

## Product Overview

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# PVE5

Pressure Vessel Engineering  
&  
Heat Exchanger Design

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***Whessoe Technology Centre, Darlington***

## WHESSOEVER COMPUTING SYSTEMS

The name Whessoe is recognised throughout the world for quality and excellence in engineering and manufacturing. An international engineering design, manufacturing, installation and service company, Whessoe celebrated 200 years of operation in 1990, its current focus being high integrity structures with particular emphasis on LNG, Ethylene and LPG storage tanks and handling systems.

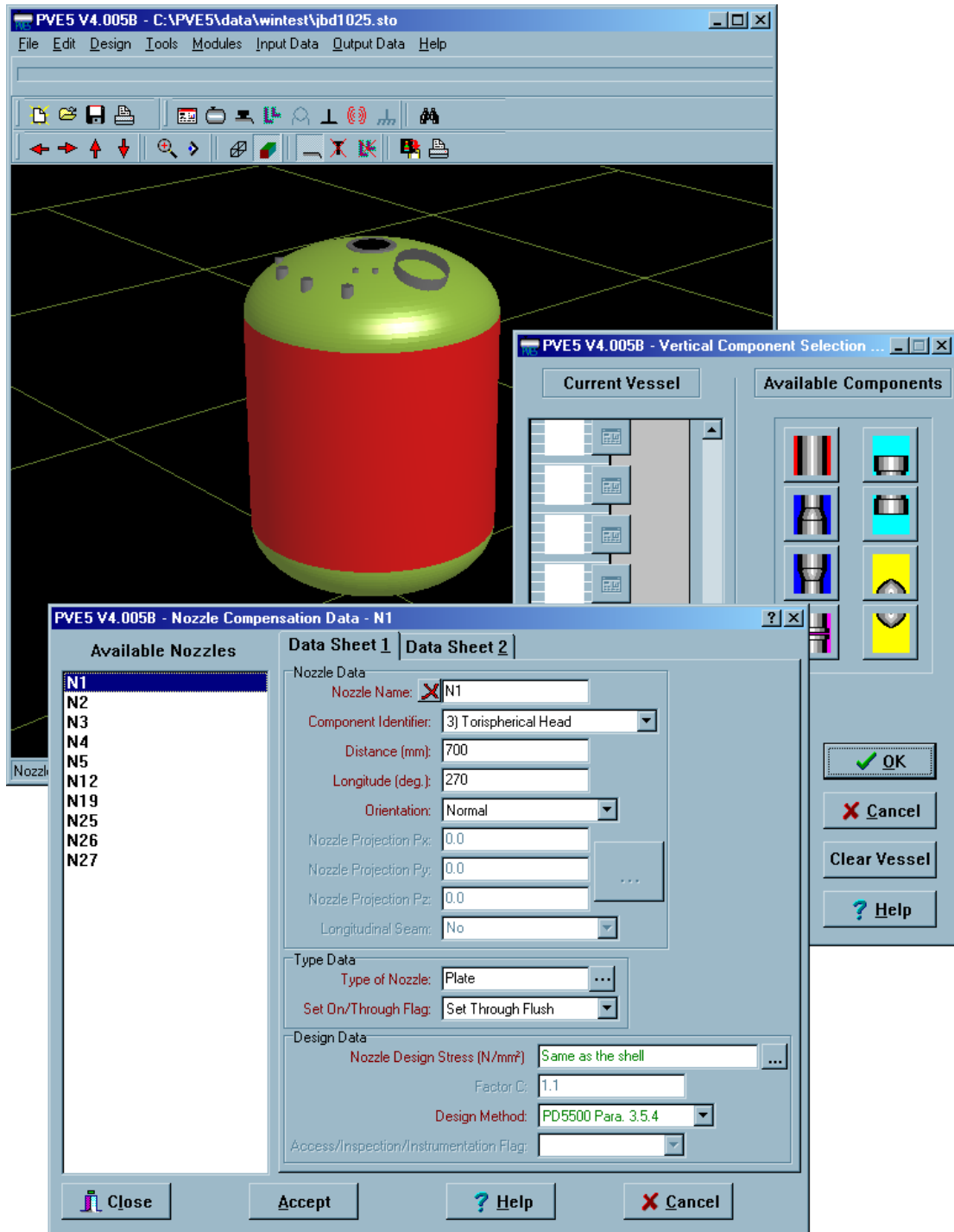
Whessoe Computing Systems was established in the 1960's, to provide high quality software solutions and services to satisfy demanding and exacting standards. In achieving these objectives Whessoe Computing Systems has acquired a uniqueness within the industry in terms of standards of professionalism, depth of knowledge and breadth of experience.

Today's products and services, in addition to Pressure Vessel Design, include:

### **PSA5 – Pipe Stress Analysis Software and Training Piping & Plant Design Consultancy**

All products and services are supplied on a world-wide basis with the benefit of a dedicated back-up and support service.

Whessoe Computing Systems is now a division of Whessoe Projects Limited. With its engineering pedigree dating back to 1790, Whessoe Projects has developed its technical excellence by working for the oil and gas, refining, petrochemical, nuclear, water, power and offshore industries. Whessoe's main focus is now the storage and handling of liquid gases in both refrigerated and pressurised form.



## *PVE5 Pressure Vessel Engineering*

## PVE5

PVE5 embodies the experience of the Whessoe Group in designing pressure vessels since the turn of the century and more recently the reactor vessels for the UK power generation programme. This experience has been used to design a package that delivers the following benefits over hand calculations:-

**Saves Time** - typically greater than 90% saving on the time taken to carry out the equivalent hand calculations. Results are presented in a format suitable for direct presentation to client or insurance authority and PVE5 is recognised and accepted by all leading insurance companies and certifying authorities.

**Improves Accuracy** - computer programs, unlike humans, perform calculations in a consistent manner and, once validated, produce consistently accurate results. This consistency also avoids the omission of additional checks required by design codes, easily omitted when carrying out hand calculations, particularly when incorporating design changes.

**Allows Design Optimisation** - the speed with which the effect of design changes can be assessed using PVE5, allows the designer to try several design iterations and minimise material costs.

PVE5 performs design and compliance calculations in accordance with

- PD5500
- ASME VIII Div. 1, or
- BS EN13445-3

A database of material stresses for PD5500 and ASME VIII Div. 1 is provided as an integral part of the package and a dedicated team of software and vessel engineers supports its users.

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| PVE5 4.004B 9999/05 Job:      TC02 17/06/2004 PD 5500      Page C2
| ENQ/ORDER: TC02                                     Revision: 0
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DESIGN OF SADDLE SUPPORTS  
 =====

NOTE :- ALL STRESS VALUES ARE EXPRESSED IN N/mm2

	WITH PRESSURE				NO PRESSURE				ALLOW. STRESS fm
	HIGHEST POINT f1	S.INT.	LOWEST POINT f2	S.INT.	HIGHEST POINT f1	S.INT.	LOWEST POINT f2	S.INT.	
OPERATING	12.7	18.9	20.7	20.8	-3.2	3.2	4.9	4.9	102.2
TEST	30.5	36.5	38.5	38.8	-3.2	3.2	4.9	4.9	222.3

THE STRESS INTENSITIES AT MID-SPAN (based on f1 & f2) ARE SATISFACTORY

COMPRESSIVE STRESSES AT MID-SPAN ARE SATISFACTORY  
 (based on limits of 17.7 (operating) and 97.5 (test))

	WITH PRESSURE				NO PRESSURE				ALLOW. STRESS fm
	HIGHEST POINT f3	S.INT.	LOWEST POINT f4	S.INT.	HIGHEST POINT f3	S.INT.	LOWEST POINT f4	S.INT.	
OPERATING	17.1	17.2	16.3	18.6	1.2	1.2	0.5	2.9	102.2
TEST	34.9	35.2	34.1	36.2	1.2	1.2	0.5	2.9	222.3

THE STRESS INTENSITIES AT SUPPORTS (based on f3 & f4) ARE SATISFACTORY

COMPRESSIVE STRESSES AT SUPPORTS ARE SATISFACTORY  
 (based on 17.7 (operating) and 97.5 (test))

STRESSES	OPERATING		TEST	
	WITH PRESSURE RESULT	ALLOW	WITH PRESSURE RESULT	ALLOW
IN THE SHELL	11.7	81.8	11.7	110.9

TANGENTIAL SHEARING STRESS( $\tau$ ) IS SATISFACTORY

STRESSES AT	OPERATING		TEST	
	WITH PRESSURE RESULT	ALLOW	WITH PRESSURE RESULT	ALLOW
EDGE OF PLATE	-3.0	102.2	-3.0	165.0
EDGE OF SADDLE	-1.3	102.2	-1.3	165.0

CIRCUMFERENTIAL STRESSES(f5) AT THE LOWEST POINT ARE SATISFACTORY

## Saddle Design Output

## PVE5: DESIGN OF BARRELS, DISHED ENDS AND CONES FOR INTERNAL PRESSURE

PVE5 calculates the thickness required for internal pressure in accordance with:

- PD 5500 section 3.5
- ASME VIII Div. 1 paragraph UG-27 or UG-32 and Appendix 1
- BS EN13445-3 Clause 7

The user is given the opportunity to adjust the calculated values upwards if desired. Three types of dished end are handled: torispherical, ellipsoidal and hemispherical. Cones, with or without knuckles, are catered for. Test pressure is evaluated for both vertical and horizontal orientations.

## PVE5: DESIGN OF BARRELS, DISHED ENDS AND CONES FOR EXTERNAL PRESSURE

PVE5 calculates the thickness required for external pressure in accordance with:

- PD5500 section 3.6
- ASME VIII Div. 1 paragraph UG-28 or UG-33 and Appendix 1
- BS EN13445-3 Clause 8

The user is given the opportunity to increase the calculated thicknesses if necessary for failure conditions. External or internal stiffening rings can be used and designed in accordance with either PD5500 section 3.6; ASME VIII Div. 1 paragraph UG-29 using the external pressure graphs from ASME II Part D; or BS EN13445-3 clause 8.

## PVE5: STRESSES INDUCED BY SADDLE OR RING SUPPORTS ON HORIZONTAL VESSELS

Stresses induced by either saddles or ring supports are calculated in accordance with PD5500 appendix G or L.P. Zick. ASME designs can be checked to PD5500 appendix G if the user desires. Wrapper plates can be included and the vessel stiffened by means of stiffening rings, either internal or external; adjacent or in-plane. All stresses are checked against allowables.

## PVE5: WIND AND EARTHQUAKE LOADINGS ON VERTICAL VESSELS

PVE5 calculates the stresses due to wind and earthquake loading on vertical vessels. The method used is taken from the Pressure Vessel Design Handbook (E.F. Megyesy) but is such that most wind and earthquake Codes of Practice can be satisfied. These stresses are compared with the maximum allowable stresses as defined in PD5500 or ASME VIII or BS EN13445-3.

The vessel may have multiple sections, with or without cones (including inverted cones), and is considered to be free standing on a skirt (straight or conical) fixed by anchor bolts to a concrete or steel foundation.

The calculations are performed for the operating, test and 'no pressure' condition. For the 'no pressure' condition the design loadings are considered at ambient temperature and zero pressure. At the test condition the vessel is assumed to be full of water. The pressure used is the test pressure at the top, increased by the static head of water above the section under consideration.

The calculations can include wind, and weight effects of the shell, heads, skirt, trays, nozzles, attached piping, platforms, ladders, davits and equipment supported off the column.

PVE5 will calculate the stresses at the base of each component and at the base and top of the skirt. The maximum bearing pressure under the base ring and the stresses in the H.D. bolts are also calculated. The programme checks that the calculated stresses in the vessel, the skirt, the base plate and the bolts do not exceed the allowable values.

An assessment on a static basis of the deflection at the top of the vessel is made for both the wind and earthquake conditions.

## PVE5: REINFORCEMENT OF OPENINGS

PVE5 checks the reinforcement requirements of:

- PD5500 section 3.5.4 or PD5500 3.5.4.9
- ASME VIII Div. 1 UG-36, 37, 40, 42, 45, 46 and Appendix 1
- BS EN13445-3 Clause 9

Single and/or multiple openings are checked and can be flush, protruding, set-on, set-through and, if required, fitted with a single or double sided pad. Nozzle types can be a pipe, plate, forging or hole. The code requirements for internal/external pressure and code minimum thicknesses are checked and any physical clashes between openings are stated. In the case of PD5500 design, the Maximum Stress Intensity at the edge of the openings is calculated in accordance with paragraph G.2.3.5.2 for cylinders and paragraph G.2.5 for dished ends.



PVE5 4.004B 9999/05 Job: TC21 17/06/2004 PD 5500 Page E3  
 ENQ/ORDER: TC 21 Revision: 0

SUMMATION OF MAX.STRESSES DUE TO LOCAL LOAD NO. 1 LOAD REF. NOZ1  
 =====  
 AT EDGE OF NOZZLE

Circumferential Stresses	Q1		Q2		Q3		Q4	
	In	Out	In	Out	In	Out	In	Out
Membrane Comp. Nphi/t due to								
Radial Load	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Circ.moment	-9.5	-9.5	-9.5	-9.5	9.5	9.5	9.5	9.5
Long.moment	-7.8	-7.8	7.8	7.8	7.8	7.8	-7.8	-7.8
Sub-total	-16.0	-16.0	-0.4	-0.4	18.6	18.6	3.1	3.1
Pressure fp	155.6	155.6	155.6	155.6	155.6	155.6	155.6	155.6
Sub-total fphim	139.6	139.6	155.1	155.1	174.2	174.2	158.7	158.7
Bending Comp. 6Mphi/t2 due to								
Radial Load	-6.9	6.9	-6.9	6.9	-6.9	6.9	-6.9	6.9
Circ.moment	66.2	-66.2	66.2	-66.2	-66.2	66.2	-66.2	66.2
Long.moment	33.3	-33.3	-33.3	33.3	-33.3	33.3	33.3	-33.3
Sub-total fphib	92.5	-92.5	26.0	-26.0	-106.3	106.3	-39.8	39.8
Total Circ. Stress (fphi)	232.1	47.1	181.2	129.1	67.9	280.5	118.9	198.4
Longitudinal Stresses								
Membrane Comp. Nx/t due to								
Radial Load	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Circ.moment	-9.4	-9.4	-9.4	-9.4	9.4	9.4	9.4	9.4
Long.moment	-3.1	-3.1	3.1	3.1	3.1	3.1	-3.1	-3.1
Sub-total	-11.2	-11.2	-5.0	-5.0	13.8	13.8	7.7	7.7
Pressure fp	155.6	155.6	155.6	155.6	155.6	155.6	155.6	155.6
Sub-total fx m	144.4	144.4	150.5	150.5	169.4	169.4	163.2	163.2
Bending Comp. 6Mx/t2 due to								
Radial Load	-4.9	4.9	-4.9	4.9	-4.9	4.9	-4.9	4.9
Circ.moment	42.2	-42.2	42.2	-42.2	-42.2	42.2	-42.2	42.2
Long.moment	42.5	-42.5	-42.5	42.5	-42.5	42.5	42.5	-42.5
Sub-total fx b	79.8	-79.8	-5.1	5.1	-89.6	89.6	-4.6	4.6
Total Long. Stress ( fx )	224.2	64.6	145.4	155.7	79.8	258.9	158.6	167.9
Shear stresses G.2.3.6.3 due to								
Torsional	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Circ.load	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Long.load	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Total shear	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8

## Stresses due to Local Loads

## PVE5: STRESSES DUE TO LOCAL LOADS ON SHELLS - CYLINDRICAL SHELLS

PVE5 calculates the stresses in cylindrical shells due to external loadings in accordance with:

- PD5500 Annex G.2
- WRC107 (alternatively WRC297)
- BS EN13445-3 Clause 16.5 for loads on nozzles; and Clause 16.7 for lifting lugs.

Calculation flow may be dealt with by considering first PD5500 and WRC107; and secondly BS EN13445-3 Clauses 16.5 and 16.7.

**For WRC107 and PD5500**, attachment types can be round, square or rectangular, with or without reinforcing pads. PVE5 calculates stresses at the edge of the loaded area, and optionally at two points remote from the loaded areas for PD5500 type designs. Stresses and deflections due to a radial load, a circumferential moment and a longitudinal moment are calculated as per paragraphs G2.2 and G2.3 of PD5500 or WRC107/WRC297. Stresses due to circumferential and longitudinal shear loads and a torsional moment are also calculated for a round attachment. The shell deflection information is particularly useful in enabling the user to incorporate the nozzle shell flexibility into connecting pipe stress analysis.

For attachments other than nozzles and at the edge of reinforcing pads the membrane effects of pressure are included. For nozzles, the maximum stress intensity due to pressure is calculated in accordance with PD5500 paragraph G.2.3.5.2.

Summation of circumferential stresses, longitudinal stresses and shear stresses at the inside and outside surface of the shell due to the various loadings can be carried out by WRC107, the quadrant method of BS5500 Issue 2 August 1988 or a method derived from WRC107.

For PD5500 designs PVE5 checks the maximum value against the allowable stress of  $2f$  (for a pad) or  $2.25f$  (at the edge of a nozzle). The total circumferential or longitudinal compressive stress is checked against  $0.9 \times \text{yield}$ . In addition, for attachments other than nozzles, the maximum membrane stress intensity is checked against  $1.2f$ .

**For BS EN13445-3**, lifting lugs may optionally have a rectangular reinforcing plate.

For a lifting lug, the allowable load is computed and then compared against the actual load. For a nozzle, a set of allowable loads: maximum allowable loads and pressure are computed and compared to the actual values according to Clauses 16.5.6 or 16.5.4. Stress range checks according to Clause 16.5.7 may be made by defining more than one load for a given nozzle. Finally, a check on the stresses in the nozzle according to 16.5.8 is made.

PVE5 V4.004A	TCM2	24/08/2004 @ 16: 8	Page 1		
Pressure vessel engineering to	PD5500:2003		Jan 2003		
Customer : WHESOE COMPUTING SYSTEMS	Enq/Order: TCM2				
Title : Test Case 2	Drq.No. : 2				
Originator :	Approval :				
Description: Validation manual example					
INPUT DATA :-					
Radial Gauge Measurement (Method 2 from PD5500: Enquiry Case 33)					
Number of readings : 24					
Station	Measured Radius Readings(mm)	Calculated Departure from mean	Station	Measured Radius Readings(mm)	Calculated Departure from mean
1	1881.69	-0.035	13	1882.73	-1.894
2	1893.56	11.685	14	1892.42	7.946
3	1900.40	18.286	15	1896.77	12.535
4	1899.55	17.125	16	1897.30	13.376
5	1896.06	13.273	17	1895.93	12.368
6	1891.10	7.924	18	1894.33	11.156
7	1884.06	0.496	19	1887.78	4.995
8	1875.81	-8.116	20	1876.70	-5.723
9	1868.90	-15.337	21	1866.05	-16.063
10	1862.88	-21.595	22	1861.53	-20.344
11	1858.83	-25.795	23	1858.93	-22.794
12	1896.46	11.784	24	1876.42	-5.254
Mean radius of cylinder : 1883.50 mm					
Modulus of elasticity : 208.00 kN/mm2					
Minimum calculated thickness : 15.00 mm					
Unsupported length of shell : 6744.00 mm					
yield stress (sf) : 130.00 N/mm2					
Approximation (Gamma = 0) used					
Allowable pressure if cylinder is within tolerance (Pa) : 0.10613 N/mm2					
Maximum value of departure = 25.7947 mm					
As a percentage of mean radius = 1.370%					
MAXIMUM DEPARTURE IS OUTSIDE 0.5% TOLERANCE SPECIFIED IN PD5500 SECTION 3.6.2.					
NEW ALLOWABLE PRESSURE MUST BE CALCULATED.					
P(allowable) = 0.08642 N/mm2					

## Out of Roundness Calculations

## PVE5: STRESSES DUE TO LOCAL LOADS ON SHELLS - SPHERICAL SHELLS

PVE5 calculates the stresses in spherical shells due to external loadings in accordance with PD5500 Annex G.2 or WRC107 for round, square or rectangular attachment types, with or without reinforcing pads. Stresses are calculated at the edge of the loaded area and, optionally away from the loaded areas for PD5500 type designs. Again, calculation flow may be dealt with by considering first PD5500 and WRC107; and secondly BS EN13445-3, in this case Clauses 16.4 and 16.7.

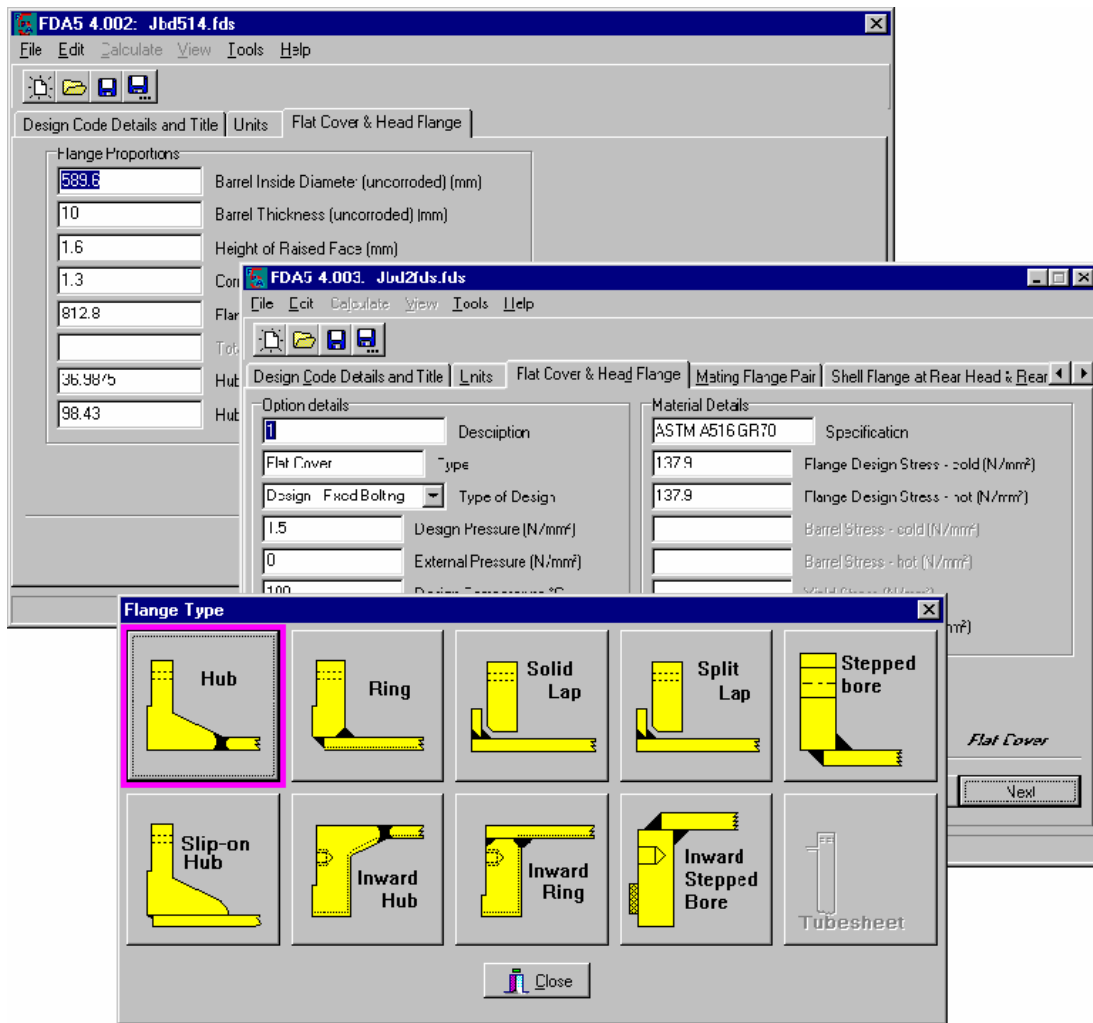
**For WRC107 and PD5500**, stresses due to a radial load, two moments and two shear loads on a rigid attachment are calculated as per PD5500 paragraph G.2.4 or WRC107. Shear stresses due to a torsional moment are also calculated for round attachments. For attachments other than nozzles and at the edge of reinforcing pads the membrane effects of pressure are included. For nozzles, the maximum stress intensity due to pressure is calculated in accordance with PD5500 paragraph G.2.5.2.

The summation of hoop stresses, meridional stresses and shear stresses at the inside and outside surfaces due to the various loadings is carried out at four positions around the attachment or pad using the method derived from WRC107. The hoop, meridional and shear stresses are combined in accordance with PD5500 Annex B clause B.3.1, at the eight inside and outside locations in order to determine the maximum principal stress. PVE5 checks compressive, membrane, membrane plus bending and shear stresses against those allowed by the Code. PVE5 also checks all the limitations specified in the Code.

**BS EN13445-3:** For of a lifting lug, the allowable load is computed and then compared against the actual load. For a nozzle, a set of allowable loads: maximum allowable loads and pressure are computed. The allowable values are compared to the actual values according to Clauses 16.4.6 or 16.4.4. Stress range checks according to Clause 16.4.7 may be made by defining more than one load on a nozzle. Finally, a check on the stresses in the nozzle according to 16.4.8 is made.

## PVE5: OUT OF ROUNDNESS OF CYLINDRICAL SHELLS (PD5500)

A module is available for determining (from survey data) if the code limit of "out of circularity" as specified in 3.6 has been exceeded. Calculations are carried out showing the safe external working pressure for cylindrical sections outside this limit.



## FDA5 Flange Design

## FDA5 - FLANGE DESIGN

FDA5 designs flanges in accordance with either PD5500 or ASME V111 Div. 1 (with additional TEMA rules if required). FDA5 enables the user to design a flange or check an existing design. The program is particularly suited to the design of flanges encountered in shell and tube heat exchangers, but it will also cater for the design of any single or mating flanges with the input units being in either metric, imperial or any mixture.

FDA5 has five alternative options for design:

1. designs the flange dimensions, gasket size and bolting requirements for specified operating conditions, allowable stresses and flange and gasket type
2. designs the flange dimensions and gasket size as above but with a fixed bolt diameter
3. designs the flange thickness with specified bolt, gasket size and flange dimensions
4. calculates the maximum allowable working pressure (MAWP) for specified flange dimensions, bolting and gasket details, operating conditions and allowable stresses;
5. calculates the actual stresses in the flange for specified flange dimensions, bolting and gasket details and operating conditions

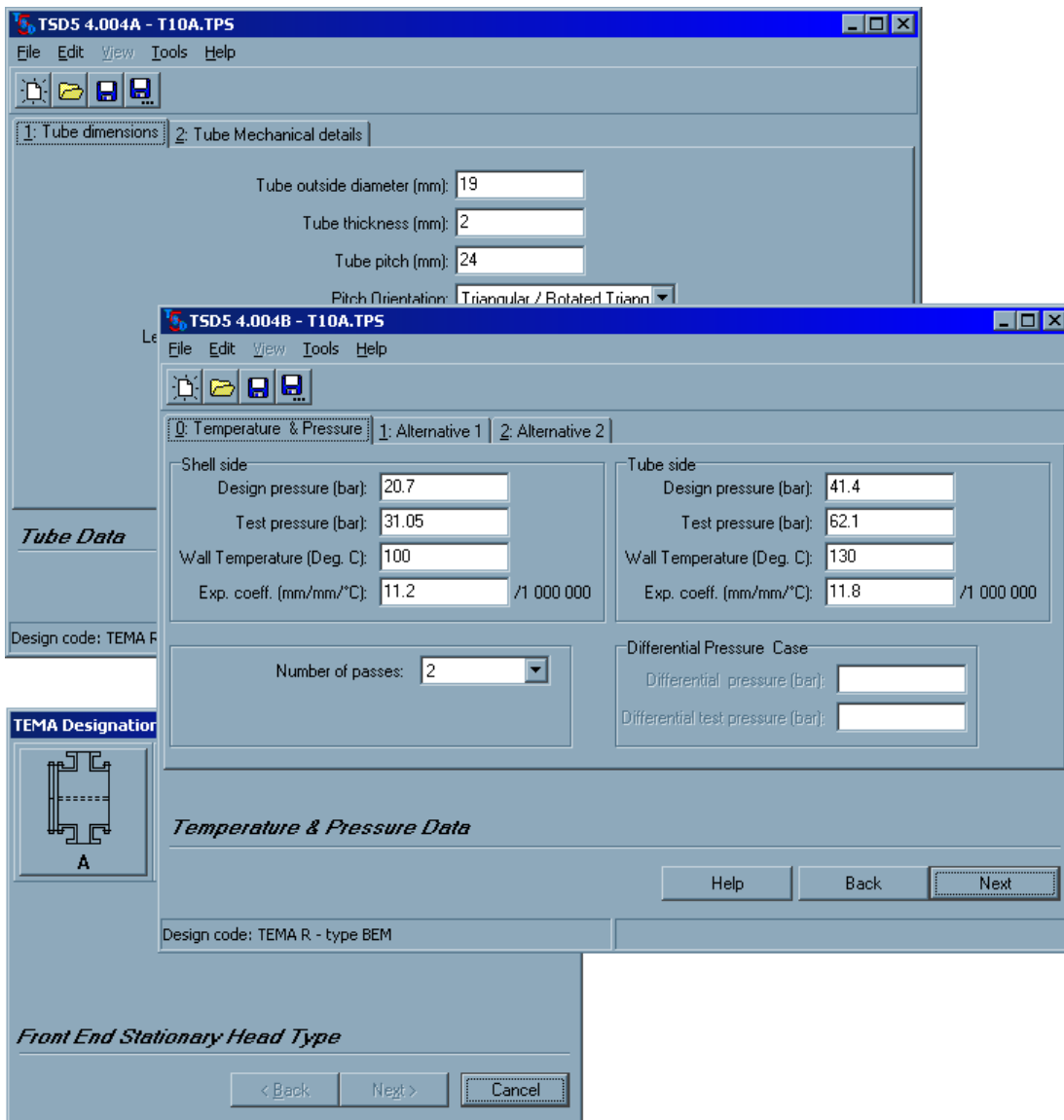
and covers hub, ring, inward-facing hub or ring, lap and split lap flanges, allowing single or mating flanges, floating head cover flanges with or without split-backing rings.

RING FLANGE(INTEGRAL) to ASME VIII:2001& TEMA DES-FG			
Channel Flange - WORKING UNITS ARE NEWTONS & MILLIMETRES			
DESIGN CONDITIONS & MATERIALS		GASKET AND FACING	TABLE 2-5&6
DES.PRESS. =	0.400 (N/mm2)	O/DIA =	492.125
DES.TEMP. =	50.000 deg C	I/DIA =	460.000
CORR.ALLOW.=	0.000	THICK =	1.600
FLANGE MAT.=	ASTM A182 M 316L	FACING TYPE	
BOLT MAT. =	ASTM A193 B8M	FLAT FACE	
GASKET MAT.=	Klingerit PTFE env	TYPE 1A	
		N=	16.063
		b=	7.142
		G=	477.842
		y=	25.500
		m=	2.750
		w=	0.000
ALLOWABLE STRESSES (N/mm2)		LOAD AND BOLT CALCULATIONS	
FLANGE DES TEMP Sfo =	80.70	Wm2 =	273241.
ATM TEMP Sfa =	80.70	Hp =	23574.
BOLT DES TEMP Sb =	99.00	H =	71697.
ATM TEMP Sa =	130.00	Wm1 =	95270.
		Am =	2101.9
		Ab =	3127.7
		W =	339923.
LOAD * LEVER ARM =		MOMENT	
OPERATING: HD =	60280.	hD =	34.3000
HG =	23574.	hG =	21.4540
HT =	11416.	hT =	31.3770
		MD =	0.20676E+07
		MG =	0.50575E+06
		MT =	0.35821E+06
SEATING: HG =	339923.	hG =	21.4540
VACUUM: HD =	0.		12.8460
HT =	0.		9.9230
		M(op) =	0.29316E+07
		M(atm) =	0.72927E+07
		MD =	0.00000E+00
		MT =	0.00000E+00
		M(vac) =	0.00000E+00
ALLOW	STRESS CALC OPERATING	K AND HUB FACTORS	
121.05	SH = 48.11	K =	1.27582
80.70	SR = 12.62	T =	1.80762
80.70	ST = 11.67	Z =	4.18617
80.70	(SH+SR)/2 = 30.37	Y =	8.10930
80.70	(SH+ST)/2 = 29.89	U =	8.91130
		g1/g0 =	1.46982
		h0 =	64.602
		h/h0 =	0.21671
		F =	0.89177
		V =	0.41084
		f =	1.36229
		e =	0.01380
		d =	0.127130E+06
ALLOW	STRESS CALC SEATING	ASME App. S	STRESS FORMULA FACTORS
121.05	SH = 119.69	J =	0.18293
80.70	SR = 31.41		
80.70	ST = 29.02		
80.70	(SH+SR)/2 = 75.55		
80.70	(SH+ST)/2 = 74.36		
		FLANGE t =	29.00000
		ALPHA =	1.40032
		BETA =	1.53376
		GAMMA =	0.77468
		DELTA =	0.19184
		LAMBDA =	0.96652
FLANGE DIMENSIONS			
A =	559.00	g1 =	14.00
B =	438.15	g0 =	9.52
C =	520.75	STEP =	0.00
E =	19.13	h =	14.00
R =	27.30	SLOPE =	1/ 3.1
		NO.OF BOLTS =	24
		BOLT DIAM =	0.625"
		BOLT SPACE =	68.131
		MIN. SPACE =	38.100
		MAX. SPACE =	85.287
		M(op)/B =	0.6691E+04
		M(atm)/B =	0.1664E+05
FINISHED SIZE	559.00 O/D	460.20 I/D	29.0000 THK(inc.step)
FINISHED WEIGHT	18.00 kg		ROTATION 0.11 Degrees

## Flange Design Output

FRONT END STATIONARY HEAD TYPES		SHELL TYPES		REAR END HEAD TYPES	
<b>A</b>	 CHANNEL AND REMOVABLE COVER	<b>E</b>	 ONE PASS SHELL	<b>L</b>	 FIXED TUBESHEET LIKE "A" STATIONARY HEAD
<b>B</b>	 BONNET (INTEGRAL COVER)	<b>F</b>	 TWO PASS SHELL WITH LONGITUDINAL BAFFLE	<b>M</b>	 FIXED TUBESHEET LIKE "B" STATIONARY HEAD
<b>C</b>	 REMOVABLE TUBE BUNDLE ONLY CHANNEL INTEGRAL WITH TUBE-SHEET AND REMOVABLE COVER	<b>G</b>	 SPLIT FLOW	<b>N</b>	 FIXED TUBESHEET LIKE "N" STATIONARY HEAD
<b>N</b>	 CHANNEL INTEGRAL WITH TUBE-SHEET AND REMOVABLE COVER	<b>H</b>	 DOUBLE SPLIT FLOW	<b>P</b>	 OUTSIDE PACKED FLOATING HEAD
		<b>J</b>	 DIVIDED FLOW	<b>S</b>	 FLOATING HEAD WITH BACKING DEVICE
		<b>K</b>	 KETTLE TYPE REBOILER	<b>T</b>	 PULL THROUGH FLOATING HEAD
		<b>X</b>	 CROSS FLOW	<b>U</b>	 U-TUBE BUNDLE
				<b>W</b>	 EXTERNALLY SEALED FLOATING TUBESHEET

## Heat Exchanger Types covered by PVE5



## TSD5 Tubesheet Design

## TSD5 - TUBESHEET DESIGN

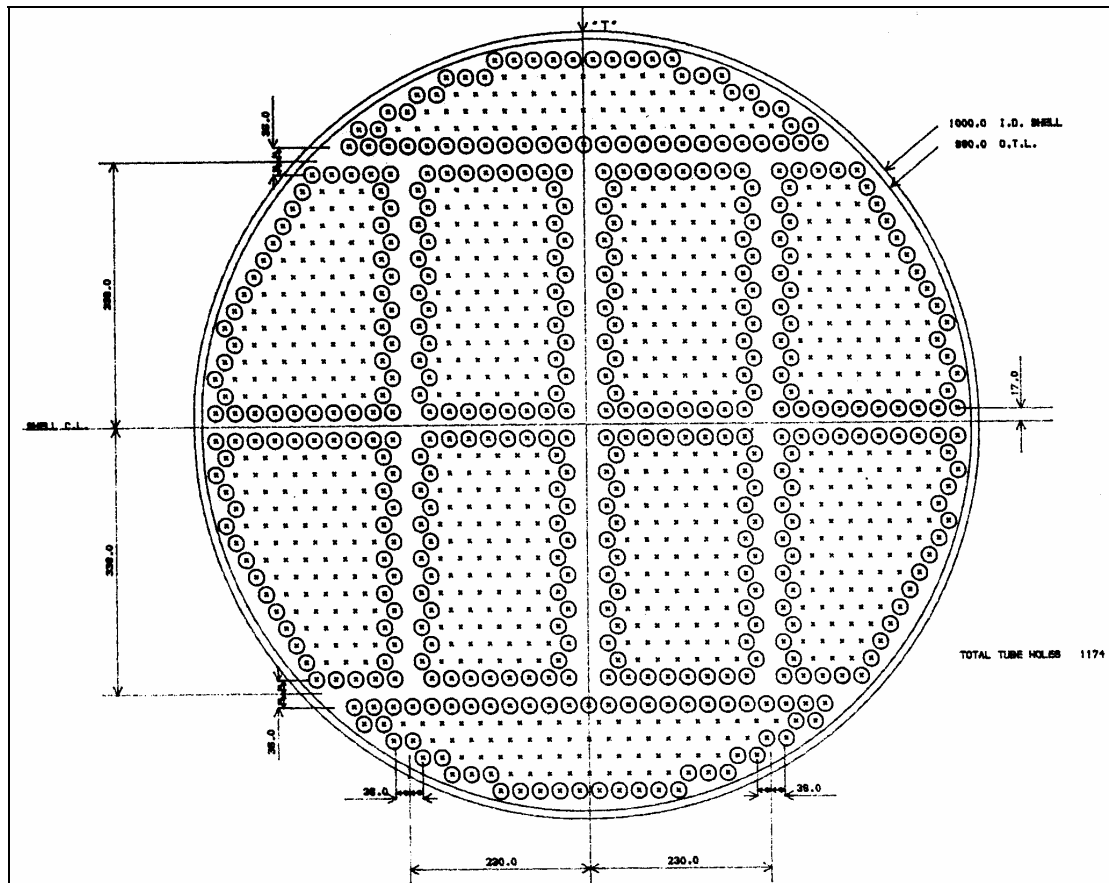
TSD5 designs tubesheets in accordance with either PD5500 ASME VIII Div.1, Part UHX or TEMA R, B and C. It enables heat exchanger engineers to quickly produce an accurate optimised design with resultant savings in time and materials.

It calculates the tubesheet thickness for U-tube, floating head and fixed tubesheets including kettles in the corroded and uncorroded condition. Where the tubesheet is extended to provide a flange, a peripheral thickness check is performed.

Shell and tube longitudinal stresses and tube pull-out loads are checked for exchangers with fixed tubesheets.

The user has the choice of either specifying a shell expansion bellows in the design or leaving the program to decide whether one is necessary. In the latter case a shell expansion bellows will be inserted if the shell and/or tubes are over-stressed.

Conditions other than normal design (e.g. start up/shut down etc.) can be accommodated by the use of alternative pressures and temperatures, including differential pressure.



*Tubesheet Layout Drawing produced by PVE5*

## TSL5 - TUBESHEET LAYOUT

TSL5 performs two separate functions, which will assist the thermal design engineer to establish the shell diameter and number of tubes, and the draughtsman to produce a full size workshop drawing of the tube layout.

TSL5 will calculate :

either a) the maximum number of tubes for a given shell diameter

or b) the minimum shell diameter required for a given number of tubes.

In each case the tube distribution is optimised to achieve a balance between tube passes.

A large number of combinations of pass arrangement/number of passes is available, ranging from a pass arrangement of 1 into 1 pass through to a pass arrangement of 3 into 16 passes.



## QUALITY ASSURANCE

PVE5 has been validated by comparing the answers obtained with hand calculations, results from competitors software, published results, analytical solutions and results from previously validated releases. Details of the above are documented in the comprehensive PVE5 Validation Manual.

Whessoe Computing Systems operate a QA programme designed to meet the requirements of ISO9001, BS5882:1980 and the ASME Boiler and Pressure Vessel Code Section III. This programme has been audited by a number of companies and found to be satisfactory. In particular one contract specified BS5882 - the QA programme for nuclear power stations. The development, testing, maintenance and support of PVE5 are carried out within the framework of the Whessoe Computing Systems quality management system. This quality system has been subject to third party audit by a TickIT accredited certification body and Whessoe Computing Systems have been registered as a certificated organisation.

The validation procedure adopted by Whessoe Computing Systems is as follows:-

- Generate a comprehensive set of validation benchmarks covering all PVE5 facilities from independent sources e.g. hand calculations. These are documented in the PVE5 Validation Manual.
- Compare the answers produced by PVE5 with the above and include comparison in the Validation Manual when compatible.
- For each new version of PVE5, run all the above benchmarks and compare these with the validation results produced on the previous version. When satisfactory comparison is obtained a Product Modification Issue Form is signed signifying that the new version has been successfully verified and validated.
- Issue Product updates to all licensees consisting of copies of the master executables on disk, updates to the User Manual and an Installation Guide. We include on the disks the input data for a subset of the validation benchmarks, together with execution instructions and expected results. This allows the client to carry out his own verification tests if required.

## NOTES

### **Whessoe Computing Systems**

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