option to exclude the use of section 10.4.4.4 for calculation of welded flat ends in case the end user do not want to include an analysis of fatigue to section 17.
- Added calculation of deformation to EN13445-4 section 9.2, and check of cold forming deformation limits to Table 9.4-1.
- When calculating openings/nozzles located in rectangular vessels the user may now specify the value for the ligament efficiency manually.
- The module for fatigue analysis has been modified so that it will automatically update the component list if any of the input parameters in this table has changed, i.e. thickness, Pmax, f etc. Suggestive values for Etta for piping bends are now taken from Table 10.3.2-5 in EN13480.
- The material database has been expanded and updated.
- Added a new option to accommodate a local reduction of thickness in the periphery of the tubesheet for a gasket/relief groove to EN13445 section 13.5.2.1 b) and 13.6.2.1 c).
- The volume for jacketed vessels could in some cases become overestimated, resulting in too conservative loads on the vessel support. This problem has been corrected, however when defining a new model the type of vessel to be selected needs to be ‘Jacketed Vessel’ in order to avoid this problem.
- The command for moving the ref. datum line has been improved. However keep in mind that some parameters may need to be altered manually, like the liquid level in the process card(s).
- When applying skew/side loads on a lifting lug, the additional stresses in the pad and shell are now checked in addition to the stresses at the foot of the lifting lug.

- It is no longer possible to delete the main component(parent) if other components are copies of this component. In case the main component is re-named all references for the copies are now automatically updated.



A new option to calculate the value for buckling length according to equations 13.9.3-1 and 13.9.3-2 has now been included.

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Version 13.0 – (January 2013) Updates to latest code amendment

Version 13.0 includes a number of improvements and additions. This version is also in compliance with:

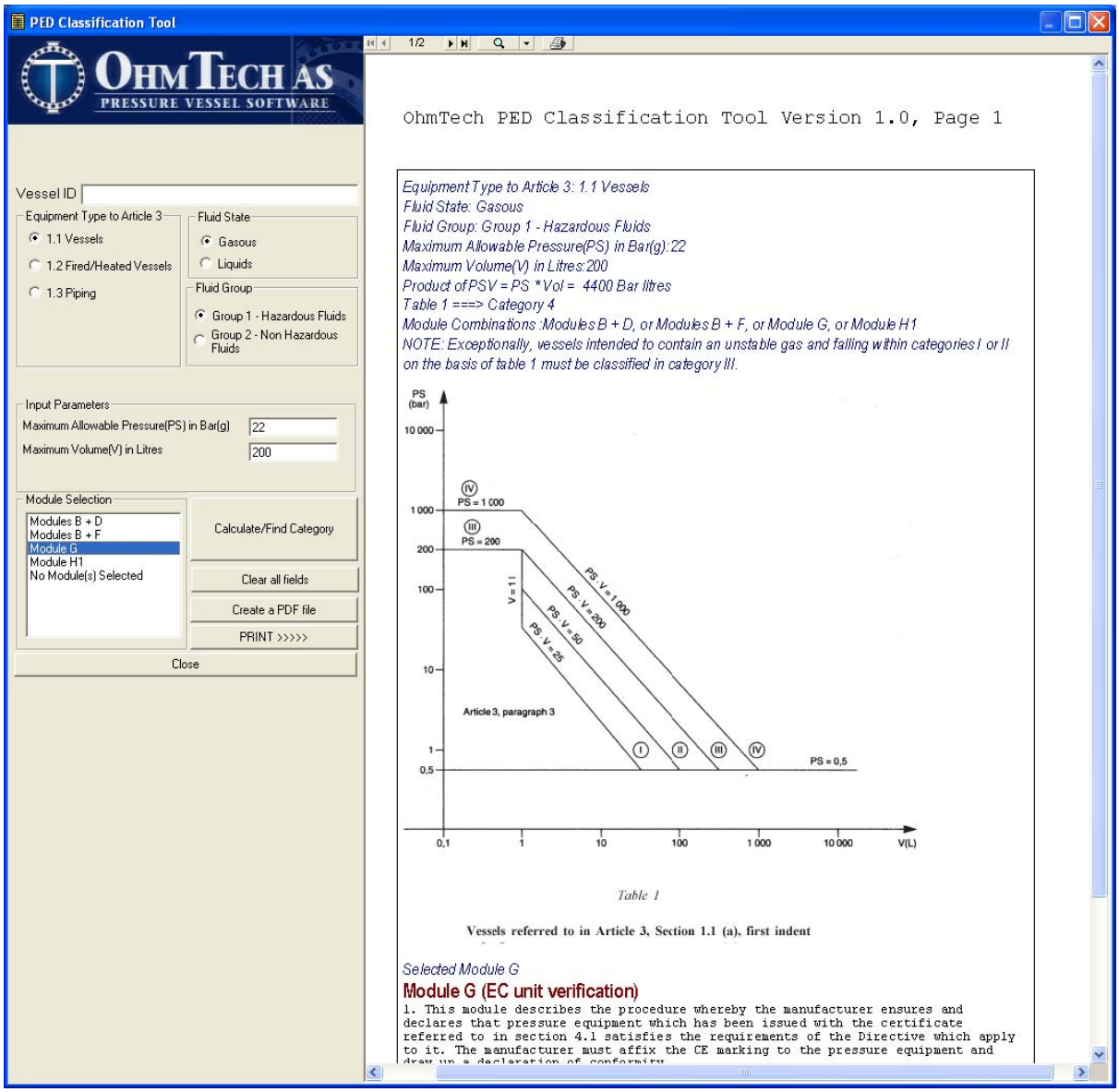
- EN13445:2009 Issue 4
- PD5500:2012+A1:2012

Version 13.0 – General

- Newsflash - Direct communication with end users. Newsflash is a new functionality that allows a direct communication with end users. Information can very quickly be transmitted to the end user. Newsflash will automatically update after a few days as long as the PC is kept online. This information channel will be used to better inform the end users of new modules available, new features,

discovered/solved problems, changes to standards, testing of new modules, available courses and so on. This new feature will greatly enhance the communicating with the end users.

- VVD Version 13.0 is compatible with Microsoft Windows 8.
- For external loads on nozzles, a new method has been added for calculation of stresses in nozzle neck to accommodate all external loads including shear forces and torsional moment. Design method has been based on PD5500 Annex B.
- Improved the 3D drawing module
- The module for calculation of expansion bellows now can handle half a convolutions, so that the cylindrical shells on either side of the bellow can have different diameters.
- The module for calculation of rectangular vessels to EN13445 Section 15 and ASME VIII Div.1 Appendix 13 is no longer is test status.
- Added TEMA Table R-4.41 for minimum thickness of baffle/support plates.
- Updated the material libraries. Added a new column for minimum material thickness for the EN-material library according to Table E.2-1 in EN13445-2:2009 issue 4. For some EN-materials, the material properties for thicknesses between 150 mm to 250 mm was not yet included, these have now been added.



- A new tool has been added for PED classification of vessels. Based on fluid type, pressure and volume the applicable PED category is determined and a report can be generated. The applicable module combinations will also be displayed and when selecting a module/module combination all relevant requirements will be included in the report.

The external loads module have been rebuild and significantly enhanced:

- Any type of vessel, no limit on geometry, is now supported by the external load module. The external loads module can now be used on all the different support types, including skirt support, bracket support, ring support and leg support (legs welded to bottom head or in cylindrical shell). In case of a vessel where loads will be transferred thru nozzles, the required nozzle loads will be determined.
- Added seismic load calculation to EUROCODE 8 / EN1998-1, the horizontal elastic response spectrum is generated based on values for TB, TC and TD. TB

and TC are the lower and upper limit of the period of the constant spectral acceleration, while TD is the value defining the beginning of the constant displacement response range of the spectrum. A library has also been included with values for all required input parameters.

Comment	Seismic response spectrum for BASF in Ludwigshafen Ground Type BASF - LU		
Design ground acceleration	ag	0.4000	m/s2
Lower limit of the period of the constant spectral acc.	TB	0.1000	s
Upper limit of the period of the constant spectral acc.	TC	0.5000	s
Value defining the beginning of the constant displ.range	TD	2.00	s
Soil/ground factor	S	0.7500	
Damping correction factor(beta0=2.5 for 5% viscous damping)	Beta0	2.50	
Behavior factor(q=1.5 for steeel structures in ductility class 1)	q	1.50	
Criticality factor(gamma=1.0 to 1.6 depending on impact and fluids)	gamm	1.00	
Vertical spectral response in percent of horizontal	vs	70.00	%

……

- Openings in the skirt are now checked according to the new EN rules, and a complete analysis is performed for all specified openings. Openings of non circular shape can also be included. The reinforcement of the opening can also be specified and checked. The moment of inertia is calculated along the complete length of the skirt and the report will show the location of all weakening spots and the strength reduction. There is no limit to the number of openings that can be included in the analysis. For more information regarding this method, reference is made to the relevant sections in the VVD Code Assistant. The printout includes a table listing all weak points of the skirt as shown below.

WEAK AREAS IN SKIRT DUE TO OPENINGS

Z-Loc.(mm)	Skirt Mean D(mm)	Area A4(mm2)	Sect.Mod.W4(mm3)	eps(mm)	No.Open.	psi1	psi2
-848	2050	112347	46817984	118.06	2	0.872	0.716
-435	2050	118072	59927004	0.000	6	0.917	0.917

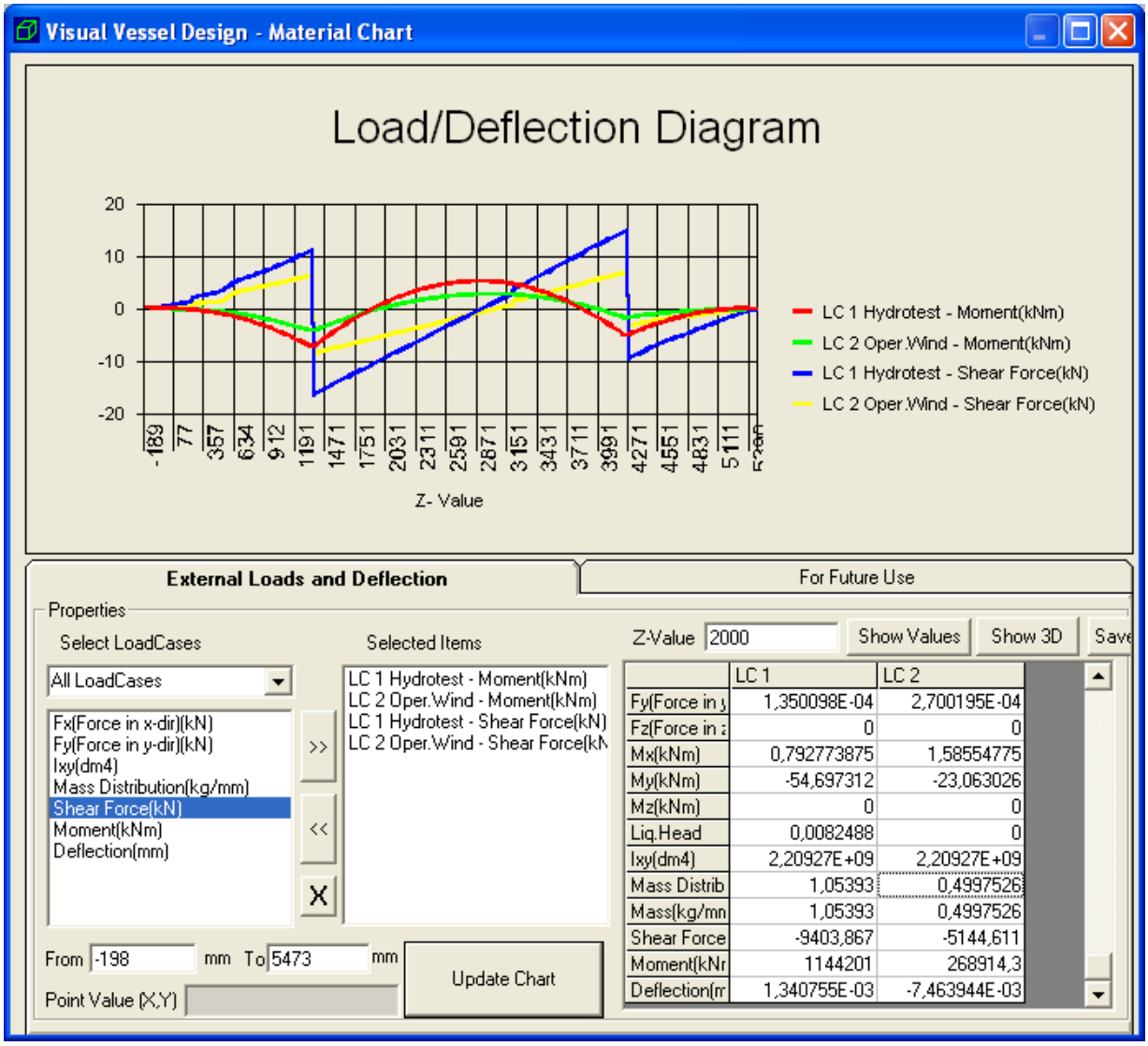
psi1 = area reduction of skirt = actual area / area of unpierced skirt.
psi2 = section modulus reduction of skirt = actual value/value of unpierced skirt.

Note: Skirt is pierced and has the maximum weakening at z= -848mm

- New module for Tall Tower Analysis. This new module allows the user to apply a global load analysis of all vessel geometries, on any type of support.
- The required torque of the anchor bolts will now be calculated for vertical vessels on skirt support, the user may however specify any value for the bolt assembly factor.
- Safety factors for the anchor bolts are now taken from the new equation 22.8-1 in EN13445, using a safety factor of 1.65 against yield at calculation temperature of the anchor bolts, and 2.0625 against tensile stress at 20 ‘C. The user may specify a different calculation temperature for the anchor bolts.
- A new option has been included so the calculation temperature for the base of the skirt can now be specified by user, and set to a different temperature than the

design temperature of the vessel.

- A new option has been included to allow the user to select different materials for the lower part and upper part of the skirt.
- The calculation of exposed area is now uniquely defined in section 22 of EN13445, for all components, including body, skirt, platforms, ladders, external piping etc. The drag/force coefficients have also been defined for all these components.
- The external load module for i.e. wind and seismic loads to UBC or Eurocode can now be applied to all the different types of support available in the software, not only limited to skirt support.
- Platforms can now also be located on top of the vessel.
- Live/traffic loads on platforms can now be included in the external load analysis, EN13445 recommends a uniformly distributed loads of 2.5 kN/m2 to be used. If more than two platforms exist, the traffic loads only on the three largest platforms have to be considered.
- The force/drag coefficient can now be specified separately for all user specified components, default values are as suggested in the EN13445 standard.
- The anchor bolt calculation for vessels supported on legs have now been corrected as previous design was over-conservative.
- Foundation loads can now be included in the report for all type of vessel supports.
- The module for detailed load analysis of external loads can now also be used for vessels with legs attached to the end/head of the vessel.
- The external loads plot function is significantly improved and can be used as a tool to verify the applied external loadings on the vessel. It is possible to plot the deflection, forces, moments, shear forces, mass distribution and stresses in the vessel along the z-axis for all the individual load cases.



The plot above is related to the sample file Steam Generator, a vessel located on saddle supports, where the load distribution is asymmetrical. Shown are the shear forces and moments for the two load conditions Hydrotest and Operating Wind. It is also possible to display the results at any z-value along the length of the vessel, above is the value displayed at z = 2000 mm.

- External loads from nozzles can now be retrieved automatically in the external load module. The combination of nozzle loads can be performed conservatively.
- Components can now be located outside the boundaries on the z-axis, i.e. a platform can be located on top of the vessel.
- Added a new module for calculation of natural frequency of complete vessel for all load cases. The natural frequency can now be calculated for all vertical vessels, not only those supported by skirts as in previous versions. To enable calculation of natural frequency with high accuracy the mass distribution needs to

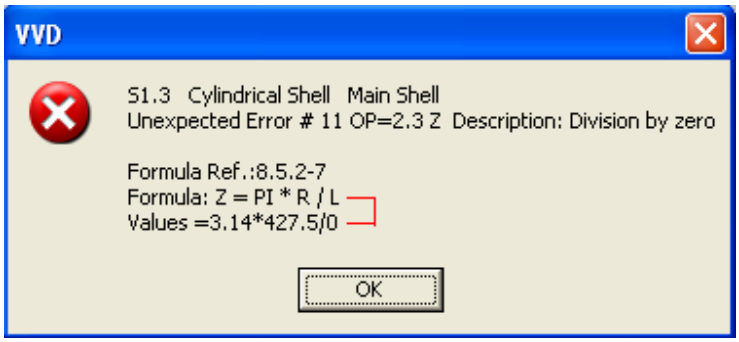
be specified in detail by the end user. For non-pressurized parts please add ‘User Specified Components’ (U) to define additional weight, live loads, projected surface area etc. A number of pre-defined user specified components are available, including platforms, ladders, insulation, lining, trays, packing box, and external pipes.

Natural Frequency of Vessel

The natural frequency of vibration is based on Rayleighs method of approximation:
T = 2*pi*Sqr(Sum(Wi*yi^2)/(g*Sum(Wi*yi))); where
Wi is the weight of the i th. element and yi is the deflection of this element.

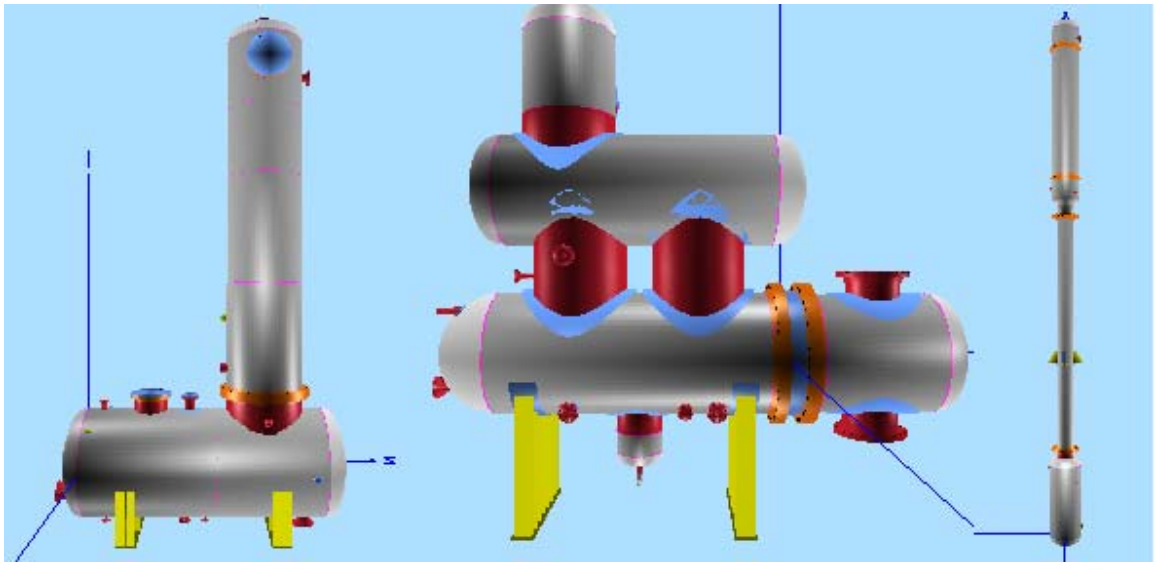
LOAD CASE	Fundamental Period(s)	Natural Frequency(Hz)
LOAD CASE NO: 1 - HYDROTEST	0.0195 s	51.16 Hz
LOAD CASE NO: 2 - ERECTION	0.0109 s	91.56 Hz
LOAD CASE NO: 3 - OPER.WIND	0.0198 s	50.56 Hz

- Added a new option so that the user may connect a conical shell directly to the nozzle pipe.
- PD5500: Figures 3.9-3 to 3.9-10 applicable for floating tubesheets have all been re-digitised.
- The error handler has been improved, and should be able to provide valuable feedback to the end user with regards to the cause of the error/problem. Below is an example of a of cylindrical shell subjected to external pressure, the value for the unsupported length L was incorrectly set to zero by the end user. In this case a division by zero is encountered for the calculation of parameter Z, a reference to formula in standard is provided and the formula along with the values is displayed.



- Corrected some functionality problems i.e.:
  - Sometimes a warning could be incorrectly displayed when using the ASME module with temperatures above 343 ‘C.
  - In some cases the drawing of expansion bellows was incorrect/missing
  - In some cases the reinforcement pads was drawn incorrect.
  - The error handler could sometimes go into a loop when division by zero was encountered.

- Almost any odd shaped vessel can be designed using the VVD software.



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