

## Product Overview

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# PSA5

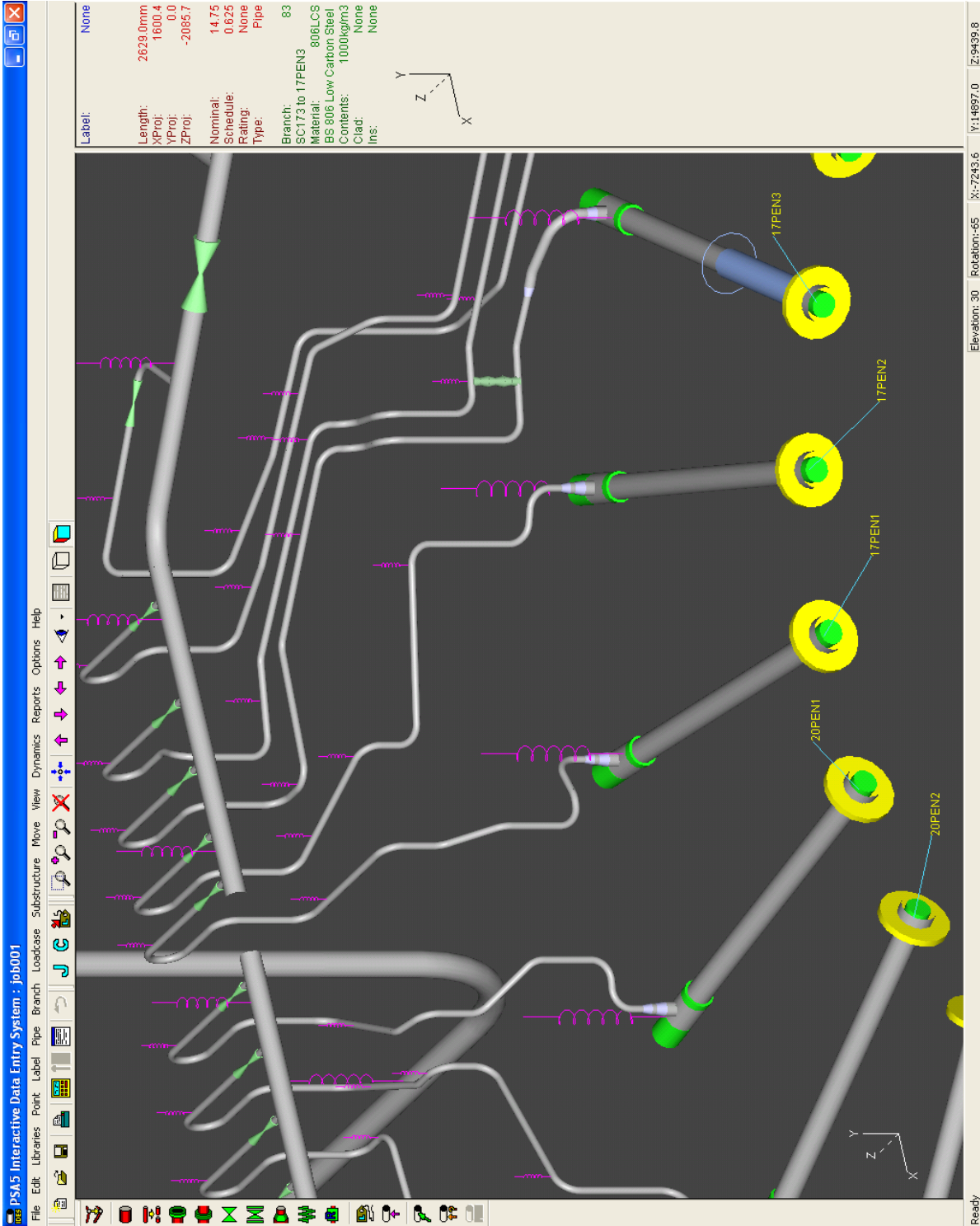
*Pipe Stress Analysis  
&  
Design Code Compliance Checking*

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## CONTENTS

	Page
<i>Whessoe Computing Systems</i>	3
<i>PSA5 Pedigree</i>	5
<i>System Overview</i>	7
<i>Interactive Data Entry</i>	9
<i>Static Analysis</i>	11
<i>Dynamic Analysis</i>	13
<i>Design Code Compliance Checking</i>	15
<i>Pipe, Fitting &amp; Material Libraries</i>	15
<i>Interactive Results Interrogation</i>	17
<i>Quality Assurance</i>	23
<i>Notes</i>	24



**“the most complex systems can be modelled”**

## WHESOE COMPUTING SYSTEMS

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

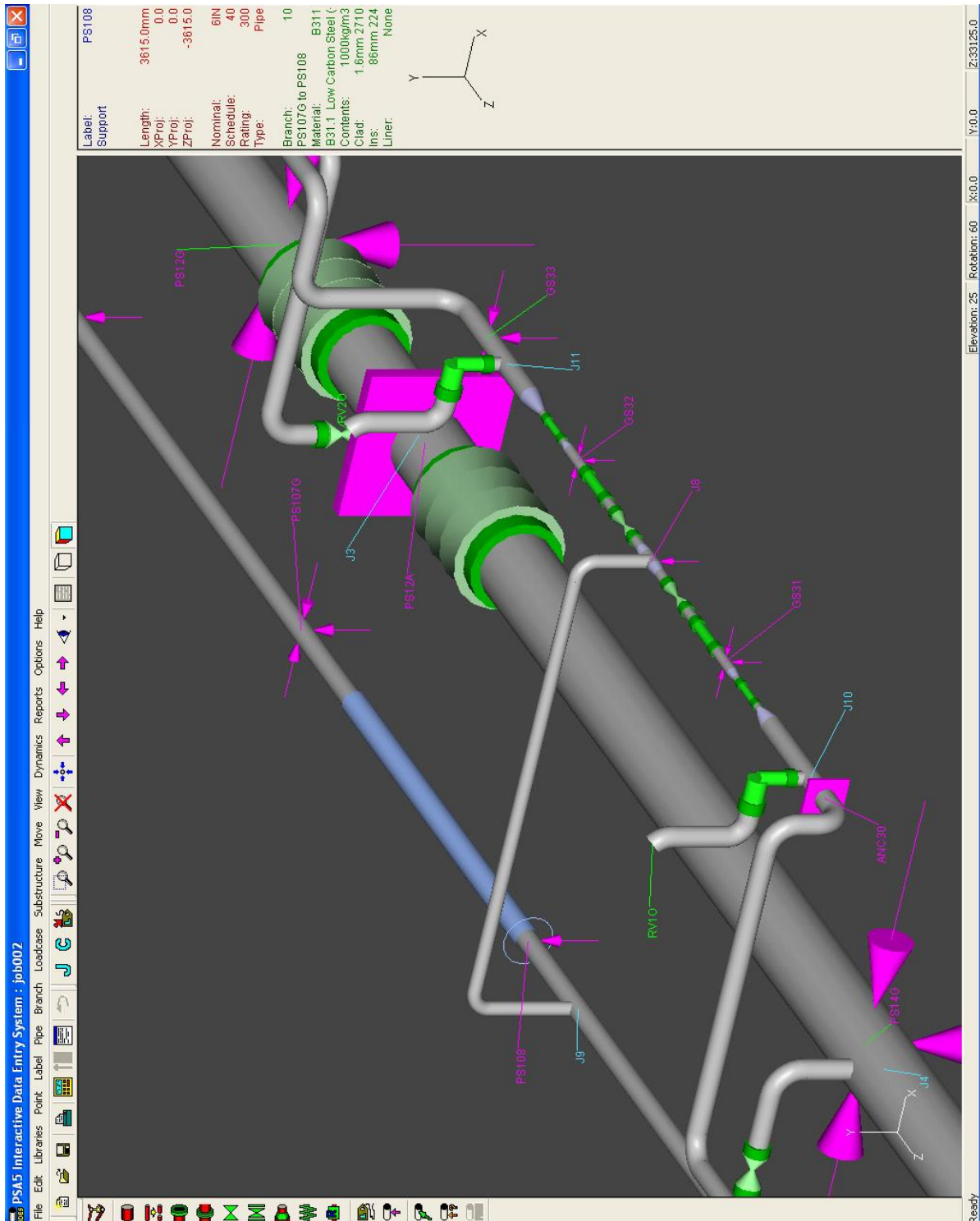
Whessoe Computing Systems was established in the 1960's, to provide high quality software solutions and services to satisfy demanding and exacting standards. In achieving these objectives Whessoe Computing Systems has acquired a uniqueness within the industry in terms of standards of professionalism,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

Today's products and services, in addition to Pipe Stress Analysis, include:

### **PVE5 - Pressure Vessel & Heat Exchanger Design Software Piping & Plant Design Consultancy**

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

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



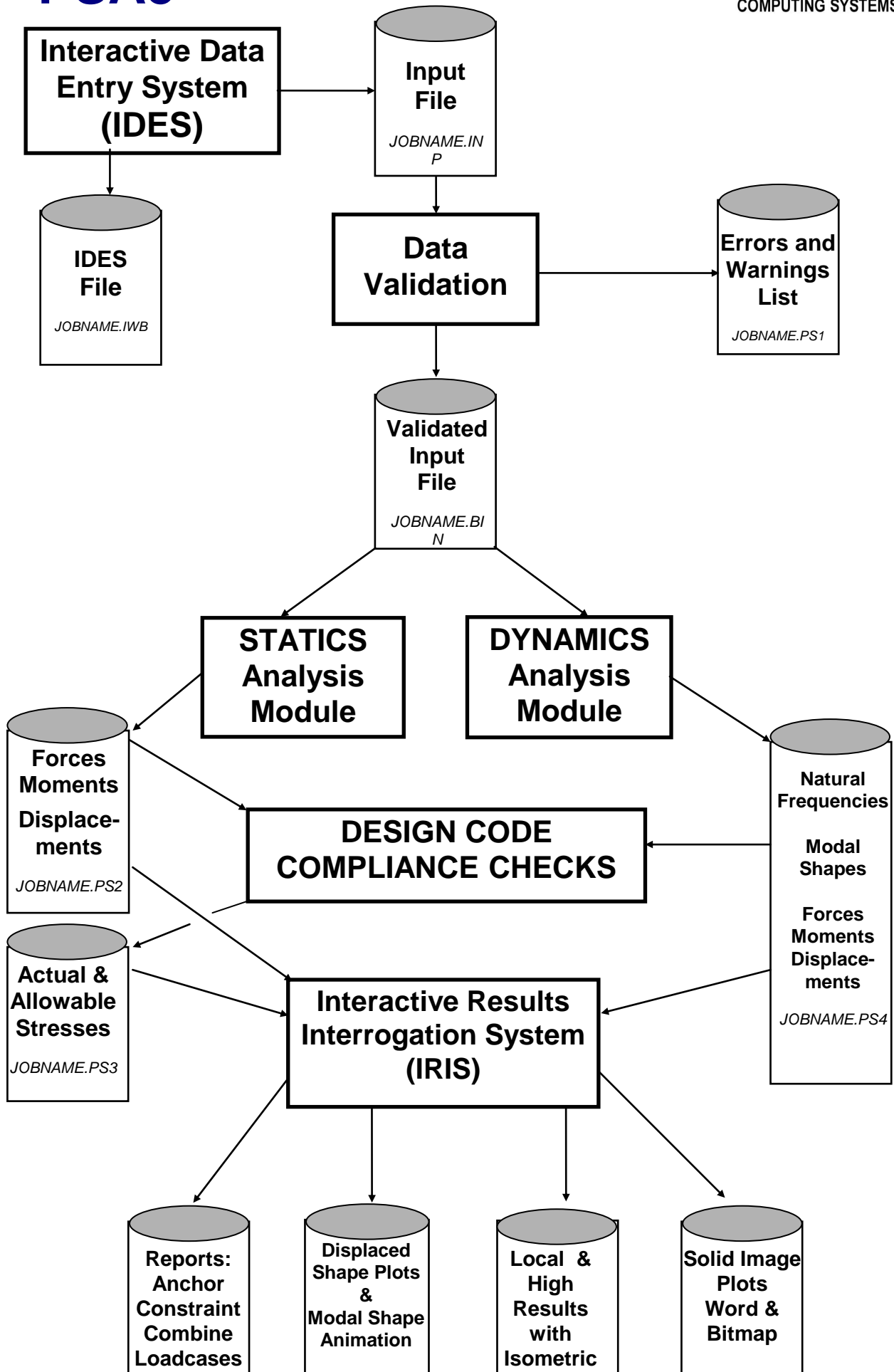
“the model is used as an index for displaying pipe attributes”

## PSA5 PEDIGREE

PSA5, one of a number of software packages developed and supported by Whessoe Computing Systems, allows piping engineers to accurately and efficiently calculate stress levels within their designs and compare these with allowable values for a range of national/industry standards.

Pipe stress analysis is a safety critical activity in the design cycle and as such the client must have absolute confidence in the quality of any tool used. PSA5 has a proven track record going back over 40 years, during which it has been used to continuously service the stressing requirements of blue chip companies. During this period revenues have been continually reinvested in development and support to meet the ever changing/expanding requirements of the user and to take full advantage of hardware advances. The result is a quality product with a proven track record in which clients have such a degree of confidence that many insist on its use when inviting tenders for plant design. Where safety is concerned there should be no compromise on quality and PSA5 has a quality reputation second to none, gained from a long history of serving the top companies in the power and petrochemical industries.

Whessoe Computing Systems operate a QA programme designed to meet the requirements of ISO9001, BS5882:1980 and the ASME Boiler and Pressure Vessel Code Section III. This quality system has been subject to third party audit by an accredited certification body and Whessoe Computing Systems have been registered as a certificated organisation.

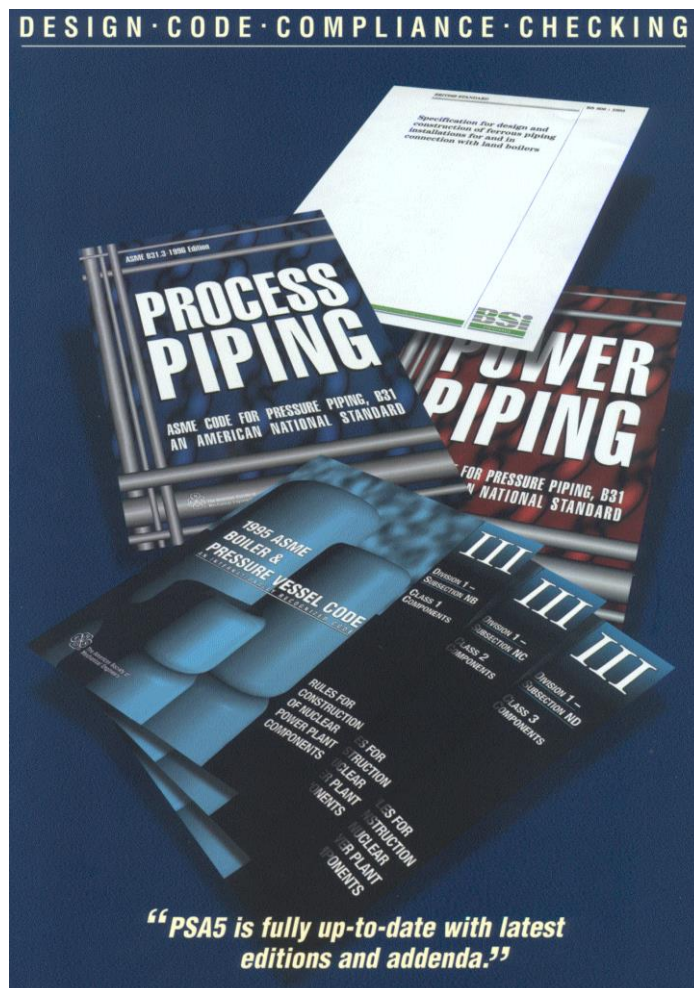


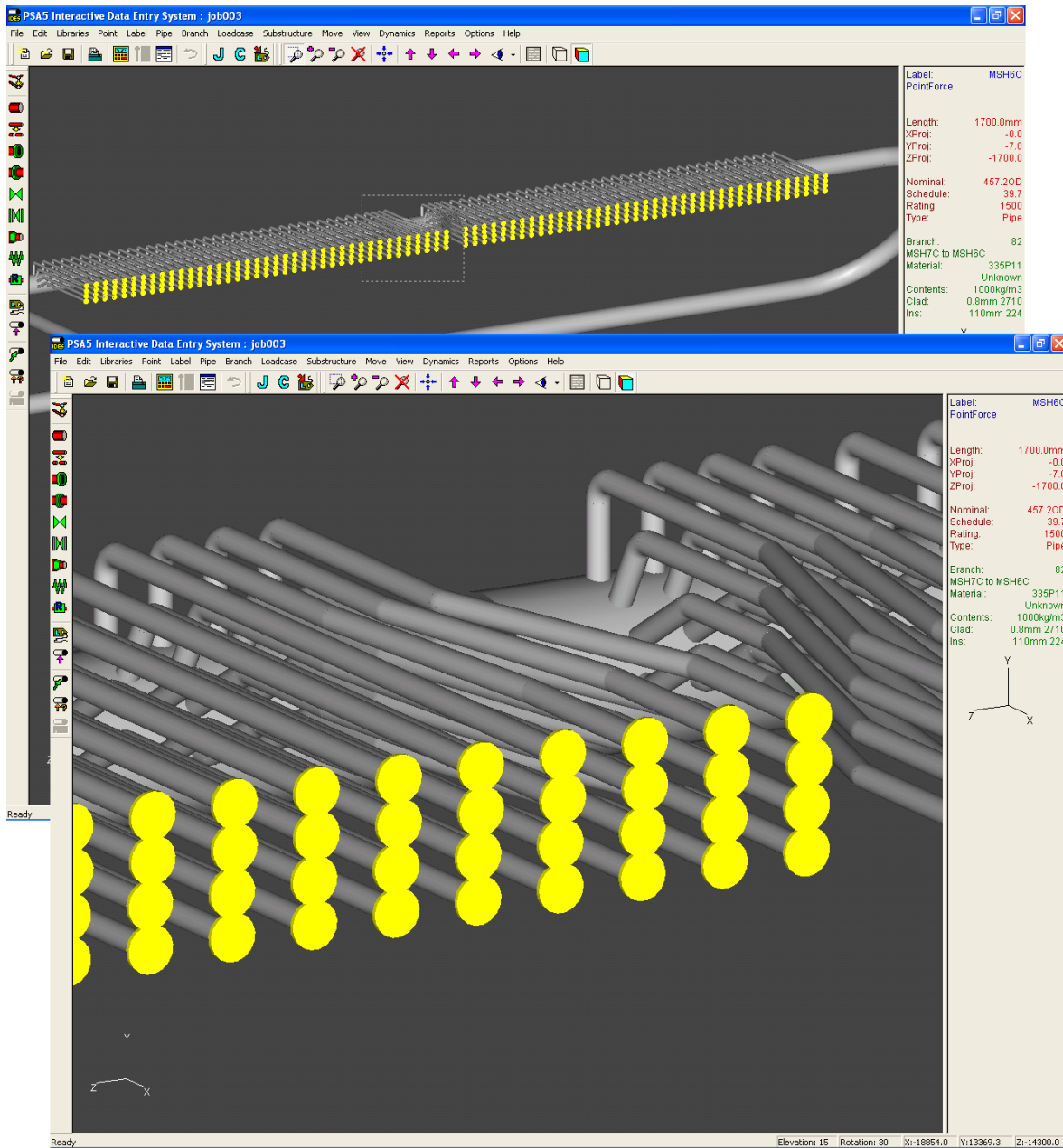


## SYSTEM OVERVIEW

PSA5 is a suite of computer programs providing comprehensive facilities for the static and dynamic analysis and subsequent code compliance checking of piping systems. The key elements of the system, illustrated in the Figure opposite, are an interactive data entry system (IDES), dynamic and static analysis modules, a range of design code compliance checking modules and an interactive results interrogation system (IRIS).

The static analysis module calculates the deflections of the pipework and the loads on the anchors and supports due to combinations of static thermal, self-weight and applied loading. The dynamic analysis module produces the natural frequencies and normal modes of vibration of the pipework and can also carry out a seismic response spectrum or time history analysis. The design code post-processors can process the results of a static analysis (combined if necessary with the results of a dynamic analysis) to produce stresses and compare these with maximum allowable values according to a range of international design codes.





**“the user has full control over the display, including zoom”**

## INTERACTIVE DATA ENTRY

An interactive graphics program allows you to define and edit your pipe system on screen. It is menu/icon driven with help and error checking facilities and uses user friendly input screens to input non-graphical data. Extensive use is made of system libraries which cover materials (Young's Modulus, thermal expansion and density), pipe geometry (diameters, thicknesses and bend radii for a range of schedules and sizes), pipe supports (maximum travel, maximum & minimum loads for a range of different manufacturers sizes) and fittings (lengths, weights and rotary inertias for a range of flanges and valves). As routes are defined, pipe and branch attributes are assigned from a 'piping specification' set up by the user. The attributes cover:

### Pipe data

nominal pipe size  
pipe schedule  
pressure rating  
manufacturer's tolerance  
corrosion allowance

### Branch data

material  
contents density  
cladding thickness  
cladding density and thickness  
insulation density and thickness

Pipe guides, supports, hangers, point loads etc. can be added at any point during or after routing and properties (e.g. spring flexibility) defined where appropriate. In-line fittings (e.g. valves, flanges, bellows units, reducers etc.) can be placed on the routes - the fitting properties (e.g. in-line length) being automatically picked up from libraries supplied with the program. Facilities to add your own fittings to the libraries are provided.

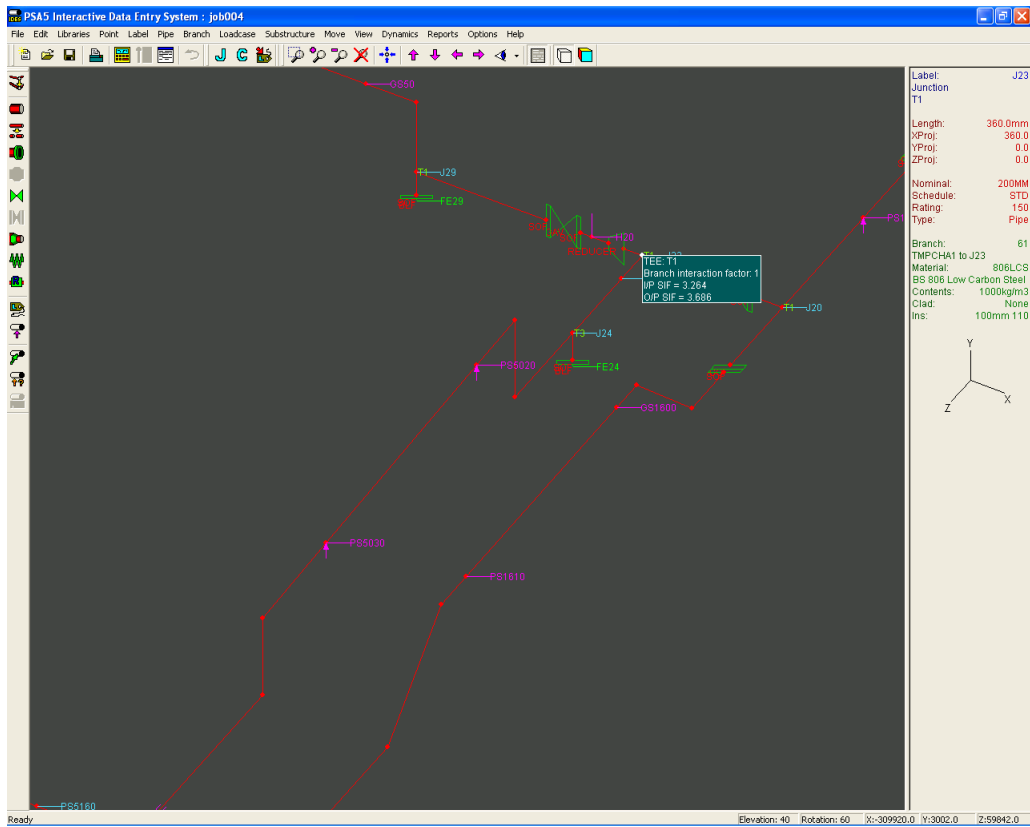
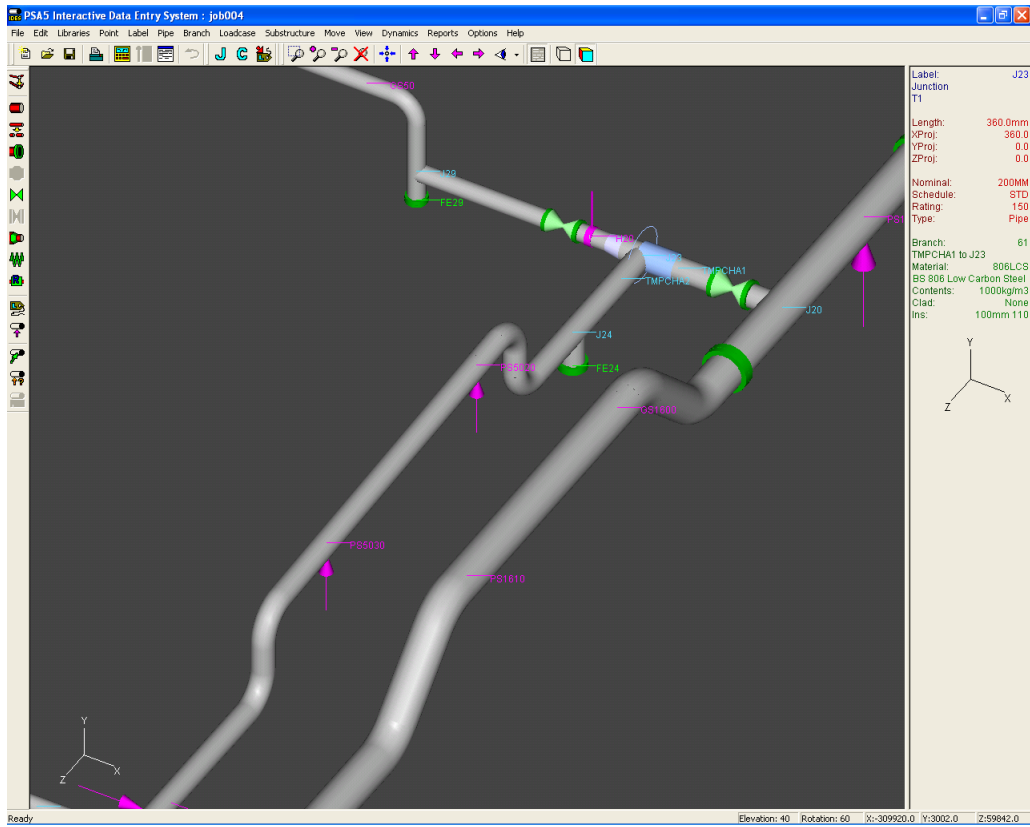
Load case data, like the pipe and branch data, is specified prior to routing and is allocated to branches automatically during routing and covers:

### Load case data

temperature  
internal pressure  
maximum allowable stress  
dead weight factors  
contents weight factors

Once the analysis model has been set up, very flexible editing facilities are provided for incorporating design changes or correcting errors. One of the most powerful of these is the ability to define segments of the model as 'substructures' and then edit attributes for the whole substructure. For example, one command would change the material of every pipe in the substructure. Substructures can also be copied, mirrored and repositioned - useful, for instance, when modelling identical headers off a main.

The model creation process is supported by a sophisticated graphical interface that shows the pipe routes entered as a centre line or 3D display with all fittings, supports and constraints represented by standard symbols. The user can walk/jump around the pipework highlighting individual projections and points of the model. As he does, all attributes pertinent to the current projection/branch are displayed. Facilities for colour coding the lines according to attribute values are provided, e.g. each leg with a different temperature for a given load case can be coloured differently.

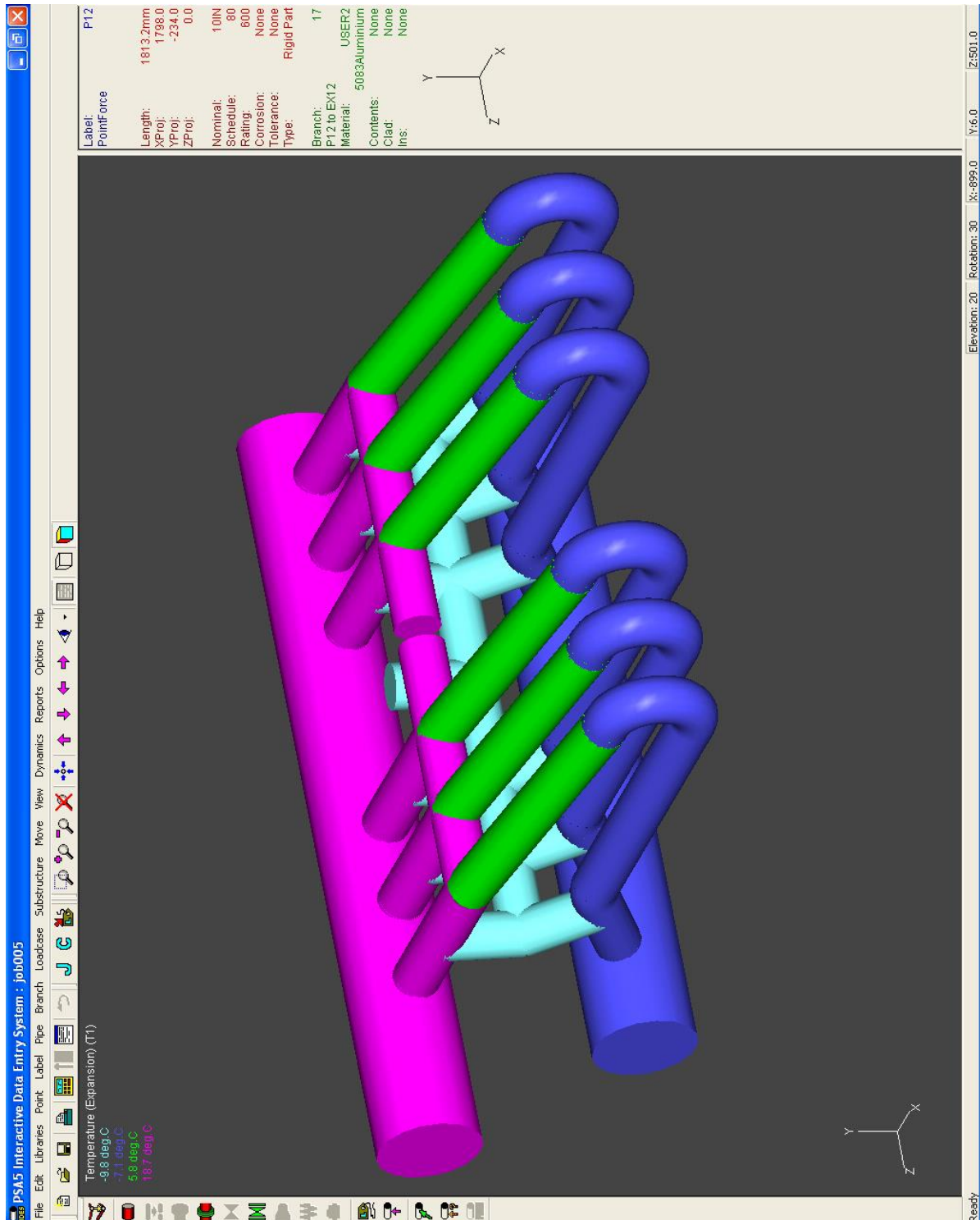


**“3D or centre-line views are displayed during data input”**

## STATIC ANALYSIS

The statics module performs a flexibility analysis to determine forces and moments at all constraint and anchor points, and the deflections of all significant points throughout the system. Although the analysis is basically linear elastic, non-linearity such as unidirectional and limit stop constraints can be dealt with automatically by iteration. Each execution of the statics module can analyse the effect of several independent load cases. The analysis includes the following features:

- Self-weight acting in any direction, factored between load cases
- Uniformly distributed loads (e.g. wind loading) in any direction, factored between load cases
- Internal pressure loading
- Thermal loading, including variation of Young's Modulus and expansion between load cases
- Cold pull or push in any direction
- Imposed displacements at anchor points
- Partial or total constraints
- Spring supports including pre-set
- Limit stop and unidirectional constraints
- Externally applied point loads and moments
- Choice of input and output units
- Rigid sections for modelling valves, flanges etc.
- Bellows and other sections with user-supplied flexibilities
- Treatment of jacketed piping
- Automatic Hanger selection algorithms



**“routes can be colour coded by temperature, pipe size etc”**

## DYNAMIC ANALYSIS

The dynamic analysis module calculates the natural frequencies of the pipework system, including detailed modal shapes, and can carry out response spectra analyses to estimate the maximum deflections, forces and moments in the pipework due to seismic excitation of anchor and constraint points. The module can also carry out a full time history analysis to calculate deflections, forces and moments as they vary with time, when the system is subjected to transient loads.

The following facilities are included:

- \* Use of consistent mass matrices as opposed to simple lumped mass idealisations
- \* Automatic economisation and choice of masters if necessary
- \* User control over the detail of the analysis
- \* Choice of single or multiple response spectra analysis
- \* Choice of Newmark and Housner type library spectra or user-supplied spectra
- \* Combination of response spectra effects in orthogonal directions
- \* Closely spaced modes treated according to USNRC guide 1.92
- \* Sinusoidal and/or user supplied forcing functions for time history analysis
- \* Seismic anchor motion

The screenshot displays the PSA5 software interface with several overlapping windows:

- Materials Library:** Shows a list of materials including BS 806 Austenitic Stainless, BS 806 ASTM A335 P11 Low Chrome Moly, BS 806 Low Carbon Steel (<0.3%), Aluminium, Austenitic Stainless, and Carbon Moly Steel. Buttons for New, View, and Delete are visible.
- Material Data (Background):** Shows fields for Material Description (Carbon Moly Steel), Material Code (CMO), and Units (Metric/Imperial).
- Material Data (Foreground):** Shows a table for Mean Coefficient of Linear Thermal Expansion from Base Temp.
 

°F	µinch/inch/°F
-325	5
-300	5.07
- Modulus of Elasticity : Carbon Moly Steel:** A graph showing Modulus of Elasticity (millions of psi) vs Temperature (°F). The y-axis ranges from 15.0 to 32.5, and the x-axis ranges from -500 to 500. The data points show a downward trend.
- Mean Coeff of Linear Thermal Exp from Base Temp : Carbon Moly Steel...:** A graph showing Expansion Coeff (µinch/inch/°F) vs Temperature (°F). The y-axis ranges from 4.5 to 8.5, and the x-axis ranges from -500 to 1500. The data points show an upward trend.

**“extensive library of fittings, pipes and materials aids model creation”**



## DESIGN CODE COMPLIANCE CHECKING

The results produced by the analysis modules provide pipework deflections and loads on anchors and constraints due to static and dynamic loadings. These are generally independent of any particular design code. Normally, however, the designer is more interested in the stresses present in the system and the way that these are calculated from the results of the analysis modules depends on the design code to which the pipework is being designed. PSA5 provides a range of post-processors which calculate stresses and compares these with the maximum allowable values according to the rules of the following design codes:

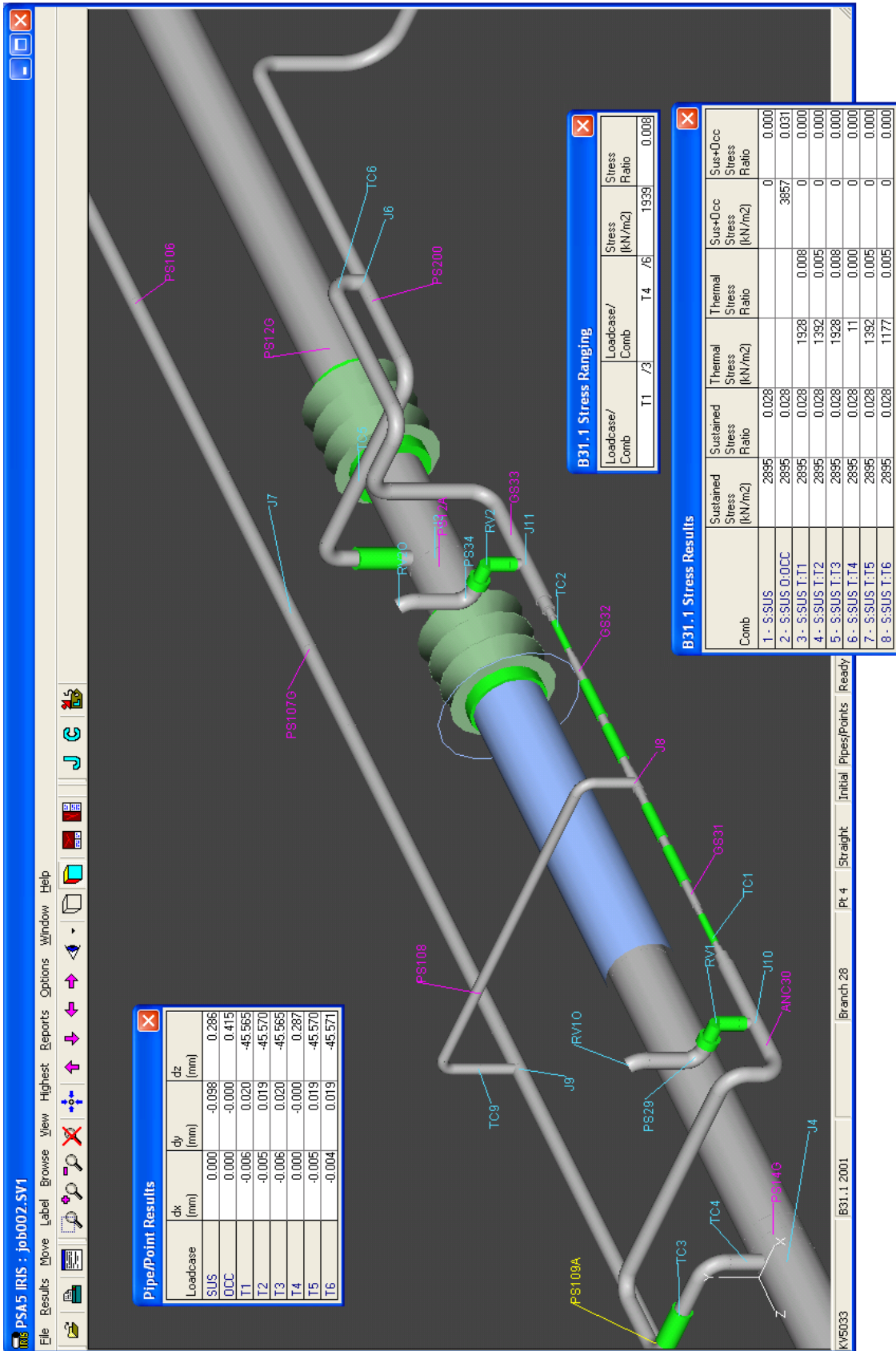
* BS EN 13480	<i>Metallic industrial piping</i>
* ANSI/ASME B31.1	<i>Pressure piping in the conventional power industry</i>
* ANSI/ASME B31.3	<i>Chemical plant and petroleum refinery piping</i>
* BS806	<i>Design and construction of ferrous piping installations for and in connection with land boilers</i>
* BS3351	<i>Piping systems for petroleum refineries and petrochemical plants</i>
* ASME III	<i>ASME boiler and pressure vessel code classes 1, 2 and 3 for nuclear power plant components</i>
* BS7159	<i>Design and construction of glass reinforced plastics (GRP) piping systems for individual plants or sites.</i>
* NEMA Sm 23	<i>Steam turbines for mechanical drive service</i>
* API 617	<i>Centrifugal compressors for general refinery services</i>
* API 610	<i>Centrifugal pumps for general refinery services.</i>

## PIPE, FITTING & MATERIAL LIBRARIES

PSA5 is supplied with a library management system that allows the storage and management of data that is applicable across a wide range of analyses within a system library, thereby avoiding repeated input of the same data. The library manager provides facilities for storing data on:

- materials
- pipe sizes
- valves
- flanges
- reducers
- variable & constant load supports.

Standard data covering a wide range of common materials, pipe sizes, supports and fittings is supplied with the program and can be referenced by the user. The user can extend the range covered by the standard data by adding his own materials, fittings etc..



“the piping model is used as an index into the analysis results”

## INTERACTIVE RESULTS INTERROGATION

Each PSA5 analysis module (i.e. statics, dynamics and code compliance) produces a full formatted output listing consisting of input data and calculated results. Although comprehensive, this output is somewhat voluminous and does not lend itself to easy analysis or communication with other disciplines. Therefore an interactive results interrogation module (IRIS) has been specially designed to provide features to facilitate the critical analysis of the results produced and the communication thereof.

IRIS allows the user to interactively display a selected subset of analysis results on the screen together with an isometric drawing with the current point of interest highlighted. This module facilitates the post analysis identification of areas of non code compliance by providing fast flexible methods to traverse the piping system. Productivity gains in the design/analysis cycle follow. Once a design is code compliant, IRIS can be used to produce hard copies of the isometric/results table for customised report generation, thereby greatly facilitating client communication.

The screenshot displays the PSA5 IRIS software interface. The main window shows a 3D isometric drawing of a piping system with various components labeled: SP1, SP2, TC1, TC2, J1, High 1, 4, 5, 10, High 9, PUMPA, and PUMPA. The interface includes a menu bar (File, Results, Move, Label, Browse, View, Highest, Reports, Options, Window, Help) and a toolbar with various icons for navigation and analysis.

Three data tables are overlaid on the interface:

### Pipe/Point Results

Loadcase	dx (mm)	dy (mm)	dz (mm)
SUS	-0.248	-0.189	0.007
T1	6.844	6.534	2.311
T2	3.691	3.295	2.888
T3	9.688	3.217	2.502
OP1	6.738	6.331	2.322
OP2	3.376	3.068	2.864
OP3	9.305	3.020	2.407
HYD	-0.165	-0.240	-0.099

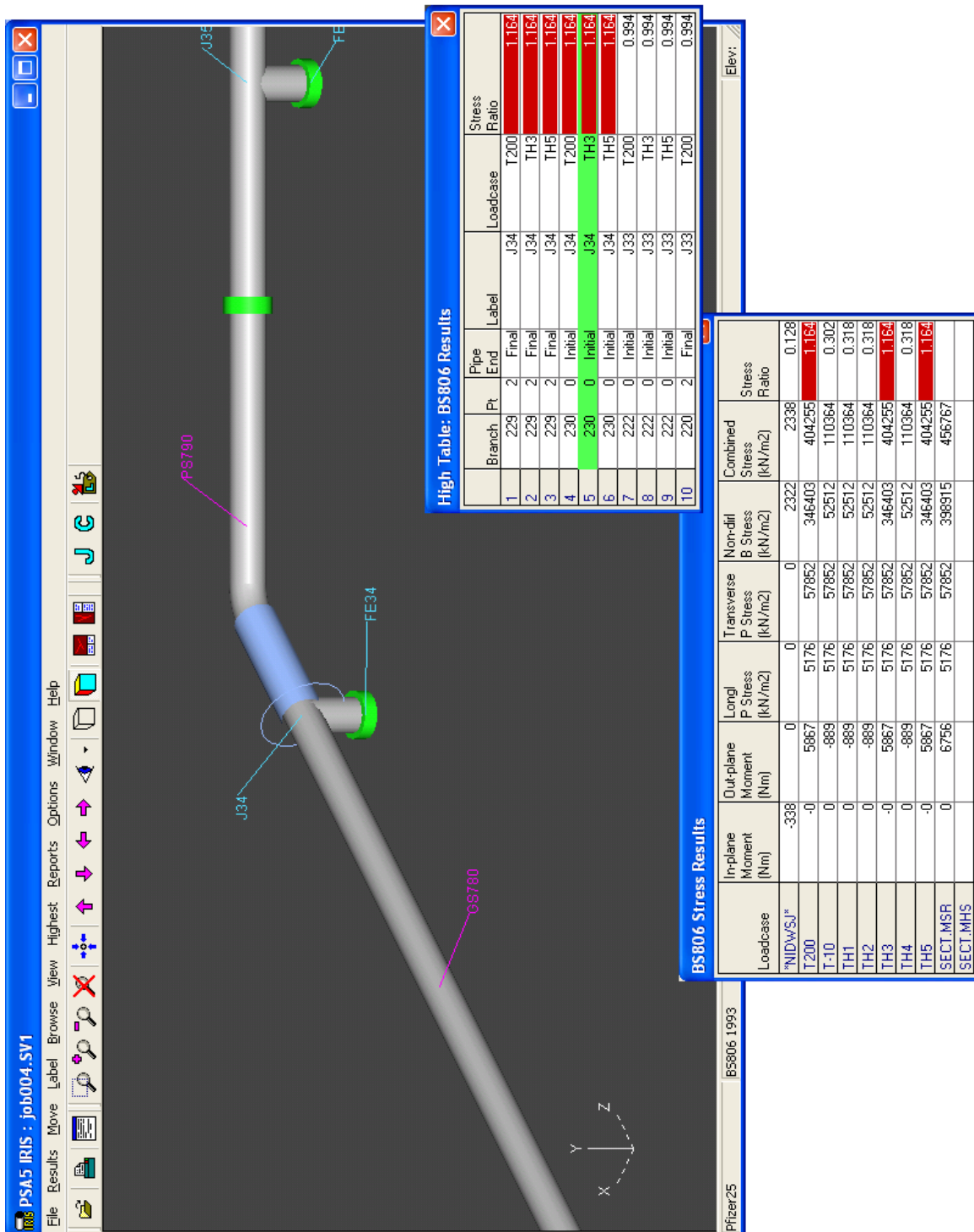
### B31.3 Stress Results

Comb	Sustained T Stress (kN/m <sup>2</sup> )	Sustained Stress Ratio	Thermal T Stress (kN/m <sup>2</sup> )	Thermal Stress Ratio
1 - S.SUS	40918	0.297		
2 - S.SUS T-T1	40918	0.297	62547	0.245

### High Table: B31.3 Results: (All categories)

Branch	Pt	Pipe End	Label	Comb	Category	Stress Ratio
1	12	3	Final	J1	2 - S.SUS T-T1	Thermal 0.392
2	1	1	Bend		2 - S.SUS T-T1	Thermal 0.371
3	1	2	Bend		2 - S.SUS T-T1	Thermal 0.370
4	15	0	Initial	J1	1 - S.SUS	Sustained 0.297
5	15	0	Initial	J1	2 - S.SUS T-T1	Sustained 0.297
6	10	2	Bend		2 - S.SUS T-T1	Thermal 0.275
7	1	0	Initial	V1	2 - S.SUS T-T1	Thermal 0.268
8	10	0	Initial	J2	2 - S.SUS T-T1	Thermal 0.256
9	16	0	Bend	SP2	2 - S.SUS T-T1	Thermal 0.247
10	15	0	Initial	J1	2 - S.SUS T-T1	Thermal 0.245

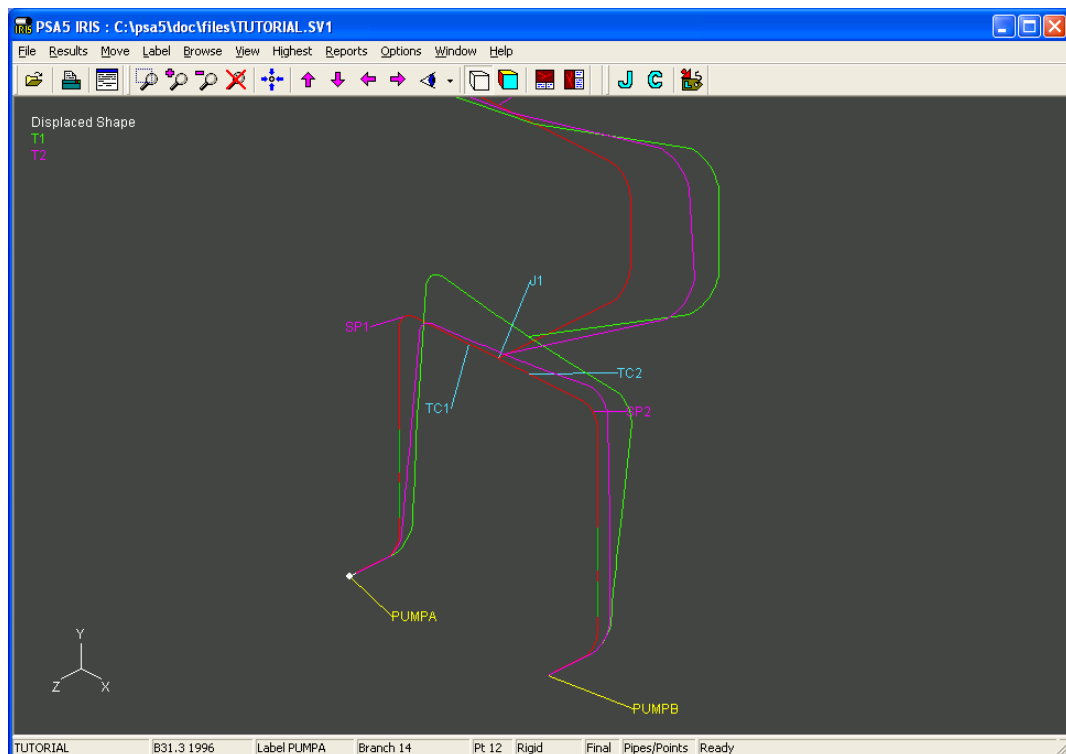
The status bar at the bottom of the window shows: TUTORIAL B31.3 1996 Label J1 Branch 15 Pt 0 Straight Initial Pipes/Points Ready Elev: 30 Rot: 45

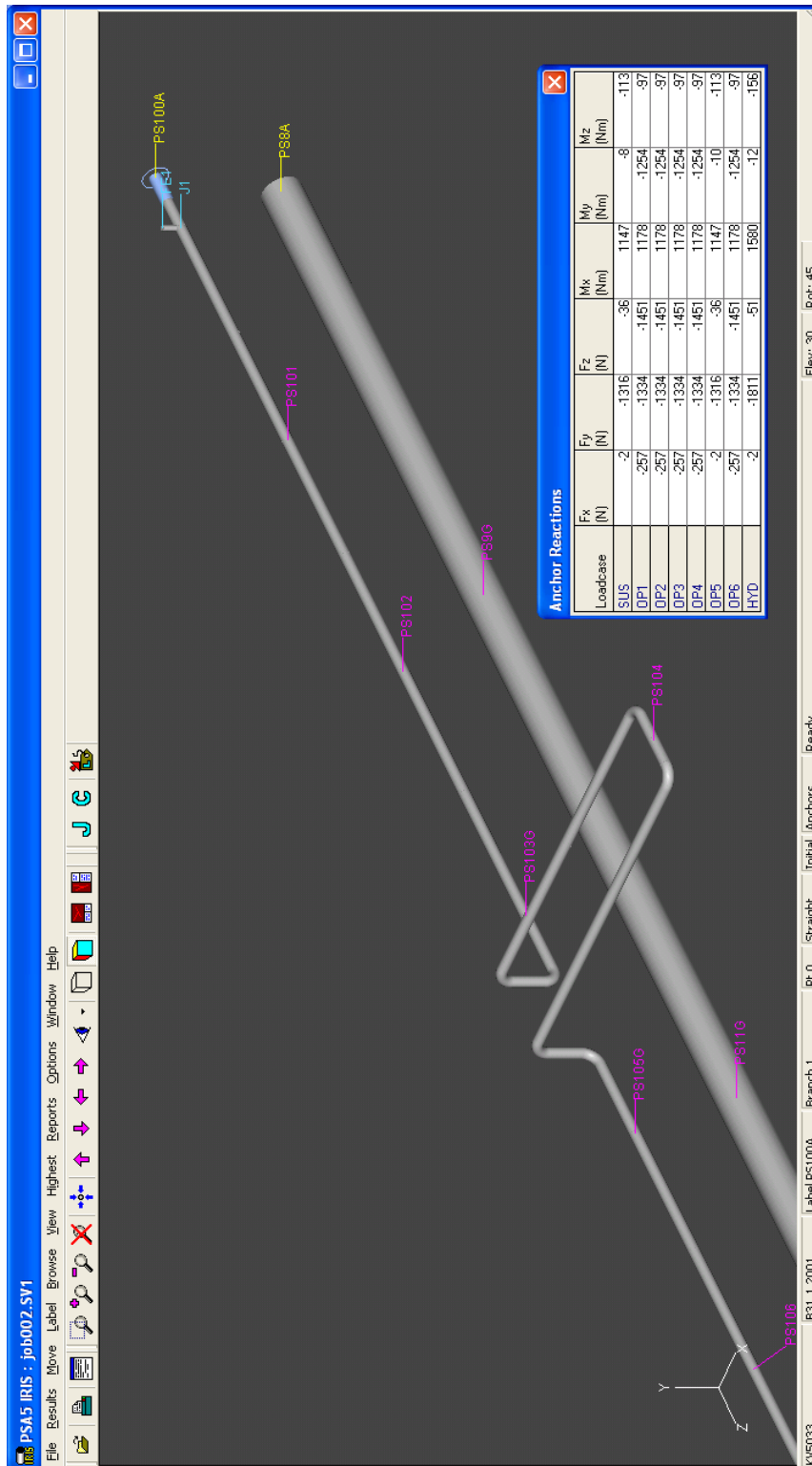


**“areas of over-stress are easily identified and associated data displayed to aid redesign”**

The following facilities are included:

- \* Uses piping isometric (or alternative 3D representation) as index into the stress database
- \* Produces customised reports containing isometric with tabulated results
- \* Complete user control over results displayed
  - displacements/rotations
  - forces/moments
  - external reactions
  - stresses
- \* Tabulates highest values of any value e.g. stress ratio and highlights positions on isometric
- \* Flexible facility to move about isometric
  - pipe to pipe
  - label to label
  - bend to bend
  - anchor to anchor
  - constraint to constraint
  - junction to junction
  - descending order of any calculated value, e.g. stress ratio
- \* Tabulated subset of results always reflects current position on isometric
- \* Zoom and pan.
- \* Screen dump to printer
- \* Displaced and Modal Shape Visualisation
  - displays graphically the displaced centre line of the pipework superimposed upon the unloaded position in a form suitable for design reports. It also allows the display and animation of the modal shapes of free vibration.





“loads on external attachments are readily interrogated”

Indexed output pages showing a formatted version of the results currently displayed on the screen can be printed or easily incorporated into a word processor via bitmap files or the clipboard.

PSA5 IRIS Results System version 6.04

Calculation KV5033	File Details job002.sv1 04/02/2004 10:33	Report Created 04/02/2004 10:42
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Label PS103G Branch 4 Pt 2 Final

**B31.1 Stress Results**

Comb	Sustained Stress (kN/m2)	Sustained Stress Ratio	Thermal Stress (kN/m2)	Thermal Stress Ratio	Sus+Occ Stress (kN/m2)	Sus+Occ Stress Ratio
1 - S:SUS	25293	0.245			0	0.000
2 - S:SUS O:OCC	25293	0.245			25301	0.204
3 - S:SUS T:T1	25293	0.245	20234	0.087	0	0.000
4 - S:SUS T:T2	25293	0.245	20240	0.087	0	0.000
5 - S:SUS T:T3	25293	0.245	20241	0.087	0	0.000
6 - S:SUS T:T4	25293	0.245	20231	0.087	0	0.000
7 - S:SUS T:T5	25293	0.245	24	0.000	0	0.000
8 - S:SUS T:T6	25293	0.245	20233	0.087	0	0.000

**B31.1 Stress Ranging**

Loadcase/Comb	Loadcase/Comb	Stress (kN/m2)	Stress Ratio
Null /0	T3 /5	20241	0.087

Customisable Anchor, Constraint and Dynamics reports are available, again easily printed or imported into a word processor.

PSA5 Results System

Job Name KV5033	Results File job002.sv1 04/02/2004 10:33	Created 04-Feb-2004 10:16
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**Anchor Report**

Label	Loadcase	External Forces (N)			External Moments (Nm)			
		X	Y	Z	X	Y	Z	
PS100A	SUS	-2	-1316	-36	1147	-8	-113	
	OP1	-257	-1334	-1451	1178	-1254	-97	
	OP2	-257	-1334	-1451	1178	-1254	-97	
	OP3	-257	-1334	-1451	1178	-1254	-97	
	OP4	-257	-1334	-1451	1178	-1254	-97	
	OP5	-2	-1316	-36	1147	-10	-113	
	OP6	-257	-1334	-1451	1178	-1254	-97	
	HYD	-2	-1811	-51	1580	-12	-156	
	Maximum		-2	-1316	-36	1580	-8	-97
	Minimum		-257	-1811	-1451	1147	-1254	-156
PS109A	SUS	-145	-1343	34	-1227	317	-85	
	OP1	-1730	-1359	1561	-1249	3641	1062	
	OP2	-1754	-1371	1637	-1265	3657	1068	
	OP3	-1708	-1355	1560	-1243	3591	1054	
	OP4	-1784	-1375	1638	-1272	3724	1080	
	OP5	-58	-1328	32	-1204	126	-114	
	OP6	-1783	-1377	1636	-1274	3722	1075	
	HYD	-181	-1836	47	-1661	394	-112	
	Maximum		-58	-1328	1638	-1204	3724	1080
	Minimum		-1784	-1836	32	-1661	126	-114
PS18A	SUS	-47	-14313	-7428	-9435	219	314	
	OP1	-189	6369	70447	-21704	947	1400	
	OP2	-147	6372	70451	-21702	740	1096	
	OP3	-189	6369	70447	-21704	947	1400	
	OP4	-47	-14313	-7428	-9435	219	314	
	OP5	-147	6372	70451	-21702	740	1096	

# Certificate of Approval

This is to certify that the Management System of:

## Whessoe Engineering Limited

Whessoe Technology Centre, Morton Palms, Darlington, DL1 4WB, United Kingdom

has been approved by LRQA to the following standards:

ISO 9001:2015



David Derrick - Area Operations Manager UK & Ireland

Issued by: Lloyd's Register Quality Assurance Limited

Current issue date: 14 August 2018  
Expiry date: 31 March 2020  
Certificate identity number: 10118062

Original approval(s):  
ISO 9001 – 23 May 2005

Approval number(s): ISO 9001 – 00007761

The scope of this approval is applicable to:

Project management services in the mechanical and civil engineering sectors including the design of mechanical engineering plant and civil engineering works, repair and re-validation of storage tanks. Contracting services for procurement and site construction in connection with mechanical and civil engineering works. The provision of packaged software and associated services to the petrochemical, power, offshore and manufacturing industries covering pipe stress analysis (PSA5) and pressure vessel design (PVE5).



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**“developed and supported by a QA programme certificated to ISO9001 and TickIT accredited”**



## QUALITY ASSURANCE

PSA5 has been validated by comparing the answers obtained with hand calculations, results from competitors software, published results, analytical solutions and results from previously validated releases. Details of the above are documented in the comprehensive PSA5 Validation Manual.

Whessoe Computing Systems operate a QA programme designed to meet the requirements of ISO9001, BS5882:1980 and the ASME Boiler and Pressure Vessel Code Section III. This programme has been audited by a number of companies and found to be satisfactory. In particular one contract specified BS5882 - the QA programme for nuclear power stations. The development, testing, maintenance and support of PSA5 are carried out within the framework of the Whessoe Computing Systems quality management system. This quality system has been subject to third party audit by an accredited certification body and Whessoe Computing Systems have been registered as a certificated organisation.

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

- a) Generate a comprehensive set of validation benchmarks covering all PSA5 facilities from independent sources e.g. hand calculations. These are documented in the PSA5 Validation Manual.
- b) Compare the answers produced by PSA5 with a) above and include comparison in the Validation Manual when compatible.
- c) For each new version of PSA5, run all the above benchmarks and compare these with the validation results produced on the previous version. When satisfactory comparison is obtained a Product Modification Issue Form is signed signifying that the new version has been successfully verified and validated.
- d) Issue Product updates to all licensees consisting of installers, updates to the User Manual and an Installation Guide. We include the input data for a subset of the validation benchmarks, together with execution instructions and expected results. This allows the client to carry out his own verification tests if required.

# NOTES

## **Whessoe Computing Systems**

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