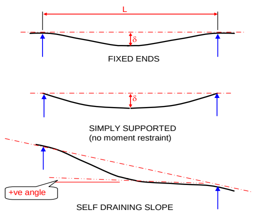
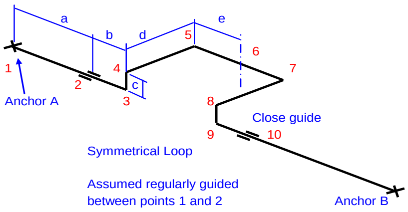
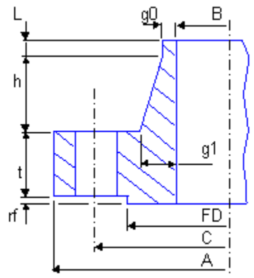
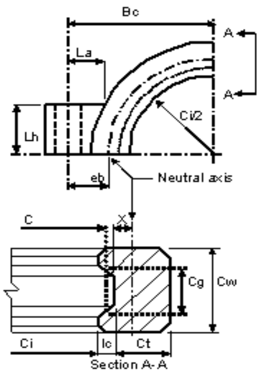
Pipemill

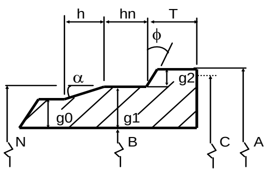
Engineering Software
User Guide

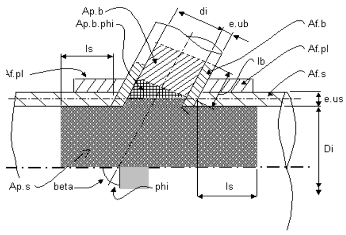


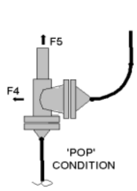


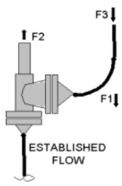


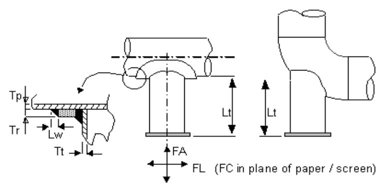












Software designed to aid the Piping Engineer and Piping Stress Engineer

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Version 4.00

Pipemill Engineering Software
User Guide, Version 4.00

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User Guide, Version 4.00

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1.0 PROGRAM DESCRIPTION

PIPEMILL has been written to aid the piping design engineer and the piping stress engineer. Its purpose is to improve accuracy and speed in both complex and simple but repetitive calculations.

Extensive and wide ranging routines area available to assist in both commonly used and rarely used calculations.

Where possible, common functions are employed throughout all elements of the program.

Context sensitive help is provided where needed. It is expected that an experienced engineer would have little recourse to any literature whilst running the software.

The software is written in Microsoft Visual Basic and takes full advantage of the Windows environment to deliver clear, user friendly input and output screens, with helpful and informative graphics.

Pipemill is provided, loaded on a (USB) Stick memory. The software will run from this location only, on any compatible PC type computer.

Do not attempt to move execution software elsewhere as this will cause permanent corruption.

Refer to the section on Installation Instructions for further information.

Pipemill has been compiled under the Microsoft Windows 8 platform.

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1.2 DISCLAIMER

Whilst each program within the PIPEMILL package has been carefully checked and tested, no guarantee is offered or implied with regard to accuracy or validity of results. The software must be used only by qualified personnel, familiar with the Codes of Practice and design rules implemented by the programs therein.

1.3 IMPORTANT NOTE CONCERNING NUMBER FORMAT:

Ensure that the number format on your computer is true decimal ONLY

USE THIS FORMAT: 123456.789

Decimal point with no spaces.

Any other format using commas or spaces such as below will cause fatal errors and will corrupt data read from the data bases:

Do not use these formats !

123 456,789	**space and comma**
123456,789	**comma**
123 456.789	**space and decimal point**

To change to the correct format select 'Regional and Language Options' from Microsoft Windows.

1.4 Technical Support

Technical support is available via e-mail. A description of the problem or query and any associated input files should be e-mailed to:

pipemill@Ivysoftlimited.com

1.5 SYSTEM REQUIREMENTS

- A PC running at least the Windows XP operating system.

- Available USB port

1.6 COMMON FEATURES

1.6.1 File Manager

Where needed, file read and write facilities appear to be the same for all parts of the program. Files are stored in the directory named in the 'Data Files' window of the Set-Up file available from the main menu.

When saving a file, only the file name itself should be entered. Files from each individual program are identified by a unique trailer which is assigned by the program when the file is saved.

When reading files from a particular program, only those relevant will appear in the file list. Simply clicking on the required file name will load it and return to the populated input form.

Once saved with a particular units set, the retrieved file units cannot be changed.

1.6.2 Data Bases

Several data bases are coded into the software and accessed by the various programs. These include:

Pipe sizes to ANSI B36.10, B36.19 and API 5L dimensions
Flange dimensions to ANSI B16.5, ANSI B17.47A & B and API 6A
Valve dimensions to ASME B36.10
Material data curves relating to external pressure design
Expansion characteristics of various materials to ASME B31.3

1.6.3 Help Files

Help files are available from most programs and are accessed usually by clicking on the yellow '**?**' button.

1.6.4 Calculator

A scientific type calculator is available from all elements of the program. It may be dragged and dropped to any location on the screen.

1.6.5 Design Codes

Calculations are generally in accordance with ASME and API UK codes of practice.

1.7 Future Developments

We encourage users to recommend future developments to Pipemill via the website.

2.0 INSTALLATION INSTRUCTIONS

Pipemill may be used on any compatible PC.

Plug the Memory Stick into an available USB port.

Either: Using Windows Explorer, click on the **PM-START.exe** file.

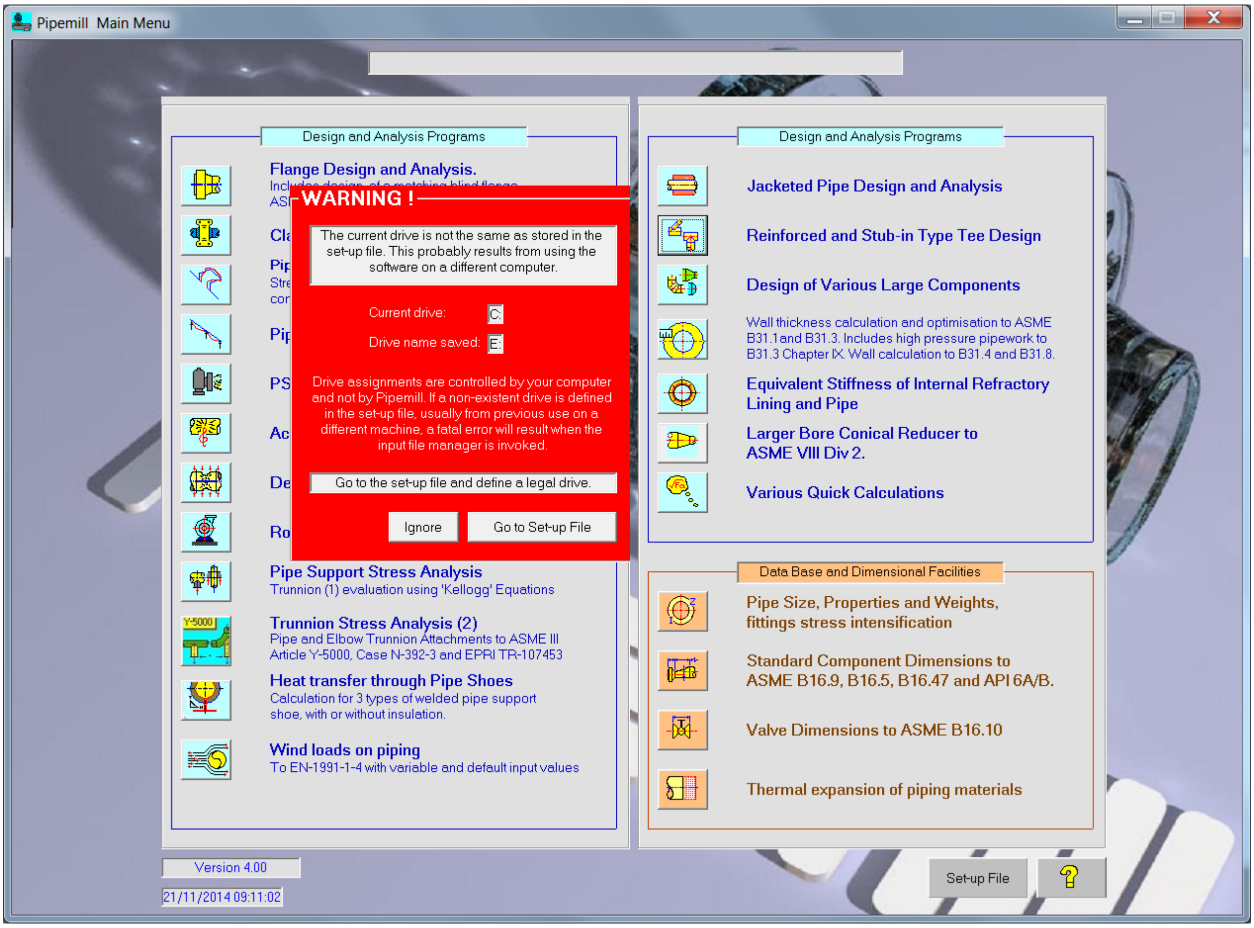
Using Windows Explorer, drag and drop the **PM-START.exe** file logo to your desktop and define a short-cut. Then use the short-cut.

Do not click on the Pipemill3.exe file, since this action will cause a file loading failure.

Allocated Drive Definition

If the Memory Stick has been used on a different computer, the USB port may not have the same name (E, F, G etc.) as the current installation. Whilst Pipemill will function normally under these circumstances, use of the file manager will cause a system abort.

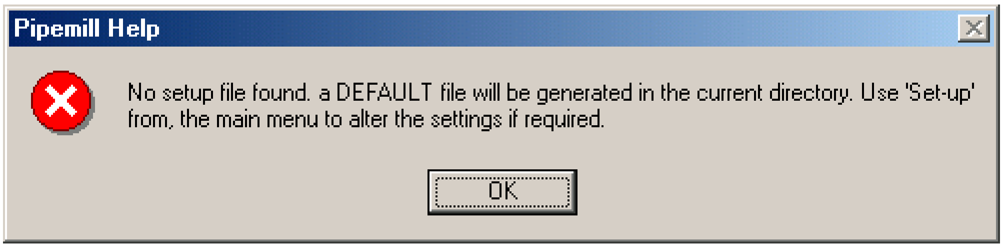
Pipemill will check the drive name and warn the user if necessary, giving the option of going directly to the set-up file, where the correct current drive location may be defined.



Input data files may be stored on any drive including the Pipemill stick memory itself.

2.1 Initial Start-up of Software

To operate normally the PIPEMILL system needs a set-up file to determine such as the system of units to be used and file structure. If the set-up file is accidentally deleted or moved, and at first start-up following installation, the following will appear:

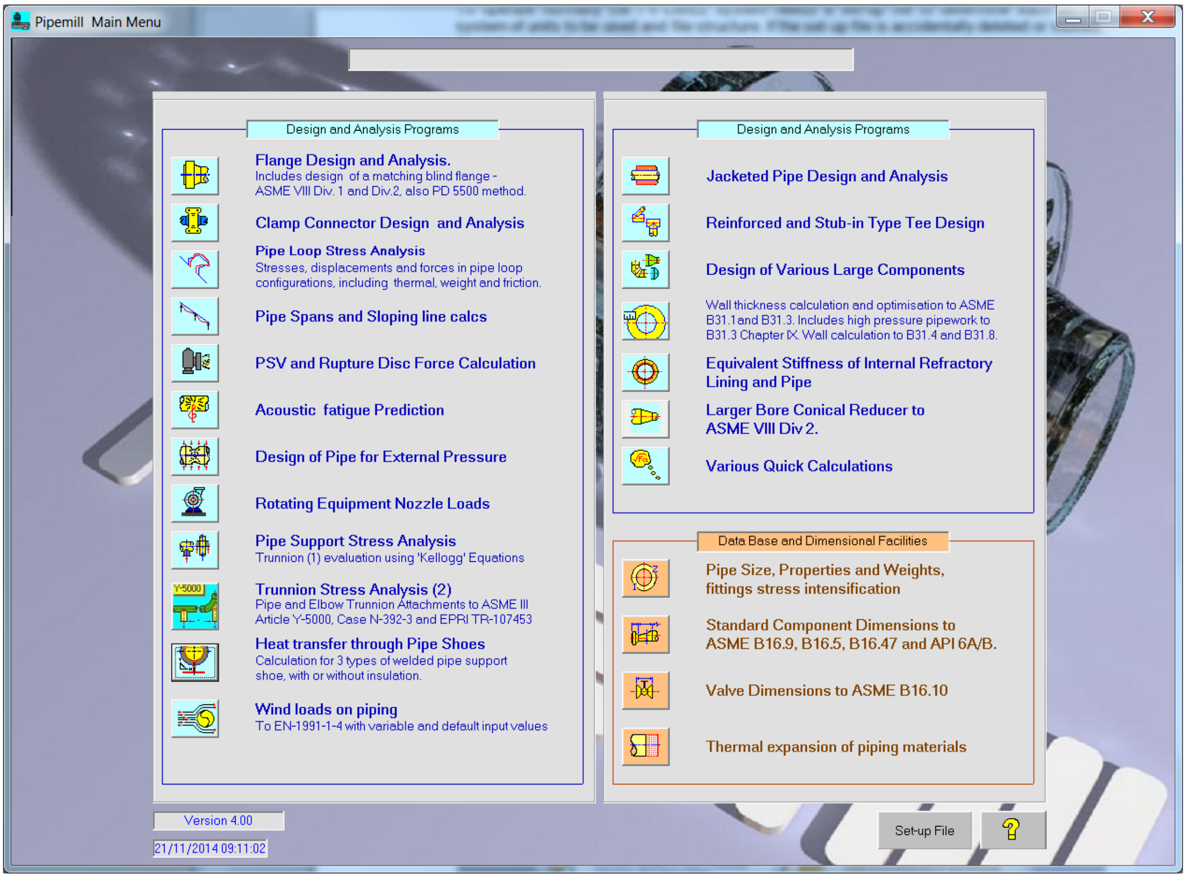


A system file will be created and the main menu will then appear.

All programs are accessed from the main menu screen as shown below.

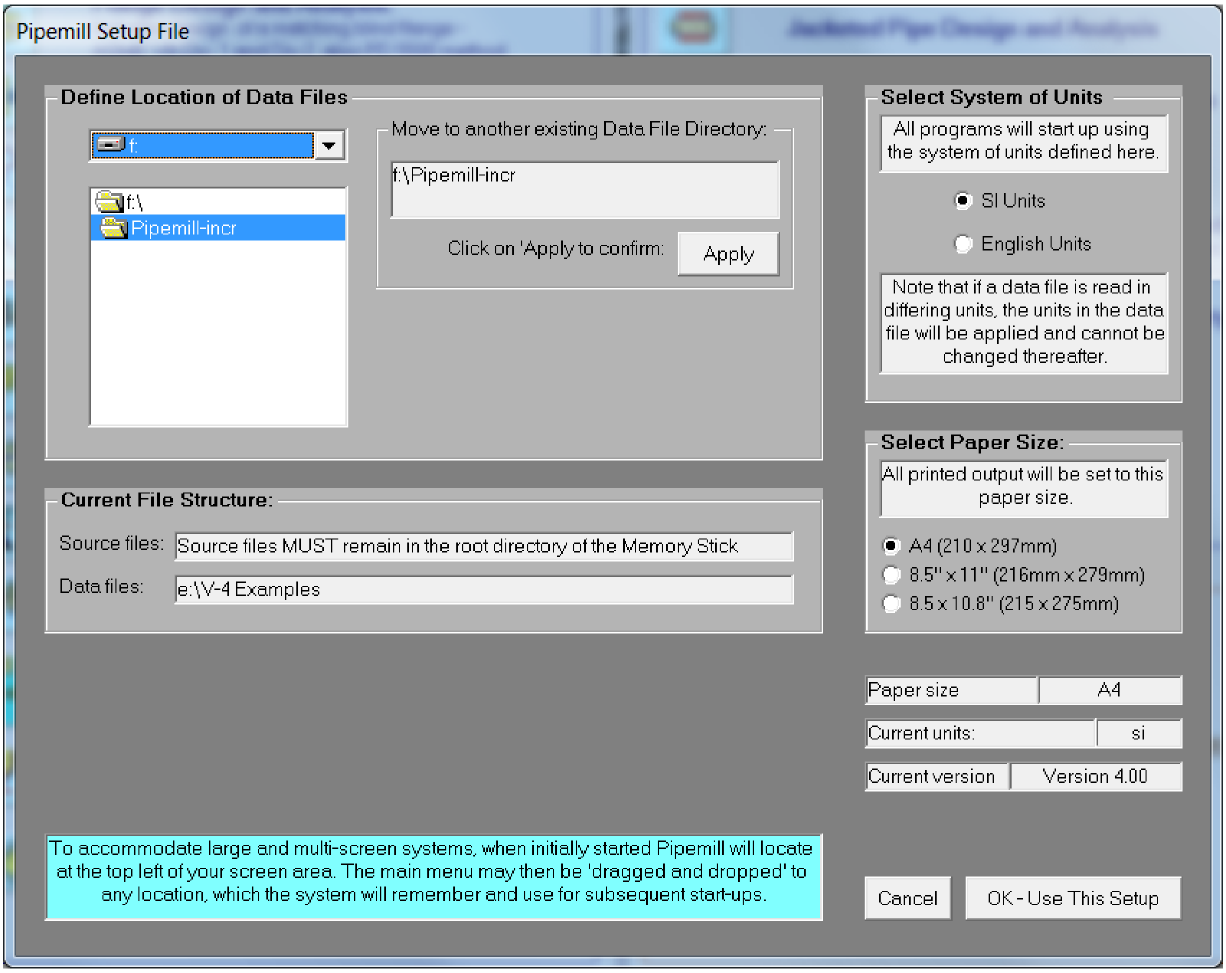
The PIPEMILL system is designed to run one program element in memory. The running program and the main menu may be minimised to the tool bar and maximised without loss of data or any interference with other software in memory.

2.1.1 Main Menu Screen



2.2 The Set-Up File

Accessed from the main menu, the set-up file may be used to select the system of units to be used in calculations, the required paper size and file structure. Once defined, these settings are stored and used in all future work.

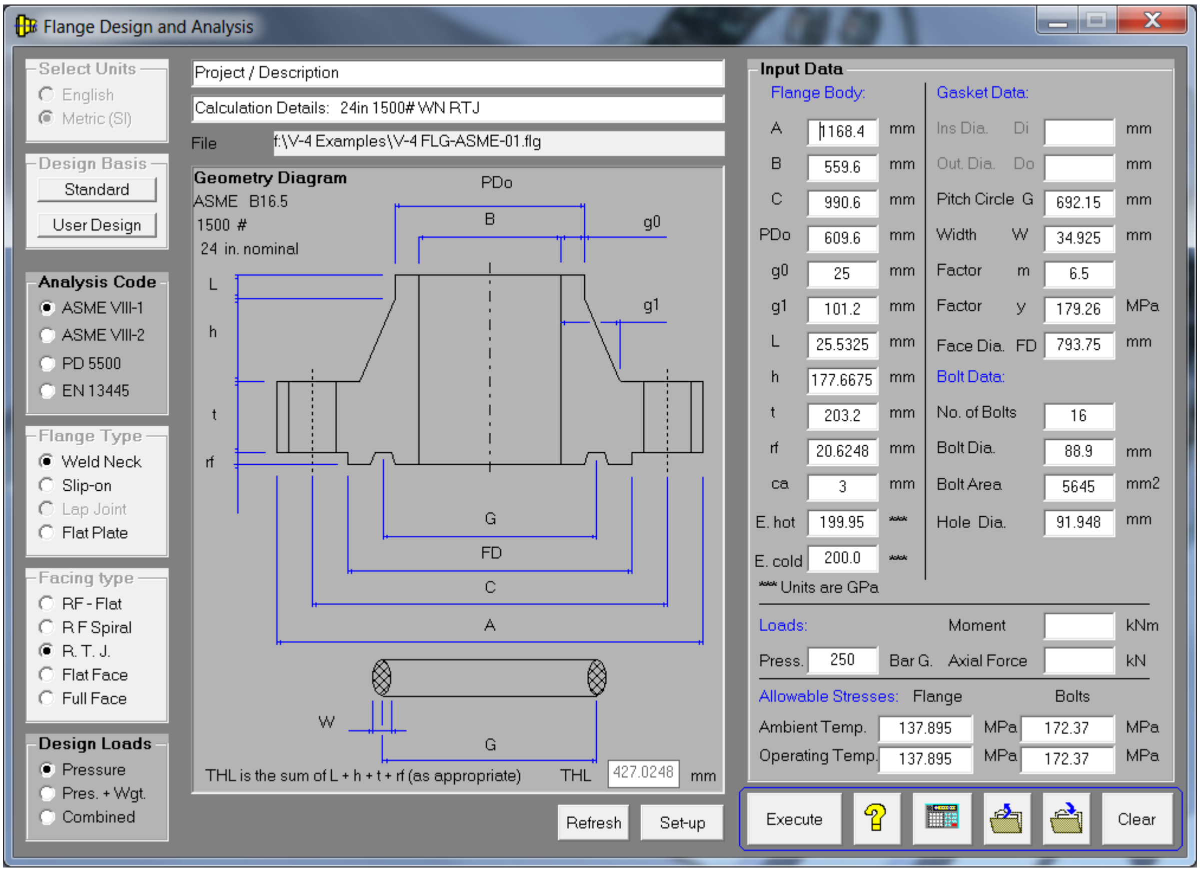


3.0 FLANGE DESIGN AND ANALYSIS (INCLUDING BLIND FLANGES) to ASME VIII and PD 5500

3.1 INPUT DATA

Input data is common to ASME VIII Div. 1, ASME VIII Div. 2 and PD5500.

Typical Input Screen



3.1.1 Starting a New Input

To initiate a new flange design, either a standard or user defined design must be selected. If a standard flange is required, data bases of ANSI B16.5, ANSI B16.47A & B and API 6Aor 6B dimensions may be accessed.

In common with user defined data, the flange type and facing type must be defined before the main input data panel can be accessed.

A comprehensive help file may be accessed and is strongly recommended to new users. In addition to definitions and descriptions, dimensional data such as bolt and gasket parameters are available. Details of the help file are displayed below.

A local set-up file controls whether dimensional data is independent or related. If geometry cells are locked, when the g0 (hub small end) dimension is entered for a standard flange, all related dimensions will be updated. Related cells will not then be accessible.

Default data will be entered for allowable stresses, and dependent upon type, relevant gasket parameters. All these values may be revised if required.

3.1.2 Defining Load Cases

Loads applied to the flange must be defined. The selection controls assignment of allowable stresses in the calculation.

For ASME VIII Div. 1 and PD5500 calculations, load cases may be selected from:

Pressure only.	Allowable stresses as per the design code.
Pressure + weight.	Allowable stresses as per the design code. Primary stress case, assuming weight causes externally applied loads which are additional to pressure.
Combined.	Operating case, including primary and secondary stresses. External loads due to a combination of weight, thermal and other loads. In this case, allowable radial and tangential stresses and combinations including these are increased in the spirit of the ASME B31.3 piping code for secondary stresses including a safety de-rating factor of 0.8. Thus the allowable stress will be 0.8(1.25Sfa + 0.25 Sfo).

It is normal to run a pressure + weight case, whenever a combined case is run, to ensure that primary stress criteria are satisfied.

External loads are converted to an equivalent pressure and added to operating load sets in the calculation by default. A check box is accessible in the local set-up file,which allows the user to apply external loads to all pressure equations, including the gasket seating case.

External loads are converted using the familiar 'Kellogg' equation, also found in ASME III:

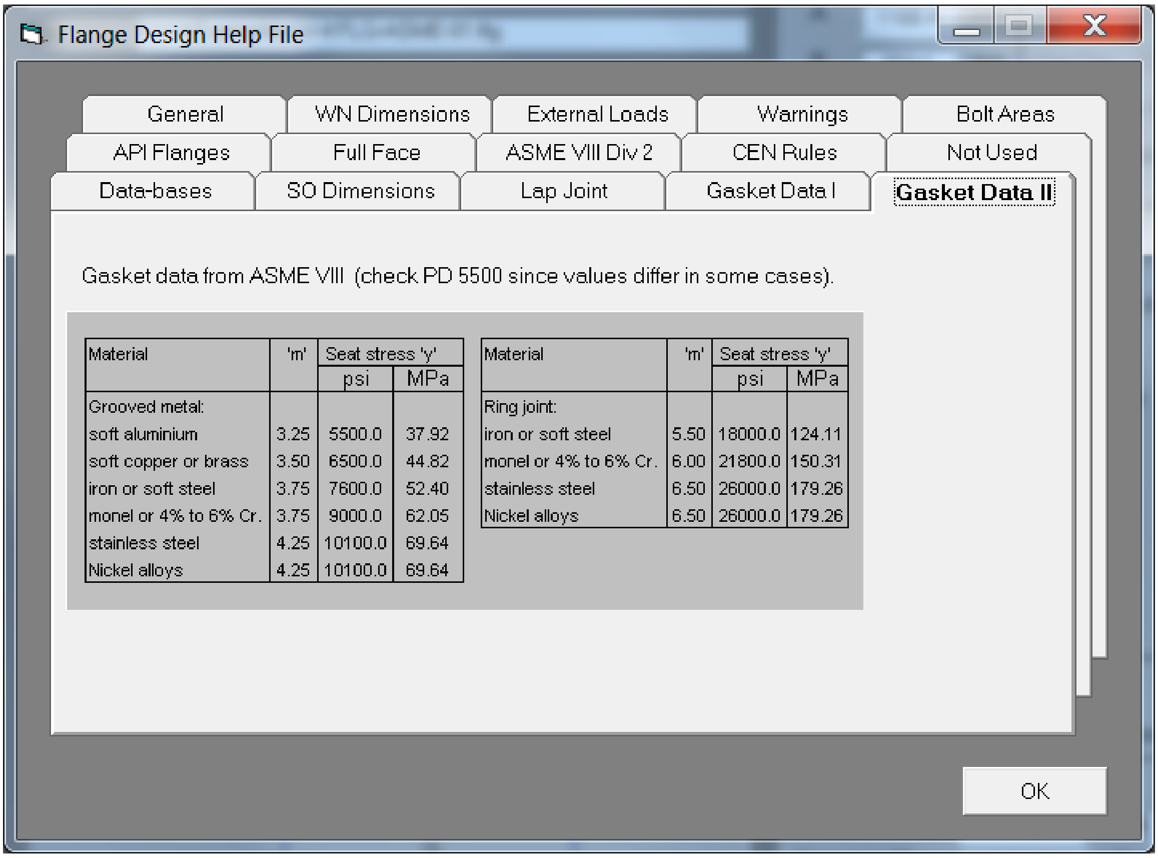
$$Peq = 16.M/\pi.G^3 + 4.F/\pi.G^2$$

Where	Peq	=	Pressure equivalent of a longitudinal moment and axial force (MPa)
	M	=	Longitudinal moment (Nmm)
	F	=	Axial force (N)
	G	=	Gasket reaction diameter (mm)

Peq is added to flange design pressure P in equations as defined in the local set-up file.

For ASME VIII Div. 2 calculations, external loads are taken into account directly by the Code method. Thus the 'equivalent pressure' is not required.

3.1.3 Help file contents



Material	'm'	Seat stress 'y'	
		psi	MPa
Grooved metal:			
soft aluminium	3.25	5500.0	37.92
soft copper or brass	3.50	6500.0	44.82
iron or soft steel	3.75	7600.0	52.40
monel or 4% to 6% Cr.	3.75	9000.0	62.05
stainless steel	4.25	10100.0	69.64
Nickel alloys	4.25	10100.0	69.64

Material	'm'	Seat stress 'y'	
		psi	MPa
Ring joint:			
iron or soft steel	5.50	18000.0	124.11
monel or 4% to 6% Cr.	6.00	21800.0	150.31
stainless steel	6.50	26000.0	179.26
Nickel alloys	6.50	26000.0	179.26

3.2 EXECUTION

Prior to running the calculation, error checking will be carried out to ensure that the data set is both complete and feasible. An error message and the input will be returned if a fatal error is detected.

3.2.1 Non-Mandatory Checks

Several non-mandatory checks are carried out and reported. These are not directly code conflicts, but if shown they should be considered in the overall design process.

Rigidity Limit

If the calculation is to a code containing rigidity limits that have been exceeded, it will be reported. This is of particular relevance to high yield material such as duplex stainless. In some circumstances a design might meet the stress limitation criteria, but due to a thin flange ring section, sealing may be difficult to achieve in practice, due to local flexibility. If this may be a potential problem a lower allowable might be assigned, more appropriate to low carbon steel. It should be considered that the design approach is more appropriate to low carbon steel than newer high yield components.

Equivalent Pressure Check

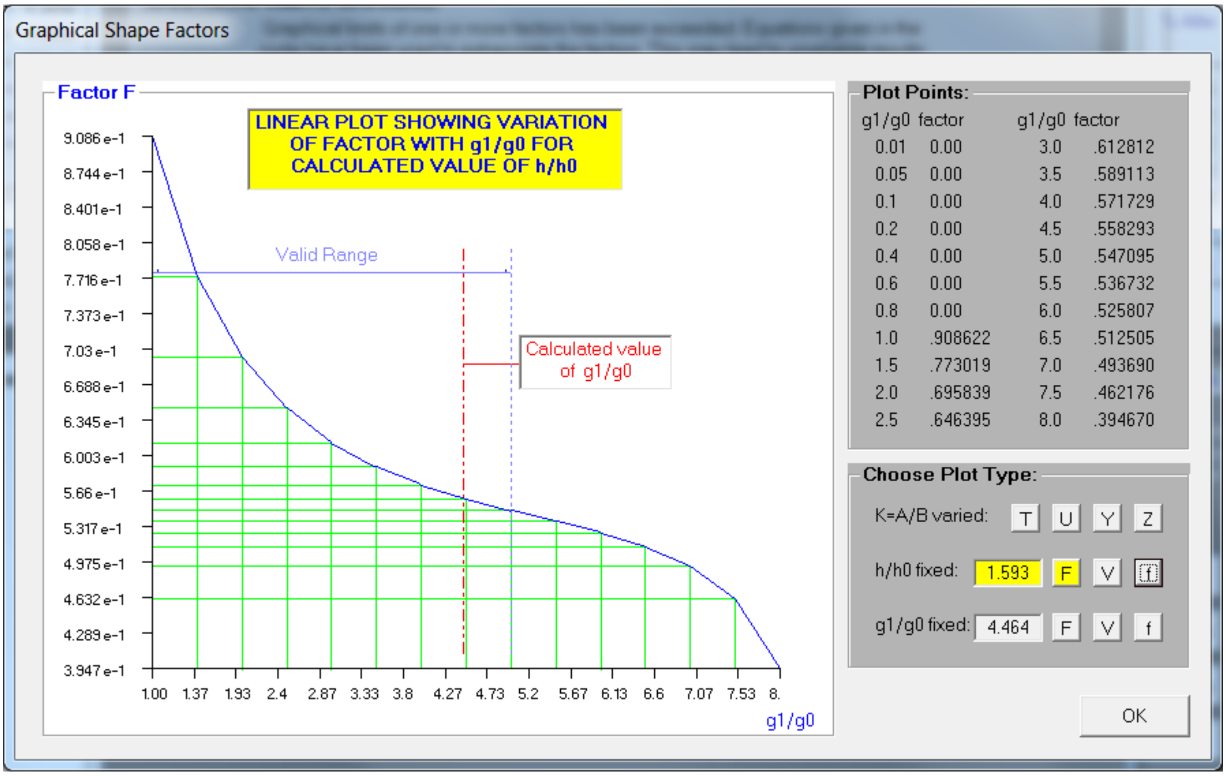
The sum of an equivalent pressure due to external loads plus internal pressure should not normally exceed the hydrotest pressure, otherwise the condition will not be tested for prior to operation. Since hydrotest of pipework is normally a minimum of 1.5 x the design pressure, should the equivalent pressure due to external loads exceed 0.5 design pressure the condition will be flagged.

Graphical Limits warning

To solve geometrical shape factors, equations as presented in ASME VIII are used. The same functions are shown graphically in that and many other codes, including all those currently offered by PIPEMILL. The limits of application of these equations are clear in the codes, and to venture beyond the limits shown invites gross errors in results. To deal with this potential problem, PIPEMILL presents a warning that graphical limits have been exceeded, and allows the user to view the graphs in question by clicking on the view graph button. Graphs are plotted in linear fashion as opposed to log in the code.

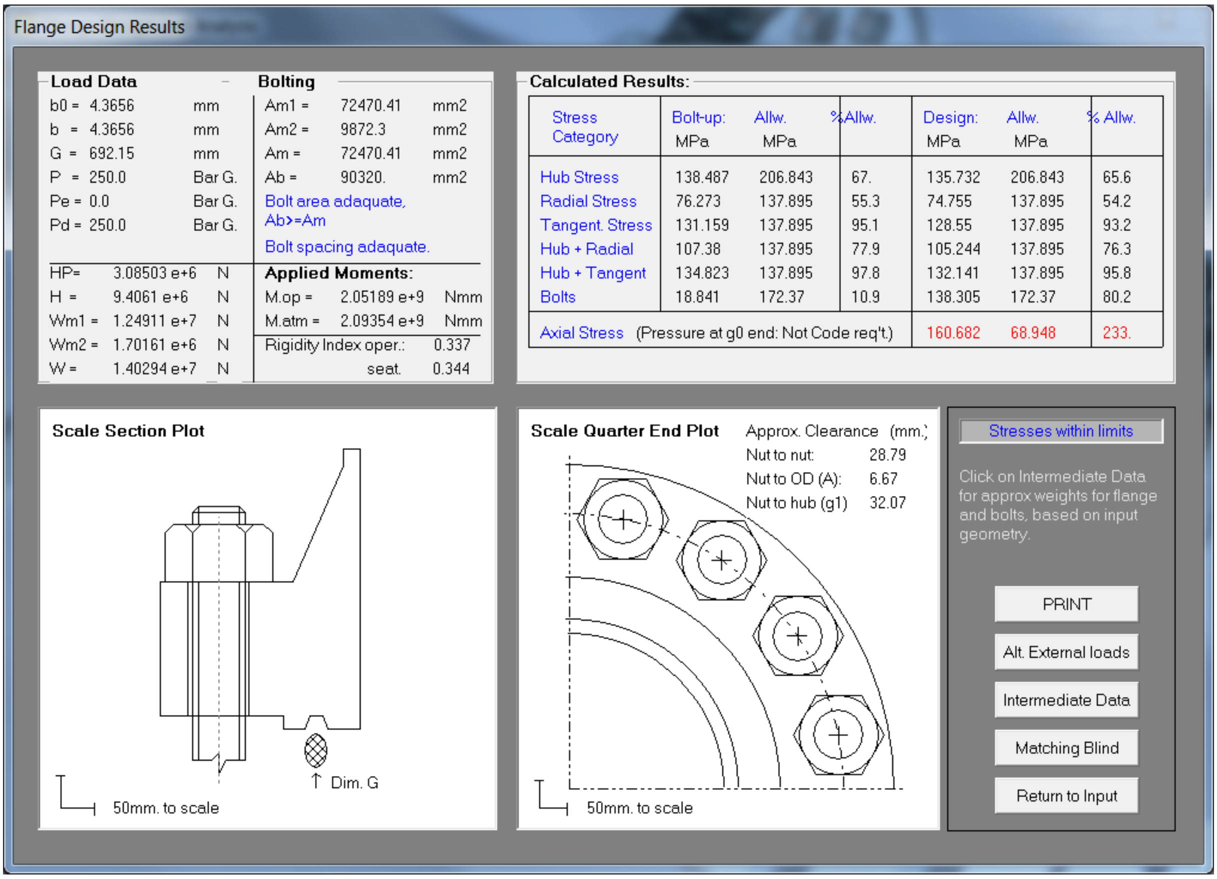
Graphs of all geometrical factors may be viewed, and a judgement then be made regarding the validity of results, from the direction and slope of the respective curves and the location of calculated data.

Graphical results will be presented as shown below.



3.3 RESULTS

Typical Flange Output Screen



Analytical results will be presented with further options available. Calculated and allowable stresses are shown together with primary system loads and associated data. Other intermediate data may be viewed. Flange and bolt weight will be presented, based on actual metal mass.

A matching blind flange may be designed, based on geometrical and other data extracted from the main flange body. Values such as allowable stresses for the blind may be revised.

Alternative methods of evaluating external loads may be accessed to compare with the equivalent method applied.

A scale section through the flange and a scale quarter end plot are presented to aid design and evaluation, particularly of custom designed items. These plots may be hard copied if required.

4.0 CLAMP CONNECTOR DESIGN AND ANALYSIS

Hub and clamp or ‘Grayloc’ type connectors may be designed and analysed in accordance with ASME VIII Div. 1 Appendix 24.

4.1 Clamp Connector Input

Input is similar to the flange design program, with input data panels specific to the hub, clamps and bolting & gasket.

To initiate design the user needs to define whether hub dimensions will be to match a standard pipe size, or dimensioned from the hub inside diameter.

Typical Clamp Connector Input

Dependent upon the selection of dimensions source, some input data fields will be derived, and consequently not accessible.

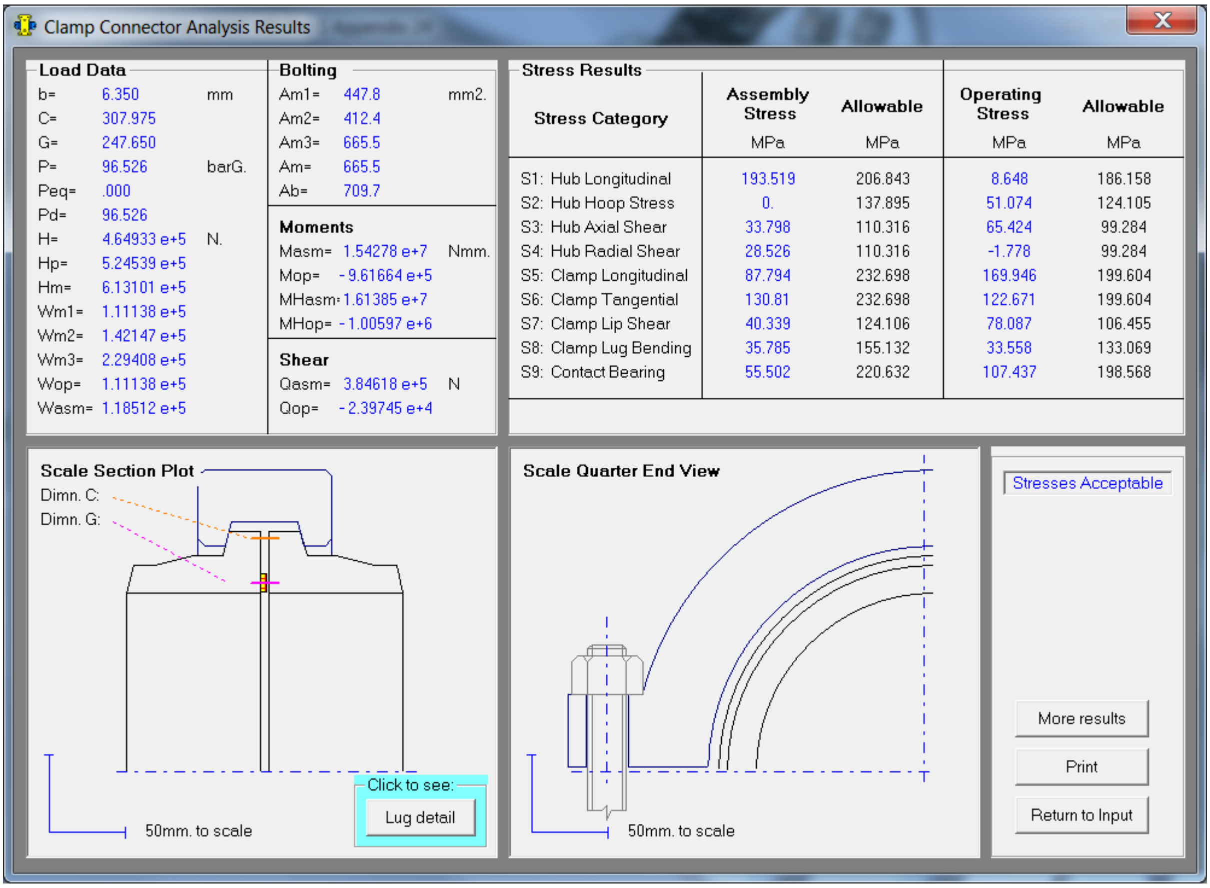
A help file is available which describes some geometrical limitations imposed and accesses the flange program help file to obtain data such as bolt areas for use in this program.

Similar to the calculation method employed for flanges, the user may choose whether or not external loads, converted to an equivalent pressure, are included or excluded from assembly stresses. The default is that these loads are excluded from assembly stresses and incorporated only in functional stress calculations.

Prior to running the calculation, error checking will be carried out to ensure that the data set is both complete and feasible. An error message and the input will be returned if a fatal error is detected.

4.2 Clamp Connector Output

Typical Clamp Connector Output Screen



In addition to the views above, a scale section plot and additional calculated data may be viewed. Bolt spacing may be varied within allowable limits. The scale plots enable the design to be visualised and a better finished product obtained.

All loads and moment arms used in stress calculations are displayed in the output and 'more results' screen.

5.0 EXPANSION LOOP STRESSES, LOADS AND DISPLACEMENTS

Four different geometries are available, three requiring similar input data, and representing typical pipe loop arrangements found in pipe racks. The fourth is a simple three leg offset which may be loaded with thermal and end displacement conditions.

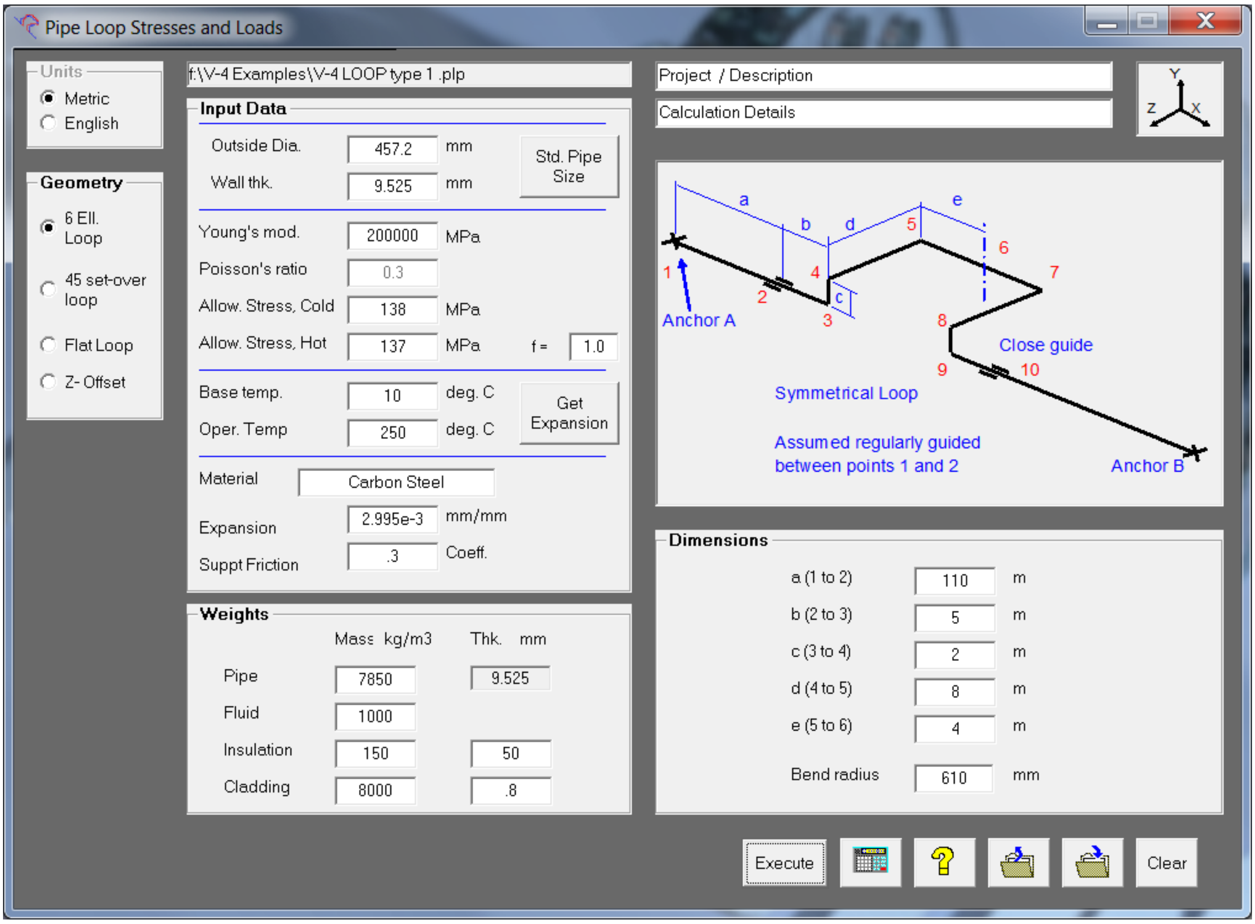
This program utilises a stiffness matrix solution and results will normally compare very closely to those from commercial pipe stress software.

Standard pipe sizes may be accessed from Pipemill's data base, and thermal expansion characteristics may similarly be quickly obtained.

Allowable stresses will be computed in accordance with ASME B31.3.

The solution assumes that pipe between loop region and anchors is properly guided, and in the close guide, rotation is negligible.

5.1 Typical Rack Type Expansion Loop Input

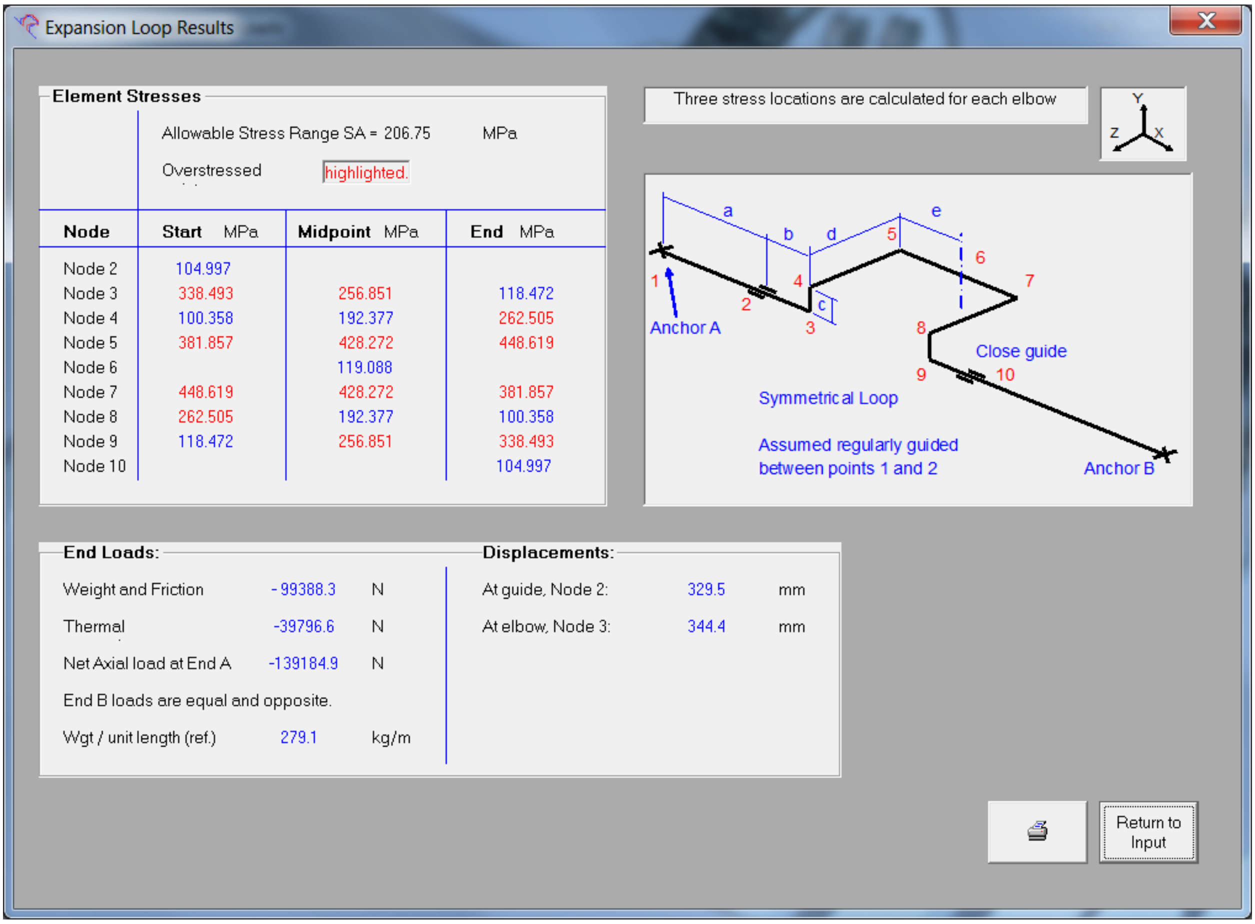


5.2 Typical Rack Type Expansion Loop Output

Calculated stresses through the system will be shown, and highlighted if excessive.

End loads due to thermal expansion, weight induced friction and combined effects will be presented.

Thermal expansion at the close guide and first elbow will be provided, to allow a check of pipe support suitability and clearance.



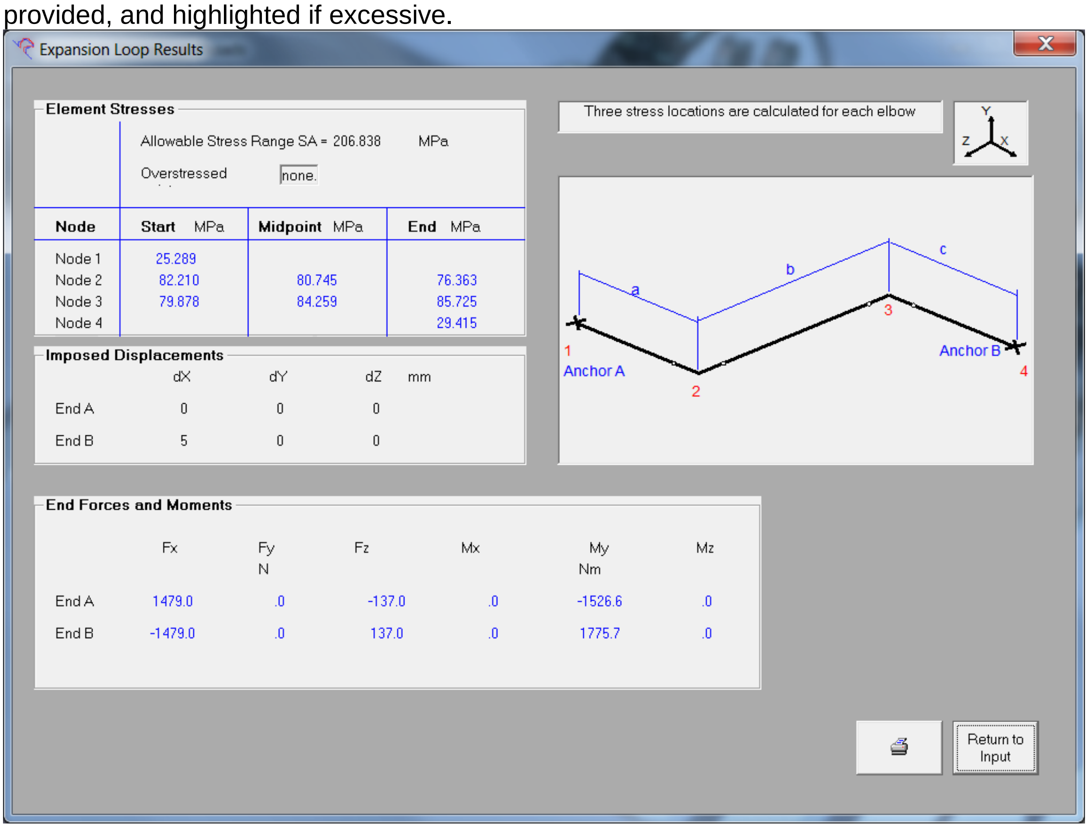
The user can thus find the optimum dimensions for pipe expansion loops, without recourse to expensive commercial stress analysis software, and with much greater accuracy than chart form solutions and the like.

5.3 Thermal Offset Design

Material properties and end displacements (which may be zero) must be defined.

5.4 Typical Thermal Offset Design Output

End forces and moments will be calculated. Stresses in accordance with ASM B31.3 will be provided, and highlighted if excessive.



6.0 PIPE SPANS AND SLOPING LINE CALCULATIONS

6.1 Span Chart

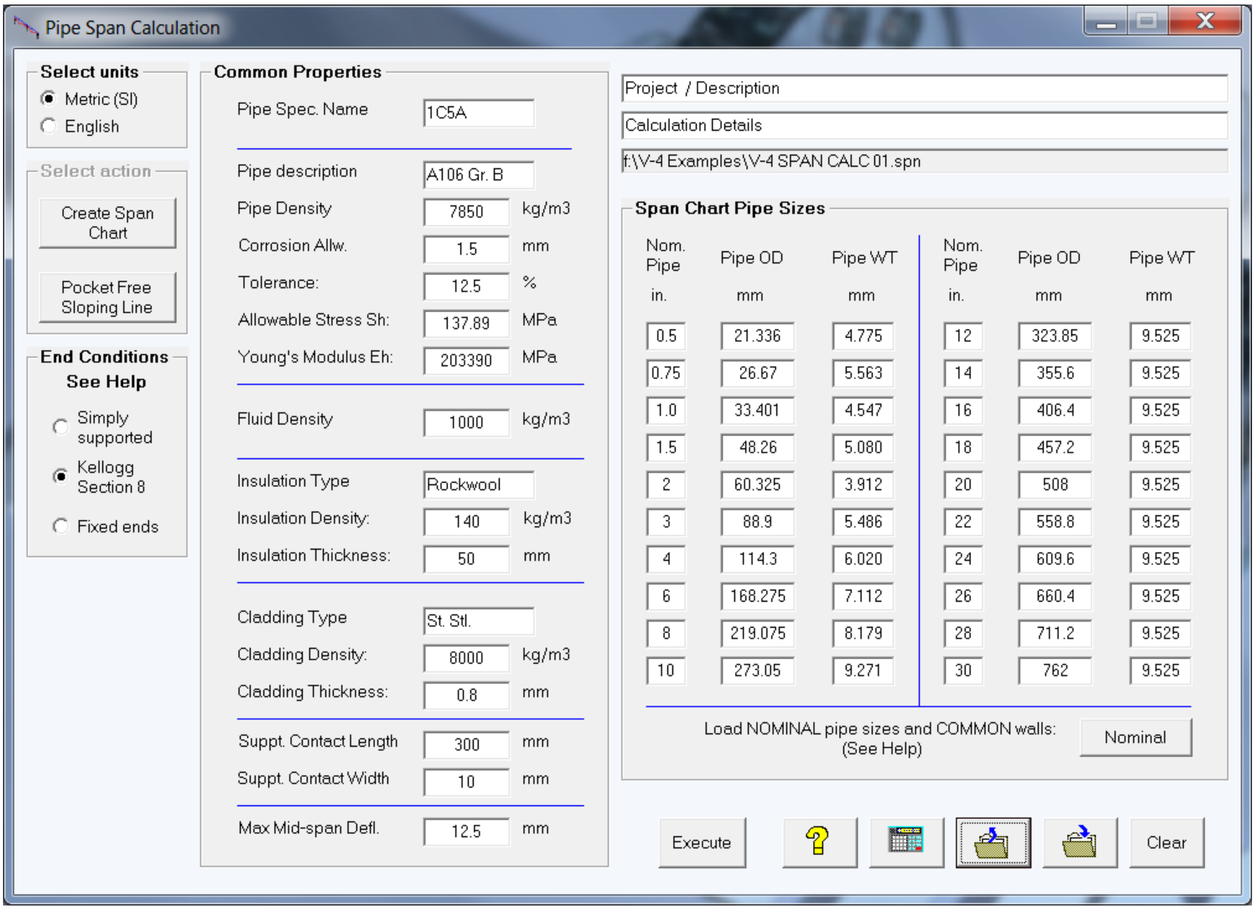
Relevant data cells must be completed, and 'Create Span Chart' selected.

End conditions must be defined, using data in the 'Help' file.

The range of pipe sizes for which spans are needed must be defined. The option of selecting Standard pipe sizes and wall thickness is available. This will automatically load all pipe sizes from 0.5" nb to 30" using STD wall. All entries may be changed if required.

Since this is not a facility normally required on-screen, the printed output will be sent directly to your printer, which must of course be on-line.

Typical Span Chart input file



6.2 Span for a Pocket Free Sloping Line

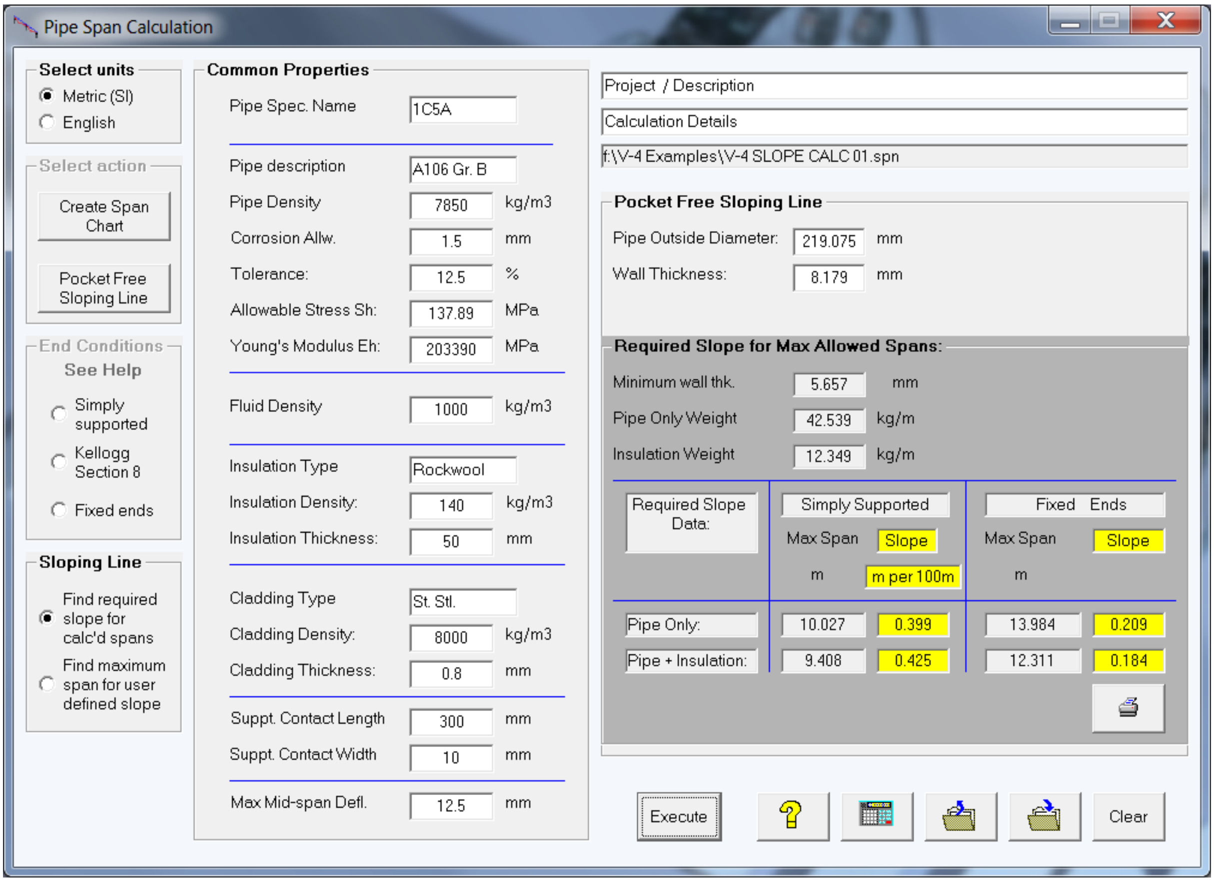
The intent of this program is to derive the maximum span for a pipe, whilst allowing free draining when sloping at some defined fall rate. This is important in two phase flow and similar systems, to avoid build-up of liquid slugs and consequent impact loads.

Similar input data to above is required.

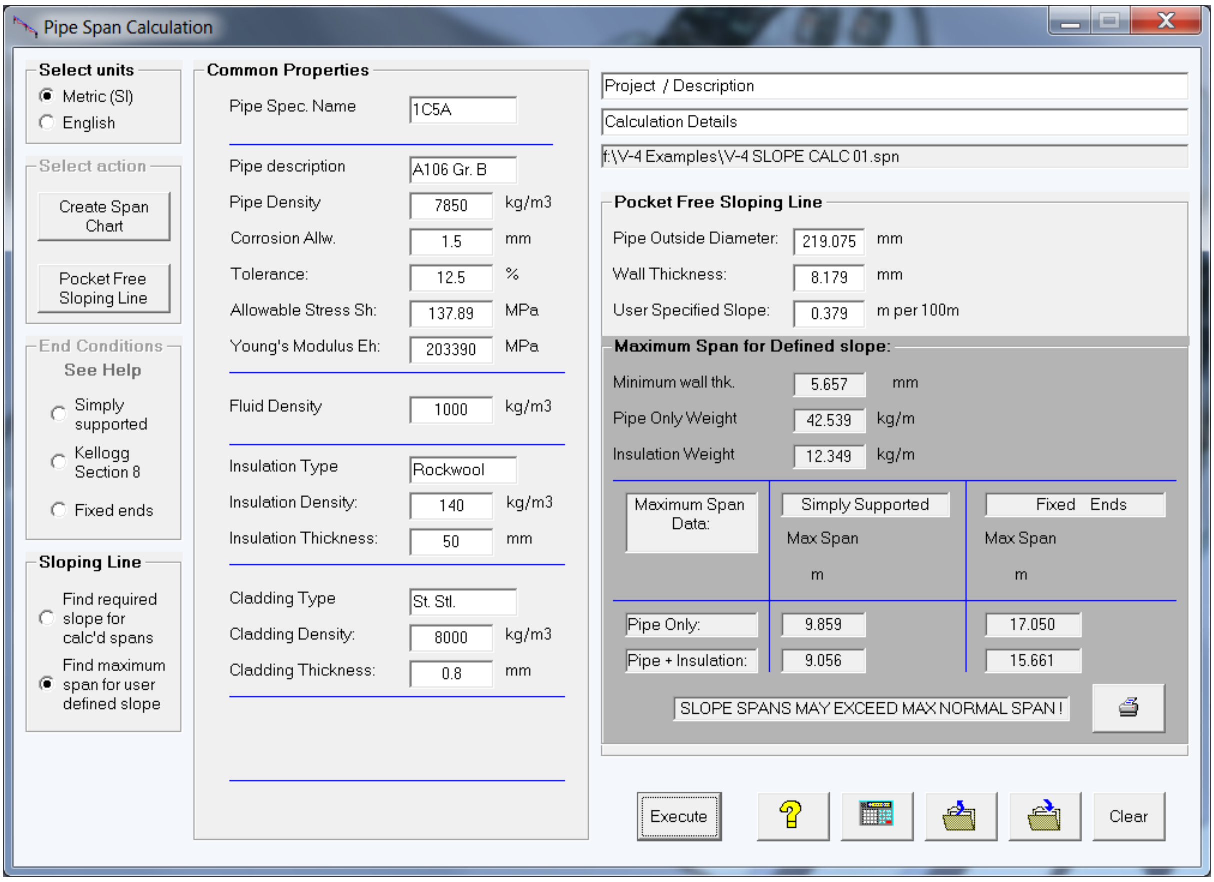
Maximum allowable span for one pipe size will be calculated based on two criteria.

The calculations are based on two end conditions, either fully fixed or pinned with no moment restraint. Significant differences will be seen in results. The user must decide which condition is the more appropriate.

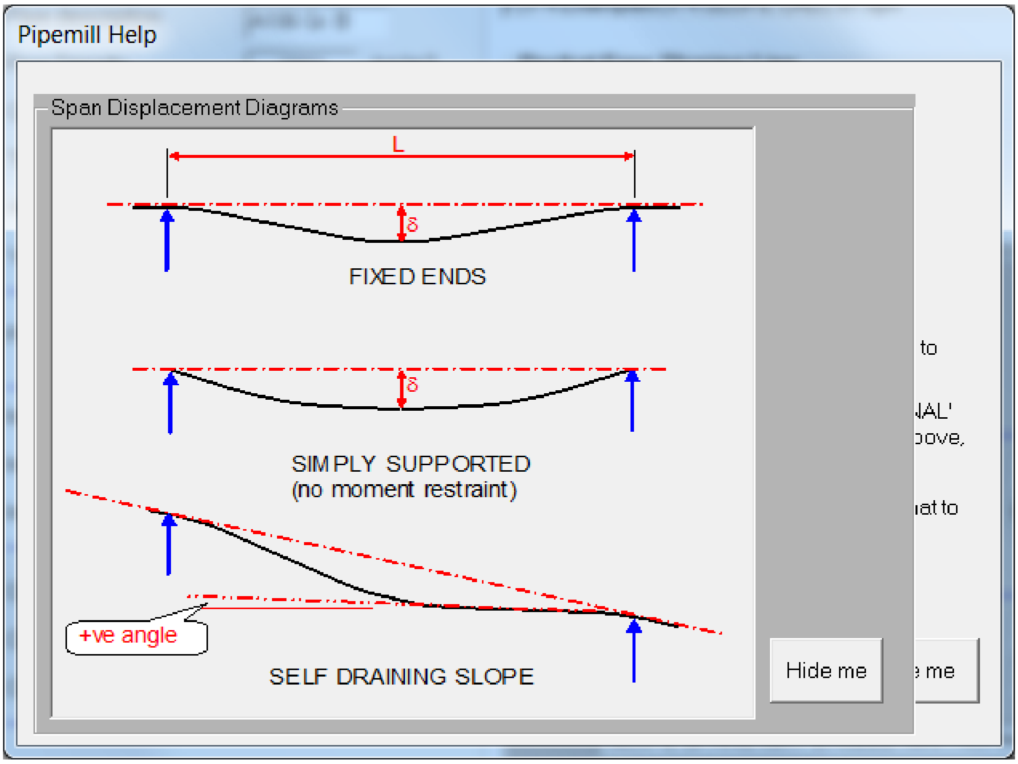
6.2.1. The slope required to allow the maximum allowed span will be calculated



6.2.2. The maximum allowable span may be found for a defined slope



The Help file allows access to diagrams to assist in defining slope and end conditions.



7.0 PSV and RUPTURE DISC FORCE CALCULATION

Force calculations for the initial or 'pop' condition and under sustained flow may be carried out for gas and vapour PSV's (pressure safety valves), discharging into a closed header or directly to atmosphere. Forces present in a liquid relief valve and a rupture disc may be calculated, similarly for the initial and sustained conditions.

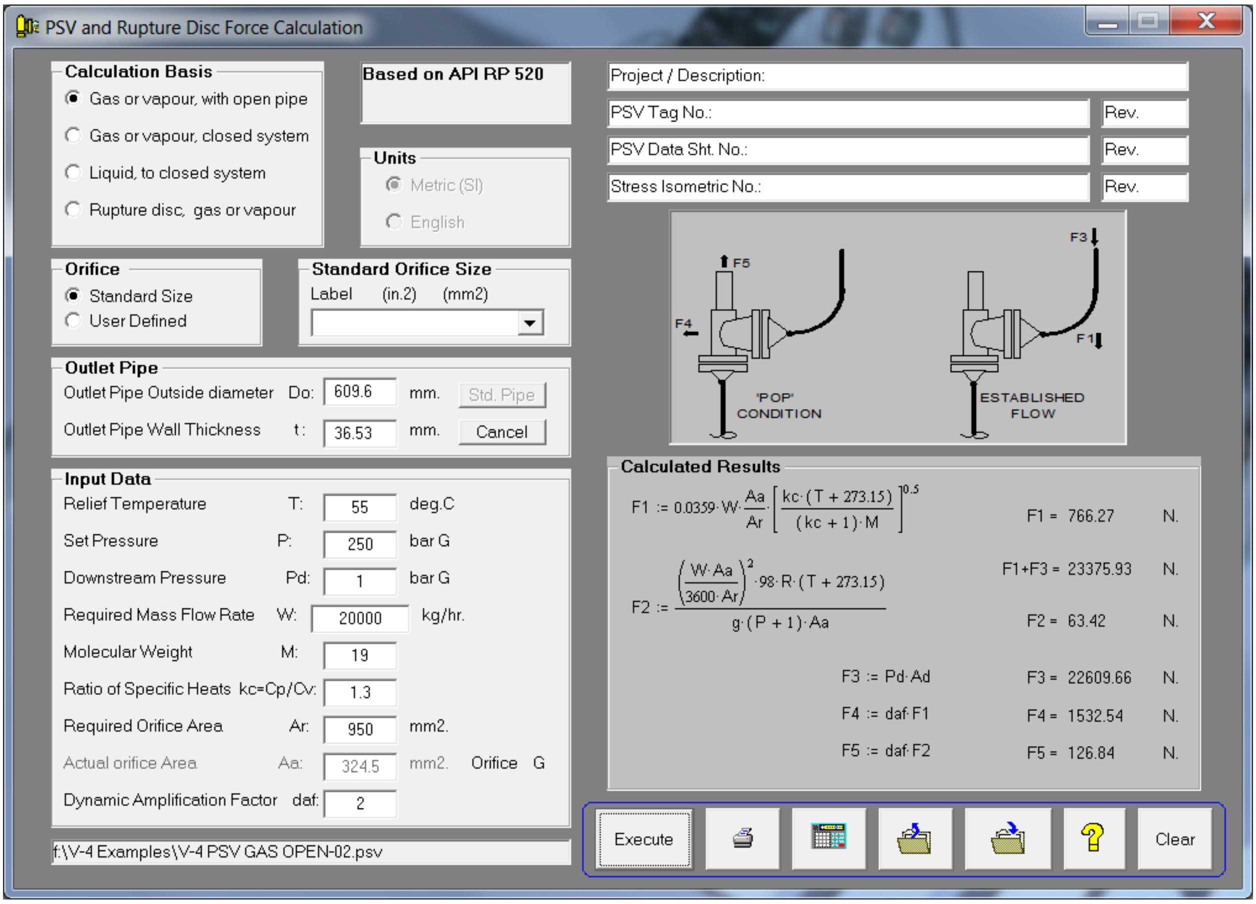
A data base of standard relief valve orifice sizes may be accessed in addition to the standard pipe data base which may be used to select outlet pipe size in an open discharge gas or closed discharge liquid PSV.

7.1 Gas / Vapour PSV

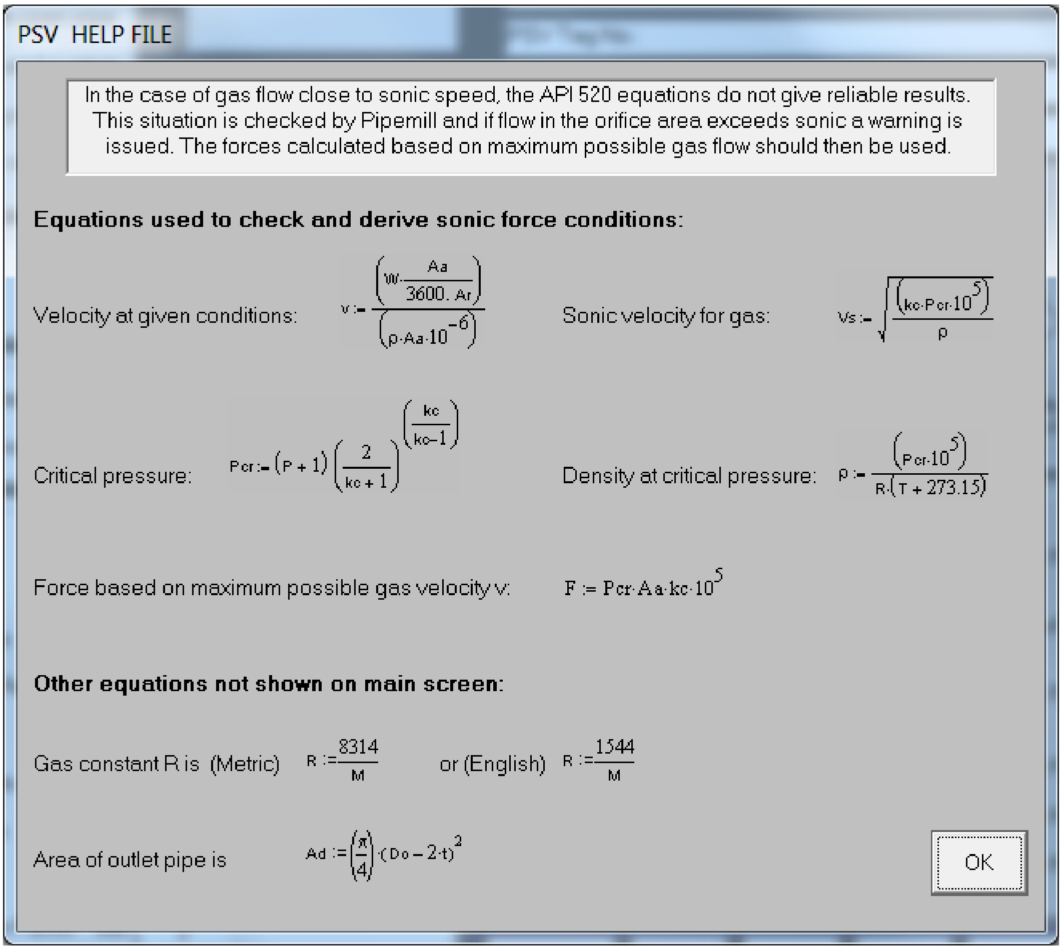
Gas and vapour PSV reactions are calculated in accordance with API RP 520 pt. II methods.

All equations used are presented, either on the input / output screen as shown below, or in the help file which follows.

7.1.1 Typical Input Screen and Output Results, Open Gas / Vapour PSV.



7.1.2 PSV Help File

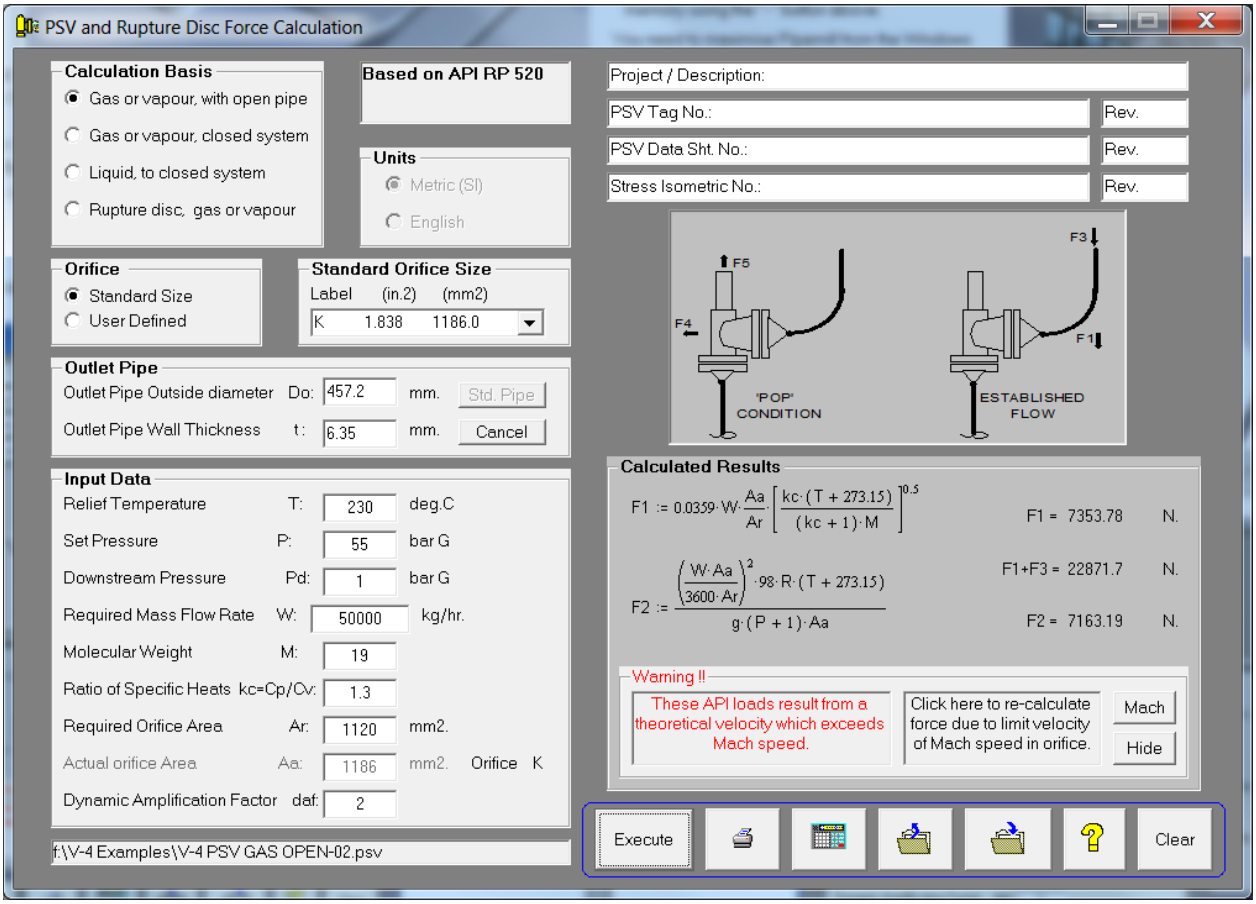


7.2 High Gas Velocity PSV's

As gas flow approaches and exceeds sonic (Mach) velocity, the API equations will tend to predict higher forces than would exist if flow were limited to Mach speed.

The software will calculate the gas velocity in the valve orifice and compare it with the sonic velocity. If the flow exceeds sonic according to the API equations, and consequently forces may be over-estimated, the user has the option of accepting API results or re-calculating forces based on critical flow regime in the orifice.

7.2.1 Typical Output Showing Additional Calculation at Mach Speed



$$F1 := 0.0359 \cdot W \cdot \frac{Aa}{Ar} \cdot \left[\frac{kc \cdot (T + 273.15)}{(kc+1) \cdot M}\right]^{0.5}$$

$$F2 := \frac{\left(\frac{W \cdot Aa}{3600 \cdot Ar}\right)^2 \cdot 98 \cdot R \cdot (T + 273.15)}{g \cdot (P+1) \cdot Aa}$$

If the user chooses to accept the directly calculated API forces rather than forces based on Mach speed, a note will be added to the printed output to this effect.

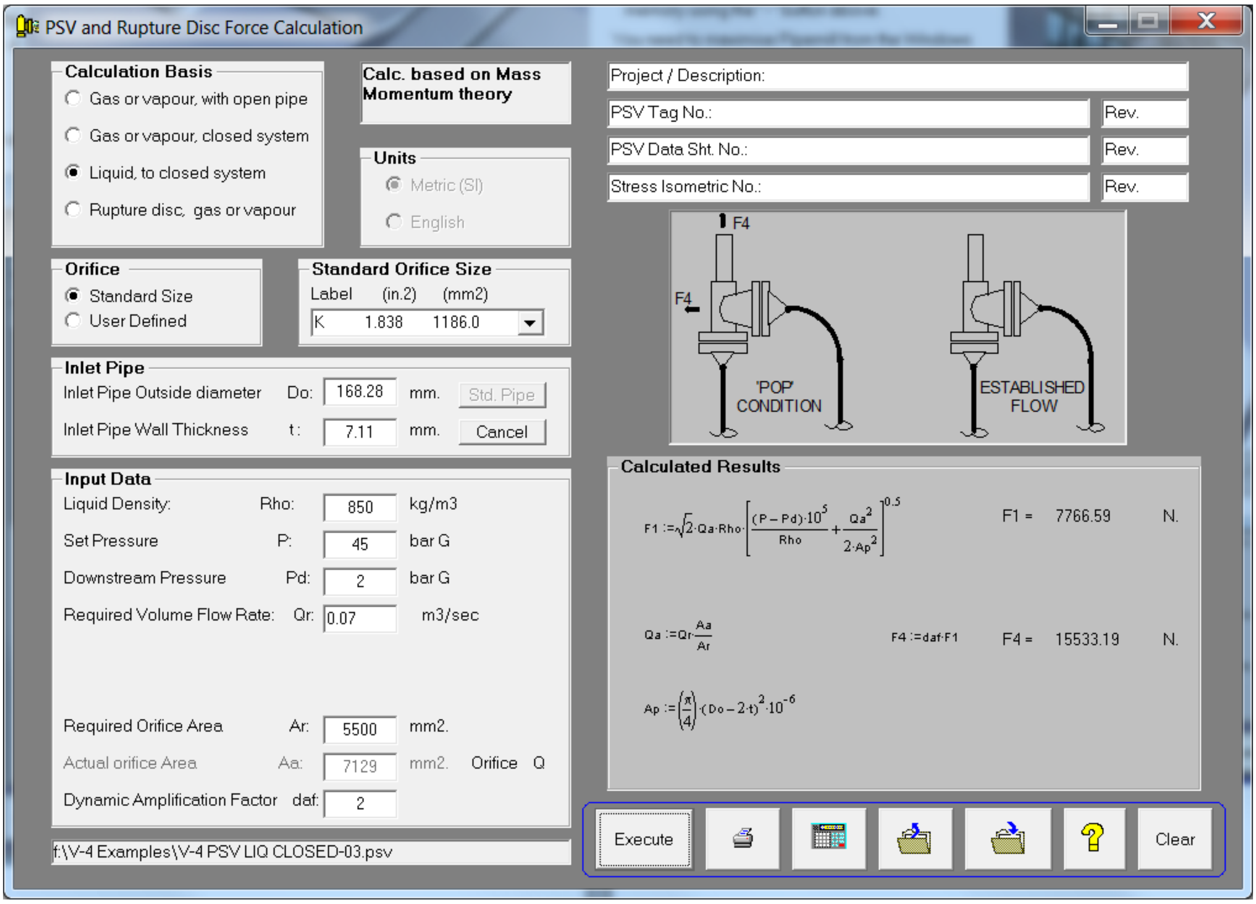
The principles above apply equally to open and closed outlet PSV's

7.3 Liquid Relief Valve

Forces generated by Liquid relief valves are not addressed in API 520, and tend to be smaller than gas discharge forces. Equations used in the program are based on change of momentum.

As the screen copy below shows, only the change of state as the valve initially operates causes an external reaction. Equilibrium is rapidly reached and no further external loads exist.

7.3.1 Typical Input Screen and Output Results, Liquid PSV.

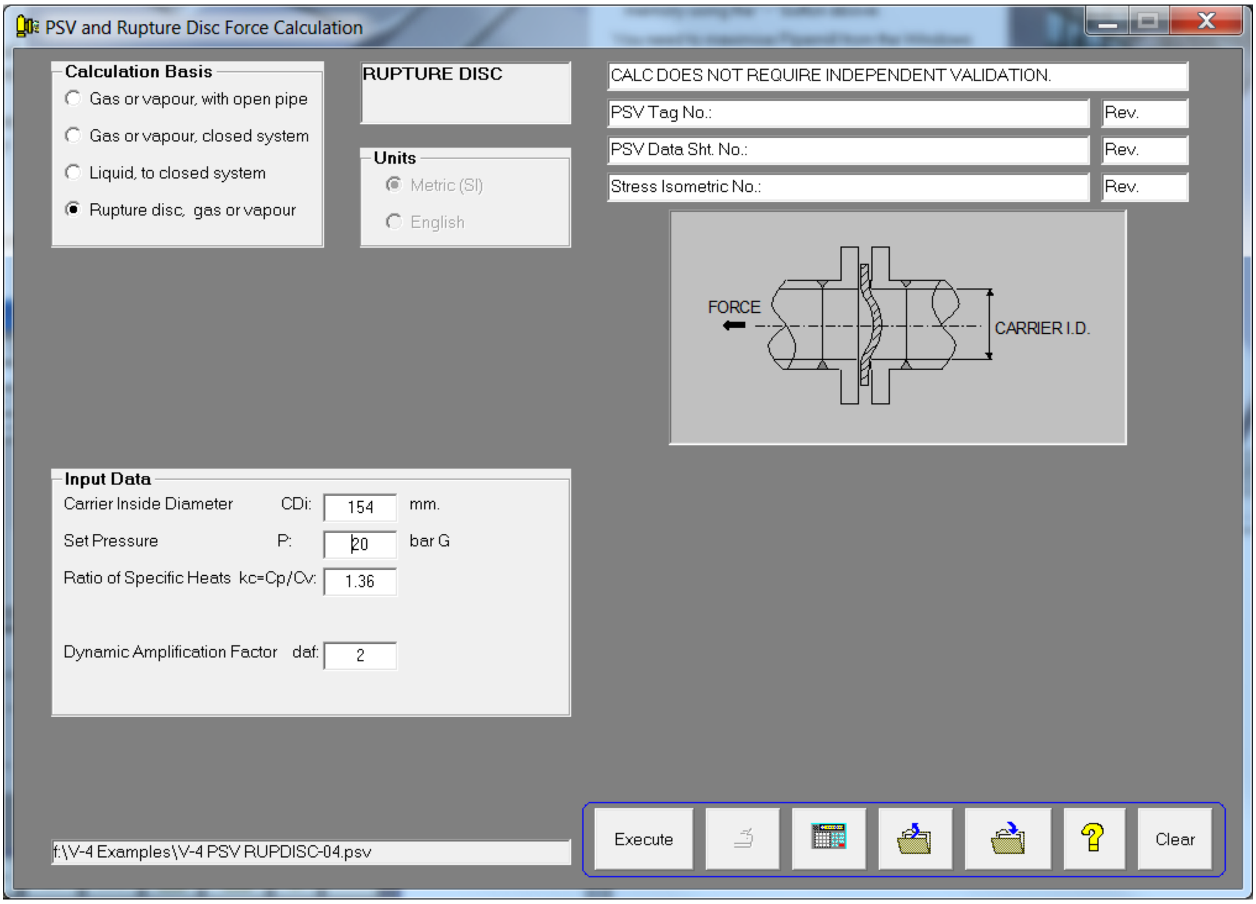


7.4 Rupture Disc

Rupture discs are normally used for gas and vapour. The calculation method used is simple, and originates in a paper from 'Hydrocarbon Processing'.

Once again a force will only be developed whist there is a change of state existing. A sustained flow though failed disc will not cause any external force.

7.4.1 Typical Input Screen and Output Results, Rupture Disc



8.0 PREDICTION OF ACOUSTIC FATIGUE

8.1 General Features

The method proposed by Carruci and Meuller in ASME paper 82-WA/PVP-8 is applied to predict the risk of acoustic fatigue in pipework downstream of a pressure reducing valve.

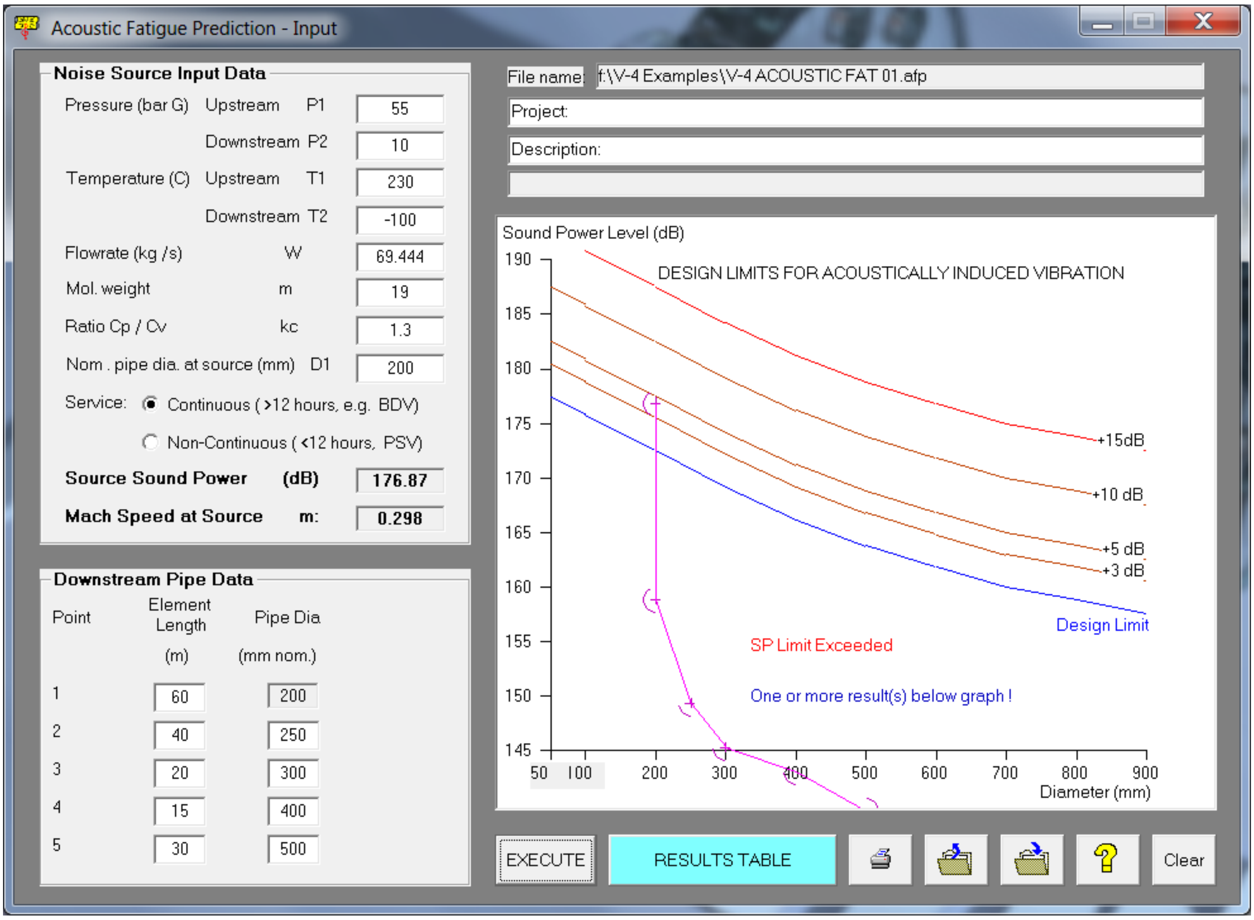
Up to five sections of pipe, generally of increasing diameter may be entered in the analysis.

Results will be displayed graphically and in table form for easy reference.

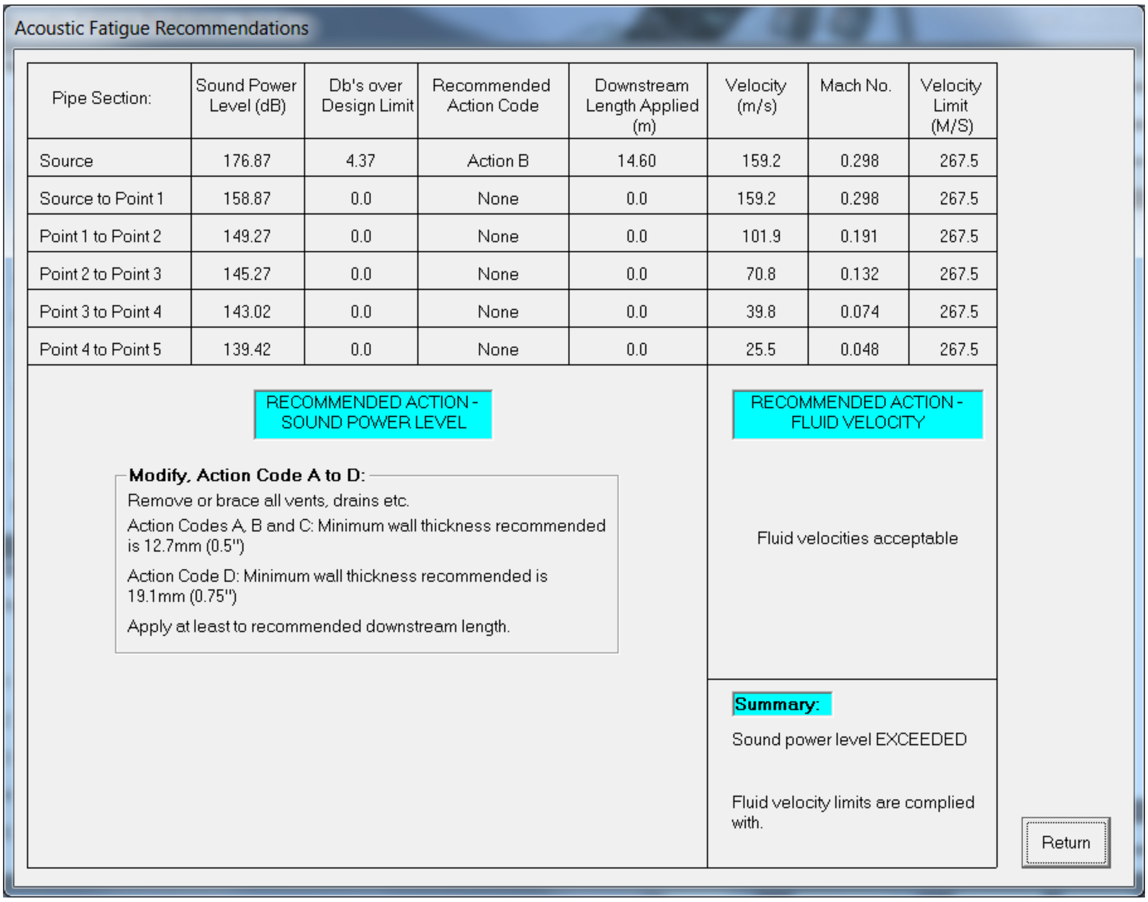
The results screen records calculated sound power level and predicted Mach speed. This is compared with acceptability criteria and modifications are recommended if required.

Recommendations regarding further action will be presented, depending upon the acceptability of results.

8.2 Typical input with output data overlaid on the graph



8.3 Typical acoustic fatigue output data



Acoustic Fatigue Recommendations

Pipe Section:	Sound Power Level (dB)	Db's over Design Limit	Recommended Action Code	Downstream Length Applied (m)	Velocity (m/s)	Mach No.	Velocity Limit (M/S)
Source	176.87	4.37	Action B	14.60	159.2	0.298	267.5
Source to Point 1	158.87	0.0	None	0.0	159.2	0.298	267.5
Point 1 to Point 2	149.27	0.0	None	0.0	101.9	0.191	267.5
Point 2 to Point 3	145.27	0.0	None	0.0	70.8	0.132	267.5
Point 3 to Point 4	143.02	0.0	None	0.0	39.8	0.074	267.5
Point 4 to Point 5	139.42	0.0	None	0.0	25.5	0.048	267.5

RECOMMENDED ACTION - SOUND POWER LEVEL

Modify, Action Code A to D:

Remove or brace all vents, drains etc.

Action Codes A, B and C: Minimum wall thickness recommended is 12.7mm (0.5")

Action Code D: Minimum wall thickness recommended is 19.1mm (0.75")

Apply at least to recommended downstream length.

RECOMMENDED ACTION - FLUID VELOCITY

Fluid velocities acceptable

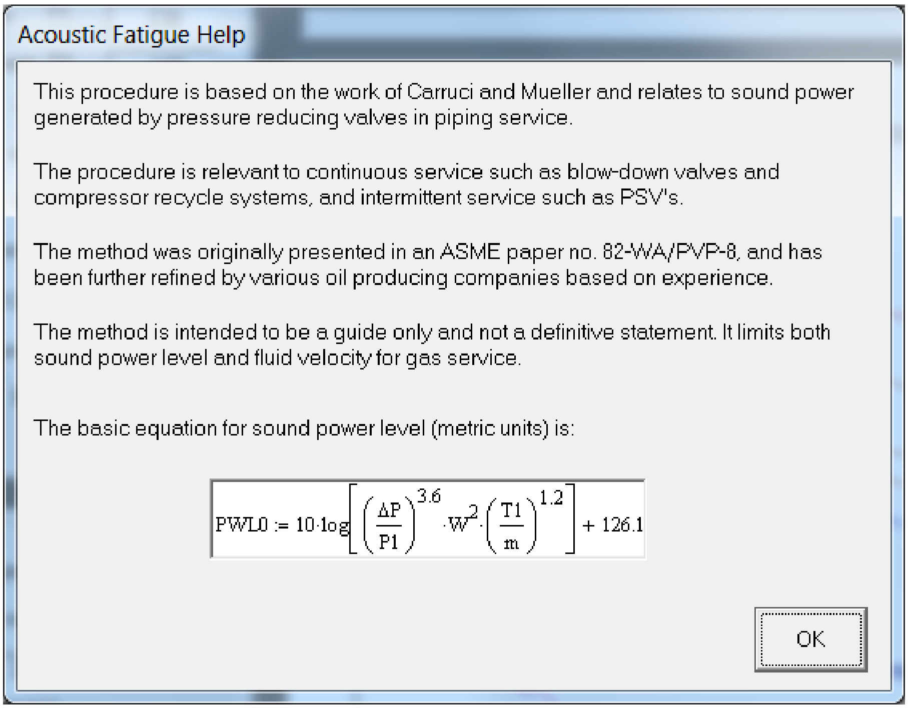
Summary:

Sound power level EXCEEDED

Fluid velocity limits are complied with.

Return

8.4 Help screen



Acoustic Fatigue Help

This procedure is based on the work of Carruci and Mueller and relates to sound power generated by pressure reducing valves in piping service.

The procedure is relevant to continuous service such as blow-down valves and compressor recycle systems, and intermittent service such as PSV's.

The method was originally presented in an ASME paper no. 82-WA/PVP-8, and has been further refined by various oil producing companies based on experience.

The method is intended to be a guide only and not a definitive statement. It limits both sound power level and fluid velocity for gas service.

The basic equation for sound power level (metric units) is:

$$PWL0 := 10 \cdot \log\left[\left(\frac{\Delta P}{P1}\right)^{3.6} \cdot W^2 \cdot \left(\frac{T1}{m}\right)^{1.2}\right] + 126.1$$

OK

9.0 DESIGN FOR EXTERNAL PRESSURE AND VACUUM

9.1 Description

Pipes and cylinders may be evaluated for their resistance to collapse under external pressure, and reinforcement may be designed to prevent collapse. Evaluation is in accordance with ASME VIII Div. 1.

Certain paragraphs of the design code allow use of nominal wall where clearly the actual minimum should be considered**. PIPEMILL always uses the minimum wall thickness.**

9.2 Materials Data

In most cases there will be no need to read or interpret material data curves in ASME II, referenced in ASME VIII. The three most commonly used curves are pre-programmed and available via a mouse click:

CS-2	Carbon steel with a minimum yield strength of 30 ksi
HA-1	Austenitic stainless steel, low chrome
HA-2	Austenitic stainless steel, high chrome

Alternatively, user defined material data may be entered.

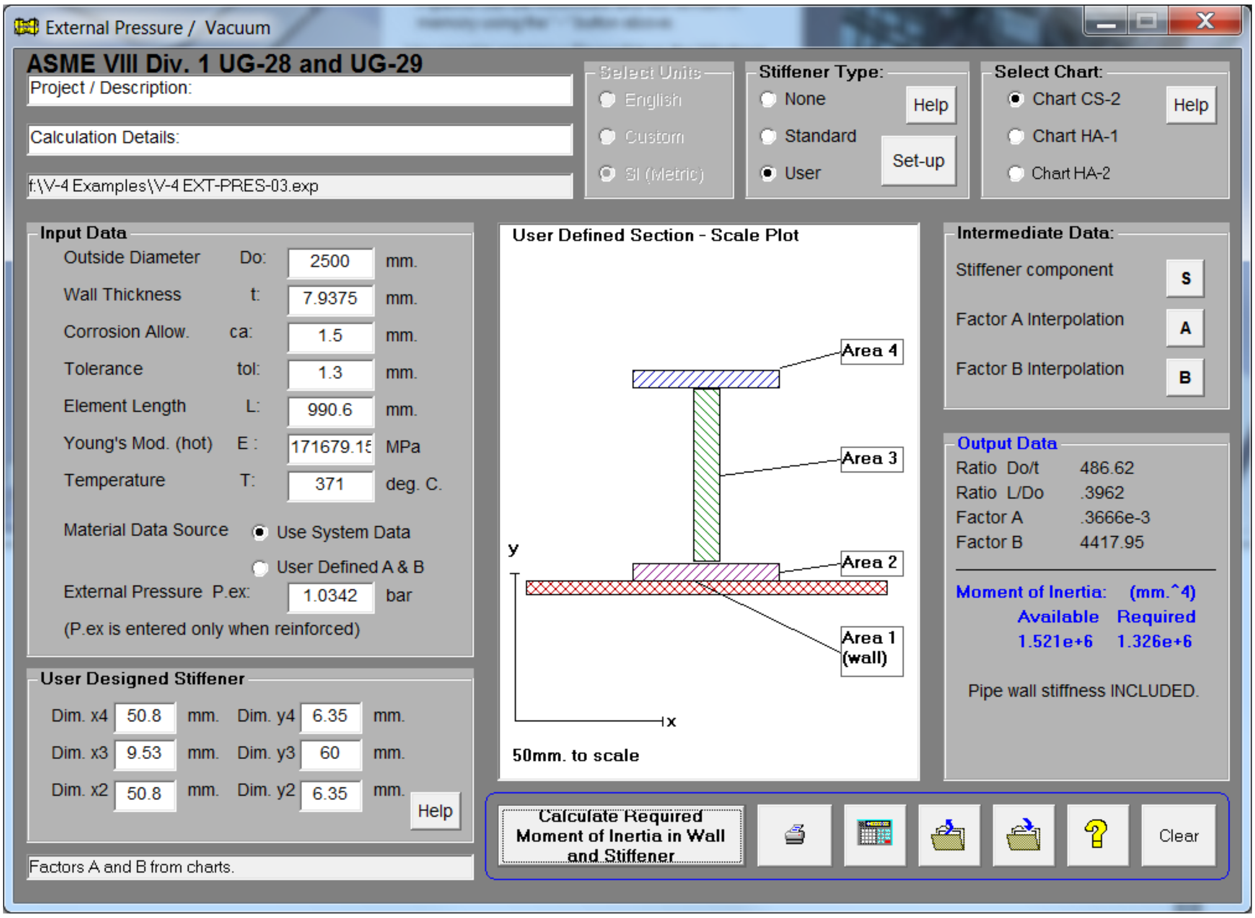
If shell parameters entered result in (length / diameter) L / Do > 50 a limit of 50 will be imposed in the calculation.

The shell may be un-stiffened, stiffened with standard section material or with a user defined section. Heavy wall shells with D /t < 10 may also be evaluated.

In analysis of a stiffened section, the pipe wall may be included or excluded from the calculation by selecting the desired option from the Stiffener Type panel.

There are many help files associated with this program, accessed from the relevant data input panel.

9.3 Typical External Pressure / Vacuum Input and Output



9.4 Non-stiffened Shell

If a non-stiffened shell is analysed, a maximum allowable external pressure will be calculated. If the resulting value is close to or below atmospheric pressure, a warning will be issued.

9.5 Heavy Wall Shell

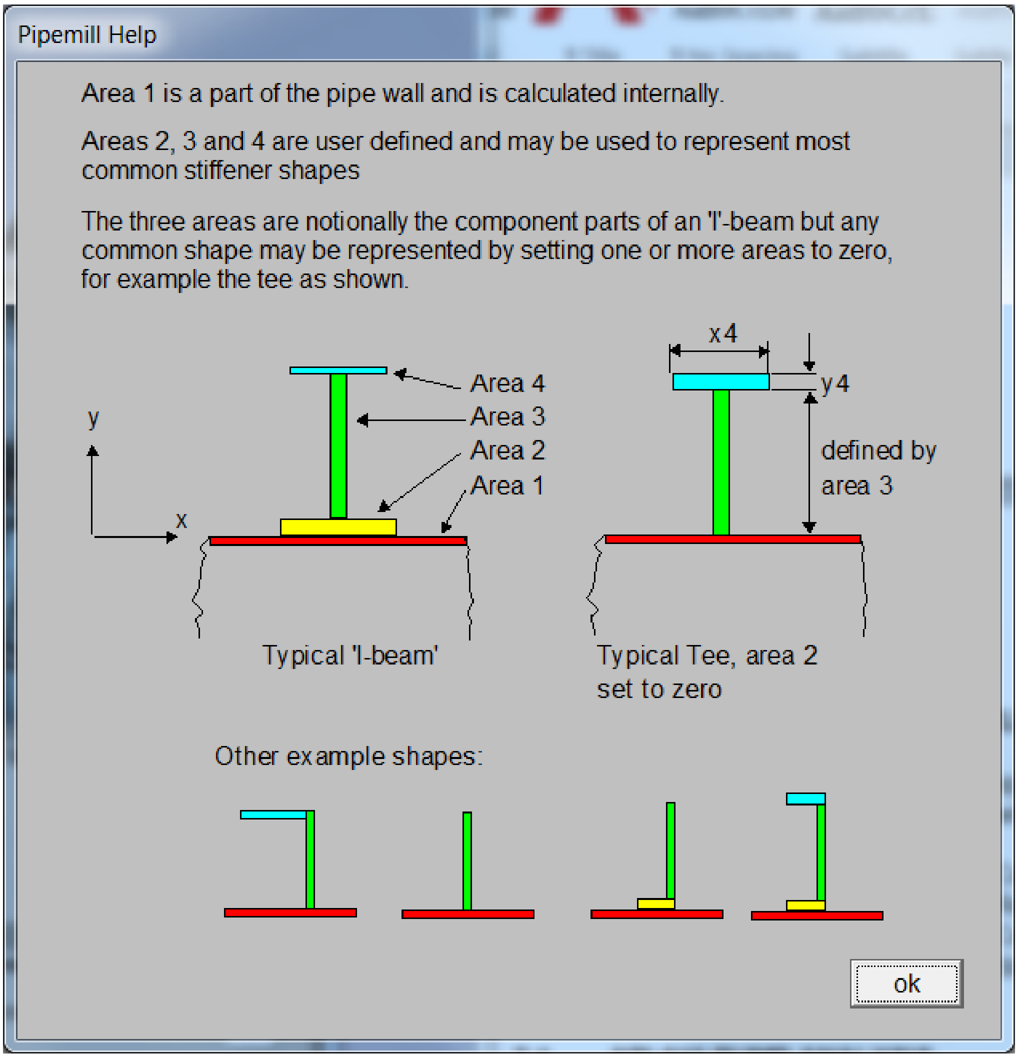
If the (diameter / wall thickness) D / t ratio is less than 10, special heavy wall rules are invoked. Reinforcement is excluded and the yield stress is required.

9.6 Standard Section Stiffener

To carry out a calculation for a shell stiffened with a standard section, in addition to the shell data, only the stiffener properties, moment of inertia, area, neutral axis distance and section width at the shell wall are required. The moment of inertia available in the combined defined section will be calculated and compared to that required to resist collapse. Unacceptable results will be clearly identified.

9.7 User Defined Section

A user defined section may be defined, consisting of three component parts in addition to the shell itself. The relevant help file clearly defines the areas used to build up a section, as shown below.



If for example, a section comprises only two components, only areas 2 and 3 would be defined and area 4 dimensions set to zero.
Operation of the program with user defined stiffeners is practically the same as with a standard section stiffener. A scale plot of the stiffener section will be presented, to aid in selection of a realistic shape.

The program does not currently consider radial buckling of a stiffener, or external loads caused for instance, by integration of a stiffener with a pipe support.

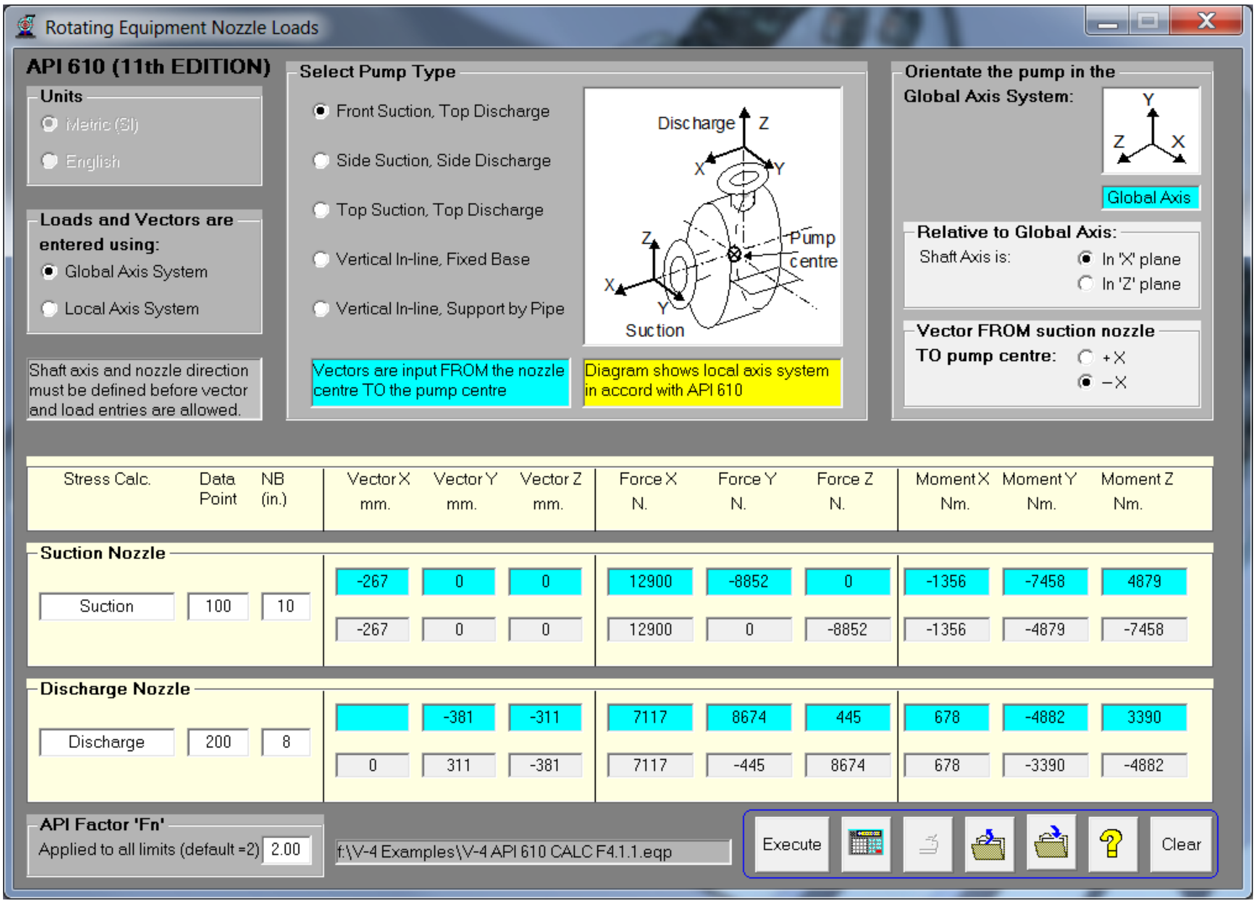
10.0 ROTATING EQUIPMENT NOZZLE LOADS ANALYSIS

Acceptability of nozzle loads applied by piping to various types of pump and compressor may be analysed with this program. The following codes are covered:

API 610	Centrifugal Pumps
API 611	Refinery Steam Turbines
API 617	Centrifugal Gas Compressors
NEMA SM-23	Steam Turbines

10.1 API 610 PUMP ANALYSIS

Typical API 610 Input Screen



10.1.1 API 610 Input Data

Two axis systems are available, one using the API local axis system (Z upward) and one utilising the more common global axis system used in piping stress analysis (Y upward).

If the API (local) axis system is used, only the pump type needs to be defined, prior to load and nozzle dimensional data entry, and subsequent analysis. If the global axis system is applied, the shaft axis orientation and the cardinal vector from suction nozzle to pump centre must also be selected, as shown above. If the global axis system is used, all nozzle data is entered with respect to the global axis. The program will re-orientate each data item to the local axis system on the line below, as it is entered.

If the analysis concerns a vertical in-line pump, the axis system must be carefully applied to avoid confusion, since the 'Y' axis points into the suction nozzle and out of the discharge.

The help file clearly defines action of the pump multiplier factor, Fn.

10.1.2 API 610 Output Data

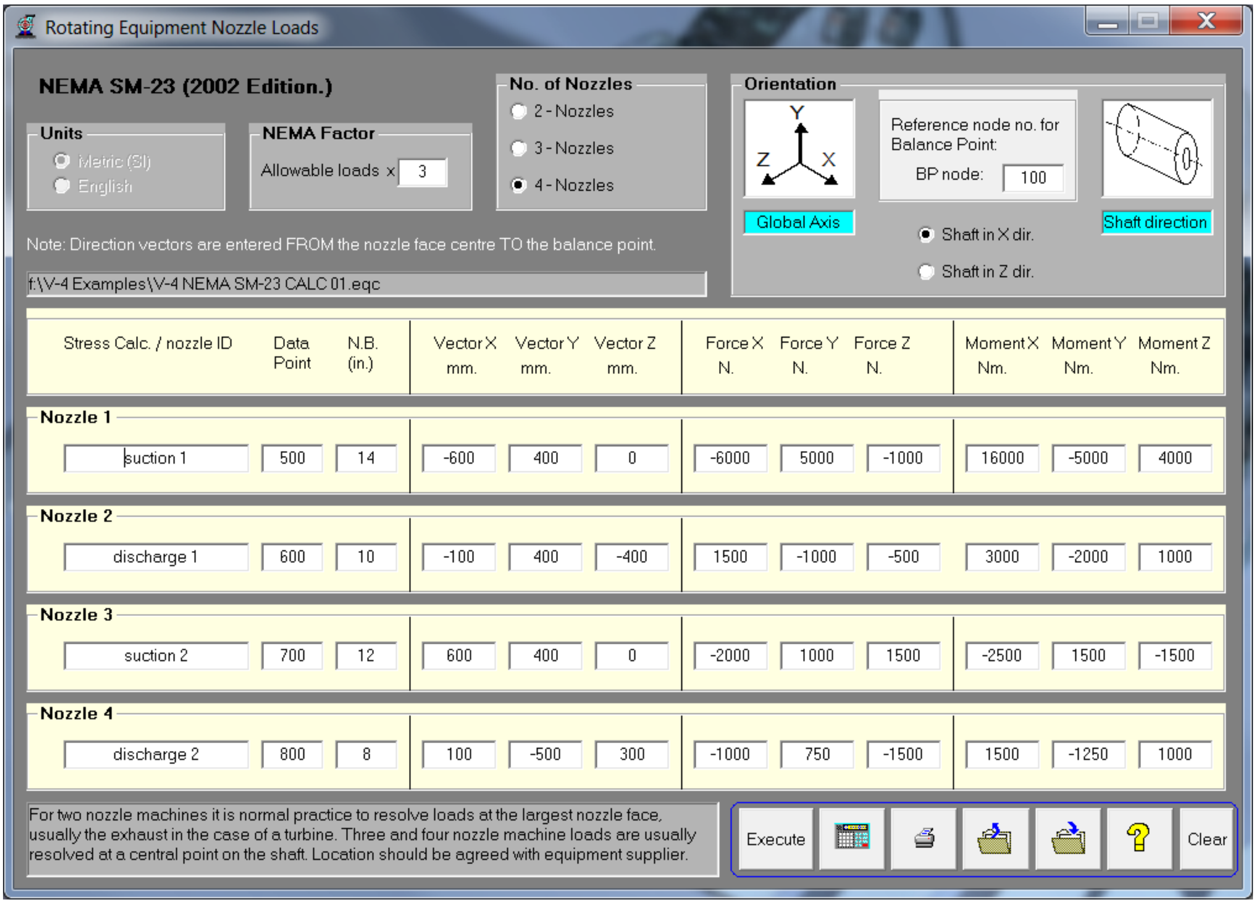
Output is presented with respect to the various clauses in the code. Each calculated load combination is presented with its respective allowable value, and acceptability or failure will be highlighted.

10.2 API 611, API 617 and NEMA SM-23 Code Analysis

API 611 and API 617 are similar and both refer to NEMA SM-23. The analysis methods are identical with the exception of differing factors employed as dictated by the respective code.

For purposes of the User Guide, operation in accordance with the NEMA SM-23 code will be described.

10.2.1 Typical NEMA SM-23 Input Screen



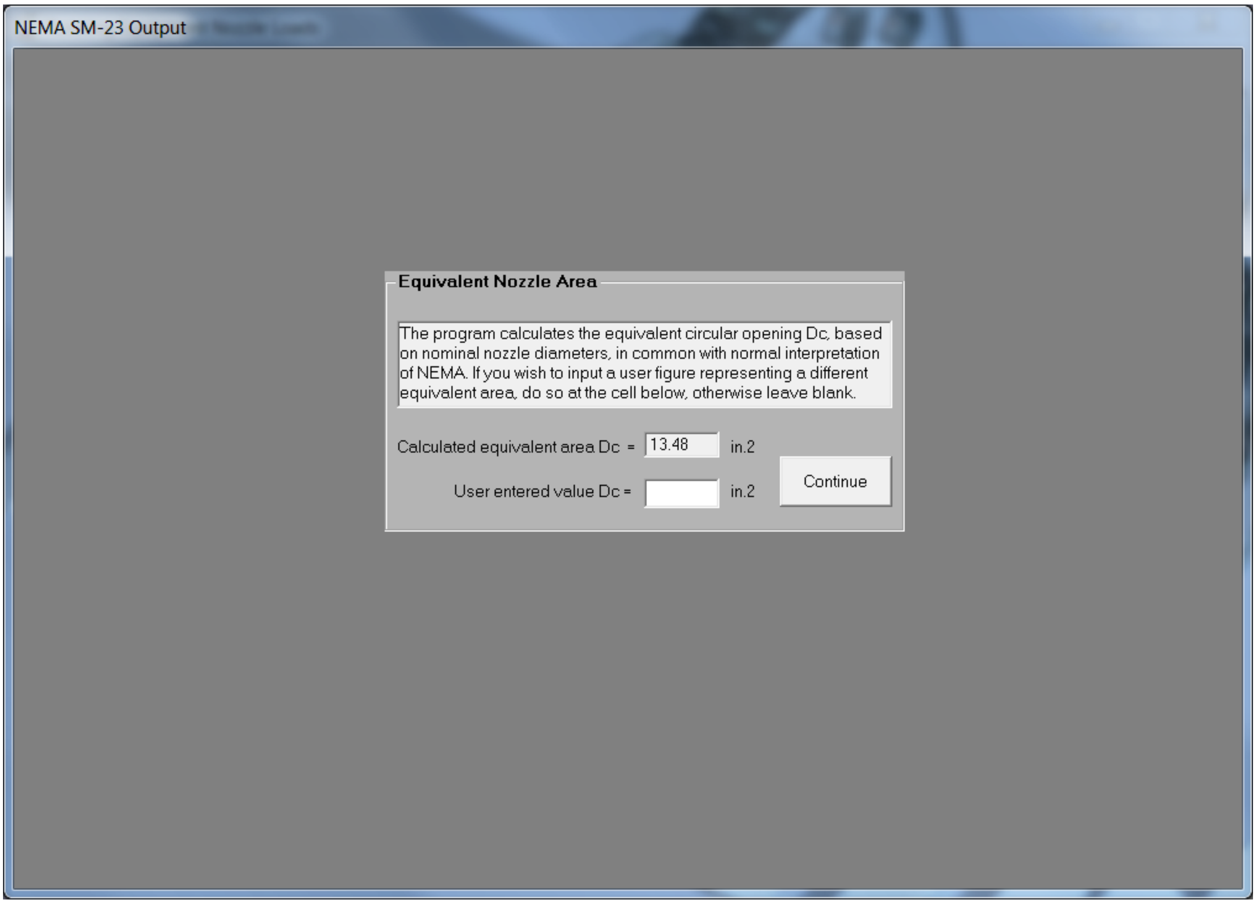
10.2.2 NEMA SM-23 Input description

Up to four nozzles may be analysed. The location of the point around which all forces and moments are resolved should be agreed with the equipment supplier. Commonly when NEMA SM-23 is applied to a two nozzle compressor, the suction (larger) nozzle face and centre-line intercept is used, and the shaft centroid of a two stage, four nozzle machine. This is not mandatory however.

The shaft axis will default to the global X direction, but may be changed.

The dimension Dc (equivalent circular opening equal to all nozzles) is normally interpreted as being based on the nominal diameter, and this is applied by PIPEMILL. The user has the option prior to analysis, of entering a different Dc value if desired, as shown below.

NEMA SM-23 Input Screen – Definition of Dc



Leaving the ‘User entered …’ cell blank and pressing ‘Continue’ applies the value of Dc as calculated by PIPEMILL.

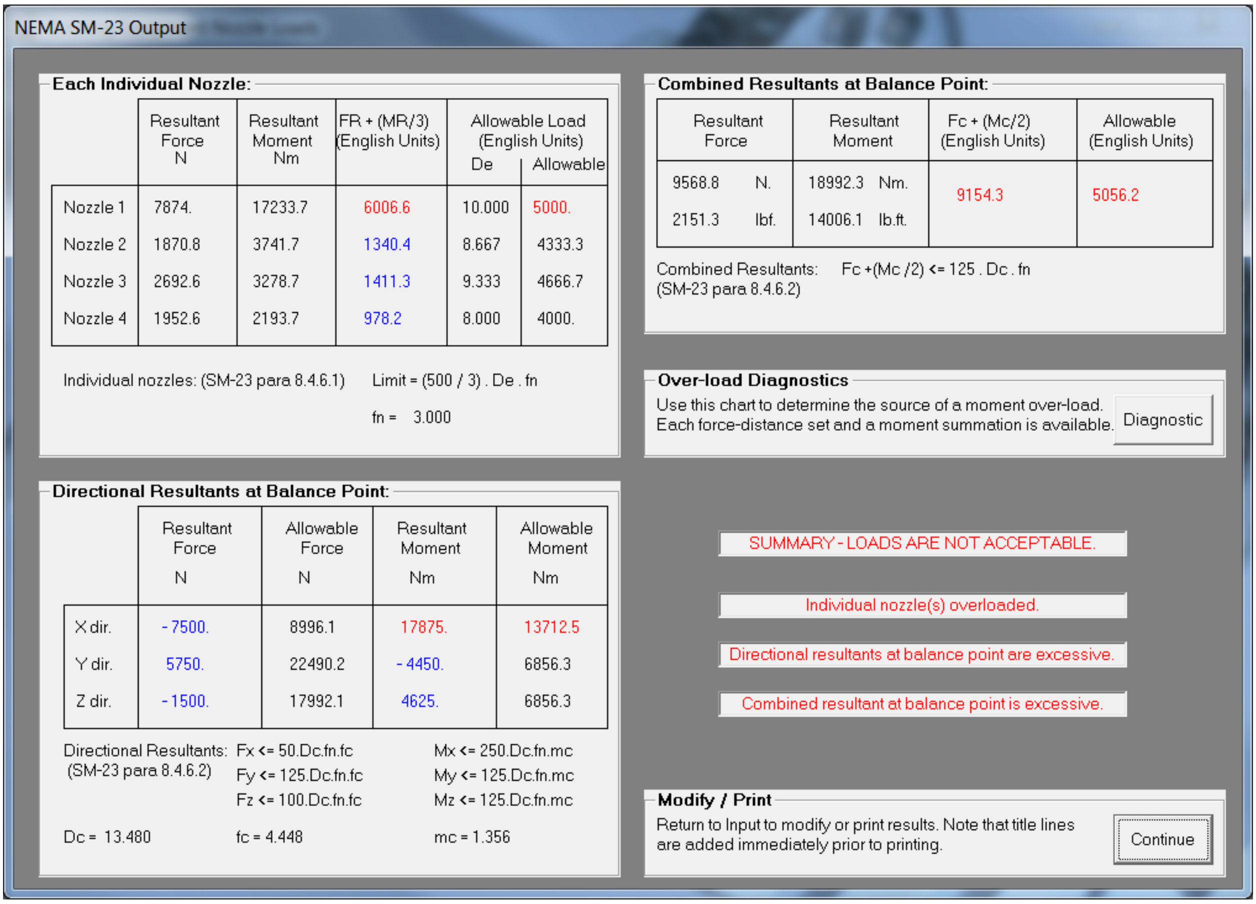
10.2.3 NEMA SM-23 Output

Output data is organised with respect to the code paragraphs and sections. Acceptability or failure of each element will be clearly identified.

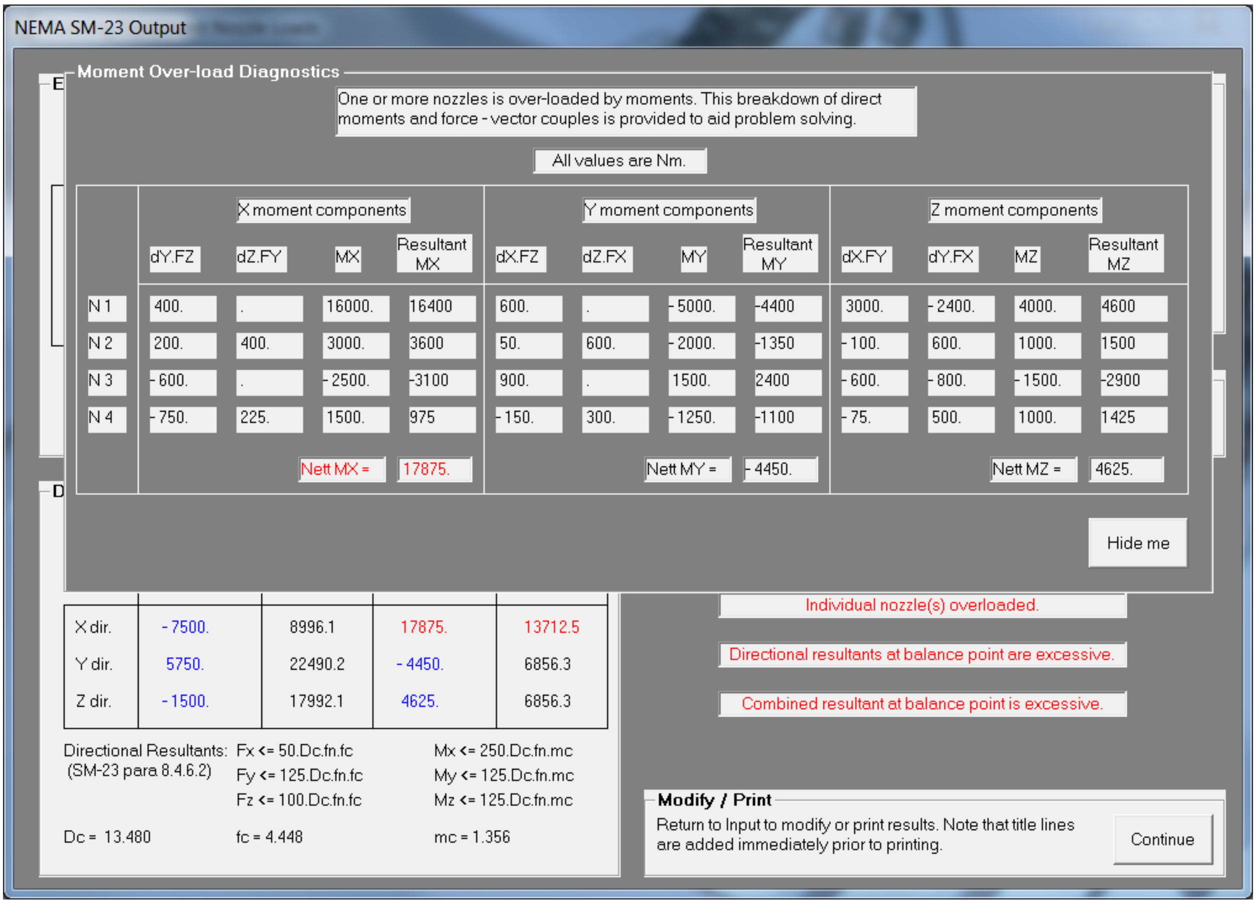
A summary of results will be provided, and if code limits have been exceeded a diagnostic chart may be accessed. The diagnostic chart allows the user to identify which load and direction vector(s) is responsible for the over-load condition, in order to solve the problem most effectively.

Screens plots of output data and diagnostic screens follow.

10.2.4 Typical NEMA SM-23 Output Screen



10.2.5 Typical NEMA SM-23 Output Screen with diagnostic chart

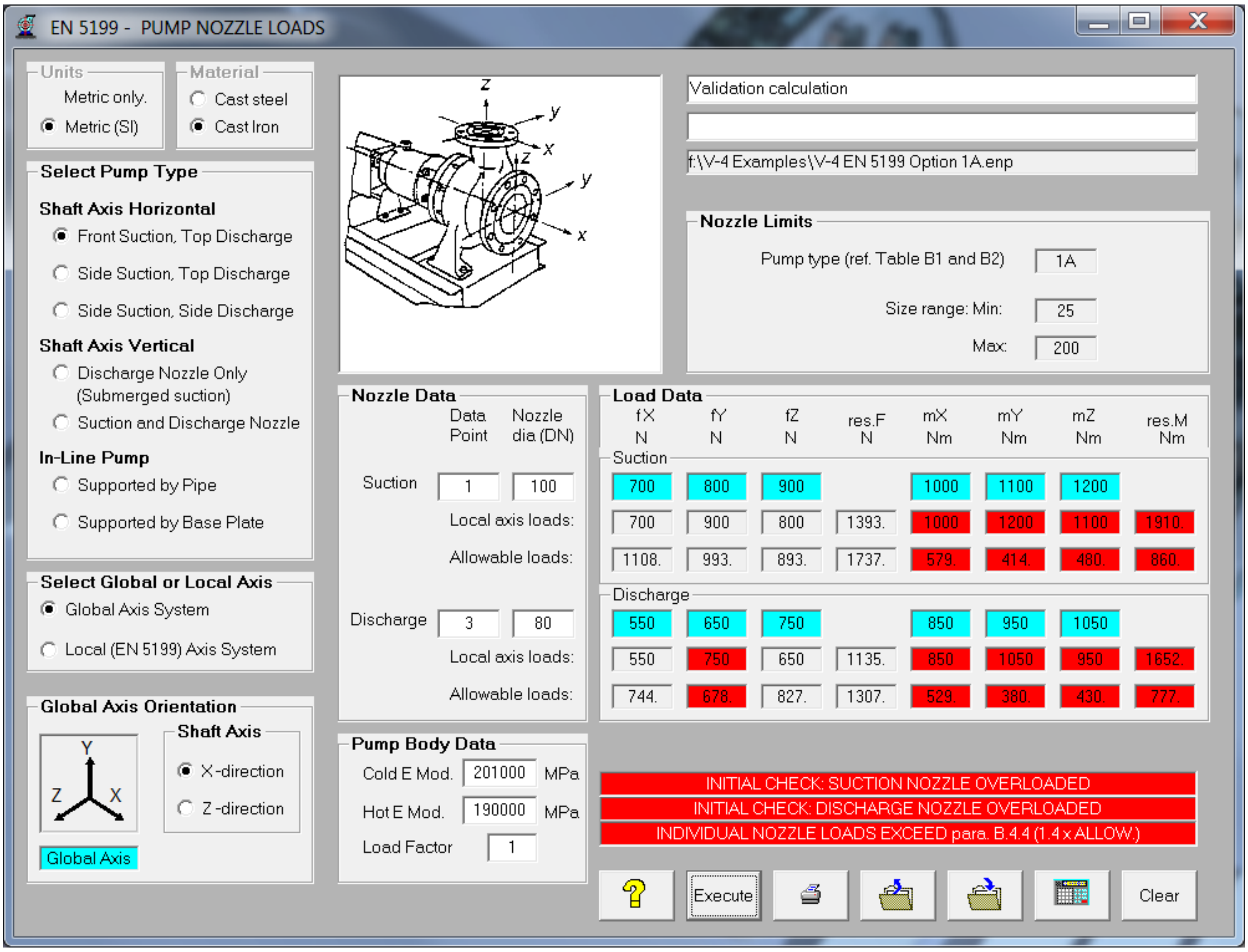


10.3 Pump Nozzle Loads to ISO EN 5199

Nozzle loads for all configurations of pumps found in EN 5199 may be analysed.

The user will be warned if any data is outside the allowed range or exceeds and allowable load value.

10.3.1 Typical ISO EN 5199 Input and Results Screen



11.0 PIPE SUPPORT STRESS ANALYSIS

Trunnion type and vertical riser (stack) type support structures may be analysed with the program. Section 11 deals with Trunnion design in accordance with the well-known ‘Kellogg’ method found in Kellogg, ‘Design of Piping ‘Systems.

Note that a more comprehensive method of analysis for Trunnion type attachments to pipe and elbows may be found in section 12.

Trunnions in accordance with ‘Kellogg’ may be with or without a stiffener ring and on straight pipe or attached to an elbow.

Riser supports may include or exclude horizontal stiffener rings. Both calculation routines include the effects of external loads and internal pressure. Riser support analysis is based on Blodgett ‘Design of Welded Structures’.

11.1 Trunnion Type Pipe Support Analysis

A standard pipe size for both the parent pipe and the trunnion may be selected from a data-base. Alternatively, user defined diameter and wall thickness may be entered. If specified, corrosion will always be deducted from the pipe wall thickness prior to calculation.

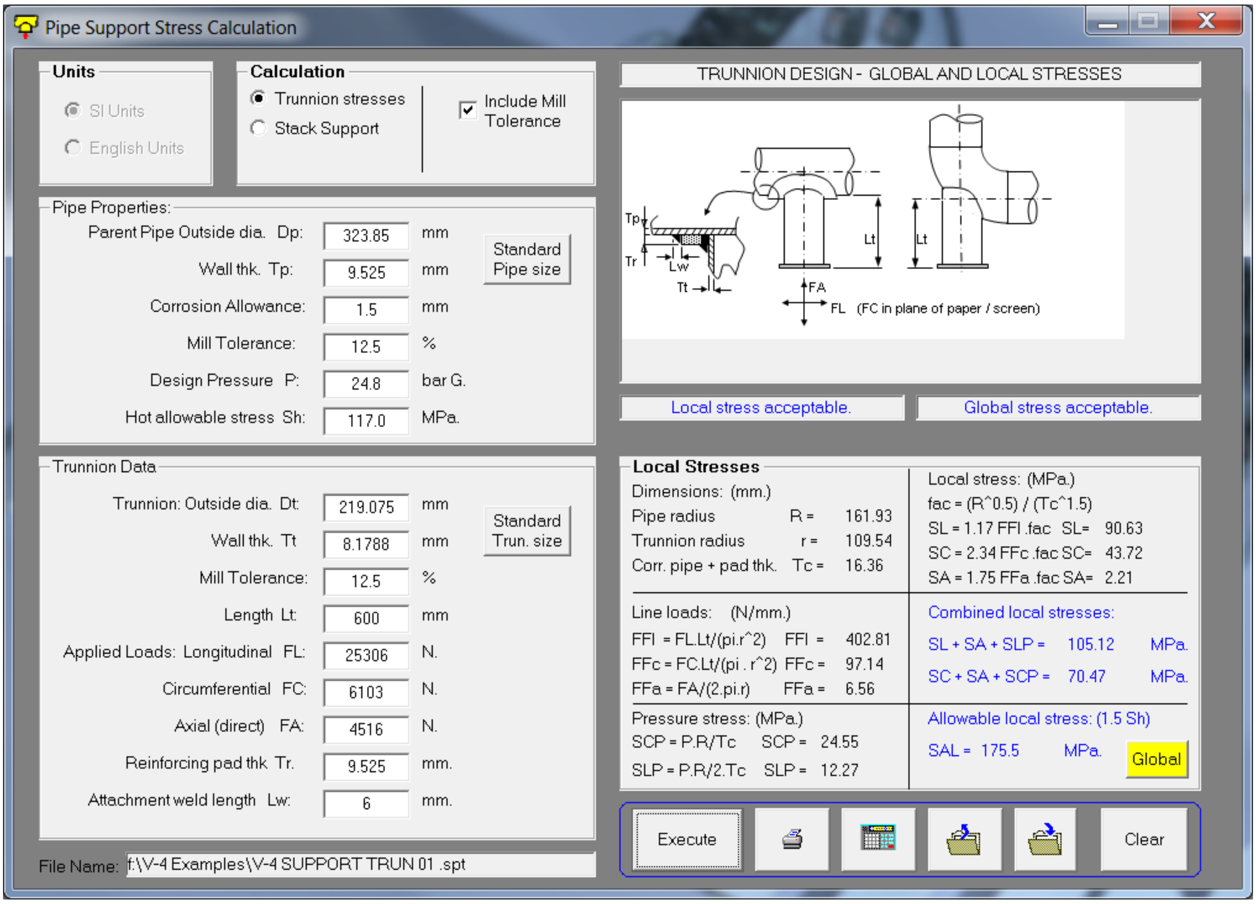
Mill tolerance may be included or excluded from the calculation by use of a check box.

As shown in the screen print below, the analysis assumes that reinforcement will be in the form of a ring, full welded on the inner and outer edges.

Since global axes are not used, the trunnion may be in any orientation. Direct load is axial in the trunnion and longitudinal in the plane of the parent pipe.

Two output panels are available, one providing local stresses at the pipe / trunnion juncture in accordance with the ‘Kellogg’ method and another giving global bending and shear stress in the trunnion. Local deflections are not calculated, however a significant global bending stress might suggest that trunnion and local pipe wall flexibility be considered, particularly if the trunnion is intended as a restraint local to equipment.

11.1.1 Typical Trunnion Stress Analysis Input and Output Screen.

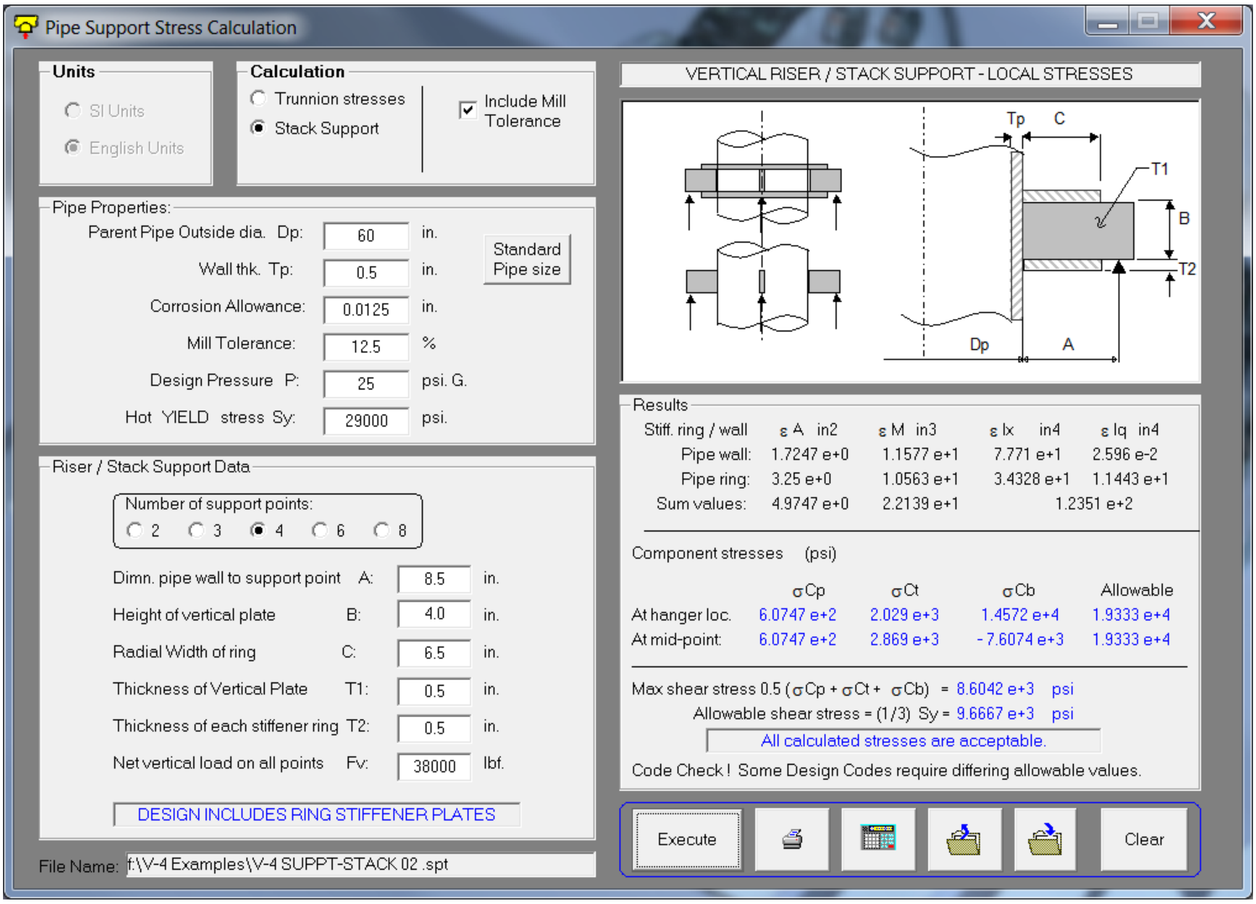


11.2 Riser (stack) Type Pipe Support Analysis

Input of data for the parent pipe is the same as used in trunnion analysis. The number of, and plate dimensions for the vertical plates must be defined, and parameters of any stiffening ring supplied. The calculation assumes that if any stiffening is defined, it will be in the form of two identical rings.

Local moments and consequently stresses will be evaluated and combined into a maximum shear stress. This will be compared to a notional limiting shear stress of 1/3 hot yield stress by the program**. The user is cautioned that some design codes specify differing limits for shear stress.**

11.2.2 Typical Riser (stack type) Support Stress Analysis Input and Output Screen.



12.0 PIPE AND ELBOW TRUNNION STRESS ANALYSIS TO ASME III Section Y-5000

The method employed originated in ASME III Code Case N-392 (1994) and is embodied in ASME III Div. 1(2007) Appendices, Article Y-5000. The work is the conclusion of extensive finite element analysis of many straight pipe models employing a perpendicular trunnion type attachment.

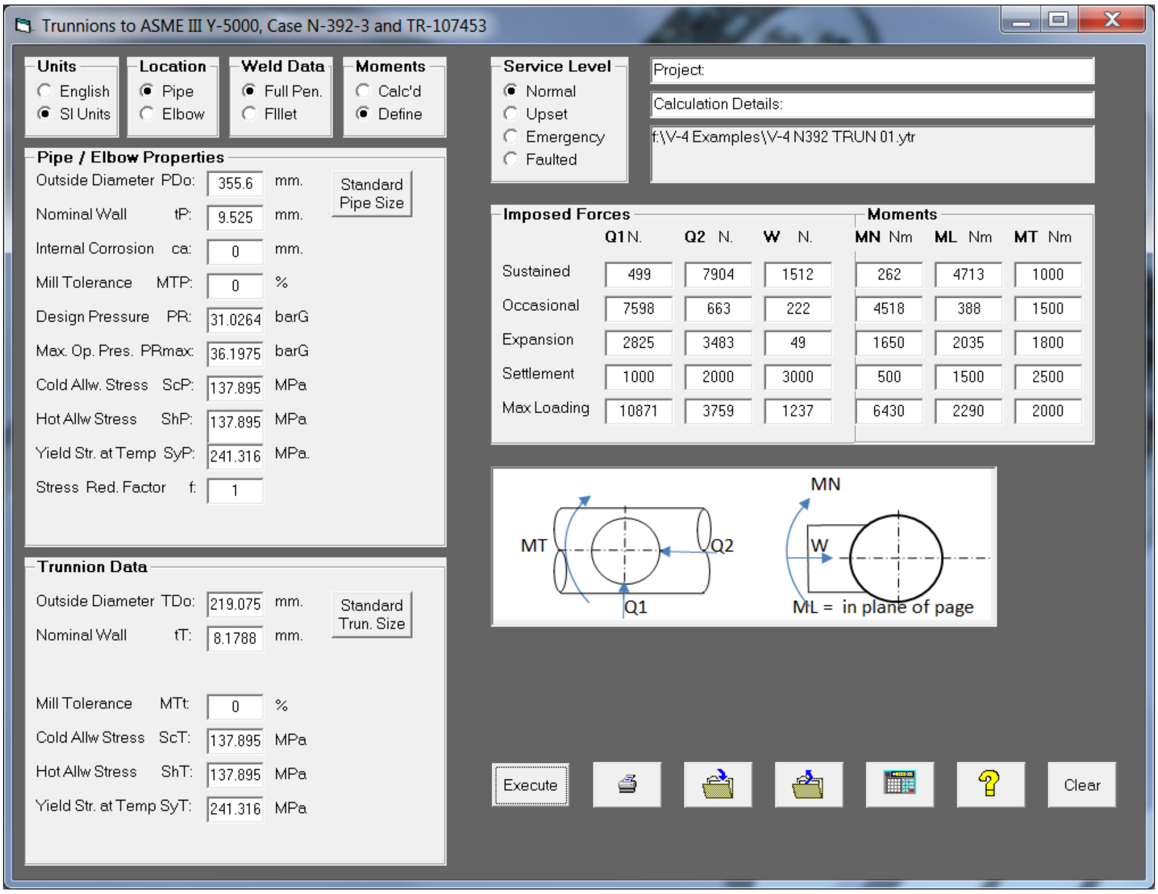
The method was extended to cover a Trunnion attached to an elbow by EPRI under report TR-107453. This method applies to a maximum bend radius of 1.5D.

Pipemill deals with both straight pipe and elbow attachments. Two sets of input are available. The user may define all forces and moments that apply at the intersection, of only define forces at the end of the trunnion. In the latter case Pipemill will determine respective moments from imposed forces. This is considered the most relevant loading case to a typical piping application, since whilst trunnion supports often resist lateral forces, they rarely also fully restrain moments at the base.

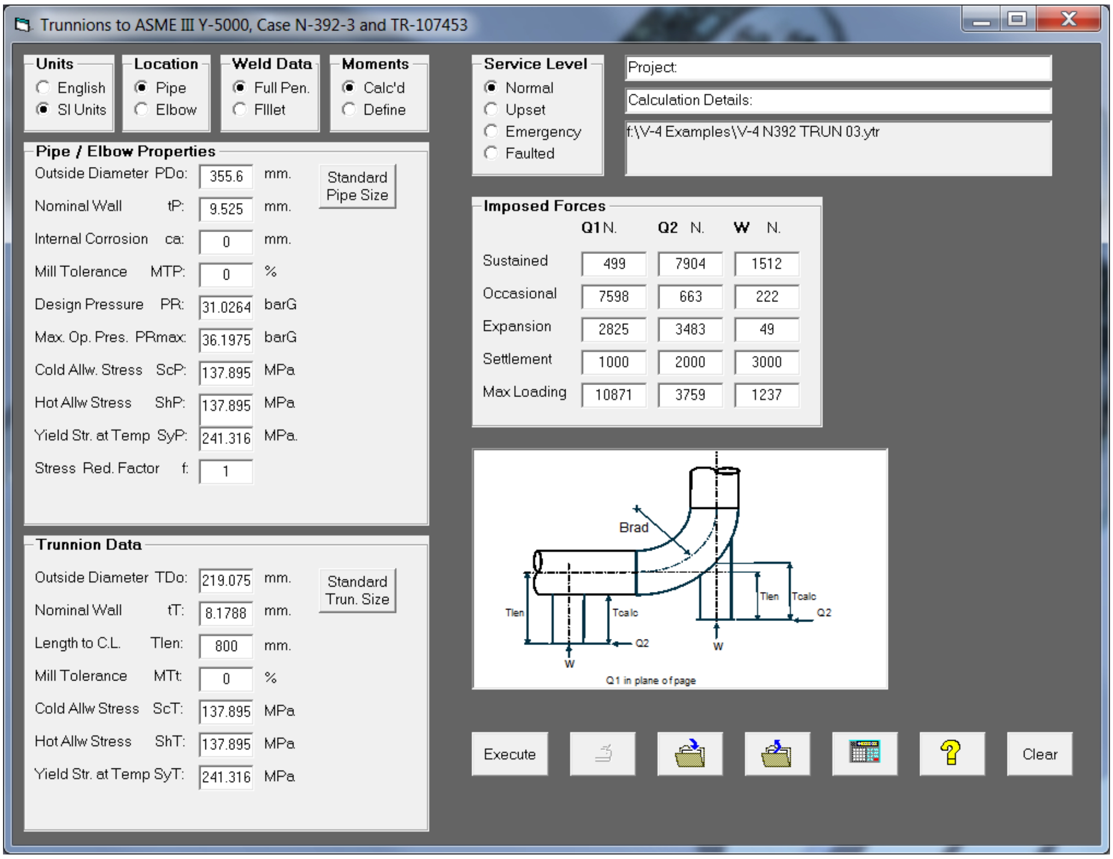
There is no direct input for a reinforcing ring since it is not addressed in the base documents.

It is considered appropriate to include a reinforcing ring as an equivalent total wall thickness, provided the ring is of the accepted proportion of a net diameter close to the2x the trunnion diameter.

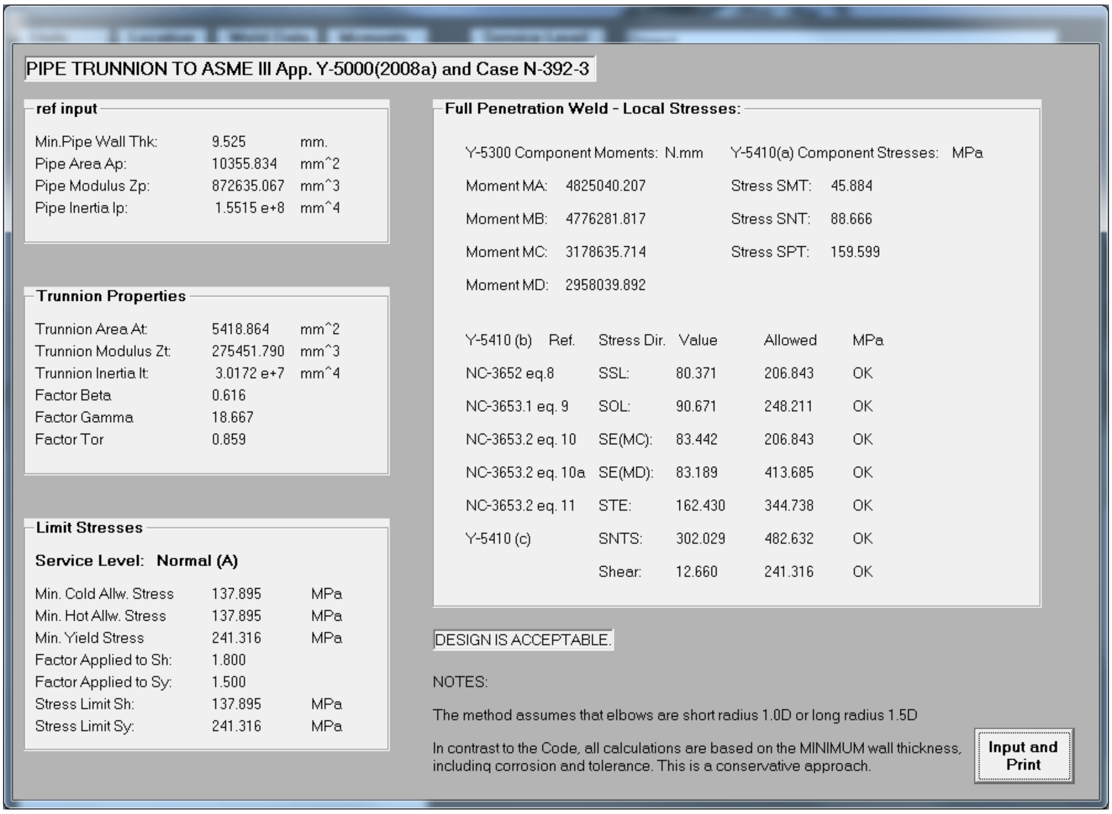
12.1 Fully defined moment input



12.2 Forces defined, moment derived input



12.3 Typical Trunnion calculation output



13.0 Heat Transfer Through Welded Pipe Support Shoes

Heat transfer through a welded attachment is calculated using methods from ASTM C680-04 and Escoe's 'Piping and Pipeline Assessment Guide'.

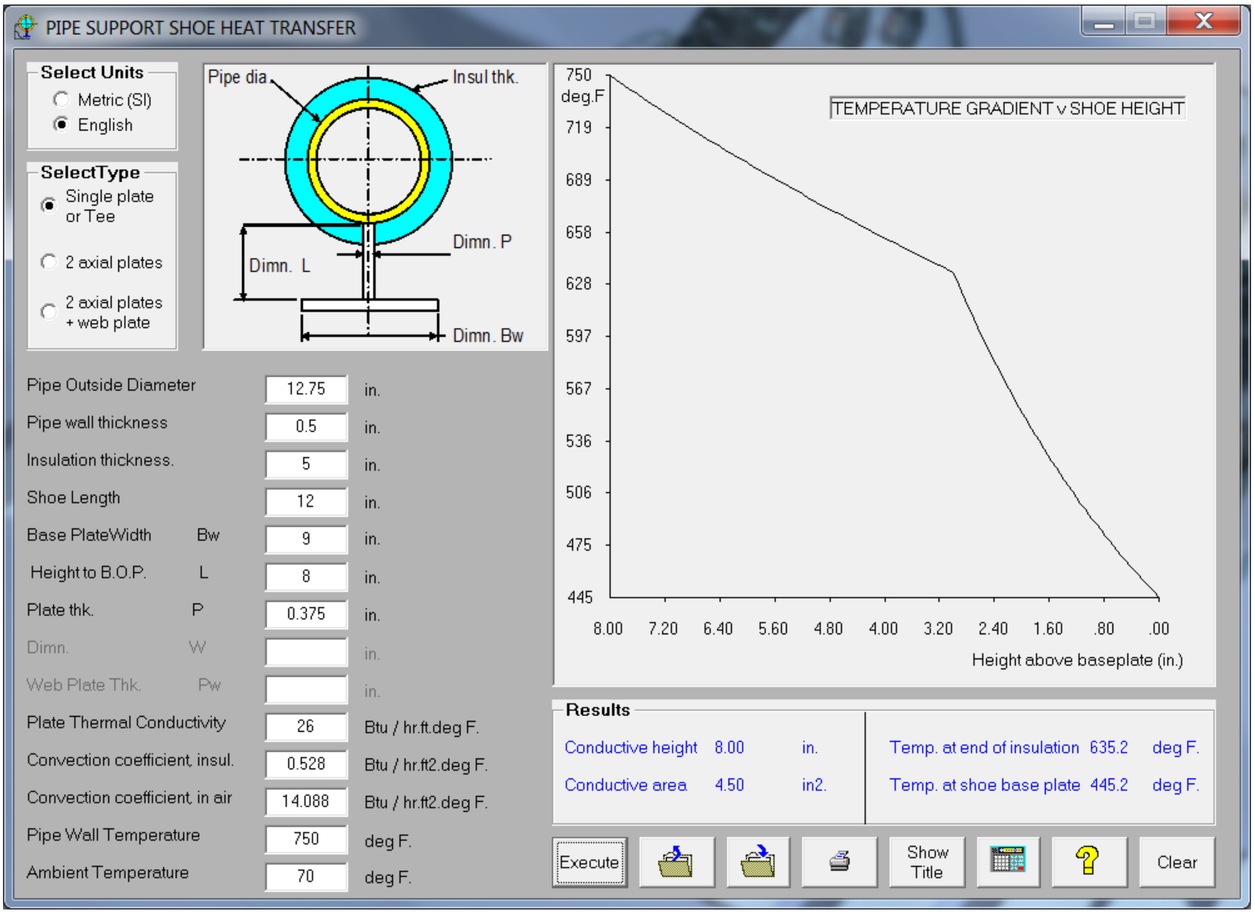
Typical values for thermal conductivity and convection coefficients are presented in the help file.

Three configurations may be considered as shown below.

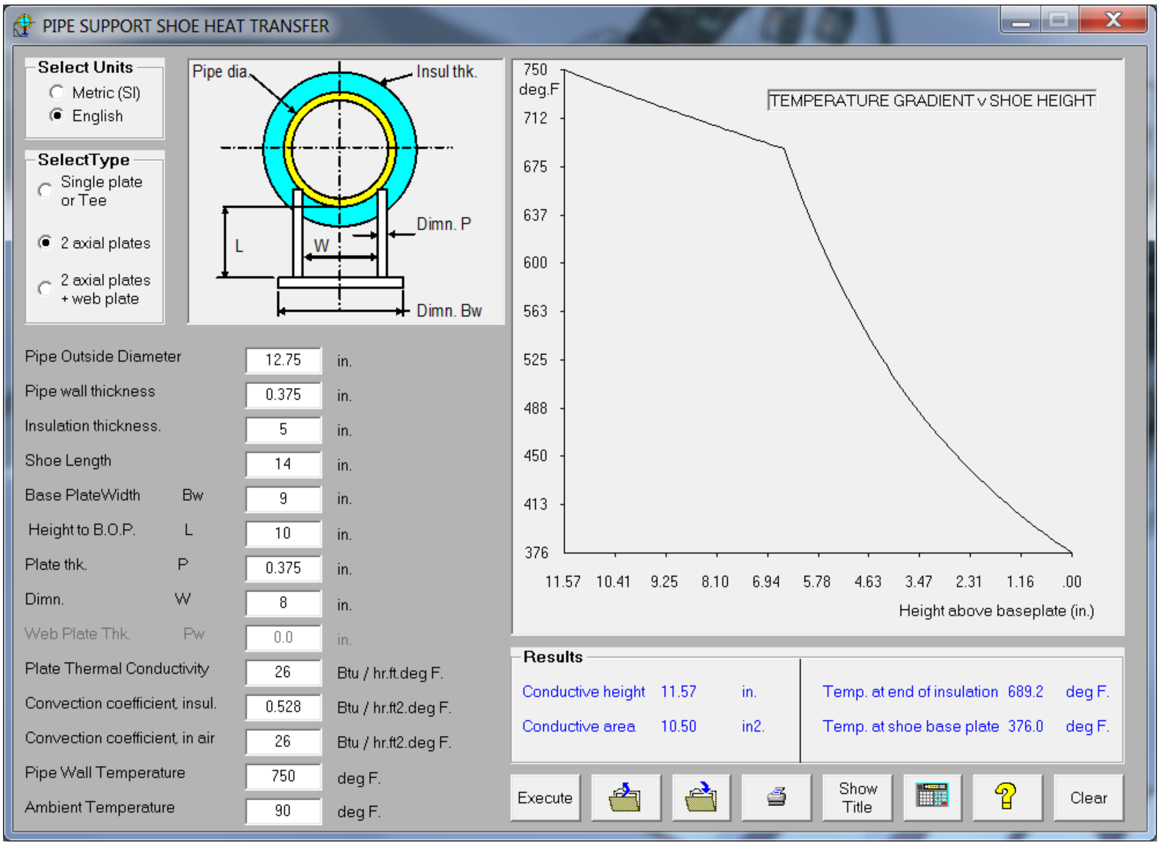
The screen print of a stiffened shoe shown below demonstrates typical results for a cryogenic support.

The intent of the program is to allow assessment of support contact temperature to aid material selection.

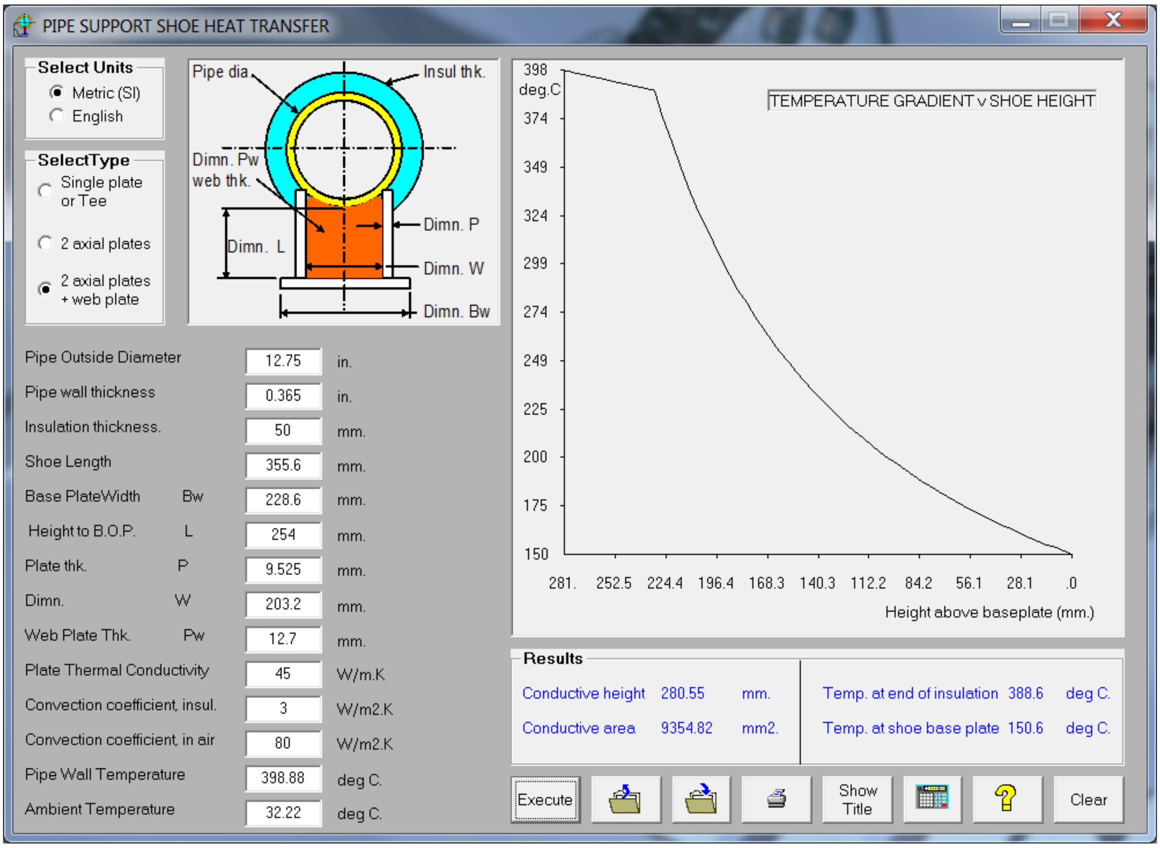
13.1 Simple Inverted Tee Shoe



13.2 Two Plate Shoe



13.3 Stiffened Shoe



14.0 Wind loads on Piping to EN-1991-1-4

14.1 General Notes on Wind Loads

This program element is specifically written to evaluate wind loads on piping and should not be applied, for example to buildings or other structures.

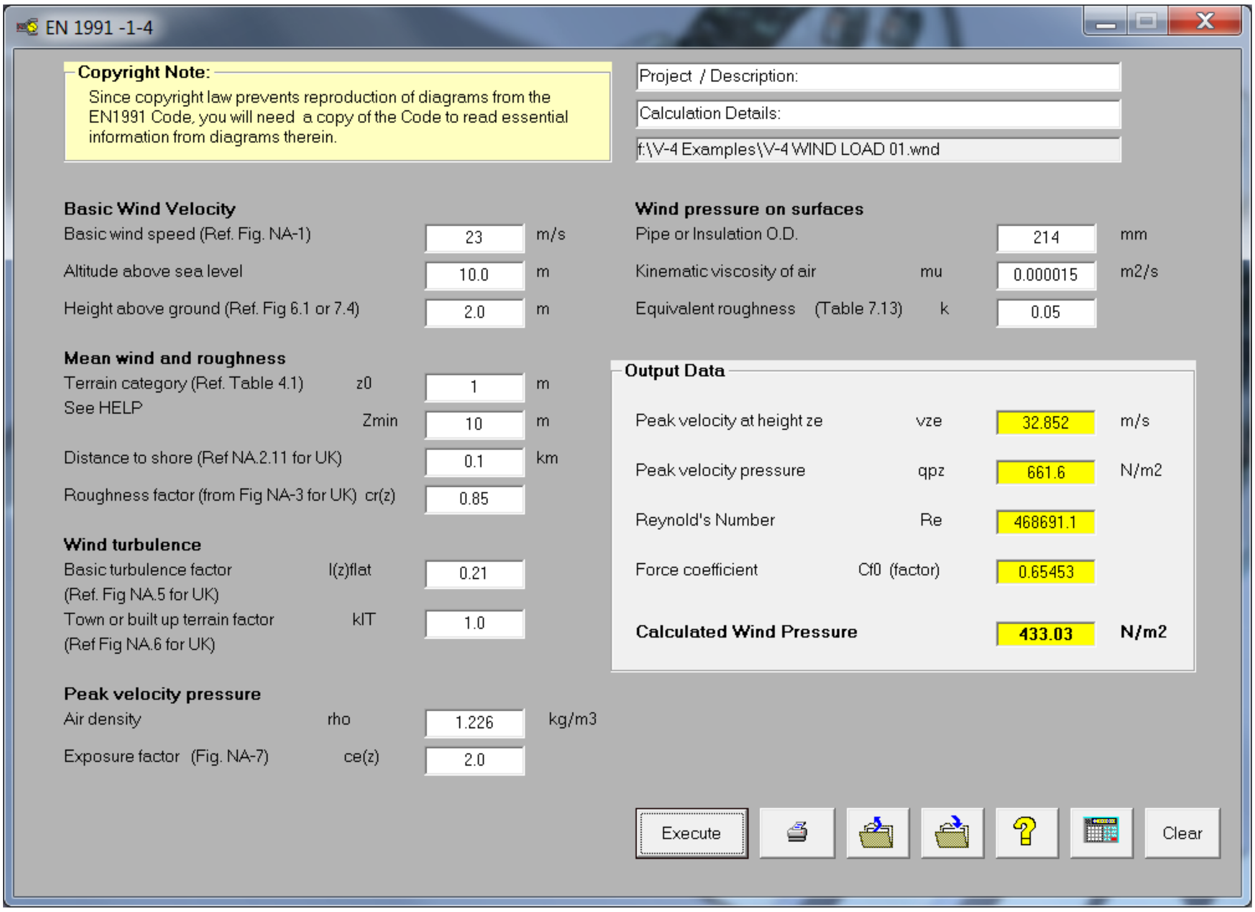
The EN-1991 method is complex, covering a large array of wind load situations. The intent of this element of Pipemill is to simplify the work as far as possible and to identify only that data needed for piping.

Predicted wind velocity and consequently force may vary significantly with height above ground. The user might consider carrying out a number of calculations representative of elevation change if piping is for example attached to a tall tower.

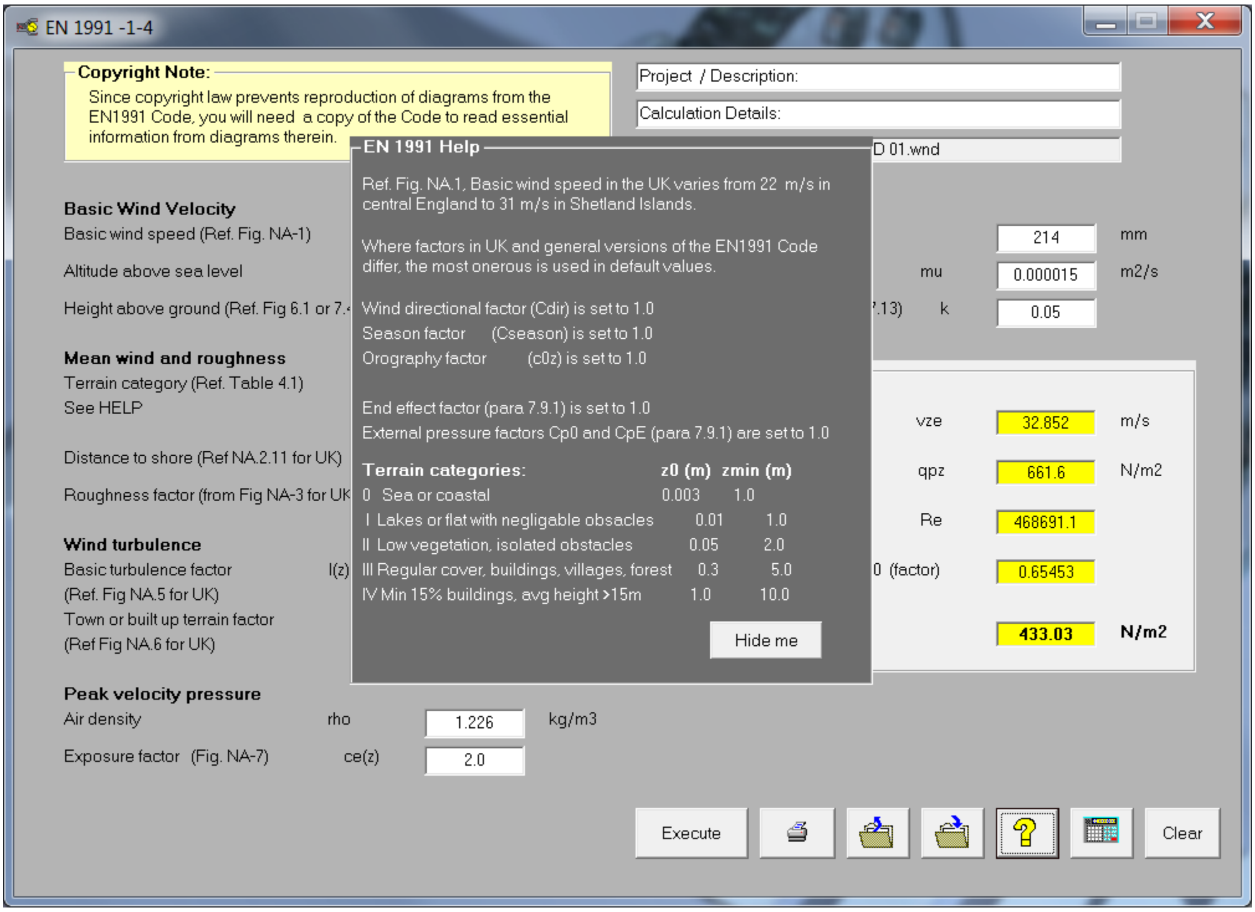
The EN-1991 Code which is copyright protected and some data cannot be reproduced in the program. Thus the User will need to obtain an official copy of this document.

Help file data contains guidance for certain factors, based on British criteria.

14.2 Typical EN-1991-1-4 Wind Load Calculation Input and Output



14.3 Typical EN-1991-1-4 Wind Load Calculation Output with help File



15.0 Jacketed Pipe Design and Analysis

15.1 General Features

Jacketed pipe is tedious and complex to model correctly in piping stress analysis software. The program is intended to aid and supplement such work.

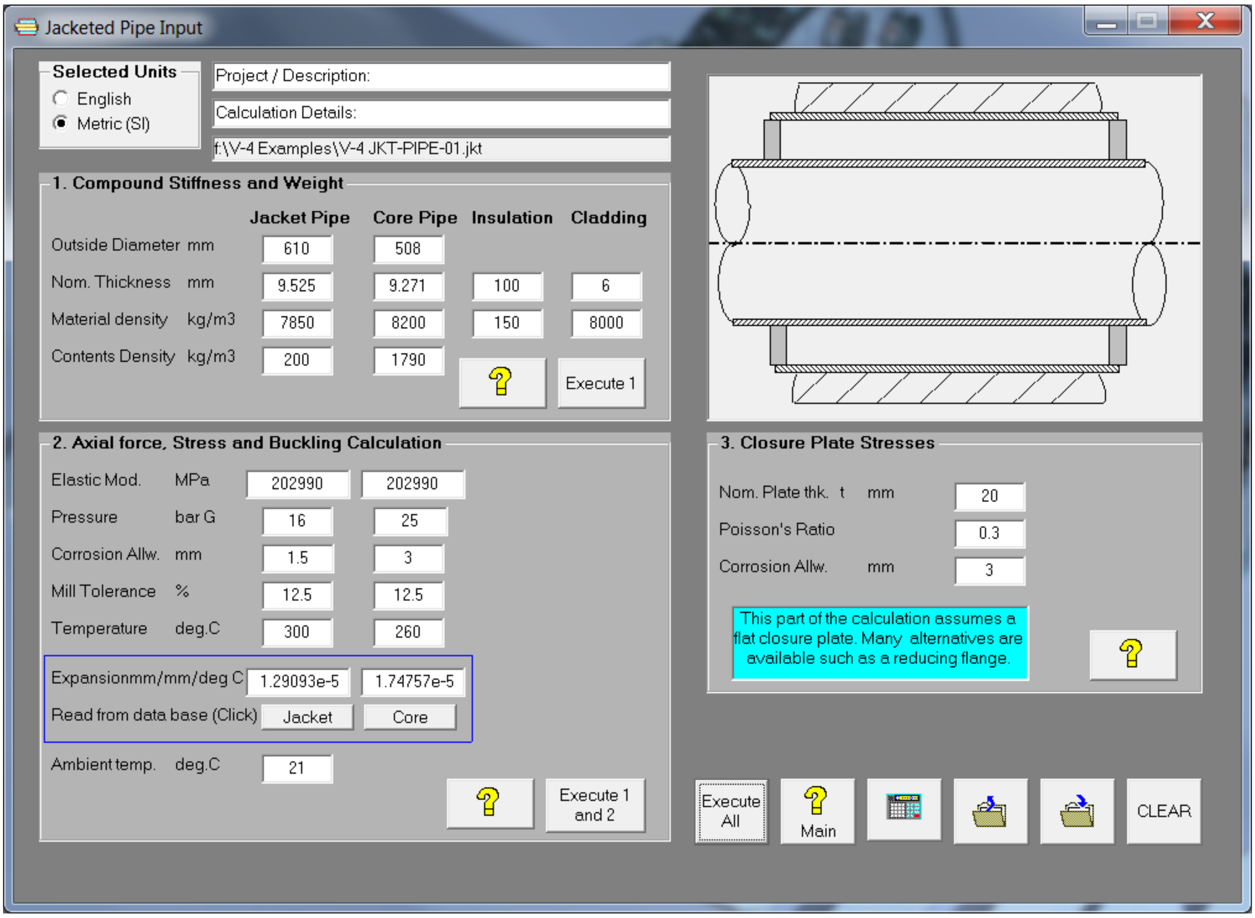
Frequently problems with jacketed pipe concerns force and moment reactions on connected equipment. The first section of the program will generate for a given diameter, equivalent wall thickness and equivalent mass representative of core pipe, jacket, contents and insulation. This allows accurate evaluation of loads on supports and connected equipment using a normal single string of pipe elements in a stress analysis program. Calculated stresses will be approximate.

The second section evaluates internal forces in the jacket and core due to relative expansion, calculates all internal stresses and loads and the critical buckling length. Expansion rates can be extracted from the PIPEMILL internal data base.

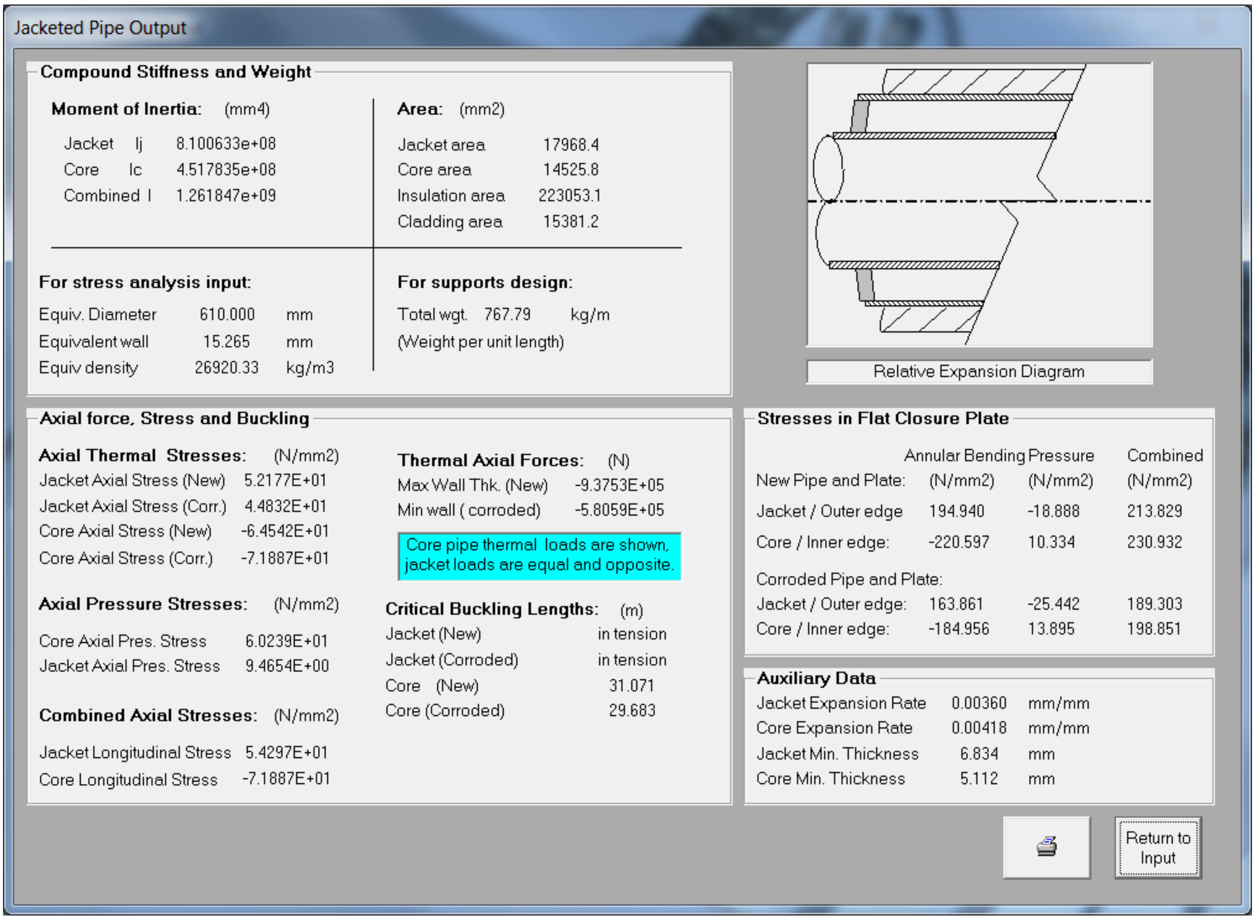
The third section of the program assumes the worst case end closure, a flat plate, is in use and calculates stresses in the plate due to imposed expansion or contraction forces.

Comprehensive help files are available for all three sections.

15.2 Typical Input Screen



15.3 Typical Output Screen



16.0 REINFORCED AND STUB-IN TYPE TEE DESIGN

This program caters for the design of tees manufactured from plate or straight pipe. Lateral branch connections are allowed to an angle from the perpendicular of 45 degrees.

The tee connection may include inherent reinforcement within the wall of the header or branch pipe, or reinforcement may be in the form of a fully welded ring.

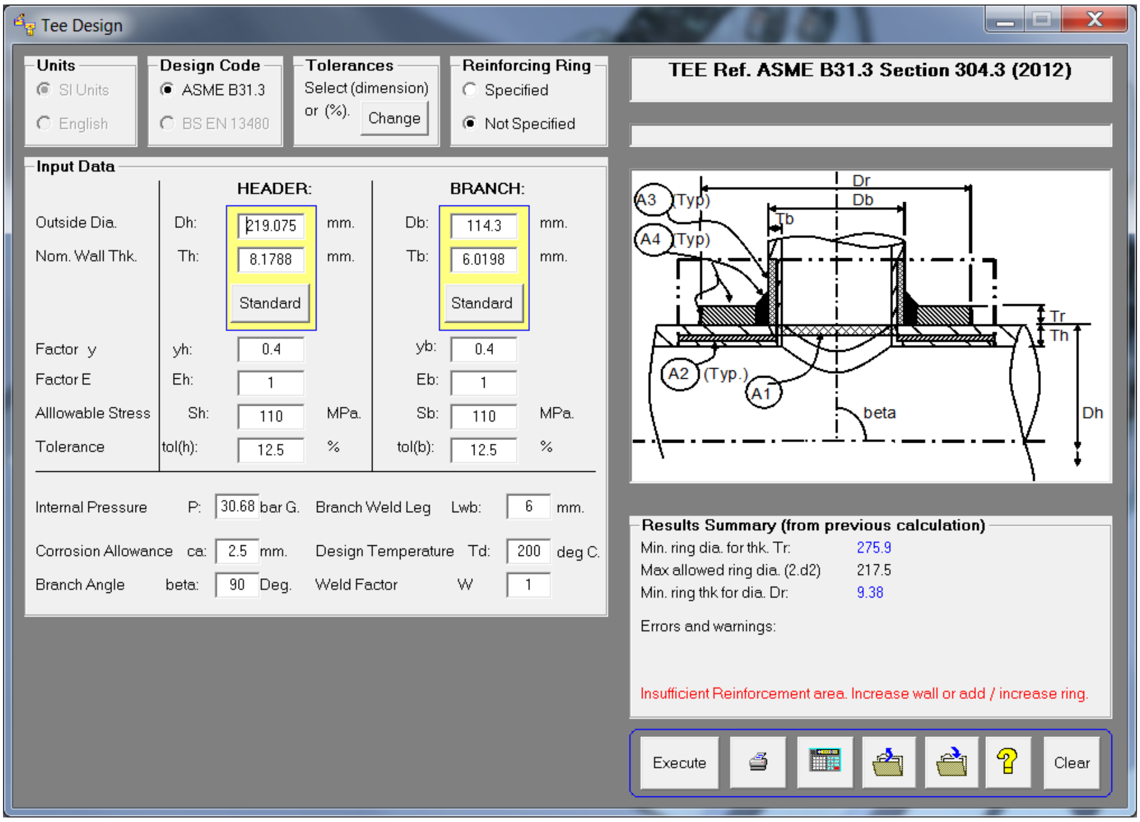
For both header and branch, a standard pipe size may be selected from a data-base, or user entered dimensions may be used.

Stress intensification factors will be calculated, based on the design code. If a lateral connection with an included angle less than 90 degrees has been defined, the stress intensification factor will be modified in accordance with the Codeti (French) code, which increases the sif as the branch angle reduces from 90 degrees. This is documented in the program help file.

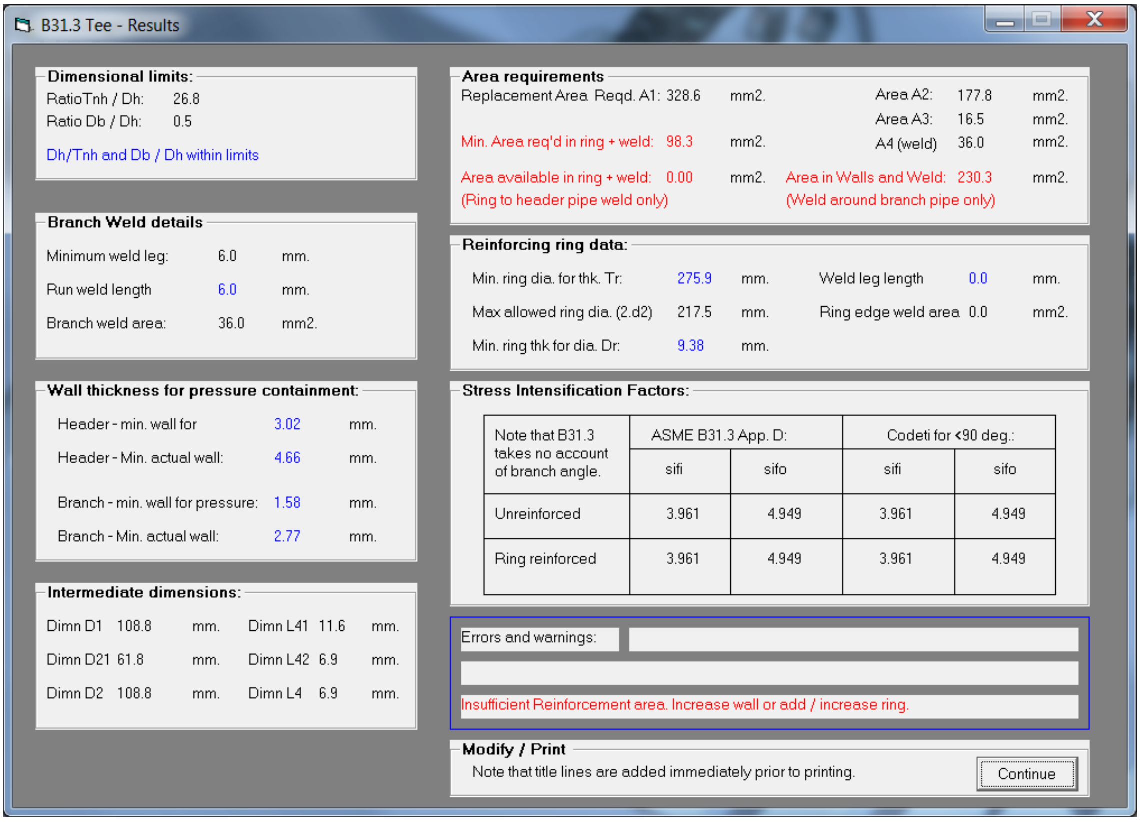
Commonly a tee analysis would be run initially without a ring, to establish the minimum requirements for reinforcement. The program will define the minimum thickness and diameter bounds for an acceptable ring. Results will be presented on a full screen, and will be summarised on the input screen when it is returned.

A series of screen images follows from the same problem. These show a non-reinforced input data screen, a related comprehensive output screen and an input screen with reinforcement, where results are acceptable.

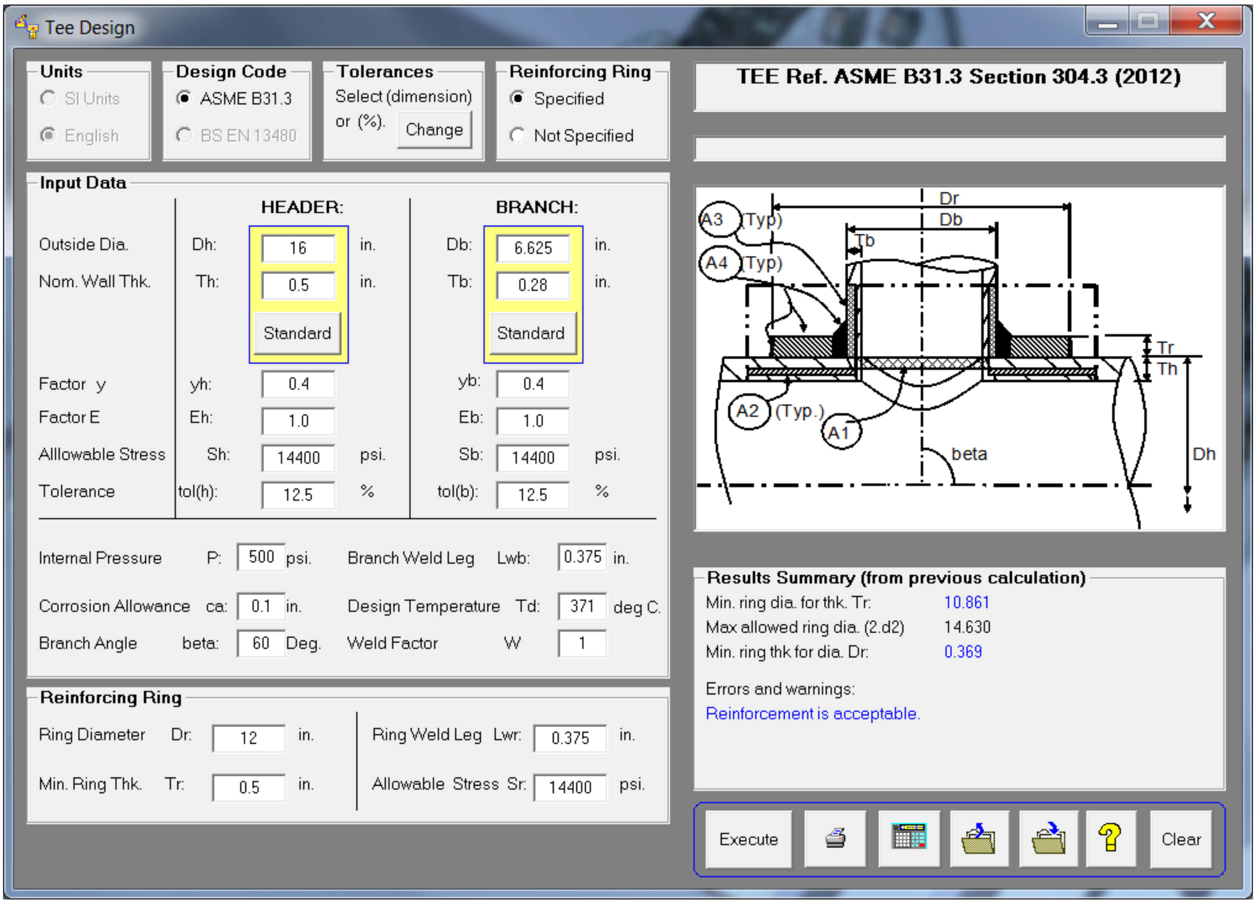
16.1 Non-reinforced Tee Input and Summary Output (results not acceptable)



16.2 Comprehensive Output Data Screen (results not acceptable)



16.3 Input Screen with Reinforcement and Acceptable Results Summary



17.0 DESIGN OF VARIOUS LARGE COMPONENTS

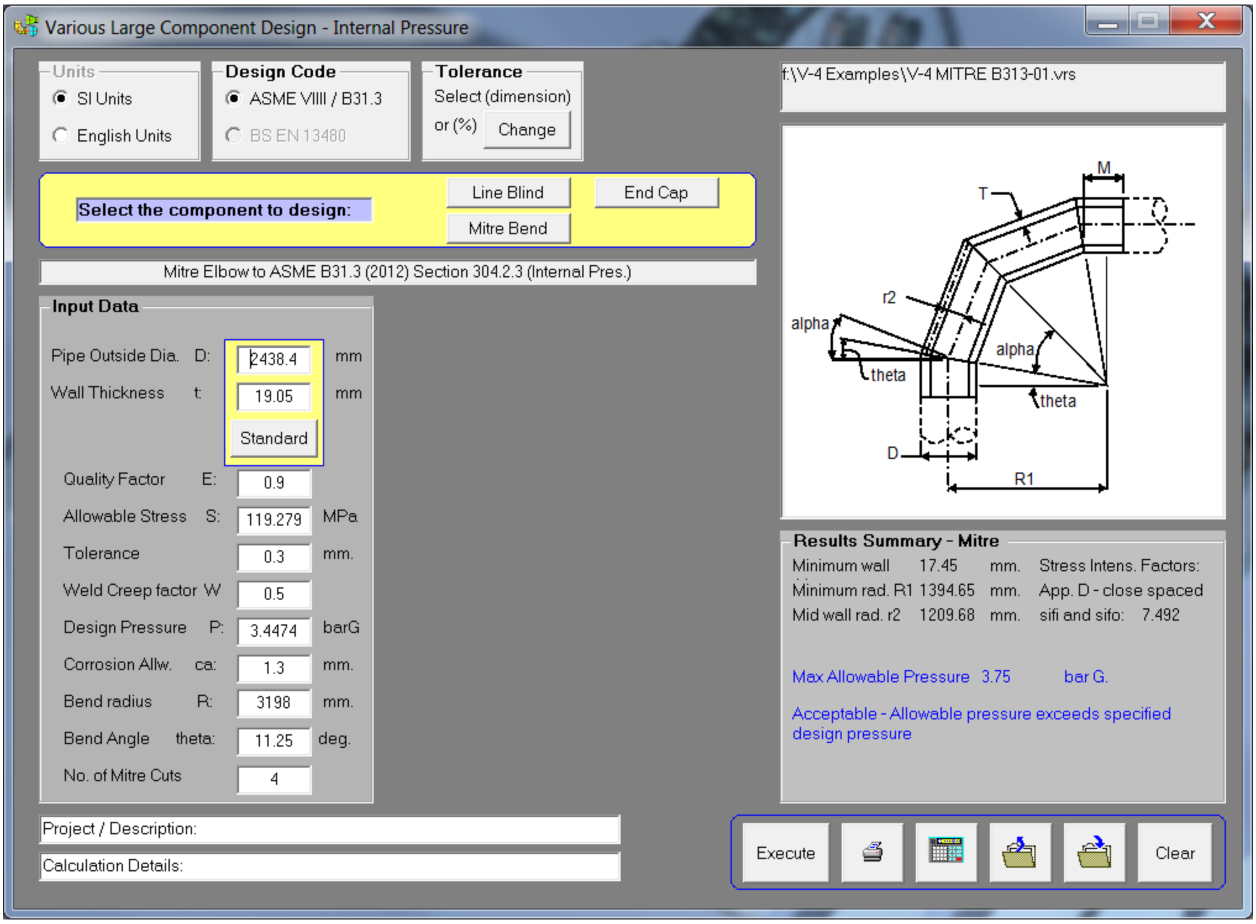
This program is intended for the design of large bore refinery type fittings where standard components may not be available. Mitre elbows with any number of cuts, reducers with or without end reinforcement, end caps and line blinds may be designed.

17.1 Mitre Elbow

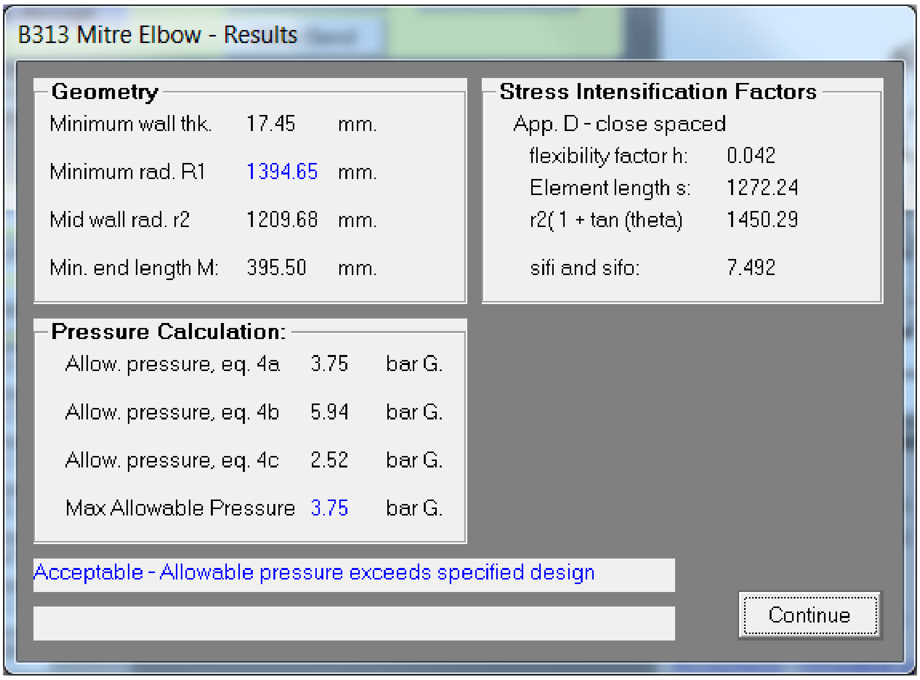
The mitre elbow calculation checks whether the construction is by code definition wide or closely spaced and evaluates acceptability accordingly. The maximum allowable pressure is calculated and compared with the required pressure. Stress intensification factors are presented in accordance with the design code.

A comprehensive output screen will be presented, and results summarised on the input screen when it is returned.

17.1.1 Mitre Elbow Input Screen with Summary Output.



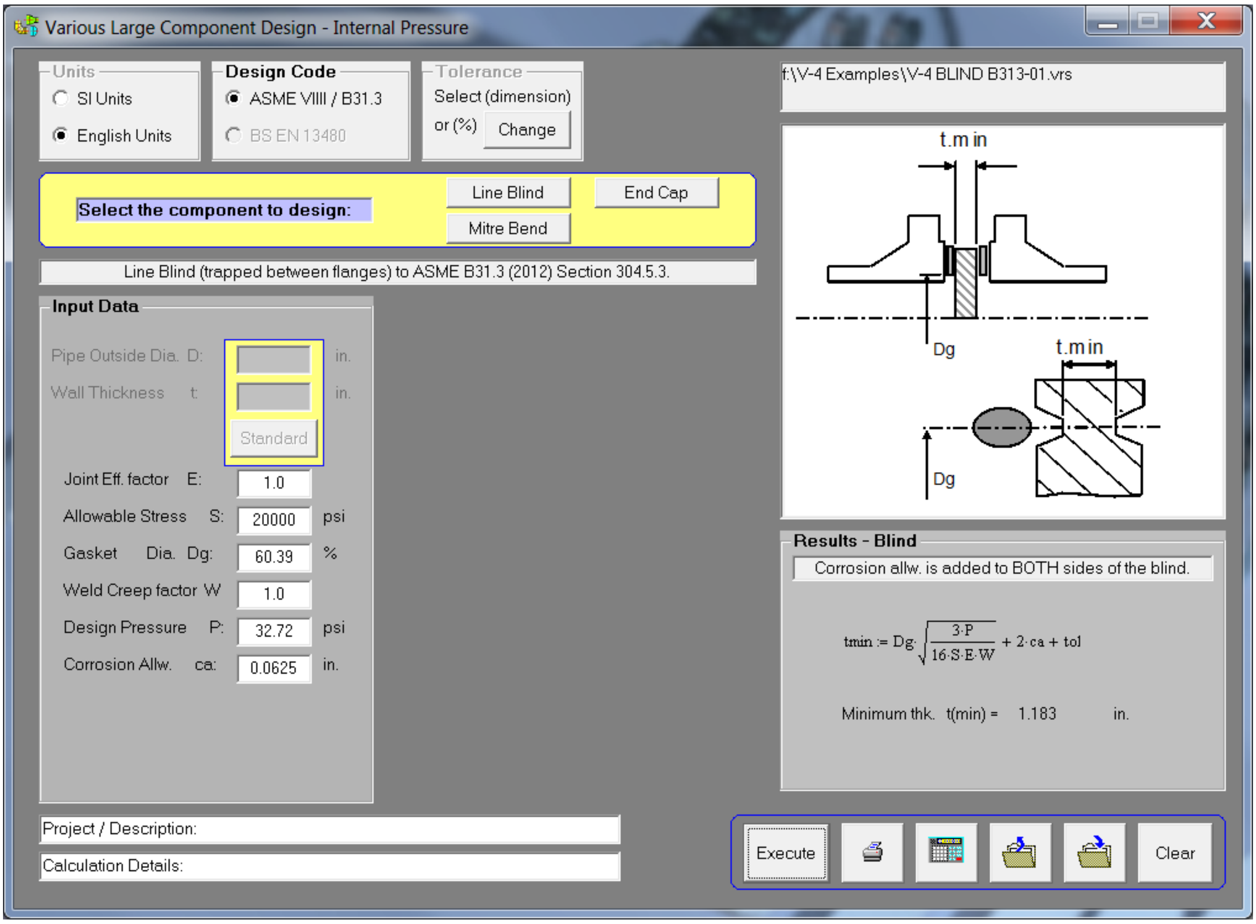
17.1.2 Mitre Elbow, Comprehensive Output Screen



17.2 Line Blind

The calculation of a line blind thickness to ASME B31.3 is straightforward. The program adds corrosion allowance to both sides of the blind if specified.

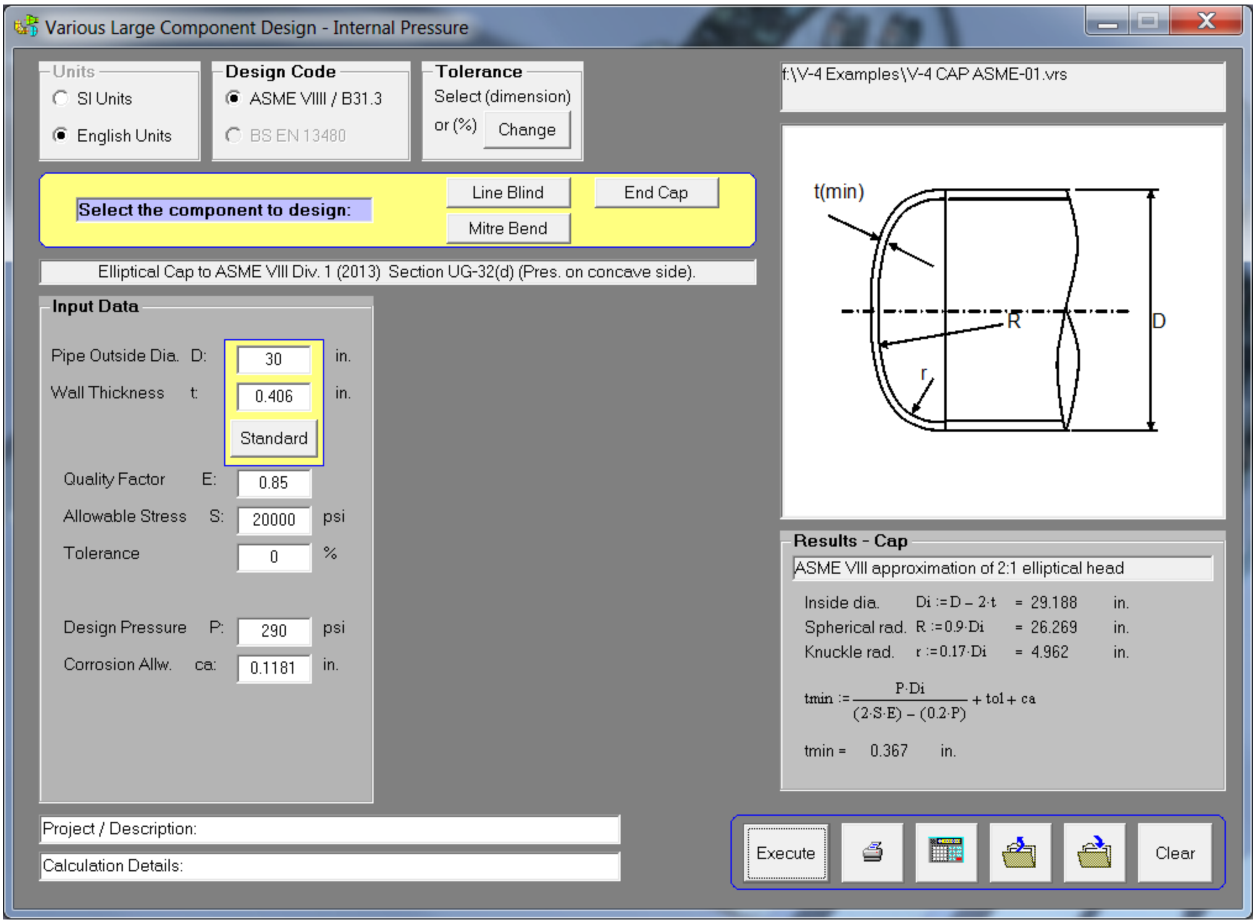
17.2.1 Line Blind Calculation and Results Panel



17.3 End Cap

End caps are currently calculated in accordance with ASME VIII Div. 1. Currently only pressure on the concave side is addressed. The minimum required thickness will be calculated, also the related spherical and knuckle radii will be reported.

17.3.1 End cap Input Screen with Summary Output.



18.0 Large Bore Reducer to ASME VIII Div. 2

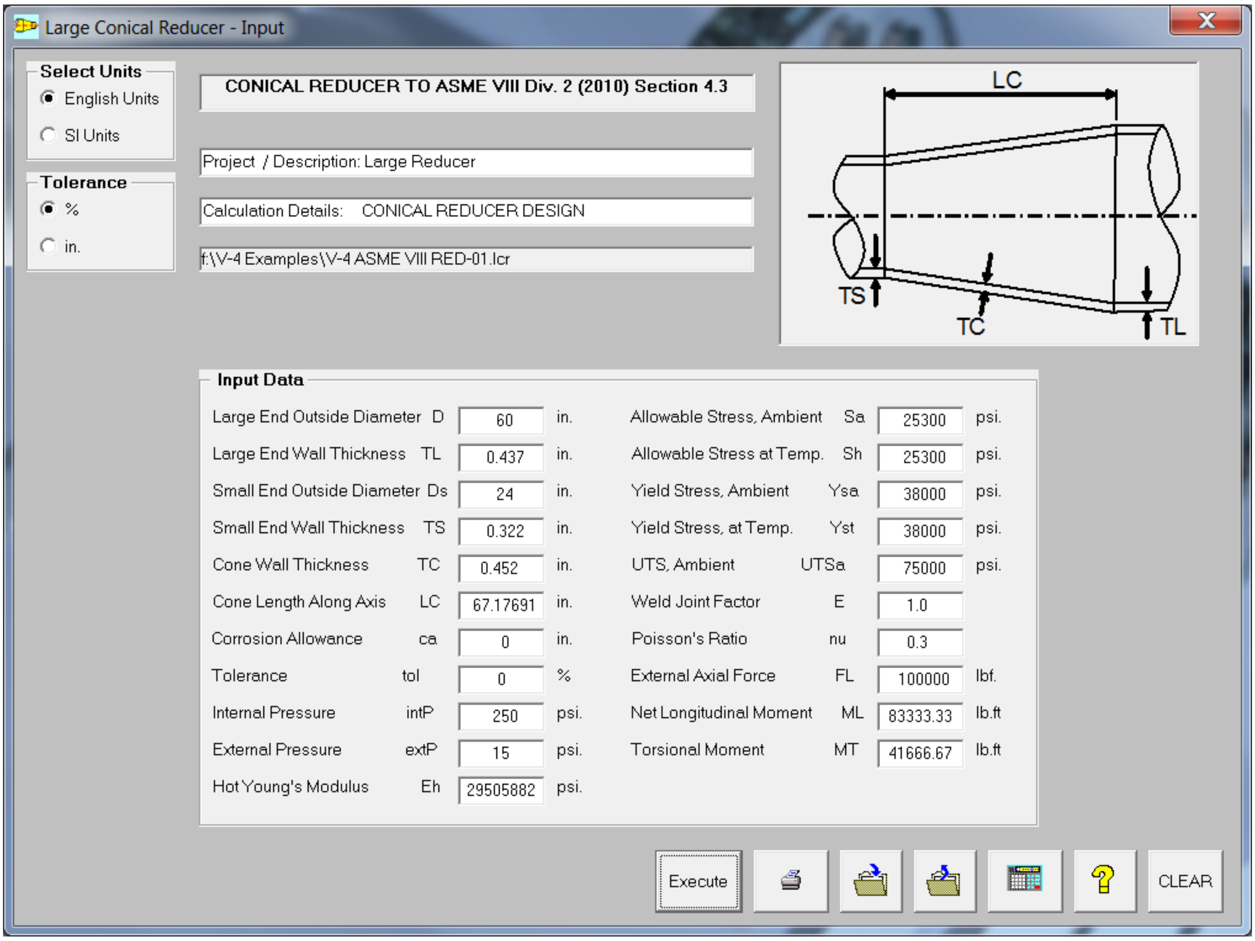
18.1 General Notes

The program carries out a rigorous analysis of any viable conical reducer in accordance with ASME VIII Div. 2 rules.

Checks are carried out to ensure that data is complete and representative of an acceptable geometry set.

Global and local stresses are calculated and presented in full and in concise form.

18.2 Large Bore Reducer - Typical Input Data



18.3 Large Bore Reducer - Typical Summary Output Data

Large Conical Reducer - Global Stress and Geometry Results

Geometry Checks:

	Required	Actual	
Min wall thk., large cylinder (in.)	0.294	0.437	OK
Min wall thk., small cylinder (in.)	0.116	0.322	OK
Min wall thk., cone (in.)	0.304	0.452	OK
Half Apex Angle (deg.)	max 60	15.000	OK
Min Cone Length (in.)	10.712	67.177	OK
RL / tl ratio 20 <= RL/tl <= 500	67.650	4.3.11.4c	OK
tc / tl ratio 1 <= tc / tl <= 2	1.034		OK
RS / ts ratio 20 <= RL/tl <= 500	36.267		OK

Moment and Shear Force Resultants:

4.3.3 L.End Moment Resultant, Pressure (lb.ft)	-1.173
4.3.3 L.End Shear Resultant, Pressure (lbf)	-4.442
4.3.4 L.End Moment Resultant, Line load (lb.ft)	-0.035
4.3.4 L.End Shear Resultant, Line load (lbf)	-0.132
4.3.5 S.End Moment Resultant, Pressure (lb.ft)	0.441
4.3.5 S.End Shear Resultant, Pressure (lbf)	-1.828
4.3.6 S.End Moment Resultant, Line load (lb.ft)	0.027
4.3.6 S.End Shear Resultant, Line load (lbf)	-0.125

Global Stresses:

Hot Allowable Stress Sh	25300.000	psi
Primary+Sec. Stress Limit sPs	76000.000	psi

Combined Stresses:

	Actual	Allowed	psi
sigma theta m (psi)	17633.784		
sigma sm (psi)	10812.765		
tor (psi)	428.464		
Combined stress sigma (psi)	15534.427	25300.000	OK

Stress Results Summary

GEOMETRY AND STRESS LIMITS COMPLIED WITH.

Compressive Stress Checks:

Meridional Stress	sigma sm (psi)	10812.765
Allowable Compressive Stress	Fxa (psi)	22386.416
		OK

Review local stresses at cylinder and cone intersections

Local Stress

Return to Input and Print

18.4 Large Bore Reducer – Local Stress Output Data

Large Conical Reducer - Local Stress Results

Internal Pressure + external loads, Local Stresses (psi):

	Cyl. Large End		Cone Large End		Cyl. Small End		Cone Small End		Allowable
sigma sm pos	10521.612	OK	10171.660	OK	16014.526	OK	11367.805	OK	25300.000
sigma sm neg	6390.859	OK	6178.102	OK	-6947.756	OK	-4960.277	OK	
sigma theta m pos	2208.025	OK	2106.787	OK	21789.472	OK	20308.718	OK	
sigma theta m neg	7918.085	OK	7836.016	OK	1758.451	OK	2494.288	OK	
sigma sb pos + sigma sm pos	-15840.407	OK	-14469.700	OK	45964.430	OK	26567.340	OK	76000.000
sigma sb pos - sigma sm pos	-36883.632	OK	-34813.020	OK	13935.377	OK	3831.730	OK	
sigma sb neg + sigma sm neg	-9477.468	OK	-8654.493	OK	-21032.261	OK	-12108.143	OK	
sigma sb neg - sigma sm neg	-22259.186	OK	-21010.697	OK	-7136.749	OK	-2187.590	OK	
sigma theta b pos + sigma theta m pos	-5700.580	OK	-5285.622	OK	30774.443	OK	24868.578	OK	
sigma theta b pos - sigma theta m pos	-10116.631	OK	-9499.195	OK	-12804.501	OK	-15748.858	OK	
sigma theta b neg + sigma theta m neg	3157.587	OK	3386.238	OK	-2466.901	OK	349.928	OK	
sigma theta b neg - sigma theta m neg	-12678.583	OK	-12285.795	OK	-5983.802	OK	-4638.648	OK	

External Pressure + external loads, Local Stresses (psi):

	Large End Cyl.		Cone Large End		Small End Cyl.		Cone Small End		Allowable
sigma sm pos	1558.002	OK	1506.286	OK	11209.138	OK	7971.815	OK	25300.000
sigma sm neg	-2572.751	OK	-2487.272	OK	-11753.144	OK	-8356.266	OK	
sigma theta m pos	-3158.813	OK	-3162.899	OK	9309.073	OK	8223.125	OK	
sigma theta m neg	2551.246	OK	2566.331	OK	-10721.948	OK	-9591.305	OK	
sigma sb pos + sigma sm pos	-2421.933	OK	-2213.878	OK	32750.380	OK	18903.966	OK	76000.000
sigma sb pos - sigma sm pos	-5537.938	OK	-5226.450	OK	10332.104	OK	2960.336	OK	
sigma sb neg + sigma sm neg	3941.006	OK	3601.329	OK	-34246.310	OK	-19771.517	OK	
sigma sb neg - sigma sm neg	9086.508	OK	8575.873	OK	-10740.022	OK	-3058.985	OK	
sigma theta b pos + sigma theta m pos	-4352.794	OK	-4278.948	OK	15771.446	OK	11502.770	OK	
sigma theta b pos - sigma theta m pos	1964.832	OK	2046.850	OK	-2846.700	OK	-4943.480	OK	
sigma theta b neg + sigma theta m neg	4505.373	OK	4392.911	OK	-17469.898	OK	-13015.880	OK	
sigma theta b neg - sigma theta m neg	-597.119	OK	-739.750	OK	3973.999	OK	6166.730	OK	

Return to Global and Combined Stresses

19.0 Wall Thickness Calculation and Optimisation to ASME B31 Codes

19.1 General Features

This routine calculates pipe wall thickness in accordance with ASME B31.1, B31.3, B31.4 and B31.8 codes and includes high pressure pipe wall thickness to ASME B31.3 Chapter IX.

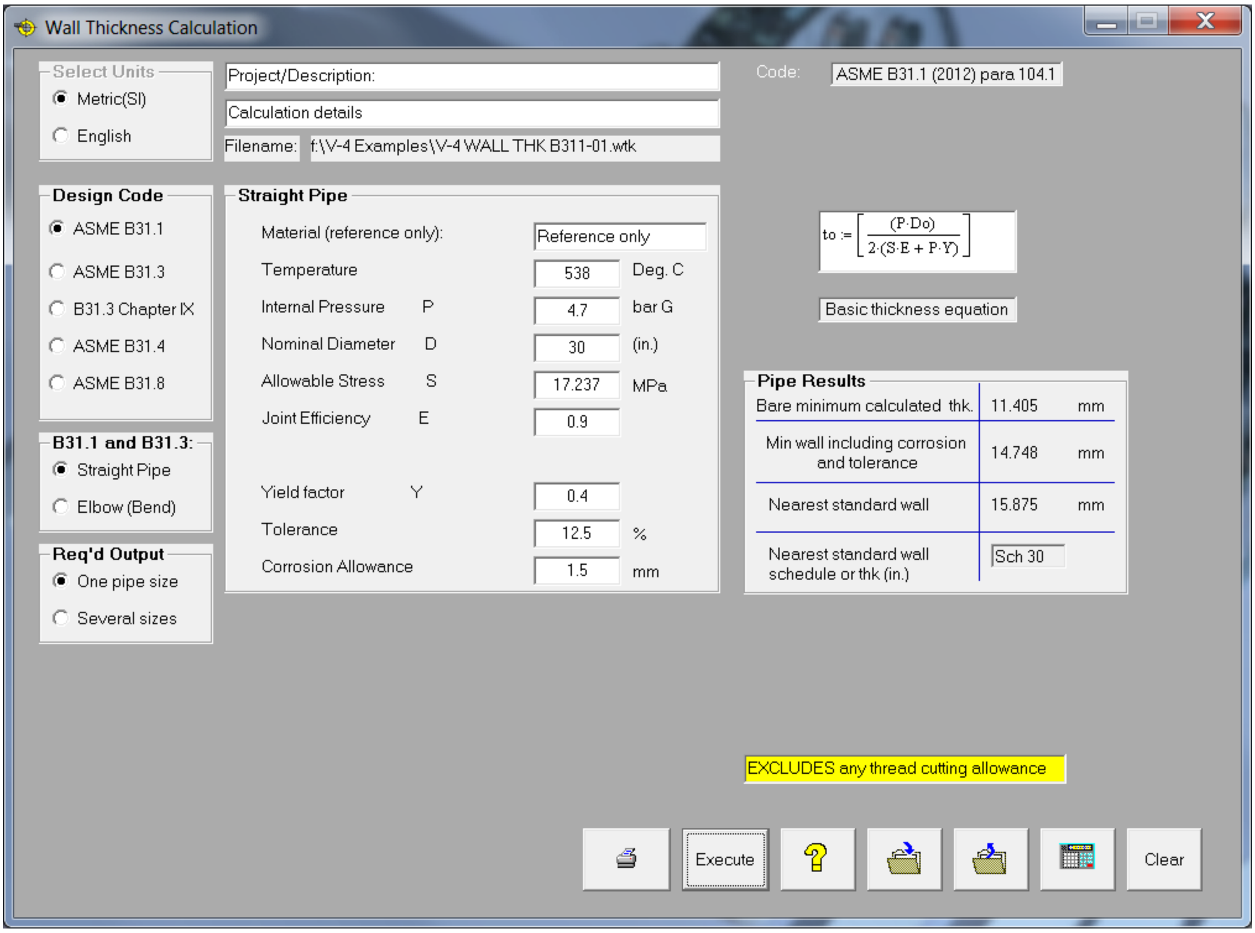
The ASME B31.3 calculation may be run for a single pipe size or, more commonly, a range of pipe sizes may be run in one calculation. In this case the user may define a range of up to 18 pipe sizes. This would for example allow the normal range from 0.5” to 24” to be calculated in one run.

The bare minimum and minimum wall including allowances is evaluated. From the PIPEMILL internal data base, the nearest standard pipe size will be selected, if one exists.

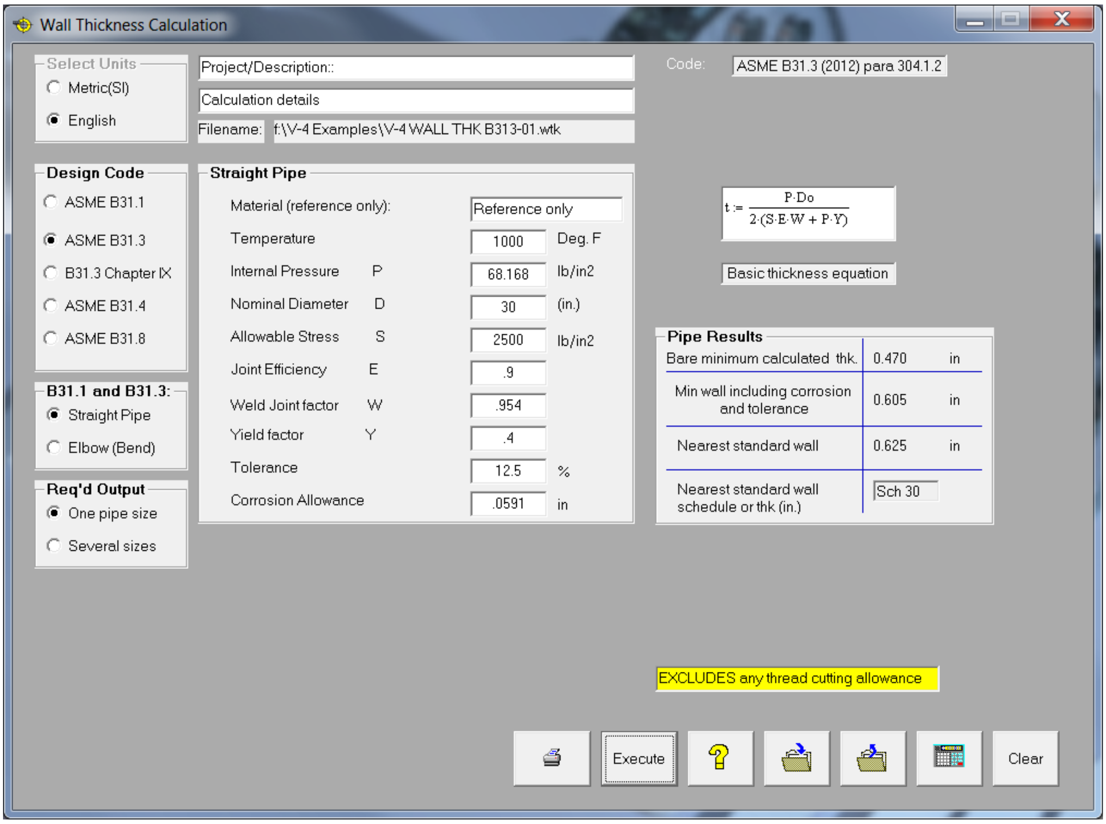
Output is hard copied in a concise manner to enable, for example, construction of a Pipe Material Specification Table.

The ASME B31.4 and B31.8 methods are similar in that a single pipe diameter is considered and a bare minimum and minimum wall including allowances is calculated.

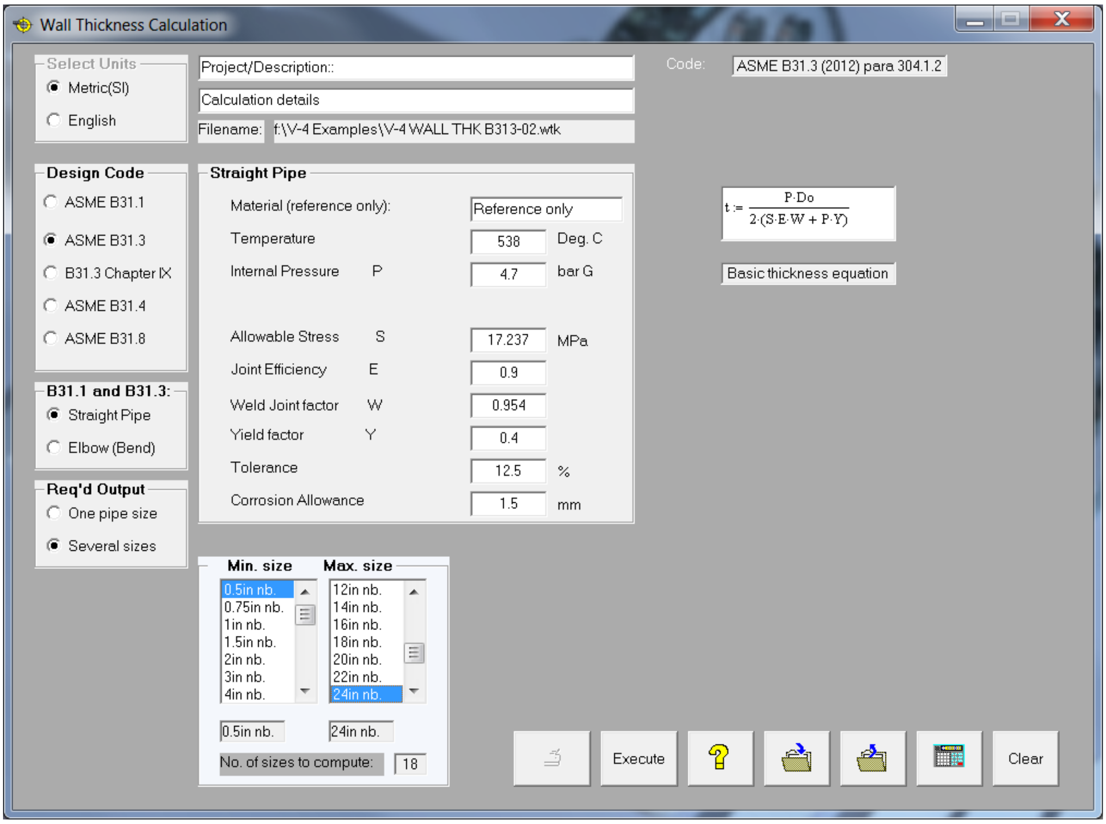
19.2 Typical ASME B31.1 Screen (Single Pipe Size)



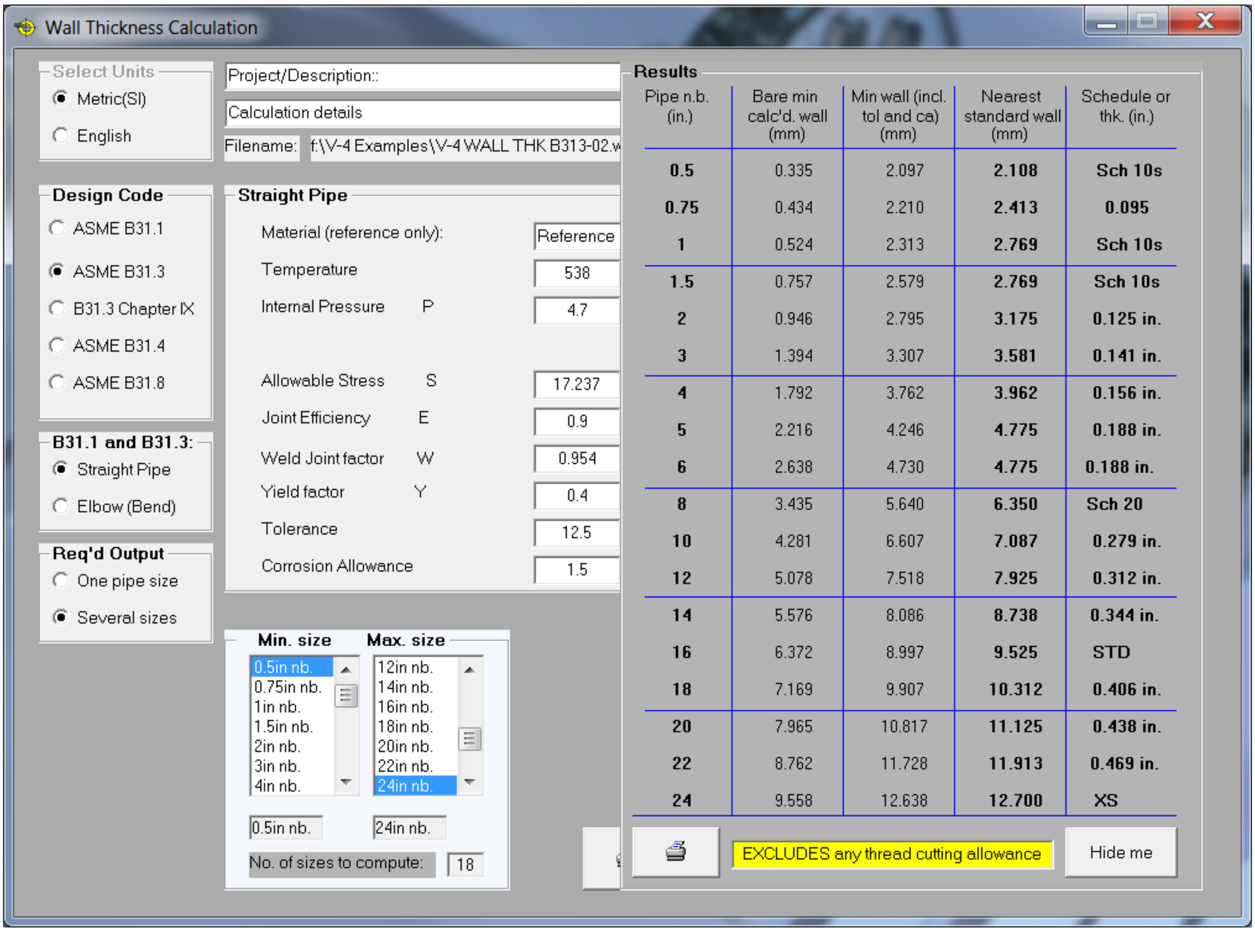
19.3 Typical ASME B31.3 Screen (Single Pipe Size)



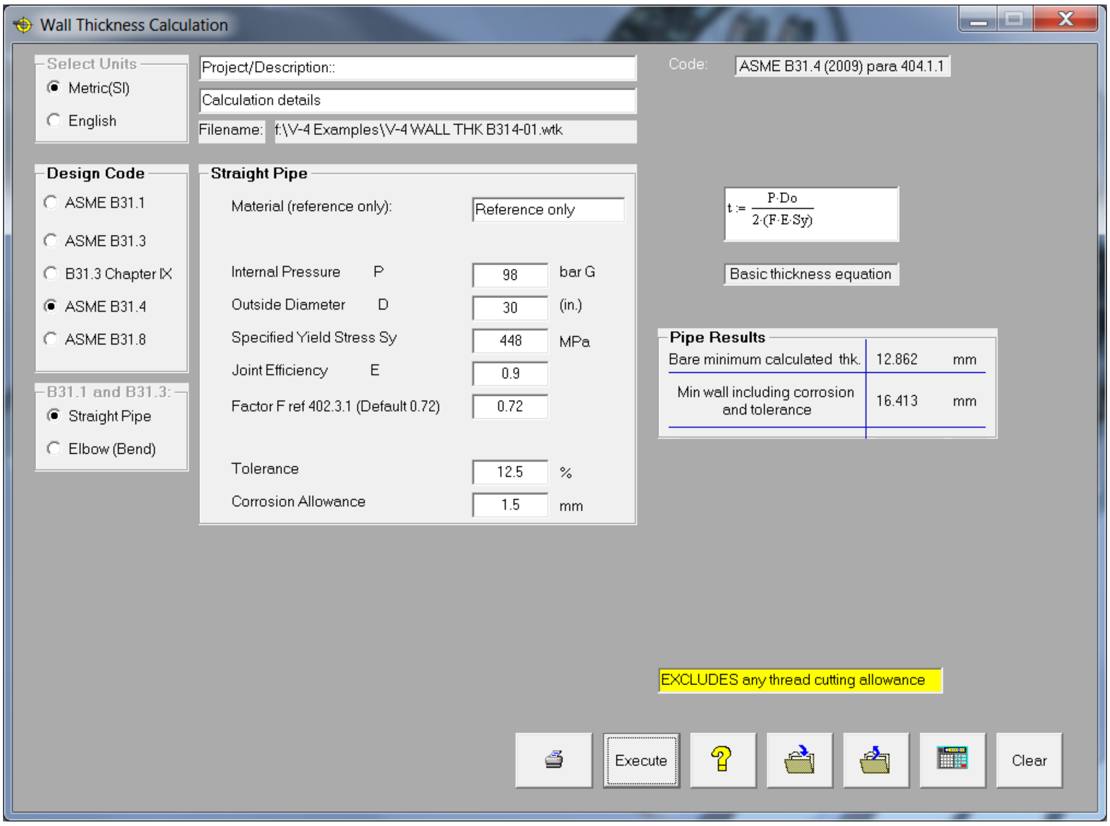
19.4 Typical ASME B31.3 Input Screen (Several Pipe Sizes)



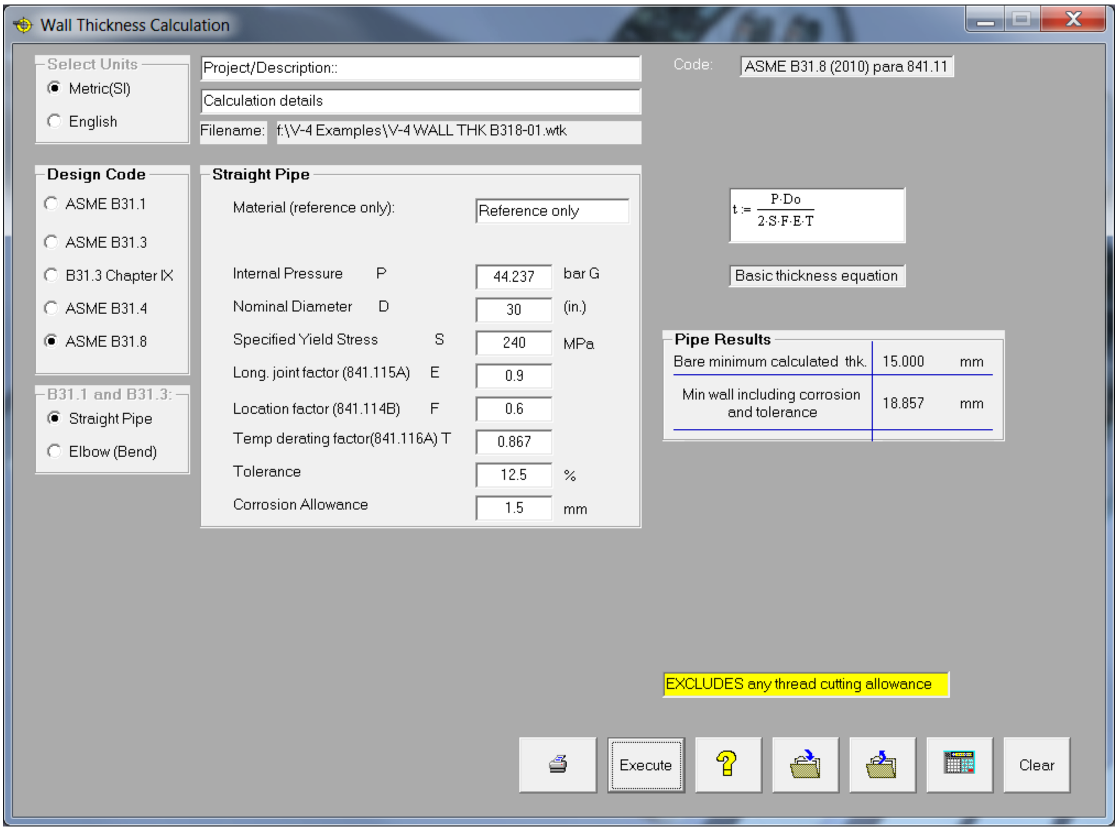
19.5 Typical ASME B31.3 Output Screen (Several Pipe Sizes)



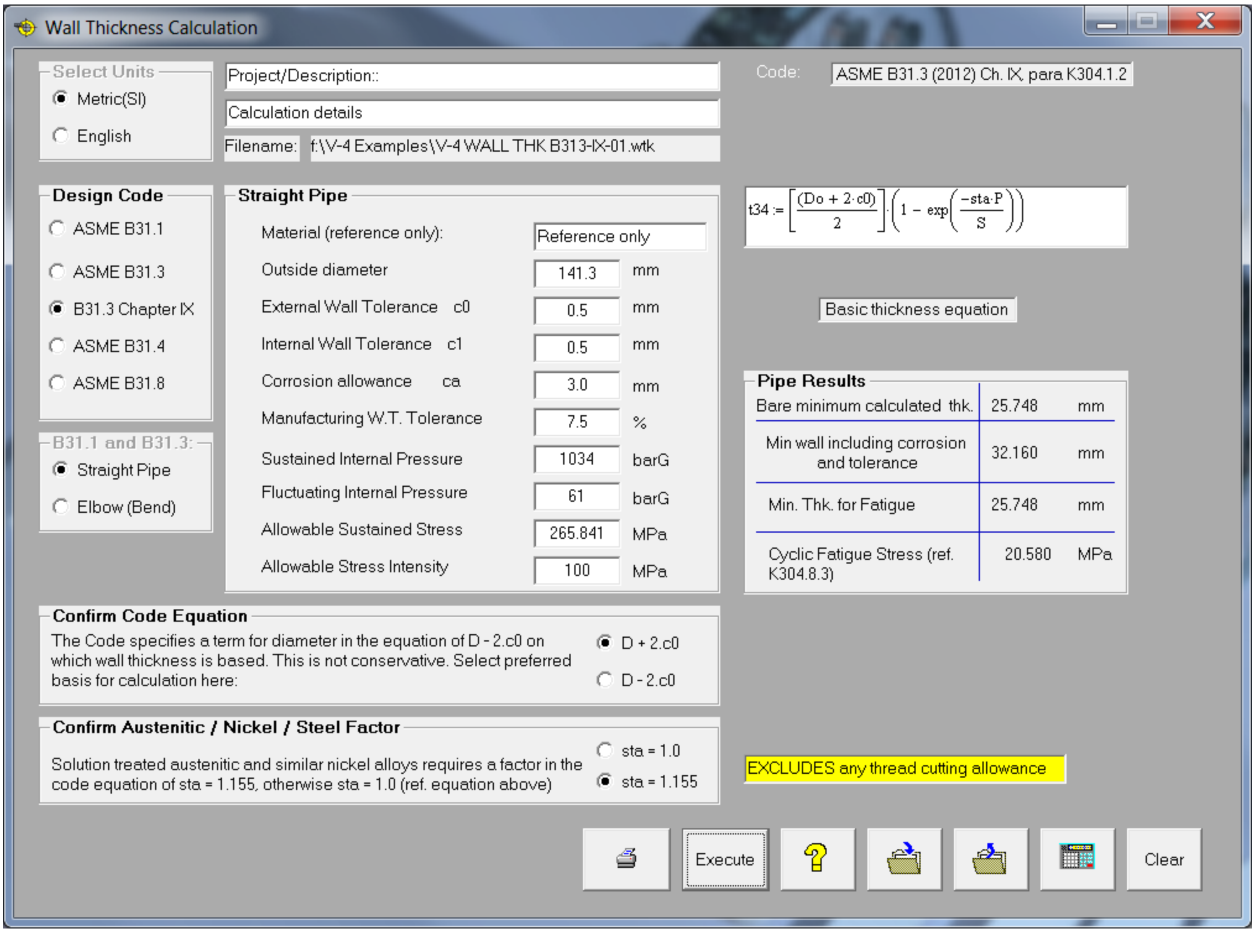
19.6 Typical ASME B31.4 Screen



19.7 Typical ASME B31.8 Screen



19.8 Typical ASME B31.3Chapter IX Input and Results Screen



20.0 Equivalent Stiffness of Internal Refractory Lining and Pipe

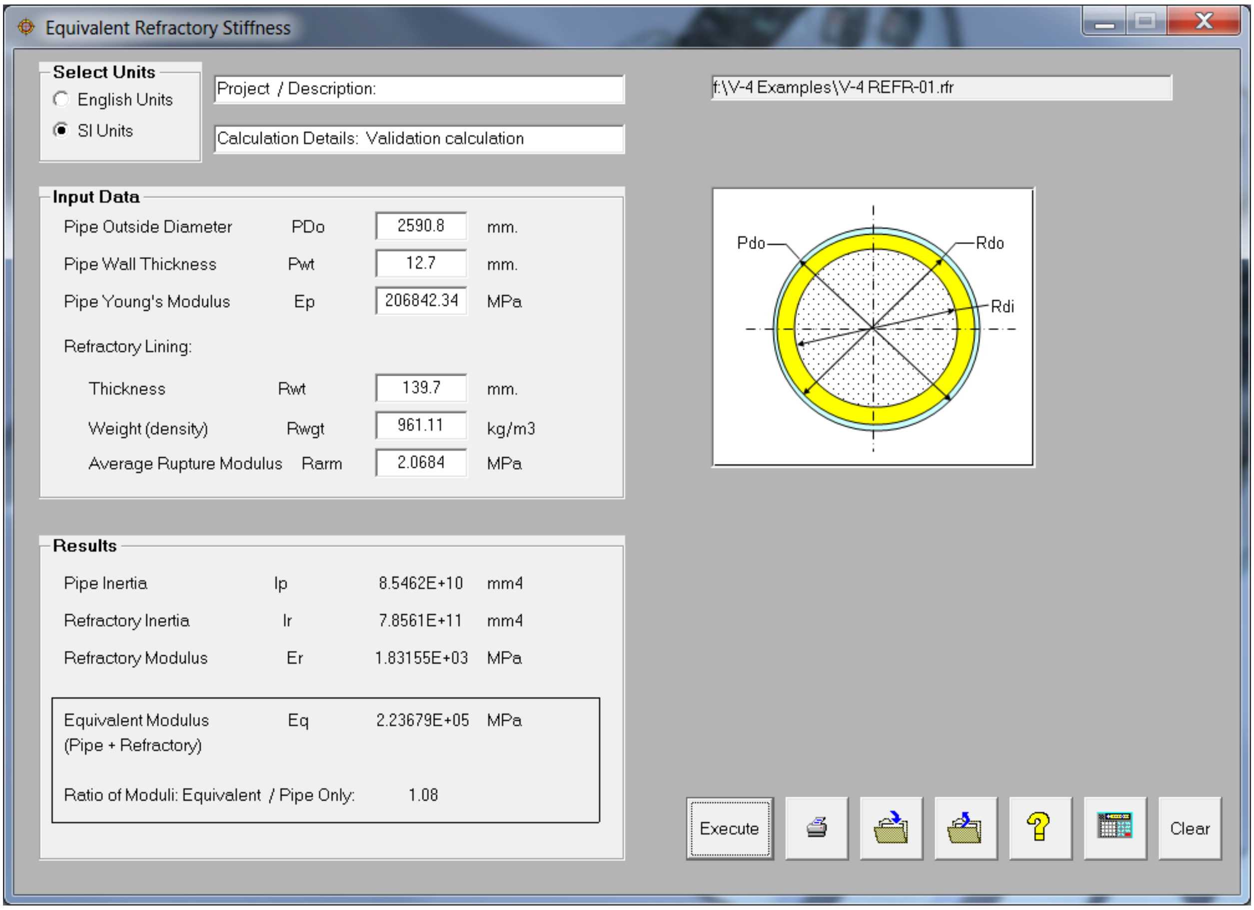
20.1 General Notes

This calculation is intended to provide only modification of elemental stiffness in piping due to refractory lining, and provides data for input to typical stress analysis software.

It is expected that the user's stress analysis software will accommodate added weight due to lining. This program provides a modified Young's modulus value representing both pipe wall and refractory lining. This may be entered directly to stress analysis software.

It may be necessary to carry out calculations for both ambient and operating conditions.

20.2 Typical Input and Output Data



21.0 VARIOUS QUICK CALCULATIONS

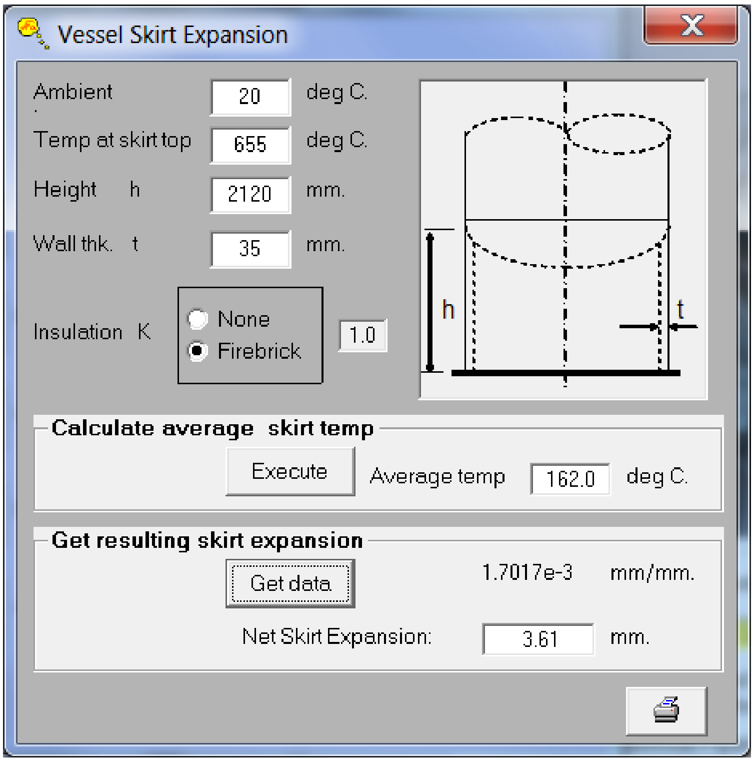
This part of the program is intended to deal with those simpler calculations, which might be unreliable if written down from memory.

It is intended that the input screen is largely self explanatory.

Calculations include:

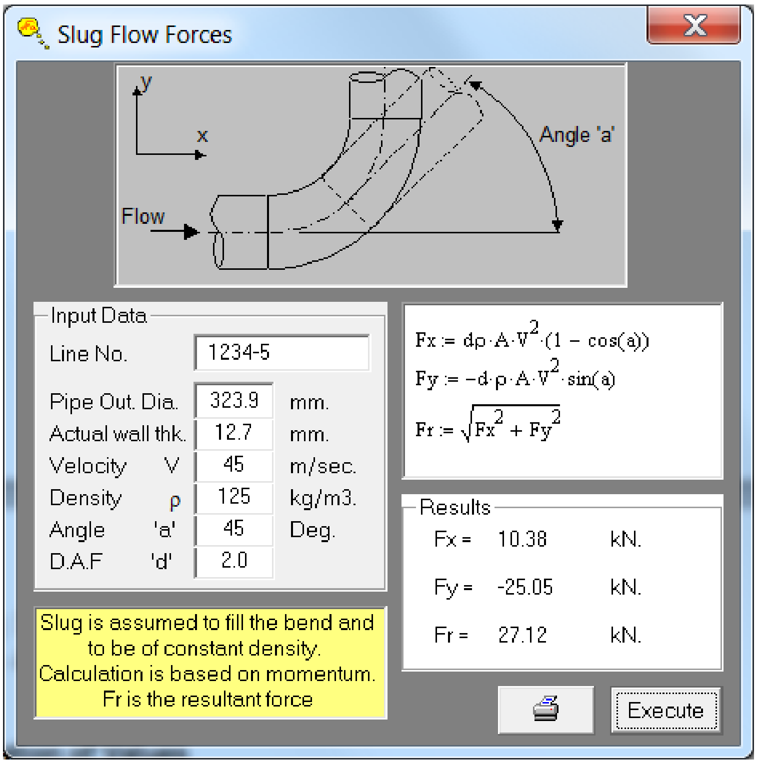
- Slug forces acting at a pipe elbow
- Linear interpolation of values
- Thermal expansion rates for common pipe materials
- Elongation of straight pipe due to internal pressure
- Methods of assessing external loads on flanged joints
- Vertical pressure vessel skirt expansion

21.1 Vertical Pressure Vessel Skirt Expansion



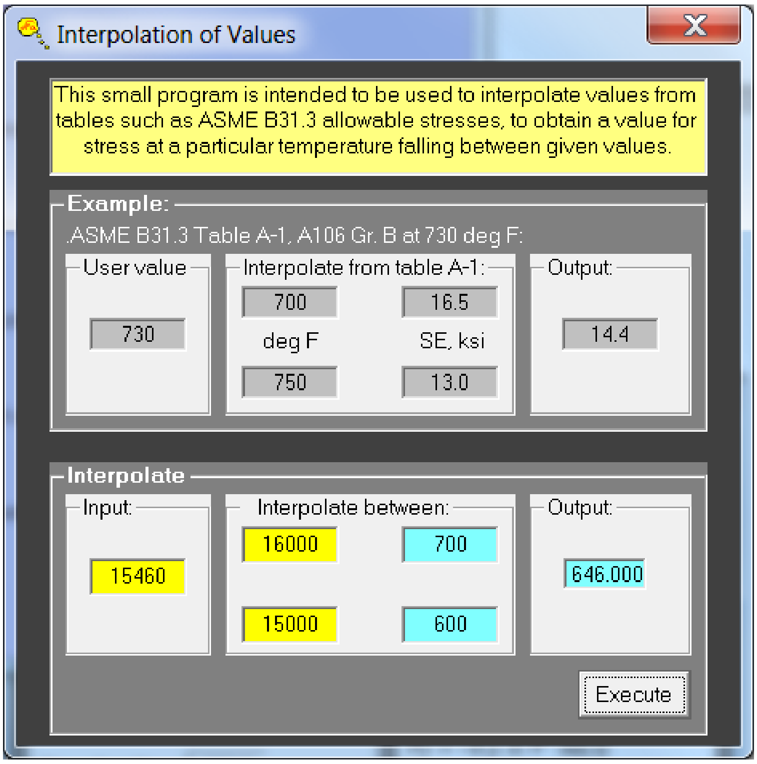
When the initial calculation of average temperature has been made, the user will be prompted to select a material. From this data the net skirt expansion will be provided.

21.2 Slug Forces Acting at a Pipe Elbow



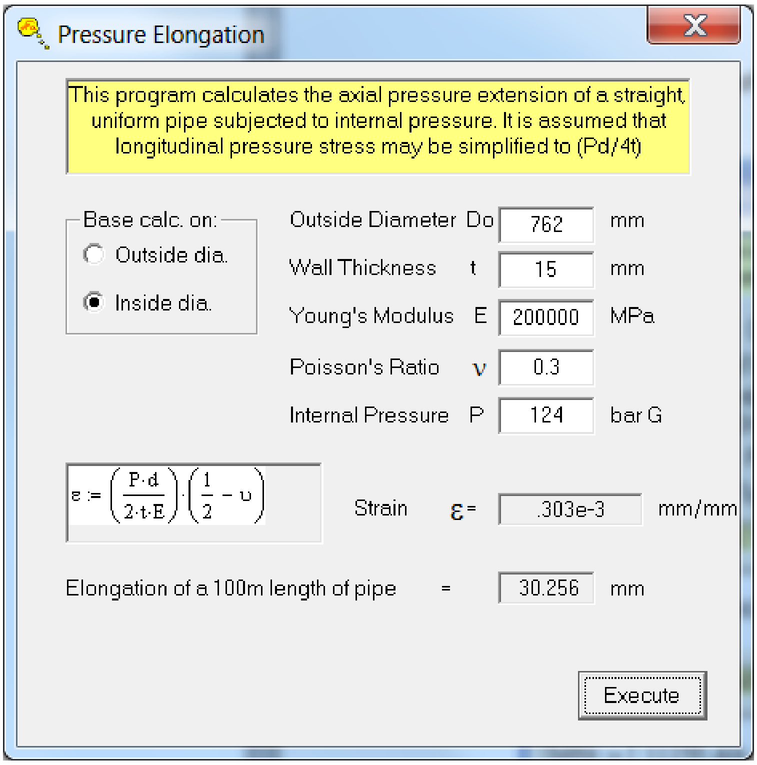
This would normally be used to calculate a transient impact force due to the temporary passing of a liquid slug in a gas line. The dynamic factor of 2.0 is conservative and cannot be exceeded.

21.3 Linear Interpolation of Values



The upper set of input cells is an example to guide the user.

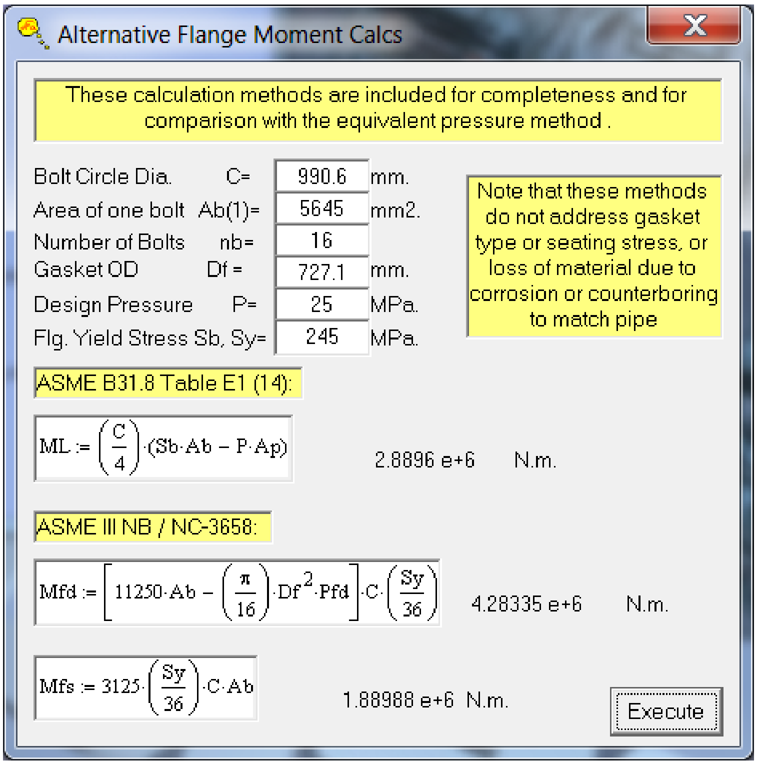
21.4 Elongation of Straight Pipe Due To Internal Pressure



The expansion of pipe due to pressure can be considerable and is not considered by some older stress analysis software.

This program allows a quick evaluation of the effect.

21.5 Methods of Assessing External Loads on Flanged Joints



This program is provided for comparison purposes. It can be used as a stand-alone program here, or it can be called up from the flange analysis package when data will be loaded from the flange package.

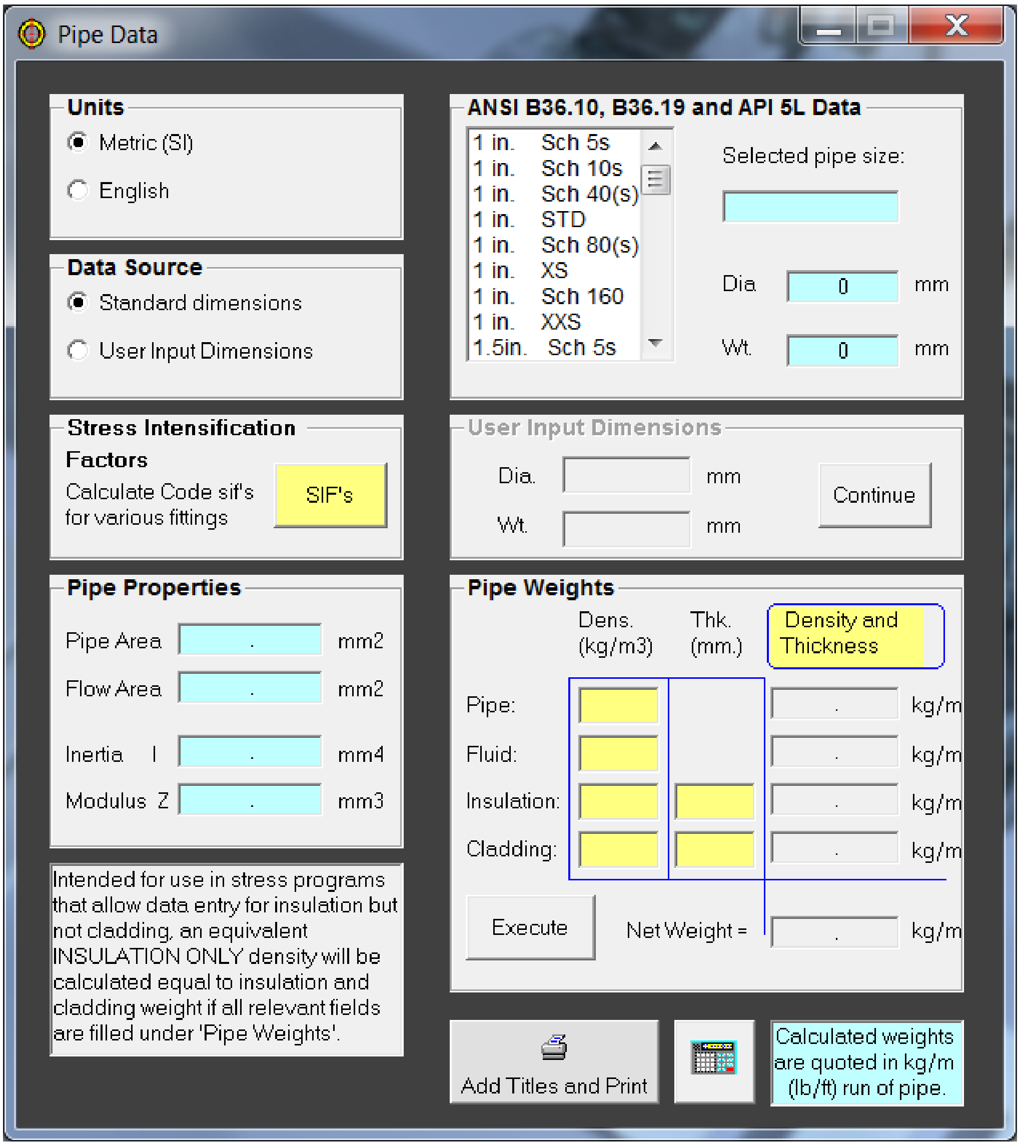
22.0 PIPE DATA

22.1 Program Description

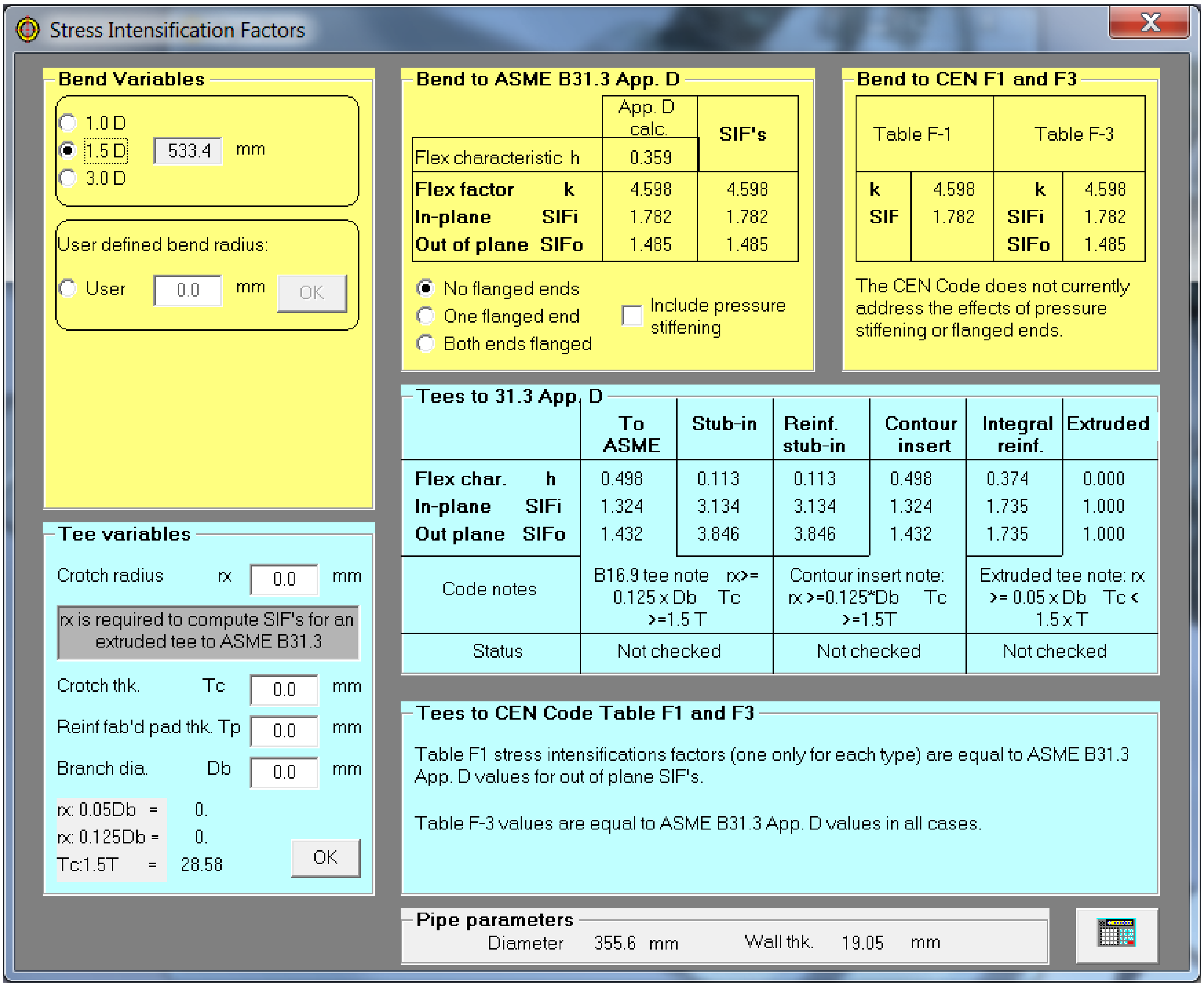
This program allows the user to click on a standard size pipe, or enter user defined data, and then calculates weight and technical data such a moment of inertia, pipe wall area and flow area for the given size.

Clicking on the SIF button provides stress intensification factors for the pipe defined, for elbows and various tees. A comparison is made between the ASME B31.3 values and CEN code values.

22.2 Typical Input and Data Screen



22.3 Stress Intensification Factor Comparison



23.0 STANDARD COMPONENT DIMENSIONS

If the user clicks onto an equal size fitting alone, individual and compound dimensions for that pipe size to ASME B16.9 will be provided as shown below

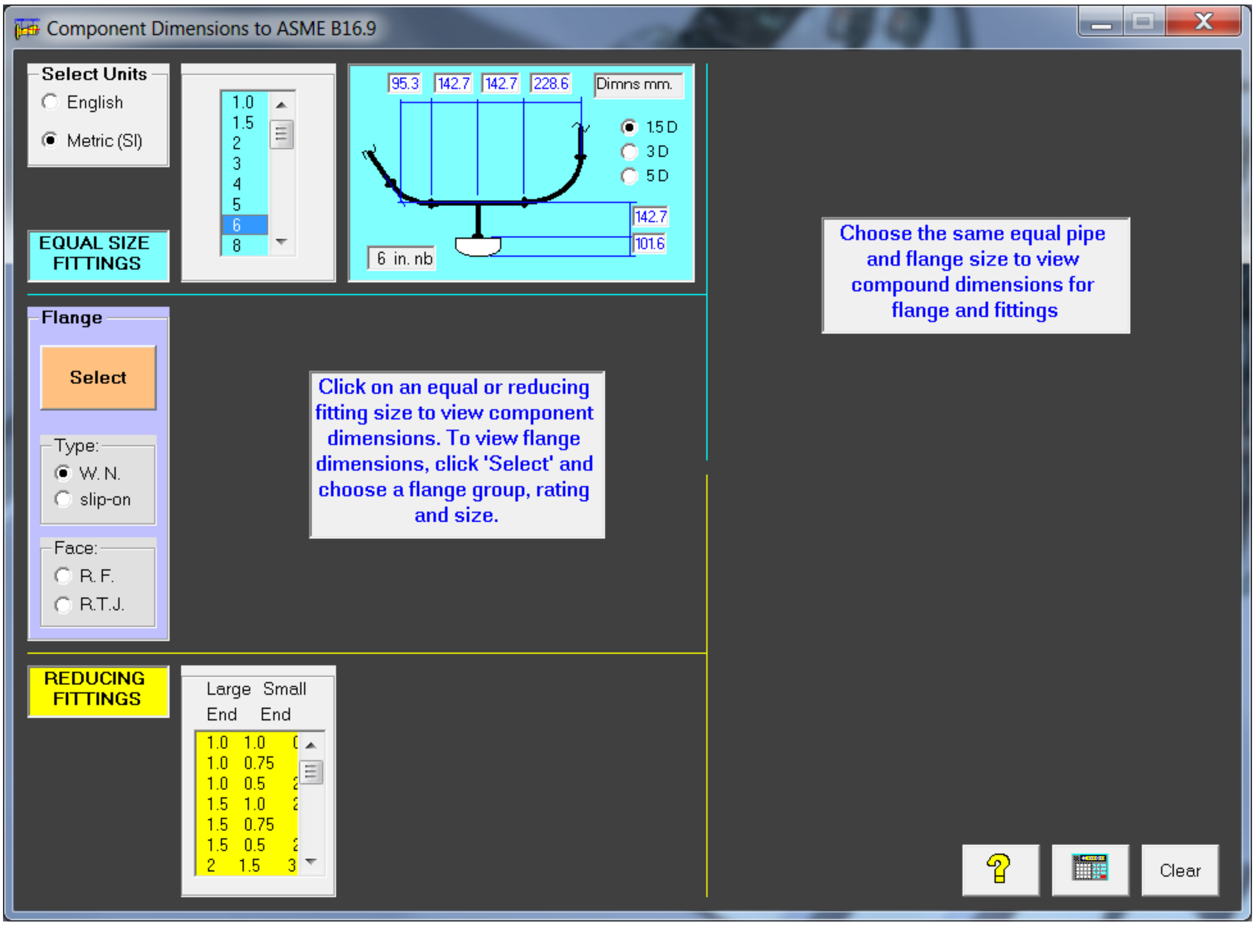
If a flange size alone is called up, dimensional data to ANSI B16.5, B16.47 or API 6A/B will be provided for that item alone.

Similarly, dimensions of reducing fittings may be obtained.

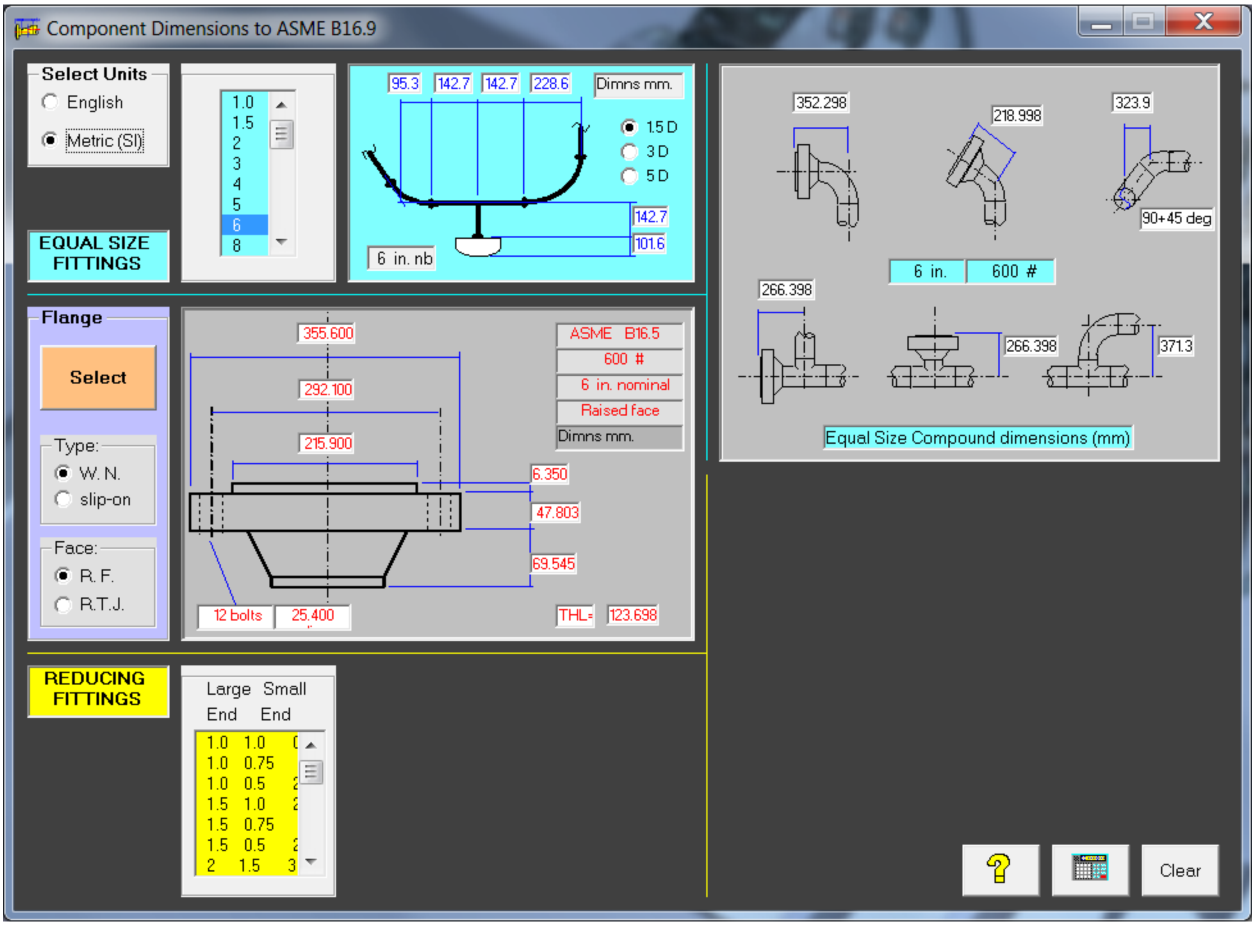
If a flange of the same nominal size as an equal fitting is called up, both the fitting and flange data will be provided on the same screen. In addition, fit-up dimensions for flanges and fittings will be available and shown below.

Also, if a reducing fitting small end matches the flange, compound dimensions will be available. This type of dimension string might well be expected at a control valve. Thus the ability to call up a trunnion support has been added to the dimension string

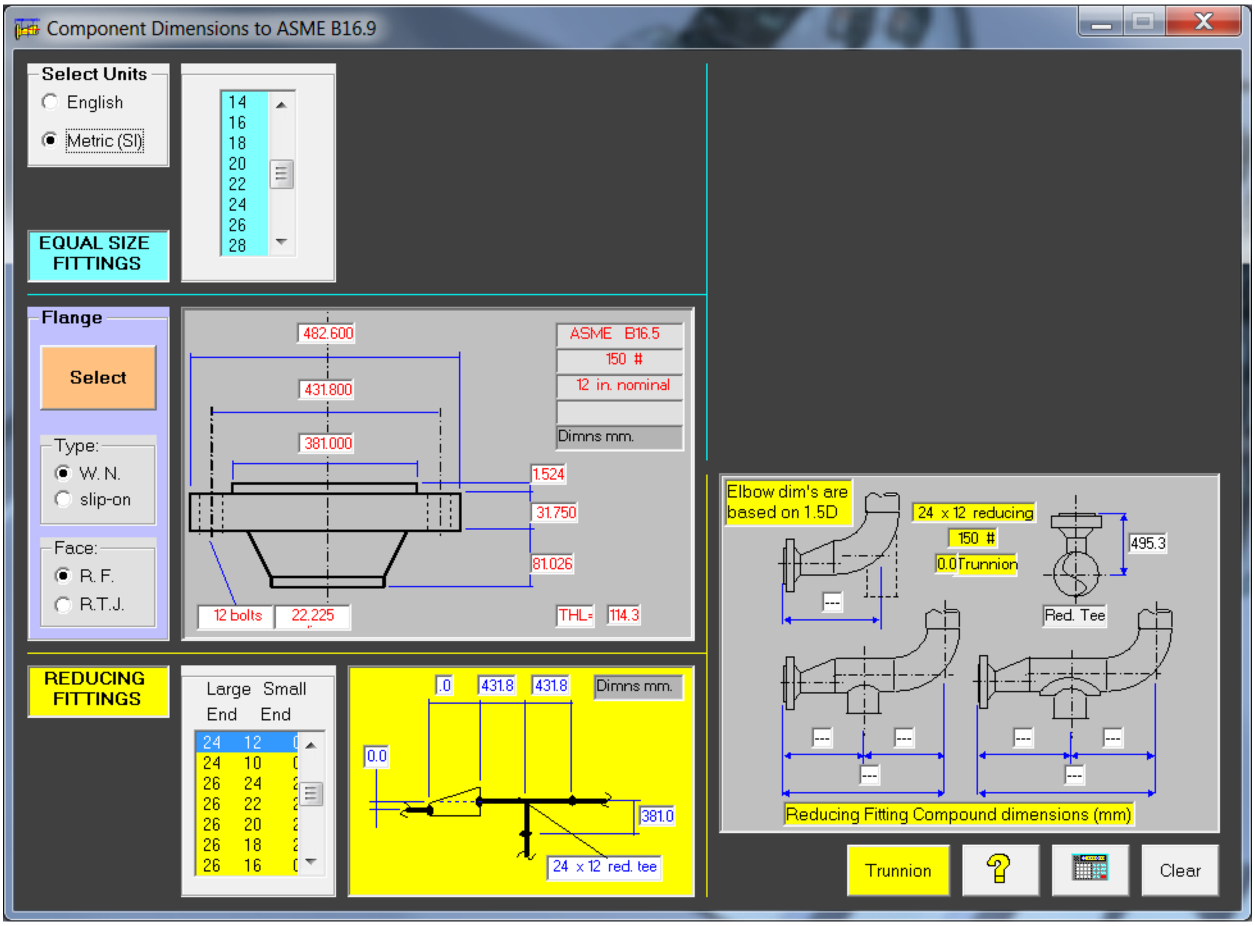
23.1 Equal Fittings Only



23.2 Equal Fitting and Flange Dimensions



23.3 Reducing Fitting and Flange Dimensions

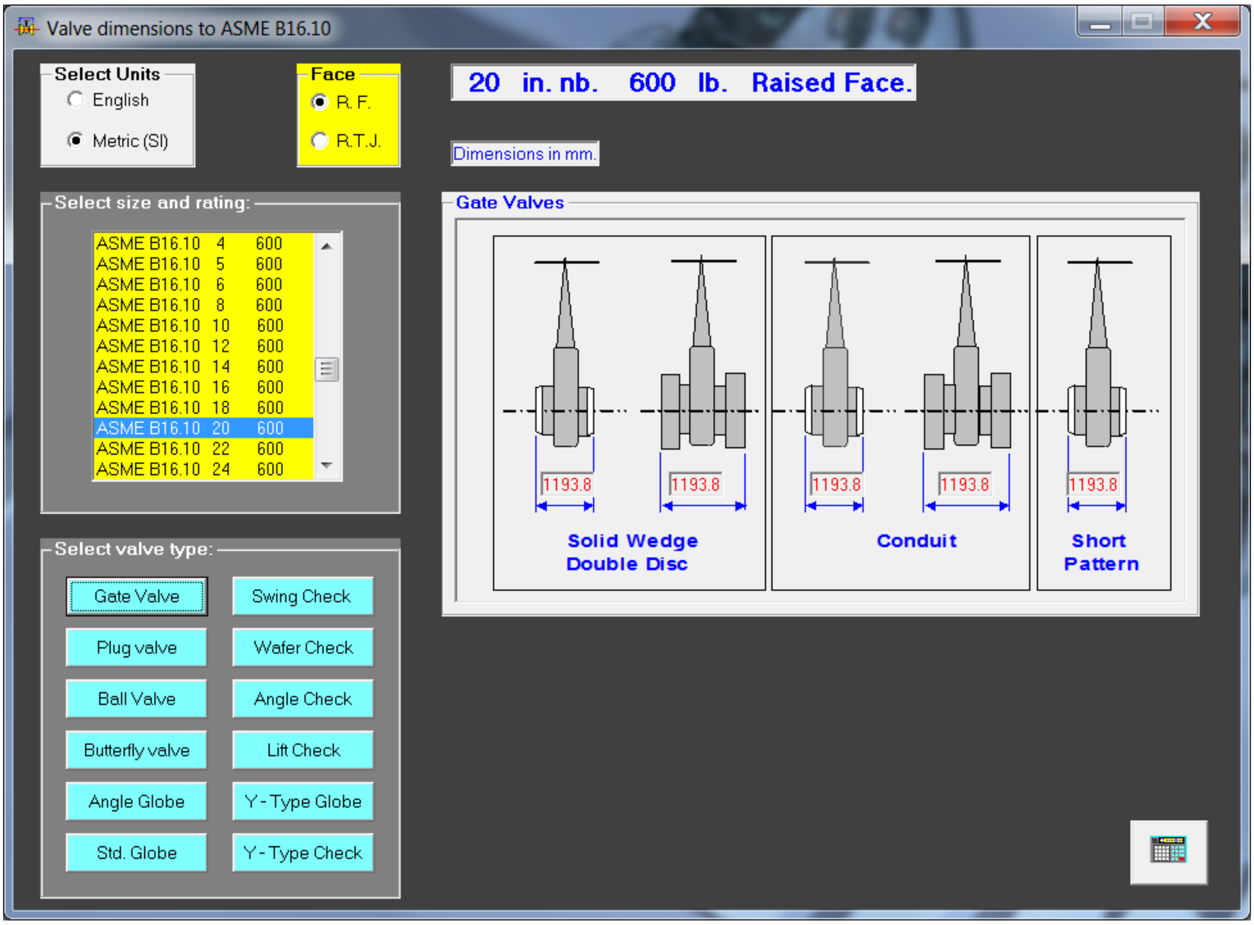


24.0 VALVE DIMENSIONS TO ASME B16.10

A complete data base of all ASME B16.10 valve dimensions is included. The user needs only to click on a pipe size and valve type, to obtain in-line dimensional data for raised face and ring type joint constructions.

If a particular type or size is not available this will be flagged.

24.1 Typical Input and Data Screen



25.0 THERMAL EXPANSION OF PIPING MATERIALS

The data base contains thermal expansion data fro common piping materials, extracted from ASME B31.3.

The base temperature and design temperature need to be entered and the relevant material must be clicked onto.

Expansion results are then produced in three forms.

This program is accessed by several other Pipemill routines.

25.1 Typical Input and Data Screen