



DESIGN OF AES TYPE HEAT EXCHANGER
(With the help of PV-Elite Soft ware)

Minimum Required inputs:

1. Design pressure
2. Design temperature
3. Specific gravity of working fluid
4. Corrosion allowance
5. Joint efficiency.
6. MOC of all the components.
7. Number of passes (Shell Side and channel side)
8. Loading data

Example:

Design the AES type HE for following design parameter

	Shell Side	Channel Side
Design pressure :	21.7 Kg/Cm²	32.6 Kg/Cm²
Design temperature:	275 °C	240°C
Specific gravity of working fluid	0.8290	0.7777
Corrosion allowance	3.2	3.2
Joint efficiency	1	1
Number of passes	1	4
Loading data		
Shell ID	1250	
Size of Tube	25.4 mm OD	
Number of tube	958	
Length of tube	6000 mm	
OTL	1200 mm	



**DESIGN OF AES TYPE HEAT EXCHANGER
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Step 1. Channel shell design:

Cylindrical shell under internal pressure.

ASME VIII DIV.1-July 2007

t = minimum required thickness	t_n = nominal thickness	E = joint efficiency	
P = internal pressure	S = maximum allowable stress	T = temperature	
R = inside radius	Ca = Corrosion allowance + Tolerance	σ = circumferential stress	
R_o = outside radius	$Tol\%$ = tolerance for pipes	P_a = maximum allowable pressure	
$t_{n,min} = (t+Ca)/Tol\%$ shall be $\leq t_n$	$t_u = (t_n \times Tol\%) - Ca$ shall be $\geq t$	P_h = hydrostatic pressure	
UG-27 (c)	$t = P(R+Ca)/(SE-0.6P)$	$\sigma = (P(R+Ca) / t_u + 0.6P) / E$	$P_a = S E t_u / ((R+Ca) + 0.6 t_u)$
Appendix 1-1.(a)(1)	$t = PR_o/(SE+0.4P)$	$\sigma = (PR_o / t_u - 0.4P) / E$	$P_a = S E t_u / (R_o - 0.4 t_u)$

**Fill up the highlighted values & Select the shell material to find out minimum required thickness under internal pressure.
Enter the value of shell length; software will check the provided shell thickness under External pressure.**

Note: Failure of thickness will be highlighted in red color (it will show minimum required thickness.)

In Our Case: (For Channel Side)

R= 625 mm

P= 32.6 Kg/Cm²

CA= 3.2 mm

T= 240°C

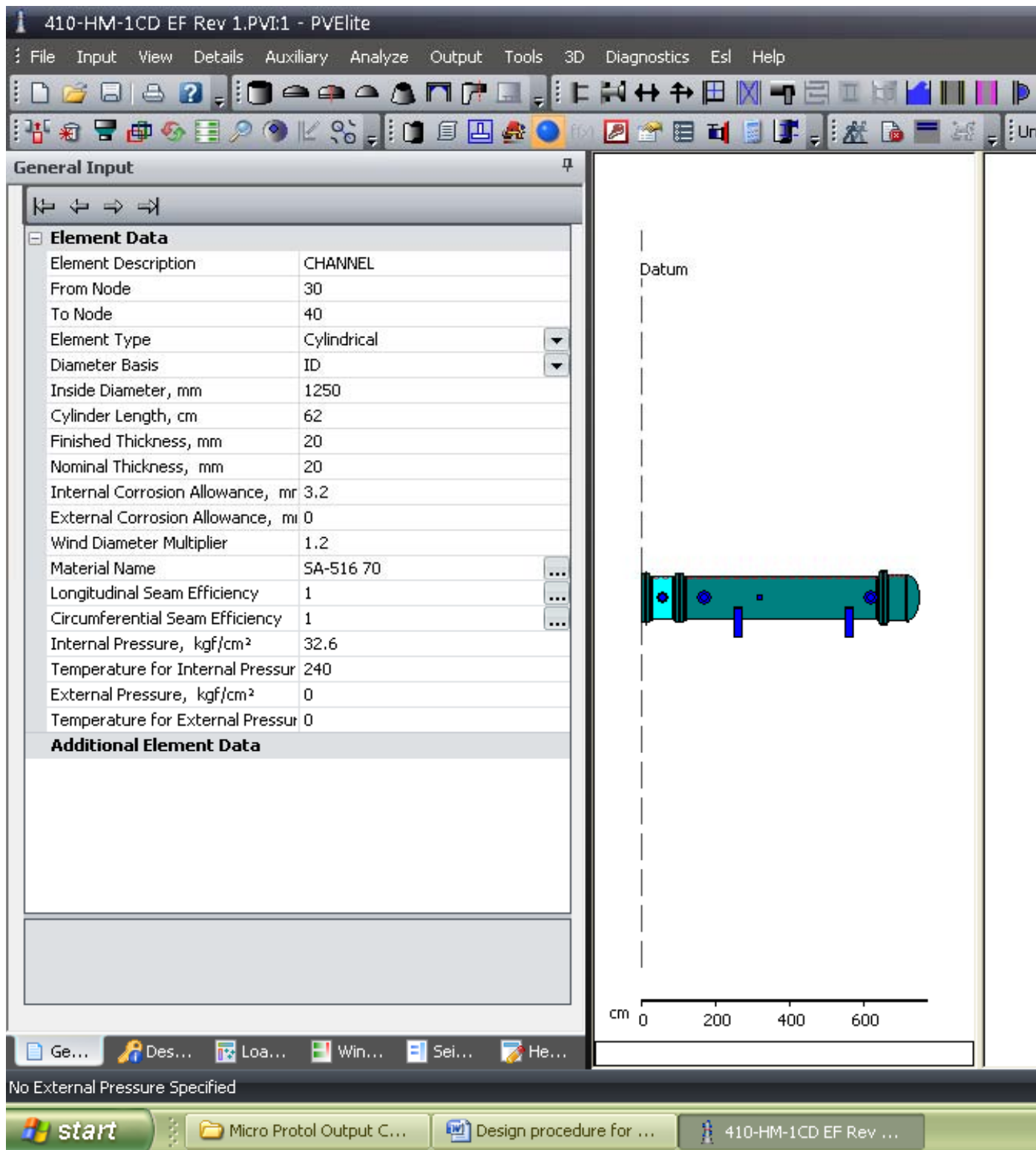
Software will compute the required thickness.

t= 18.02 mm

Round up the value and select the standard thickness of 20mm.

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Sheet shows Input for Channel shell



General Input

410-HM-1CD EF Rev 1.PVI:1 - PVElite

File Input View Details Auxiliary Analyze Output Tools 3D Diagnostics Esl Help

Element Data

Element Description	CHANNEL
From Node	30
To Node	40
Element Type	Cylindrical
Diameter Basis	ID
Inside Diameter, mm	1250
Cylinder Length, cm	62
Finished Thickness, mm	20
Nominal Thickness, mm	20
Internal Corrosion Allowance, mm	3.2
External Corrosion Allowance, mm	0
Wind Diameter Multiplier	1.2
Material Name	SA-516 70
Longitudinal Seam Efficiency	1
Circumferential Seam Efficiency	1
Internal Pressure, kgf/cm ²	32.6
Temperature for Internal Pressure	240
External Pressure, kgf/cm ²	0
Temperature for External Pressure	0

Additional Element Data

Datum

cm 0 200 400 600

No External Pressure Specified

start Micro Protol Output C... Design procedure for ... 410-HM-1CD EF Rev ...



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Step 2. Channel LH flange Design:

Give Input values in the following steps.

2.1 Select the flange type

Weld neck

2.2 Select MOC of flange

SA266 GR 4

Software will automatically take stress values for specified MOC at design conditions.

2.3 Enter Design Pressure, Temperature & Joint efficiency.

P= 32.6 Kg/Cm²

Ca= 3.2 mm

T= 240°C

Joint Efficiency= 1

2.4 Go to flange dialogue screen and enter the data in the following steps

a. Flange ID = Generally flange ID is equal to Shell ID

Flange ID= 1250 mm

b. Face ID = Shell ID

Face ID = 1250 mm

c. Gasket ID depends on type of gasket used.

Gasket ID = Face ID + 2 x Corrosion allowance

The Spiral wound Gasket consists of 13mm of inner ring and 4mm of outer ring. In this case,

Gasket ID = Face ID + 2 x Corrosion allowance + (13 x 2)

Gasket type= Spiral wound

Gasket ID= 1250 + (2 x 3.2) + (13 x 2)

Gasket ID= 1282.4 say 1283 mm

d. Gasket OD = Gasket ID + (2 x Gasket width)

Gasket OD = 1283+13x2

Gasket OD = 1309 mm

e. Face OD = Gasket OD+3 (in case of Female type face)

For male type face, Face OD = Gasket OD

For Spiral wound gasket add 8mm in Face OD for outer gasket ring.

Face OD = 1309+4x2+3

Face OD = 1320

2.5 In case of Weld neck Flange,

Thickness of hub at smaller end (Gi) = Shell (or Channel) thickness

Thickness of shell at large End (Go) = 1.5 x Gi

Hub Length (HL) = 2 x Gi (This value can be equal to 1.5 to 2 x Gi)

Gi= 20 mm

Go= 30 mm

HL= 40 mm



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2.6 Select Bolt Material, thread series & size of Bolt. (Initially consider smaller size of bolts to perform the calculation)

Bolt MOC= SA193 B7

Software will automatically take stress values for specified MOC at design conditions.

Thread series= UNC

Bolt Size= 31.75 mm

2.7 Select the number of bolts to satisfy the required bolt area.

Number of bolts= 56

2.8 BCD = Flange ID + Go + 2Rh

Rh is radial distance between Bolt circle and Flange

BCD= 1250 + 2 x 20 + 2x44.45

Minimum BCD= 1378.9

Minimum Circumferential distance between two bolts is 71.45

To satisfy the above conditions selecting the BCD of 1400 mm

2.9 Flange OD = BCD + 2E

For Minimum value for Rh & E refer TEMA Table D-5M

(Note: As size of Flange depends on BCD, try to keep BCD as minimum as possible. Minimum Circumferential spacing between bolts should be kept according to TEMA Table D-5M.)

Flange OD= 1400+2x31.75

Flange OD= 1463.5 Say 1465 mm

2.10 Select the gasket material & thickness.

Gasket MOC= Spiral wound

Gasket thickness= 4.5 mm

Software will automatically take stress values for specified MOC at design conditions.

2.11 Put the partition gasket details. (MOC of gasket, width & length of gasket.)

Partition Gasket MOC= material jacketed

Partition Gasket width= 10 mm

Partition Gasket length= 2500 mm

2.12 Put the external loading information. Put banding moment due to various attachments to the flange.

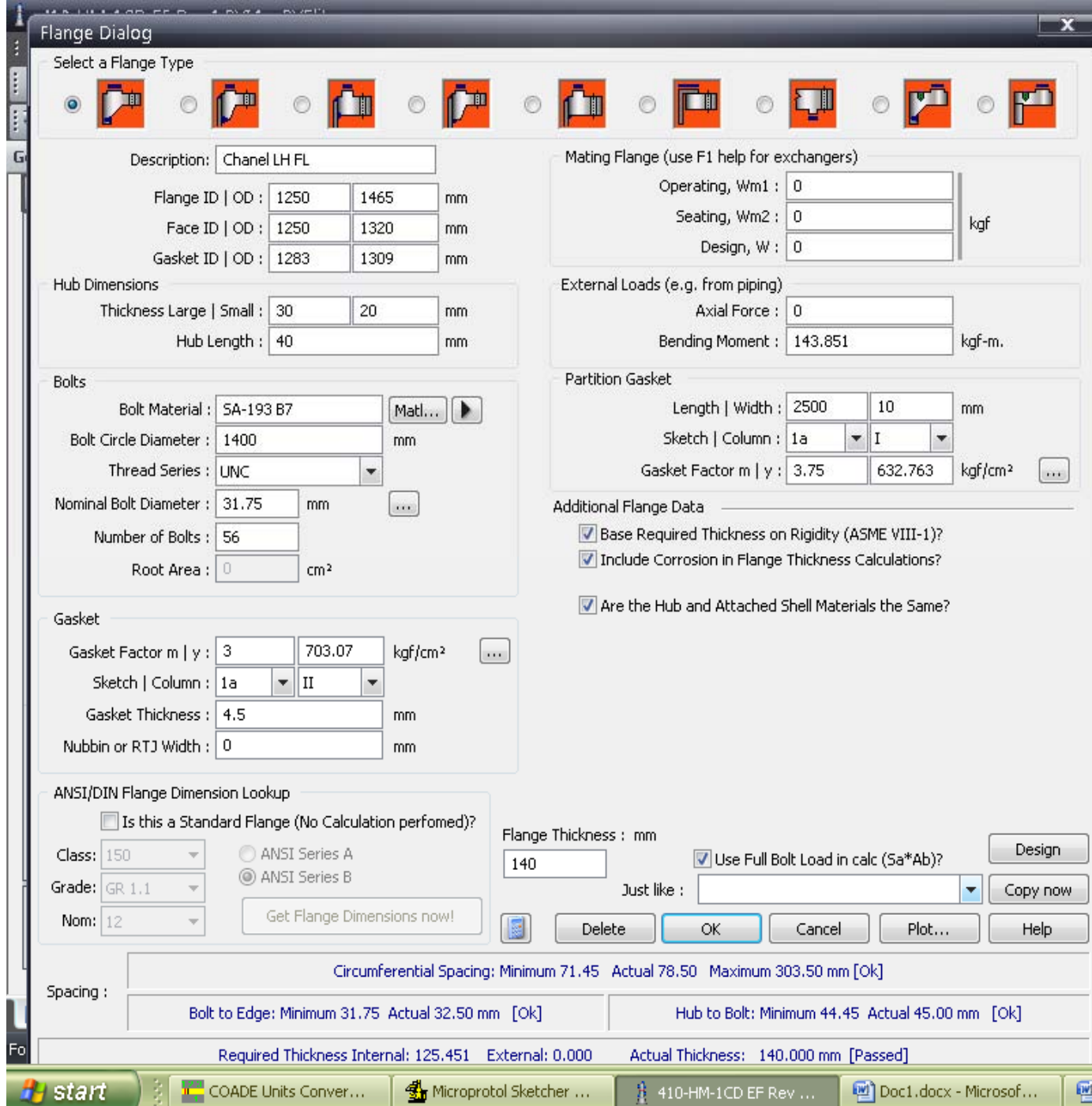
Bending Moment= 143.851 kg-m

2.13 Select the option Use full bolt load calculation. (generally customer asks this)

Flange thickness= 140 mm

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Sheet shows sample flange input sheet.



Flange Dialog

Select a Flange Type: [Icons]

Description: Chanel LH FL

Flange ID OD :	1250	1465	mm
Face ID OD :	1250	1320	mm
Gasket ID OD :	1283	1309	mm

Hub Dimensions

Thickness Large Small :	30	20	mm
Hub Length :	40		mm

Bolts

Bolt Material : SA-193 B7 [Matl...]

Bolt Circle Diameter : 1400 mm

Thread Series : UNC

Nominal Bolt Diameter : 31.75 mm

Number of Bolts : 56

Root Area : 0 cm²

Gasket

Gasket Factor m | y : 3 | 703.07 kgf/cm²

Sketch | Column : 1a | II

Gasket Thickness : 4.5 mm

Nubbin or RTJ Width : 0 mm

ANSI/DIN Flange Dimension Lookup

Is this a Standard Flange (No Calculation performed)?

Class: 150 ANSI Series A ANSI Series B

Grade: GR 1.1

Nom: 12 [Get Flange Dimensions now!]

Flange Thickness : mm

140 Use Full Bolt Load in calc (Sa*Ab)?

Just like : [Dropdown]

[Design] [Copy now] [Delete] [OK] [Cancel] [Plot...] [Help]

Spacing :

Circumferential Spacing: Minimum 71.45 Actual 78.50 Maximum 303.50 mm [OK]

Bolt to Edge: Minimum 31.75 Actual 32.50 mm [OK]	Hub to Bolt: Minimum 44.45 Actual 45.00 mm [OK]
--	---

Required Thickness Internal: 125.451 External: 0.000 Actual Thickness: 140.000 mm [Passed]

Required & provided thickness is shown at the bottom of the sheet.

Add Step in Flange thickness according to thickness of gasket.

Nominal flange thickness= Flange thickness+ Step+ Hub length

In our case add 6 mm step in flange thickness.

Nominal flange thickness= 140+6+40= 186mm



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Step 3. Design of Channel Cover.

Insert the blind flange as channel cover before flange.

Give Input values in the following steps.

3.1 Select the flange type

Bolted Blind flange

3.2 Select MOC of flange

SA266 Gr.4

3.3 Enter Design Pressure, Temperature & Joint efficiency.

P= 32.6 Kg/Cm²

Ca= 3.2 mm

T= 240°C

Joint Efficiency= 1

3.4 Go to flange dialogue screen and enter the data in the following steps

a. Face ID= adjacent Flange ID – 3

Face ID= 1250-3

Face ID= 1247mm

b. Gasket ID & OD = Similar to adjacent Flange

Gasket ID= 1283

Gasket OD= 1309mm

c. Face OD = adjacent Flange face OD – 3

Face OD= 1320-3

Face OD= 1317 mm

3.5 Bolt Material, size & number of Bolt will be same as adjacent Flange

There are three options for this entry:

1 - TEMA Bolt Table

2 - UNC Bolt Table

3 - User specified root area of a single bolt

Bolt MOC= SA193 B7

Thread series= UNC

Bolt Size= 31.75 mm

Number of bolts= 56

3.6 Gasket material & thickness will be similar to adjacent Flange.

Gasket MOC= Spiral wound

Gasket thickness= 4.5 mm

3.7 Put the partition gasket details. (MOC of gasket, width & length of gasket.)

Partition Gasket MOC= material jacketed

Partition Gasket width= 10 mm

Partition Gasket length= 2500 mm

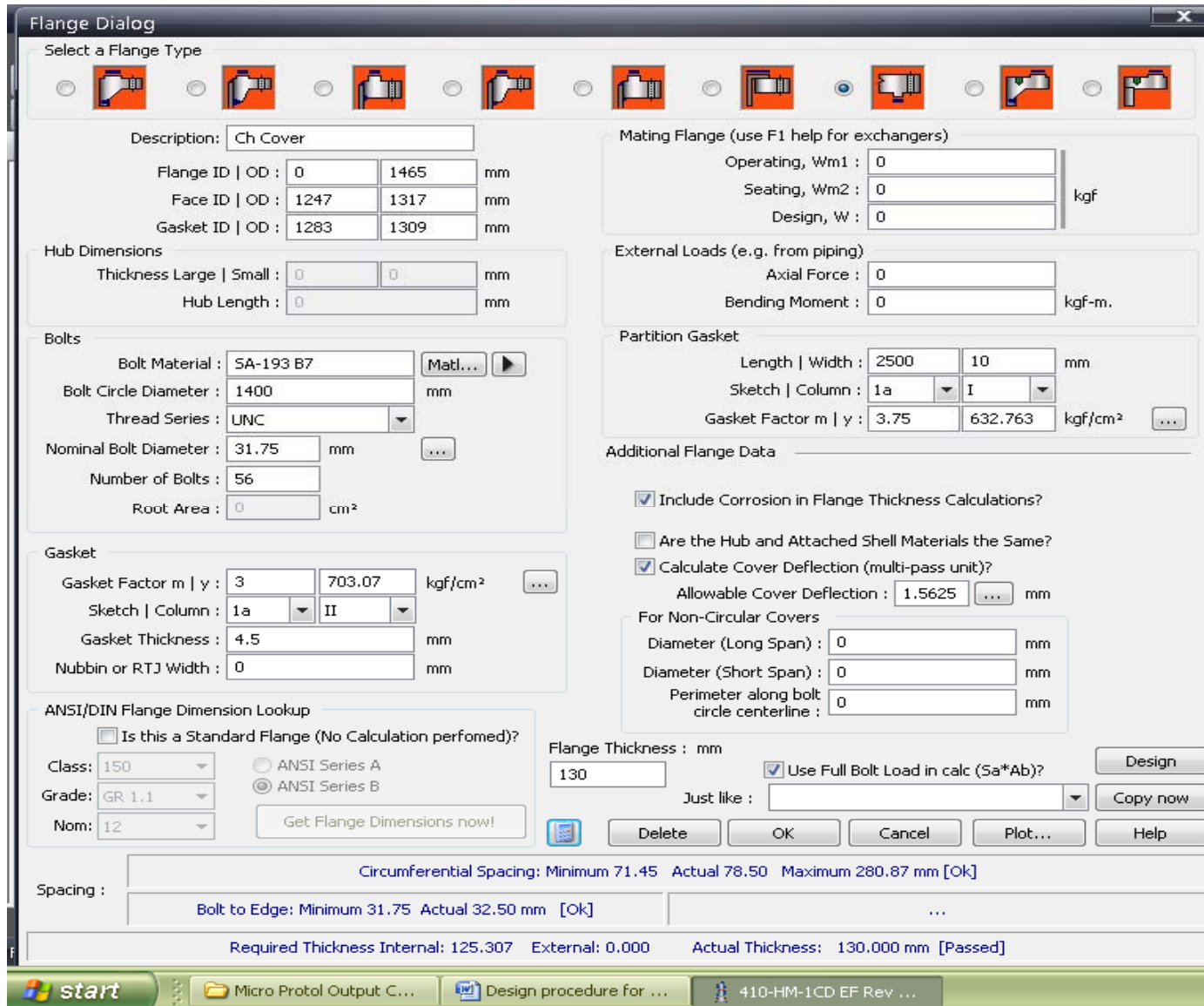
DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

3.8 Select the option of Check Cover for deflection at centre & use full bolt load in calculation.

Required thickness is 125.307 mm

For deflection check provided thickness is 130mm

Sheet shows sample Ch Cover input sheet.



Flange Dialog

Select a Flange Type

Description: Ch Cover

Flange ID | OD : 0 | 1465 mm
 Face ID | OD : 1247 | 1317 mm
 Gasket ID | OD : 1283 | 1309 mm

Hub Dimensions
 Thickness Large | Small : 0 | 0 mm
 Hub Length : 0 mm

Bolts
 Bolt Material : SA-193 B7
 Bolt Circle Diameter : 1400 mm
 Thread Series : UNC
 Nominal Bolt Diameter : 31.75 mm
 Number of Bolts : 56
 Root Area : 0 cm²

Gasket
 Gasket Factor m | y : 3 | 703.07 kgf/cm²
 Sketch | Column : 1a | II
 Gasket Thickness : 4.5 mm
 Nubbin or RTJ Width : 0 mm

ANSI/DIN Flange Dimension Lookup
 Is this a Standard Flange (No Calculation performed)?
 Class: 150
 Grade: GR 1.1
 Nom: 12
 ANSI Series A
 ANSI Series B
 Get Flange Dimensions now!

Mating Flange (use F1 help for exchangers)
 Operating, Wm1 : 0
 Seating, Wm2 : 0
 Design, W : 0 kgf

External Loads (e.g. from piping)
 Axial Force : 0
 Bending Moment : 0 kgf-m.

Partition Gasket
 Length | Width : 2500 | 10 mm
 Sketch | Column : 1a | I
 Gasket Factor m | y : 3.75 | 632.763 kgf/cm²

Additional Flange Data
 Include Corrosion in Flange Thickness Calculations?
 Are the Hub and Attached Shell Materials the Same?
 Calculate Cover Deflection (multi-pass unit)?
 Allowable Cover Deflection : 1.5625 mm
 For Non-Circular Covers
 Diameter (Long Span) : 0 mm
 Diameter (Short Span) : 0 mm
 Perimeter along bolt circle centerline : 0 mm

Flange Thickness : mm
 130
 Use Full Bolt Load in calc (Sa*Ab)?
 Just like :
 Design Copy now Delete OK Cancel Plot... Help

Spacing :
 Circumferential Spacing: Minimum 71.45 Actual 78.50 Maximum 280.87 mm [Ok]
 Bolt to Edge: Minimum 31.75 Actual 32.50 mm [Ok]

Required Thickness Internal: 125.307 External: 0.000 Actual Thickness: 130.000 mm [Passed]

Required & provided thickness is shown at the bottom of the sheet.

Add Step in Cover thickness according to thickness of gasket and raised face of matching flange. Maximum deflection is at center; hence maintain the required minimum thickness at the center.



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Step 4. Channel RH Flange

Repeat the design procedure for Channel LH Flange.

(Or Copy the flange data from Channel LH Flange as both flanges are identical)

Step 5. Shell LH Flange

Give Input values in the following steps.

5.1 Select the flange type

Weld neck

5.2 Select MOC of flange similar to adjacent flange.

5.3 Enter Design Pressure, Temperature & Joint efficiency.

P= 21.7 Kg/Cm²

Ca= 3.2 mm

T= 275°C

Joint Efficiency= 1

5.4 Go to flange dialogue screen and enter the data in the following steps

(Flange dimensions will be same as adjacent flange dimensions.)

a. Flange ID similar to adjacent flange ID.

Flange ID= 1250 mm

b. Face ID & OD similar to adjacent flange face ID & OD

Face ID = 1250 mm

Face OD = 1309+4x2+3

Face OD = 1320

c. Gasket ID & OD similar to adjacent flange Gasket ID & OD

Gasket type= Spiral wound

Gasket ID= 1250 + (2 x 3.2) + (13 x 2)

Gasket ID= 1282.4 say 1283 mm

Gasket OD = 1283+13x2

Gasket OD = 1309 mm

5.5 In case of Weld neck Flange,

Thickness of hub at smaller end (Gi) = Shell (or Channel) thickness

Thickness of shell at large End (Go) = 1.5 x Gi

Hub Length (HL) = 2 x Gi (This value can be equal to 1.5 to 2 x Gi)

Gi= 14 mm

Go= 21 mm

HL= 28 mm

(Change this value of Gi, Go & HL according to designed shell thickness)

5.6 Select Bolt Material, thread series & size of Bolt. Similar to adjacent flange

Bolt MOC= SA193 B7

Thread series= UNC

Bolt Size= 31.75 mm



**DESIGN OF AES TYPE HEAT EXCHANGER
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5.7 Select the number of bolts to satisfy the required bolt area. Number of bolts will be similar to adjacent flange.

Number of bolts= 56

5.8 BCD = Similar to adjacent flange BCD

BCD= 1400

5.9 Flange OD = Similar to adjacent flange

Flange OD= 1465

5.10 The gasket material & thickness will be similar to adjacent flange.

Gasket MOC= Spiral wound

Gasket thickness= 4.5 mm

Software will automatically take stress values for specified MOC at design conditions.

5.11 Put the external loading information. Put banding moment due to various attachments to the flange.

Bending Moment= 3146.66 kg-m

5.12 Select the option Use full bolt load calculation. (generally customer asks this)

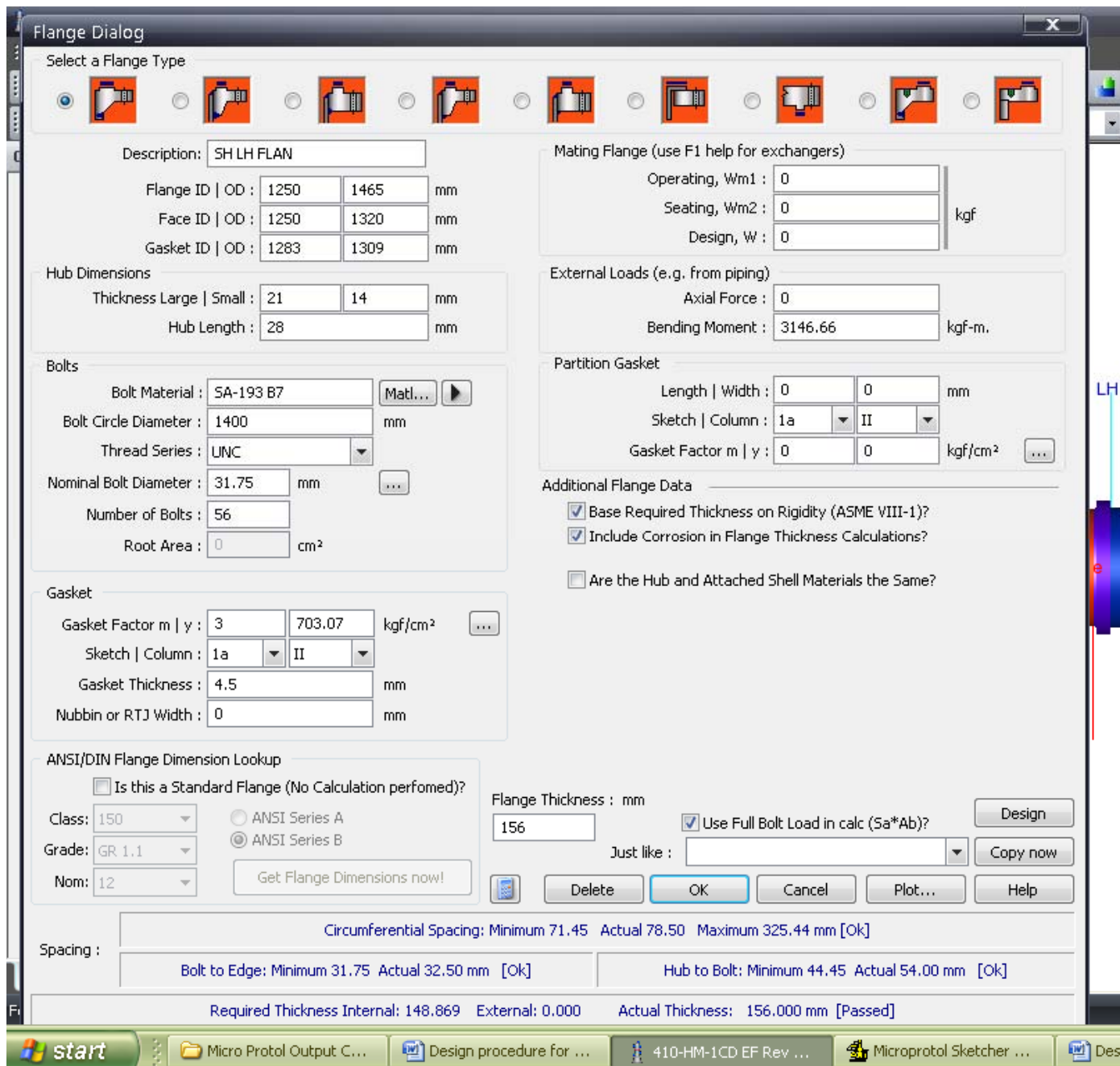
5.13 PV-Elite software will automatically considers Matching flange load.

5.14 Give flange thickness. (initially consider smaller thickness then select flange thickness to satisfy required conditions)

Flange thickness= 156 mm

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

Sheet shows sample flange input sheet.



Flange Dialog

Select a Flange Type

Description: SH LH FLAN

Flange ID | OD : 1250 | 1465 mm
 Face ID | OD : 1250 | 1320 mm
 Gasket ID | OD : 1283 | 1309 mm

Hub Dimensions
 Thickness Large | Small : 21 | 14 mm
 Hub Length : 28 mm

Bolts
 Bolt Material : SA-193 B7 [Mat...]
 Bolt Circle Diameter : 1400 mm
 Thread Series : UNC
 Nominal Bolt Diameter : 31.75 mm
 Number of Bolts : 56
 Root Area : 0 cm²

Gasket
 Gasket Factor m | y : 3 | 703.07 kgf/cm²
 Sketch | Column : 1a | II
 Gasket Thickness : 4.5 mm
 Nubbin or RTJ Width : 0 mm

ANSI/DIN Flange Dimension Lookup
 Is this a Standard Flange (No Calculation performed)?
 Class: 150
 Grade: GR 1.1
 Nom: 12
 ANSI Series A
 ANSI Series B
 Get Flange Dimensions now!

Mating Flange (use F1 help for exchangers)
 Operating, Wm1 : 0
 Seating, Wm2 : 0 kgf
 Design, W : 0

External Loads (e.g. from piping)
 Axial Force : 0
 Bending Moment : 3146.66 kgf-m.

Partition Gasket
 Length | Width : 0 | 0 mm
 Sketch | Column : 1a | II
 Gasket Factor m | y : 0 | 0 kgf/cm²

Additional Flange Data
 Base Required Thickness on Rigidity (ASME VIII-1)?
 Include Corrosion in Flange Thickness Calculations?
 Are the Hub and Attached Shell Materials the Same?

Flange Thickness : mm
 156
 Use Full Bolt Load in calc (Sa*Ab)?
 Design
 Copy now
 Delete OK Cancel Plot... Help

Spacing :
 Circumferential Spacing: Minimum 71.45 Actual 78.50 Maximum 325.44 mm [Ok]
 Bolt to Edge: Minimum 31.75 Actual 32.50 mm [Ok]
 Hub to Bolt: Minimum 44.45 Actual 54.00 mm [Ok]

Required Thickness Internal: 148.869 External: 0.000 Actual Thickness: 156.000 mm [Passed]

Required & provided thickness is shown at the bottom of the sheet.

Add Step in Flange thickness according to thickness of gasket.

Nominal flange thickness= Flange thickness+ Step+ Hub length

In our case add 6 mm step in flange thickness.

Nominal flange thickness= 156+6+28= 190mm

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Step 6. Main Shell

For main shell design follow the Step 1 & give shell side input values.

In Our Case: (For Shell Side)

Shell ID= 1250 mm

$P= 21.7 \text{ Kg/Cm}^2$

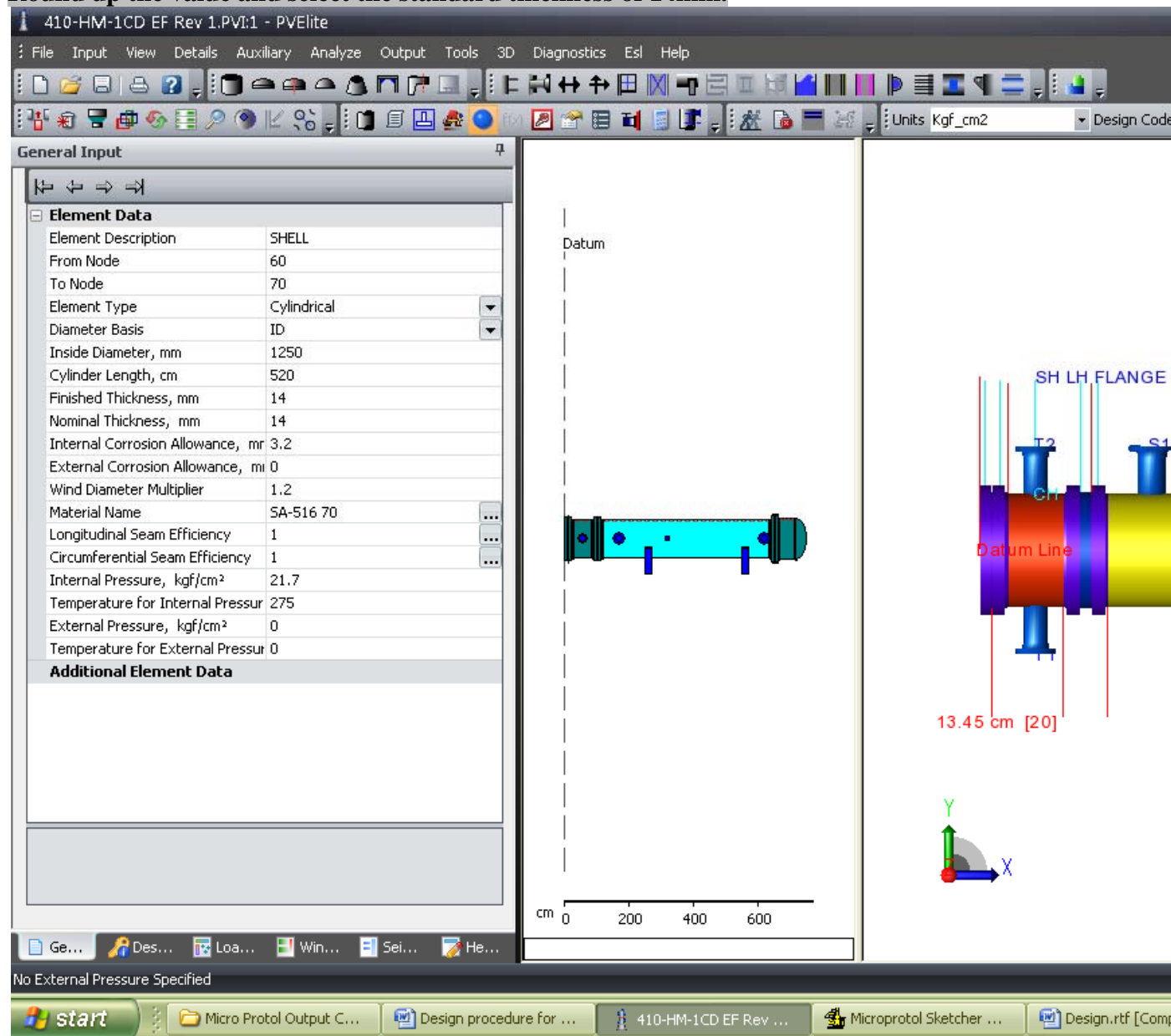
$Ca= 3.2 \text{ mm}$

$T= 275^\circ\text{C}$

Software will compute the required thickness.

$t= 13.11 \text{ mm}$

Round up the value and select the standard thickness of 14mm.



General Input

Element Data	
Element Description	SHELL
From Node	60
To Node	70
Element Type	Cylindrical
Diameter Basis	ID
Inside Diameter, mm	1250
Cylinder Length, cm	520
Finished Thickness, mm	14
Nominal Thickness, mm	14
Internal Corrosion Allowance, mm	3.2
External Corrosion Allowance, mm	0
Wind Diameter Multiplier	1.2
Material Name	SA-516 70
Longitudinal Seam Efficiency	1
Circumferential Seam Efficiency	1
Internal Pressure, kgf/cm ²	21.7
Temperature for Internal Pressure	275
External Pressure, kgf/cm ²	0
Temperature for External Pressure	0
Additional Element Data	

SH LH FLANGE
Datum Line
13.45 cm [20]

cm 0 200 400 600

start | Micro Protol Output C... | Design procedure for ... | 410-HM-1CD EF Rev ... | Microprotol Sketcher ... | Design.rtf [Comp

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

Step 7. Tube sheet design

For tube sheet design give the Input values in following steps.

7.1 Tubesheet Type and Design Code:

7.1.a. Select the analysis method.

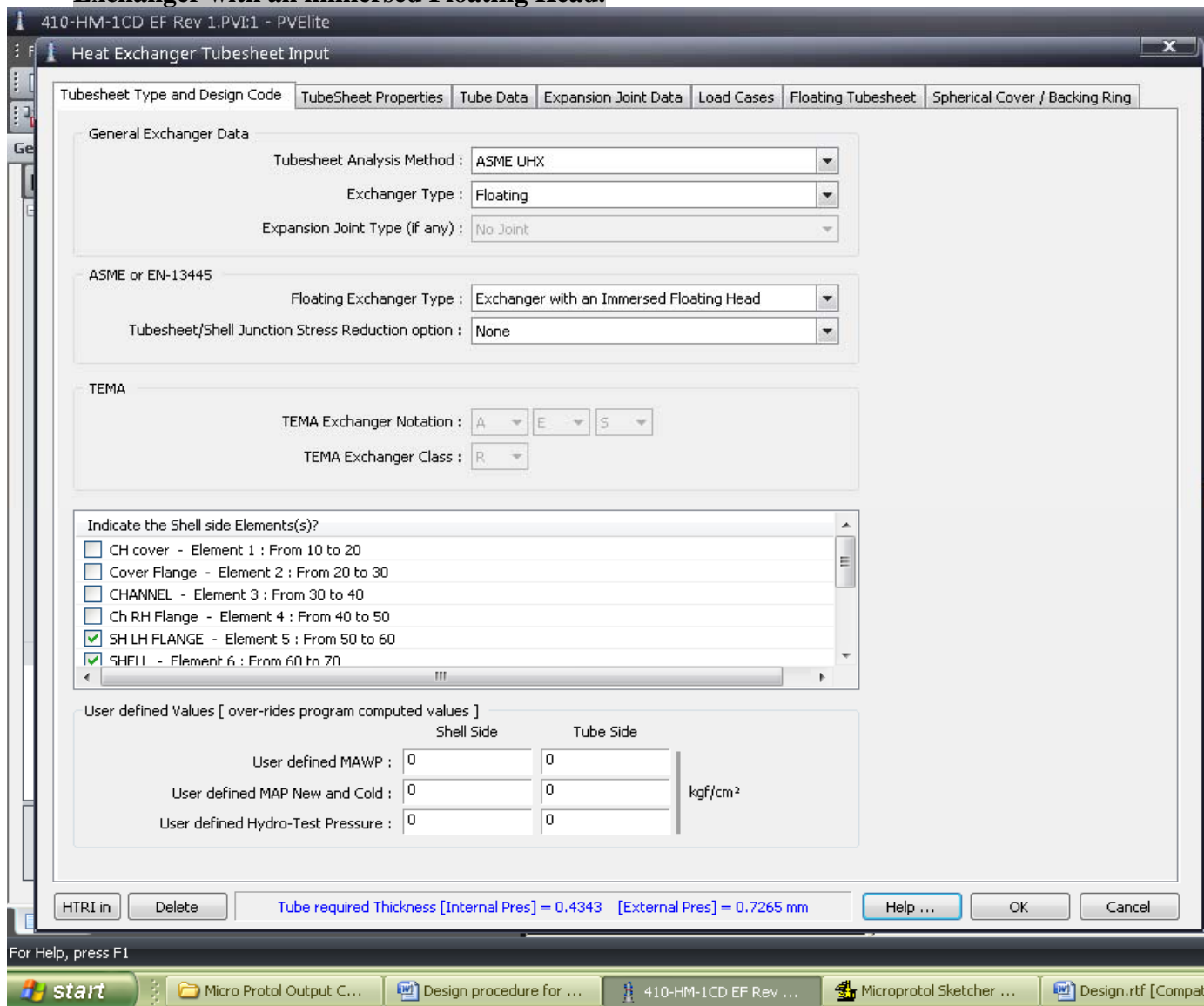
In our case Tubesheet analysis method: **ASME UHX.**

7.1.b. Exchanger type.

Floating

7.1.c. Floating Exchanger type:

Exchanger with an immersed Floating Head.





**DESIGN OF AES TYPE HEAT EXCHANGER
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7.2 Tube sheet Properties:

Fill up the tube sheet information. In our case,

7.2.a Distance from Node= 19 cm

7.2.b Tube sheet type: Stationary tube sheet gasketed on both side.

**7.2.c Outside Diameter= adjacent flange face ID -3mm
In our case Tube sheet OD= 1320-3= 1317mm**

7.2.d Corrosion allowance Shell and channel side.

Corrosion allowance Shell and channel side 3.2 mm both side

**7.2.e Give depth of Groove if any.
Depth of groove= 6 mm**

7.2.f Give thickness of extended portion if tube sheet is extended as flange.



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410-HM-1CD EF Rev 1.PVI:1 - PVElite

Heat Exchanger Tubesheet Input

Tubesheet Type and Design Code | TubeSheet Properties | Tube Data | Expansion Joint Data | Load Cases | Floating Tubesheet | Spherical Cover / Backing Ring

Description : STATIONARY TUBE

Element From Node : 40 [Press F8 - to Enable and Change if needed]

Dist. from "From" Node : 19 cm

Tubesheet Type : (d) Stationary tubesheets, gasketed on both sides

Outside Diameter : 1317 mm

Tubesheet Thickness : 116 mm

Corr. Allow. Shell side / Channel side : 3.2 3.2 mm

Depth of Groove in Tubesheet (if any) : 6 mm

Weld Leg at back of Tubesheet (if any) : 0 mm

Tubesheet Assembly is down/left? :

Tubesheet Extended as Flange? :

Thickness of Extended portion : 95 mm

Tfr/T ratio for U-Tubesheets (optional) : 0

UnTubed Lane Area : 0 cm²

Backing Ring

Backing Ring Thickness : 0 mm

Backing Ring ID / OD : 0 0 mm

G Dimension for Backing Ring : 0 mm

ASME Part UHX / EN-13445 Shell Band Data

Is there a Shell Band? :

Shell Thickness Adjacent to Tubesheet : 0 mm

Shell Band Corrosion Allowance : 0 mm

Shell Band Length adjacent to Tubesheet, front end L1 : 0 mm

Shell Band Length adjacent to Tubesheet, rear end L1 : 0 mm

PD 5500

How are Tubesheets Clamped : [Dropdown]

HTRI in Delete ... Help ... OK Cancel

For Help, press F1

start | Micro Protol Output C... | Design procedure for ... | 410-HM-1CD EF Rev ... | Microprotol Sketcher ... | Design.rtf [Compatibil...]



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7.3 Tube Data:

7.3.a Number of Tube holes

Number of holes= 958

7.3.b Hole pattern: Specify the total number of tube holes drilled in one of the tubesheets. The code expects the holes to be fairly evenly spaced over the entire area of the tubesheet without large areas that are not drilled. The pattern in which the tubes are arranged can be either a Square, or a Triangular.

Hole pattern = square

Pitch= 32 mm

Tube OD= 25.4

7.3.c Length of expanded portion of tube: Enter the length of tube that is expanded into the tubesheet hole. This value may not exceed the full thickness of the tubesheet to avoid failure of the tube at the inner tubesheet face, and is usually in the region of about 80% to 90% of the tubesheet thickness. (For tube to tube sheet joint expanded only, generally take length of expansion= Tube sheet thickness-3)

Length of expansion= 113 mm

7.3.d Radius of Outer most tube hole centre:

Enter the distance from the center of the tubesheet to the centerline of the tube furthest away.

Radius of Outer most tube hole centre= 587.3 mm

7.3.e Distance between Innermost Tube Centers:

Where a Partition Plate is installed, the innermost lanes of tubes may be further apart than general tube pitch in the remainder of the tubesheet. This is maximum distance between the tube innermost centers. If there is no partition plate, this value is zero.

Distance between Innermost Tube Centers= 45

7.3.f Straight Length of Tubes: Specify the straight length of the tubes

There are two options Straight Length of Tubes measured between inner face or in outer face.

Straight Length of Tubes measured between outer face= 5994mm



DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

7.3.g Tube Weld Joint Type

Following table lists the options for the tube/tubesheet welds (ASME UW-20):

Full Strength:	In this weld the design strength is equal to or greater than the maximum allowable axial tube strength.
Partial Strength:	This weld is designed based on the actual tube-tubesheet axial load.
Seal Weld:	No calculations are performed in this case.

7.3.h Select Tube joint type

7.3.i Maximum Distance between two Tube Supports

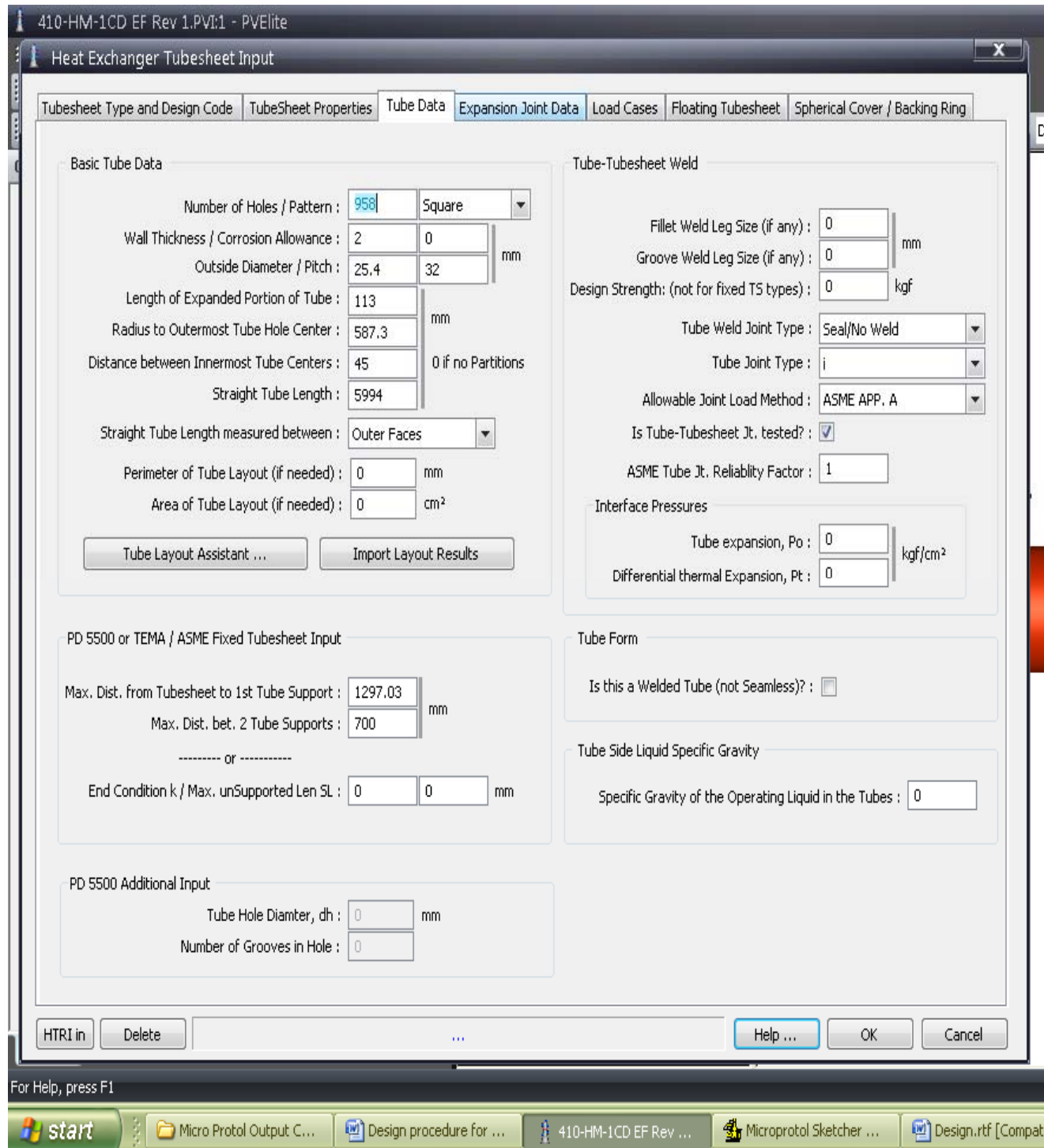
Tubes are supported by each of the tubesheets, but along the heat exchanger, there are a number of supports often called baffles. Enter the Maximum Unsupported Length between supports because PV Elite uses this dimension to determine the buckling stress in the tubes. Carefully examine the design of the exchanger, and ensure the maximum possible unsupported length is entered.

Max. Distance of 1st tube support from tube sheet = 1297.3mm

Max. Distance between two tube supports = 700 mm

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

Sheet shows tube data:



The screenshot shows the 'Heat Exchanger Tubesheet Input' dialog box in the PV-Elite software. The 'Tube Data' tab is selected, and the following data is entered:

Parameter	Value	Unit
Number of Holes / Pattern	958	Square
Wall Thickness / Corrosion Allowance	2	0 mm
Outside Diameter / Pitch	25.4	32 mm
Length of Expanded Portion of Tube	113	mm
Radius to Outermost Tube Hole Center	587.3	mm
Distance between Innermost Tube Centers	45	0 if no Partitions
Straight Tube Length	5994	mm
Straight Tube Length measured between	Outer Faces	
Perimeter of Tube Layout (if needed)	0	mm
Area of Tube Layout (if needed)	0	cm ²
Max. Dist. from Tubesheet to 1st Tube Support	1297.03	mm
Max. Dist. bet. 2 Tube Supports	700	mm
End Condition k / Max. unsupported Len SL	0	0 mm
Tube Hole Diameter, dh	0	mm
Number of Grooves in Hole	0	

Other visible parameters in the dialog include:

- Tube-Tubesheet Weld:** Fillet Weld Leg Size (if any): 0 mm; Groove Weld Leg Size (if any): 0 mm; Design Strength: 0 kgf; Tube Weld Joint Type: Seal/No Weld; Tube Joint Type: i; Allowable Joint Load Method: ASME APP. A; Is Tube-Tubesheet Jt. tested?: ; ASME Tube Jt. Reliability Factor: 1.
- Interface Pressures:** Tube expansion, Po: 0 kgf/cm²; Differential thermal Expansion, Pt: 0.
- Tube Form:** Is this a Welded Tube (not Seamless)?
- Tube Side Liquid Specific Gravity:** Specific Gravity of the Operating Liquid in the Tubes: 0.

Buttons at the bottom of the dialog include: HTRI in, Delete, Help ..., OK, and Cancel.



**DESIGN OF AES TYPE HEAT EXCHANGER
(With the help of PV-Elite Soft ware)**

**Input the load cases as shown in sheet:
Sheet shows load cases enter for our problem.**

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

410-HM-1CD EF Rev 1.PVI:1 - PVElite

Heat Exchanger Tubesheet Input

Tubesheet Type and Design Code | TubeSheet Properties | Tube Data | Expansion Joint Data | Load Cases | Floating Tubesheet | Spherical Cover / Backing Ring

Number of cases to process : 1 | Case Description : DESIGN | Vacuum Pressures and Report Options for this Load Case ...

Active Load Case : 1

	Shell	Channel	Tubes	Tubesheet	Shell Band
Design Pressure :	21.7	32.6	kgf/cm ²		
Design Temperature :	275	240	275	275	
<input type="checkbox"/> Use Operating Metal Temperatures (UHX) :	-1.13646e-007	-1.13646e-007	-1.13646e-007	-1.13646e-007	C
Material :			SA-179	SA-266 4	SA-516 70
Mean Metal Temperature along length :	0		0		C
Metal Temperature at Tubesheet Rim :	21.111	21.111		21.111	C

Database lookup and Properties : Exchanger subject to cyclic or dynamic reactions due to pressure or thermal variations? (see UHX-13.8)

Modulus of Elasticity

User-defined values :

	Shell	Channel	Tubes	Tubesheet	Shell Band
Modulus at Temperature :	0	0	0	0	0
Modulus at Mean Metal Temp along length :	0		0		
Modulus at Mean Metal Temperature :		0		0	
Modulus at Ambient Temperature :	0	0	0	0	0

kgf/cm²

Coefficient of Thermal Expansion (alpha values)

User-defined values :

	Shell	Channel	Tubes	Tubesheet	Shell Band
Alpha at Mean Metal Temp along length :	0		0		0
Alpha at Metal Temp at Tubesheet Rim :	0	0		0	0

mm/mm/C

Differential Pressure Design? :

Differential Design Pressure : 0 kgf/cm²

Expansion Joint Material : SA-516 70 | Matl... ▶

Is the Exchanger Operating in the Creep Range (skip EP, use 35 for Sps)? :

HTRI in | Delete | Tube required Thickness [Internal Pres] = 0.4343 [External Pres] = 0.7265 mm | Help ... | OK | Cancel

For Help, press F1

start | Micro Protol Output C... | Design procedure for ... | 410-HM-1CD EF Rev ... | Microprotol Sketcher ... | Design.rtf [Compatib...

Step 8. Floating tube sheet

Find out the Floating Head data in the following stages:



DESIGN OF AES TYPE HEAT EXCHANGER
(With the help of PV-Elite Soft ware)

8.1.Specify OTL

OTL= 1200mm

8.2.Specify Gasket width

Gasket width=10mm

8.3.Floating tube sheet face ID (B-3) = OTL+ 2xY

(Y=3 for tube to tube sheet joint expanded only, & y= 5 for tube to tube sheet joint type welded type.)

Floating tube sheet face ID= 1200 + 2 x 3

Floating tube sheet face ID= 1206 mm

8.4.Floating head Flange ID (B)= Floating tube sheet face ID+3

Floating head Flange ID (B)= 1206 +3

Floating head Flange ID (B)= 1209 mm

8.5.Floating head Flange Face ID= Floating head Flange ID

Floating head Flange Face ID= 1209 mm

8.6.Gasket ID= Flange Face ID+3

Gasket ID= (B+3)= 1209+3

Gasket ID= 1212 mm

8.7.Gasket OD= Gasket ID + 2x Gasket width

Gasket OD= 1212+ 2x10

Gasket OD= 1232 mm

8.8.Floating tube sheet OD= Gasket OD+ 2x4

Floating tube sheet OD= 1232+ 2x4

Floating tube sheet OD= 1240 mm

8.9.Flange face OD= Floating tube sheet OD +3

Flange face OD= 1240 + 3

Flange face OD= 1243 mm

8.10. Select Bolt size

Bolt Size= 36

8.11. BCD= Flange ID+ 3+ 2xRh

(Refet TEMA Table D-5M for Value of Rh & E)

BCD= 1209+ 2x41

BCD= 1291 mm

8.12. Flange OD= BCD+2xE

Flange OD= 1291+ 2x41

Flange OD= 1373

8.13. Backing Ring OD= Flange OD

Backing Ring OD= 1373

8.14. Backing Ring ID= B-1

Backing Ring ID= 1209- 1

Backing Ring ID= 1208

8.15. Backing Ring Groove OD= Tube Sheet OD

Backing Ring Groove OD= 1240 mm

Sheet Shows Floating Head Flange Head flange Head Input details

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

410-HM-1CD EF Rev 1.PVI:1 - PVElite

File Input View Details Auxiliary Analyz Heat Exchanger Tubesheet Input

Flange and Gasket Information

Flanged Portion ID (B) / OD (A) :	1209	1351	
Flange Face ID / OD :	1209	1243	mm
Gasket ID / OD :	1212	1232	
Gasket Factor m / y :	3	703.07	kgf/cm ²
Flange Face Sketch / Column :	1a	I	
Gasket Thickness :	4.5		mm
Nubbin Width :	0		

Partition Gasket (if present)

Length / Width :	1216	10	mm
Gasket Factor m / y :	3.75	632.763	kgf/cm ²
Flange Face Sketch / Column :	1a	I	

Thread Series : UNC Root Area : 0 cm²

Number of Bolts : 56

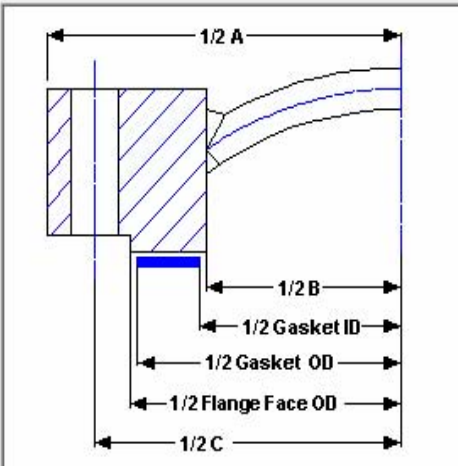
Bolt Circle Dia.(C) / Nom Bolt Dia : 1280 31.75 mm

Bolt Design Temperature : 275 C

Bolt Material : SA-193 B7M Matl...

Alternate Bolt Loads (used if greater than calculated values)

Operating Wm1 / Seating Wm2 :	0	0	kgf
Design W :	0		



HTRI in Delete ...

For Help, press F1

start Micro Protol Output C... Design procedure for ... 410-HM-1CD EF Rev ... Microprotol Sketcher ...

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

Sheet Shows Floating Head Flange Head flange Head Input details

410-HM-1CD EF Rev 1.PVI:1 - PVElite

File Input View Details Auxiliary Analyze Output Tools 3D Diagnostics Esl Help

Heat Exchanger Tubesheet Input

Tubesheet Type and Design Code TubeSheet Properties Tube Data Expansion Joint Data Load Cases Floating Tubesheet Spherical Cover / Backing Ring

Dished Cover and Flange Data

Description : FLOATING FLANGE

Design Temperature : 275 C

Type of Floating Head : d

Inside Crown Radius (L) : 970.4

Head Thickness (t) : 34 mm

Head Internal Corrosion Allowance : 3.2

Head External Corrosion Allowance : 3.2

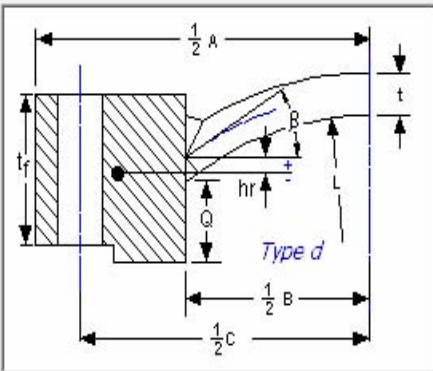
Flange Thickness (tf) : 132

Slotted Flange ? :

Full Face Gasket Option :

Head Material : SA-516 70 Mat...

Flange Material : SA-266 4 Mat... Compute "F" even if the pressure is 0



Dimensions hr and Q

Distance from Flange Centroid to Head Centerline (hr) : 21.6196 mm Perform Soehren's Calc :

Distance from Flange Top to Flange/Head Intersection : 25 Compute

Dim Q : 0 mm

Backing Ring Data

Is There a Backing Ring ? : Backing Ring Material : SA-266 4 Mat...

Backing Ring Inside Diameter / Outside Diameter : 1240 1351 mm

Backing Ring Thickness : 155 mm

Number of Splits in Backing Ring : 1

HTRI in Delete Help ... OK Cancel

start Micro Protol Output C... Design procedure for ... 410-HM-1CD EF Rev ... Microprotol Sketcher ... Design.rtf [Comp...

Step 9. Barrel design

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

Cylindrical shell under internal pressure.

For Barrel shell design follow the Step 1 & give shell side input values.

Barrel ID= Floating flange OD+ 2x M

M= Gap between barrel shell ID and Floating flange OD. Value of M depends on shell ID

Barrel ID= 1351+ 2X12

Barrel ID= 1375mm

We have considered, Barrel ID= 1385mm

P= 21.7 Kg/Cm²

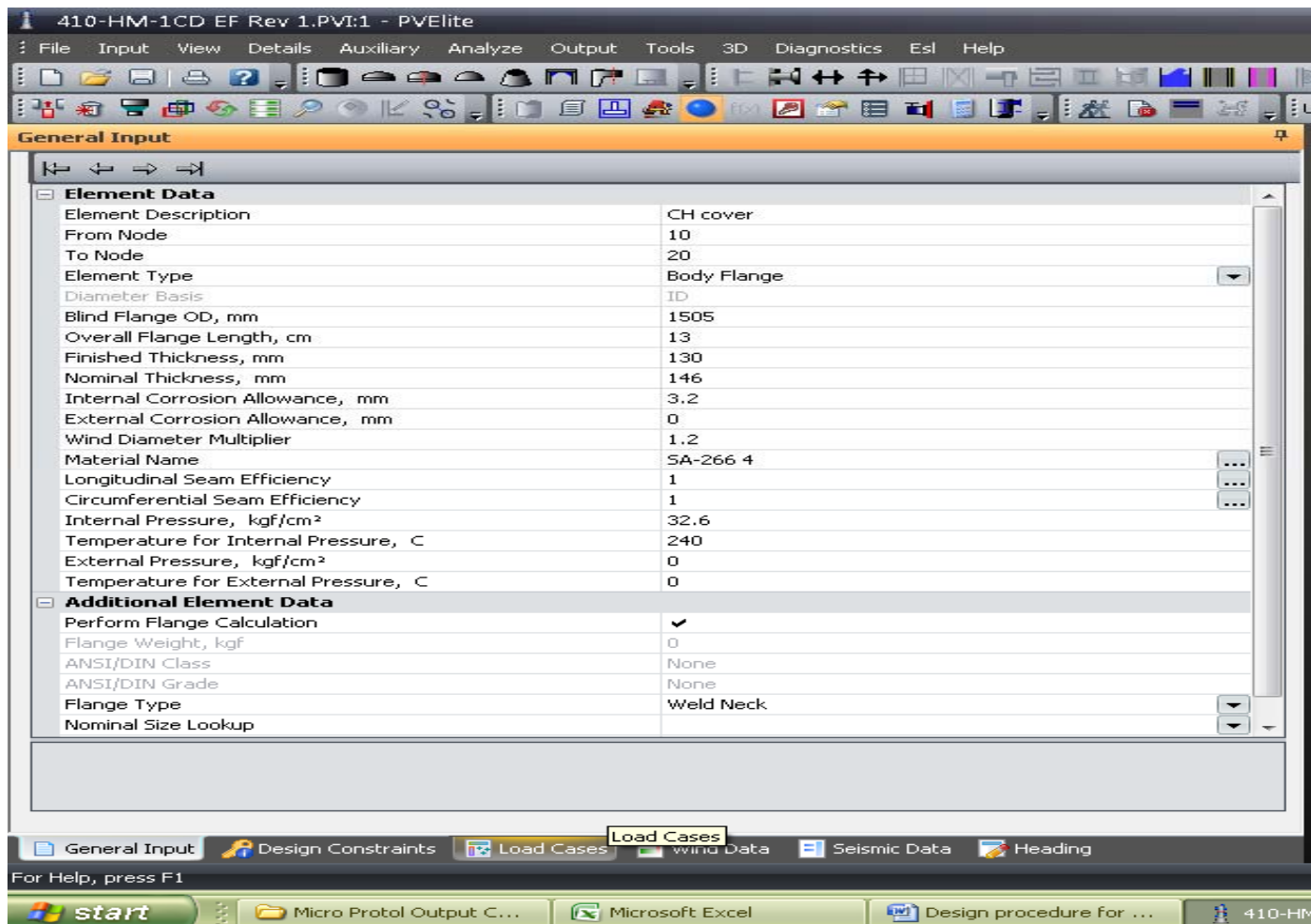
Ca= 3.2 mm

T= 275°C

Software will compute the required thickness.

t= 14.19 mm

Round up the value and select the standard thickness of 16mm.



Step 10. SH Cover Flange

Give Input values in the following steps.



DESIGN OF AES TYPE HEAT EXCHANGER
(With the help of PV-Elite Soft ware)

10.1. Select the flange type

Weld neck

10.2. Select MOC of flange

SA266 GR 4

Software will automatically take stress values for specified MOC at design conditions.

10.3. Enter Design Pressure, Temperature & Joint efficiency.

P= 32.6 Kg/Cm²

Ca= 3.2 mm

T= 240°C

Joint Efficiency= 1

10.4. Go to flange dialogue screen and enter the data in the following steps

10.4.a. Flange ID = Barrel shell ID

Flange ID= 1385 mm

10.4.b. Face ID = Flange ID

Face ID = 1385 mm

10.4.c. Gasket ID depends on type of gasket used.

Gasket ID = Face ID + 2 x Corrosion allowance

The Spiral wound Gasket consists of 13mm of inner ring and 4mm of outer ring. In this case,

Gasket ID = Face ID + 2 x Corrosion allowance + (13 x 2)

Gasket type= Spiral wound

Gasket ID= 1385 + (2 x 3.2) + (13 x 2)

Gasket ID= 1418 mm

10.4.d. Gasket OD = Gasket ID + (2 x Gasket width)

Gasket OD = 1418+13x2

Gasket OD = 1444 mm

10.4.e. Face OD = Gasket OD+3 (in case of Female type face)

For male type face, Face OD = Gasket OD

For Spiral wound gasket add 8mm in Face OD for outer gasket ring.

Face OD = 1444+4x2+3

Face OD = 1455

10.5. In case of Weld neck Flange,

Thickness of hub at smaller end (Gi) = Shell (or Channel) thickness

Thickness of shell at large End (Go) = 1.5 x Gi

Hub Length (HL) = 2 x Gi (This value can be equal to 1.5 to 2 x Gi)

Gi= 16 mm

Go= 24 mm

HL= 32 mm



DESIGN OF AES TYPE HEAT EXCHANGER
(With the help of PV-Elite Soft ware)

10.6. Select Bolt Material, thread series & size of Bolt. (Initially consider smaller size of bolts to perform the calculation)

Bolt MOC= SA193 B7

Software will automatically take stress values for specified MOC at design conditions.

Thread series= UNC

Bolt Size= 25.4 mm

10.7. Select the number of bolts to satisfy the required bolt area.

Number of bolts= 68

10.8. $BCD = \text{Flange ID} + Go + 2Rh$

Rh is radial distance between Bolt circle and Flange

$BCD = 1385 + 2 \times 24 + 2 \times 34.92$

Minimum BCD= 1502.8

Minimum Circumferential distance between two bolts is 57.15

To satisfy the above conditions selecting the BCD of 1505 mm

10.9. Flange OD = BCD + 2E

For Minimum value for Rh & E refer TEMA Table D-5M

(Note: As size of Flange depends on BCD, try to keep BCD as minimum as possible. Minimum Circumferential spacing between bolts should be kept according to TEMA Table D-5M.)

Flange OD= $1505 + 2 \times 26.99$

Flange OD= 1558.98 Say 1560 mm

10.10. Select the gasket material & thickness.

Gasket MOC= Spiral wound

Gasket thickness= 4.5 mm

Software will automatically take stress values for specified MOC at design conditions.

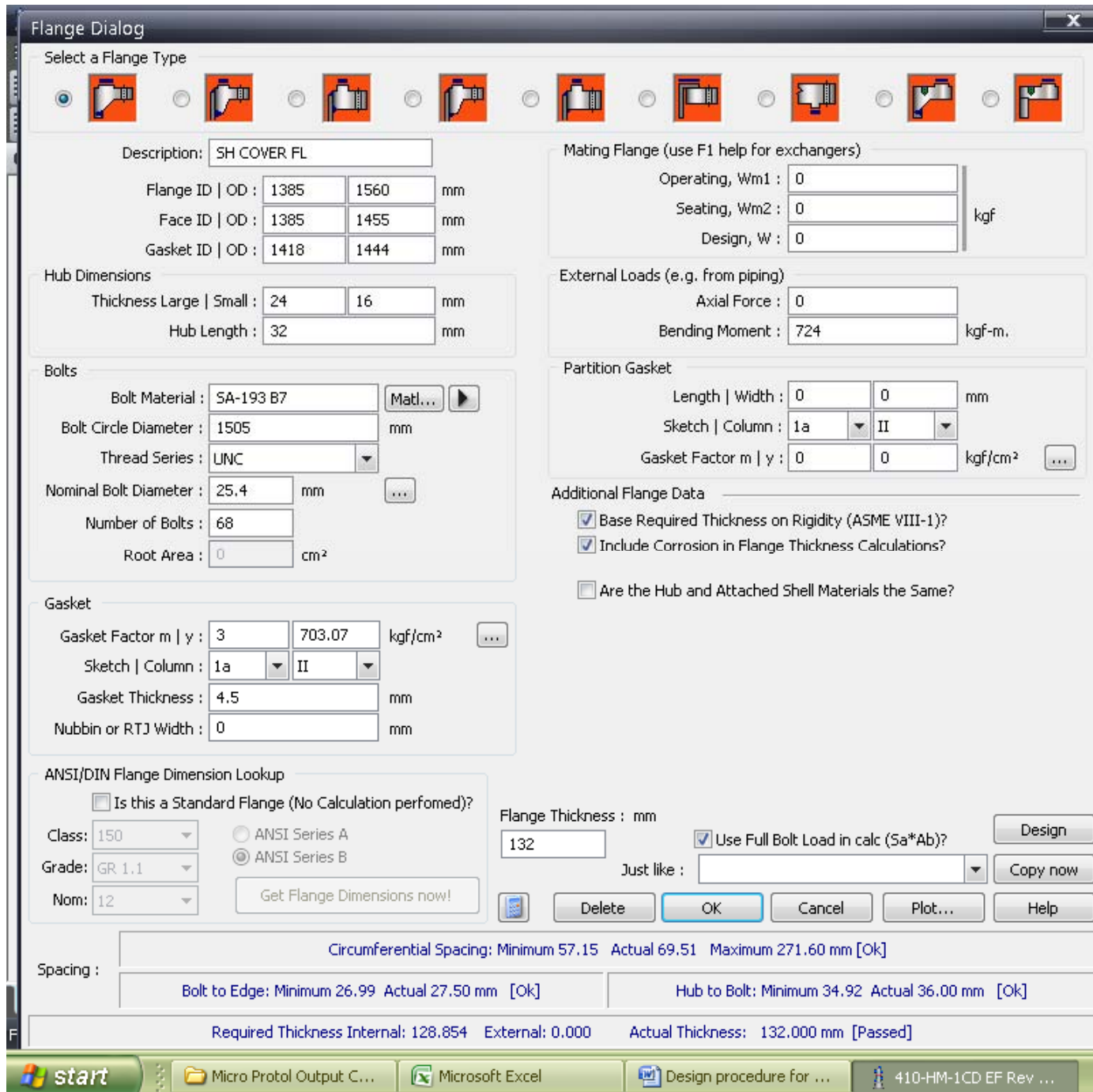
10.11. Put the external loading information. Put banding moment due to various attachments to the flange.

Bending Moment= 724 kg-m

10.12. Select the option Use full bolt load calculation. (generally customer asks this)

Flange thickness= 132 mm

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)



Flange Dialog

Select a Flange Type

Description: SH COVER FL

Flange ID | OD : 1385 | 1560 mm
 Face ID | OD : 1385 | 1455 mm
 Gasket ID | OD : 1418 | 1444 mm

Hub Dimensions
 Thickness Large | Small : 24 | 16 mm
 Hub Length : 32 mm

Bolts
 Bolt Material : SA-193 B7
 Bolt Circle Diameter : 1505 mm
 Thread Series : UNC
 Nominal Bolt Diameter : 25.4 mm
 Number of Bolts : 68
 Root Area : 0 cm²

Gasket
 Gasket Factor m | y : 3 | 703.07 kgf/cm²
 Sketch | Column : 1a | II
 Gasket Thickness : 4.5 mm
 Nubbin or RTJ Width : 0 mm

ANSI/DIN Flange Dimension Lookup
 Is this a Standard Flange (No Calculation performed)?
 Class: 150
 Grade: GR 1.1
 Nom: 12
 ANSI Series A
 ANSI Series B
 Get Flange Dimensions now!

Mating Flange (use F1 help for exchangers)
 Operating, Wm1 : 0
 Seating, Wm2 : 0
 Design, W : 0

External Loads (e.g. from piping)
 Axial Force : 0
 Bending Moment : 724 kgf-m.

Partition Gasket
 Length | Width : 0 | 0 mm
 Sketch | Column : 1a | II
 Gasket Factor m | y : 0 | 0 kgf/cm²

Additional Flange Data
 Base Required Thickness on Rigidity (ASME VIII-1)?
 Include Corrosion in Flange Thickness Calculations?
 Are the Hub and Attached Shell Materials the Same?

Flange Thickness : mm
 132
 Use Full Bolt Load in calc (Sa*Ab?)
 Just like :
 Design Copy now Delete OK Cancel Plot... Help

Spacing :
 Circumferential Spacing: Minimum 57.15 Actual 69.51 Maximum 271.60 mm [Ok]
 Bolt to Edge: Minimum 26.99 Actual 27.50 mm [Ok] Hub to Bolt: Minimum 34.92 Actual 36.00 mm [Ok]
 Required Thickness Internal: 128.854 External: 0.000 Actual Thickness: 132.000 mm [Passed]

Required & provided thickness is shown at the bottom of the sheet.

Add Step in Flange thickness according to thickness of gasket.

Nominal flange thickness= Flange thickness+ Step+ Hub length

In our case add 6 mm step in flange thickness.

Nominal flange thickness= 132+6+32= 170

DESIGN OF AES TYPE HEAT EXCHANGER
(With the help of PV-Elite Soft ware)

Step 11. SH RHS Flange

Repeat the design procedure for Sh RH Flange.

11.1. Select the flange type

Weld neck

11.2. Select MOC of flange similar to adjacent flange.

11.3. Enter Design Pressure, Temperature & Joint efficiency.

P= 21.7 Kg/Cm²

Ca= 3.2 mm

T= 275°C

Joint Efficiency= 1

**11.4. Go to flange dialogue screen and enter the data in the following steps
(Flange dimensions will be same as adjacent flange dimensions.)**

a. Flange ID similar to adjacent flange ID.

Flange ID= 1250 mm

b. Face ID

Face ID = 1250 mm

c. Face OD= Face OD of Barrel Flange - 3

Face OD = 1455-3

Face OD = 1452

d. Gasket ID & OD similar to adjacent flange Gasket ID & OD

Gasket ID= 1418 mm

Gasket OD = 1444 mm

11.5. In case of Weld neck Flange,

Thickness of hub at smaller end (Gi) = Shell (or Channel) thickness

Thickness of shell at large End (Go) = 1.5 x Gi

Hub Length (HL) = 2 x Gi (This value can be equal to 1.5 to 2 x Gi)

Gi= 14 mm

Go= 21 mm

HL= 28 mm

(Change this value of Gi, Go & HL according to designed shell thickness)

11.6. Select Bolt Material, thread series & size of Bolt. Similar to adjacent flange

Bolt MOC= SA193 B7

Thread series= UNC

Bolt Size= 25.4 mm

**11.7. Select the number of bolts to satisfy the required bolt area. Number of bolts
will be similar to adjacent flange.**

Number of bolts= 68



DESIGN OF AES TYPE HEAT EXCHANGER
(With the help of PV-Elite Soft ware)

11.8. BCD = Similar to adjacent flange BCD
BCD= 1505

11.9. Flange OD = Similar to adjacent flange
Flange OD= 1560

11.10. The gasket material & thickness will be similar to adjacent flange.
Gasket MOC= Spiral wound
Gasket thickness= 4.5 mm
Software will automatically take stress values for specified MOC at design conditions.

11.11. Put the external loading information. Put banding moment due to various attachments to the flange.
Bending Moment= 724 kg-m

11.12. Select the option Use full bolt load calculation. (generally customer asks this)

11.13. PV-Elite software will automatically considers Matching flange load.

11.14. Give flange thickness. (initially consider smaller thickness then select flange thickness to satisfy required conditions)

Flange thickness= 154 mm

DESIGN OF AES TYPE HEAT EXCHANGER (With the help of PV-Elite Soft ware)

Flange Dialog

Select a Flange Type

Description: SH RH FLANGE

Flange ID OD :	1250	1560	mm
Face ID OD :	1250	1452	mm
Gasket ID OD :	1418	1444	mm

Hub Dimensions

Thickness Large Small :	21	14	mm
Hub Length :	28		mm

Bolts

Bolt Material : SA-193 B7 Matl... ▶

Bolt Circle Diameter : 1505 mm

Thread Series : UNC

Nominal Bolt Diameter : 25.4 mm

Number of Bolts : 68

Root Area : 0 cm²

Mating Flange (use F1 help for exchangers)

Operating, Wm1 :	0	kgf
Seating, Wm2 :	0	
Design, W :	0	

External Loads (e.g. from piping)

Axial Force :	0
Bending Moment :	724 kgf-m.

Partition Gasket

Length Width :	0	0	mm
Sketch Column :	1a	II	
Gasket Factor m y :	0	0	kgf/cm ² ...

Additional Flange Data

Base Required Thickness on Rigidity (ASME VIII-1)?

Include Corrosion in Flange Thickness Calculations?

Are the Hub and Attached Shell Materials the Same?

Gasket

Gasket Factor m y :	3	703.07	kgf/cm ² ...
Sketch Column :	1a	II	
Gasket Thickness :	4.5		mm
Nubbin or RTJ Width :	0		mm

ANSI/DIN Flange Dimension Lookup

Is this a Standard Flange (No Calculation performed)?

Class : 150

Grade : GR 1.1

Nom : 12

ANSI Series A

ANSI Series B

Get Flange Dimensions now!

Flange Thickness : mm

154

Use Full Bolt Load in calc (Sa*Ab)?

Just like : ▼

Design Copy now Delete OK Cancel Plot... Help

Spacing :

Circumferential Spacing: Minimum 57.15 Actual 69.51 Maximum 309.31 mm [Ok]	
Bolt to Edge: Minimum 26.99 Actual 27.50 mm [Ok]	Hub to Bolt: Minimum 34.92 Actual 106.50 mm [Ok]

Required Thickness Internal: 151.486 External: 0.000 Actual Thickness: 154.000 mm [Passed]

Required & provided thickness is shown at the bottom of the sheet.
Add Step in Flange thickness according to thickness of gasket.
(Note: As flange face is male type, no need to add step in flange thickness)
Nominal flange thickness= Flange thickness+ Hub length
Nominal flange thickness= 154+28= 182