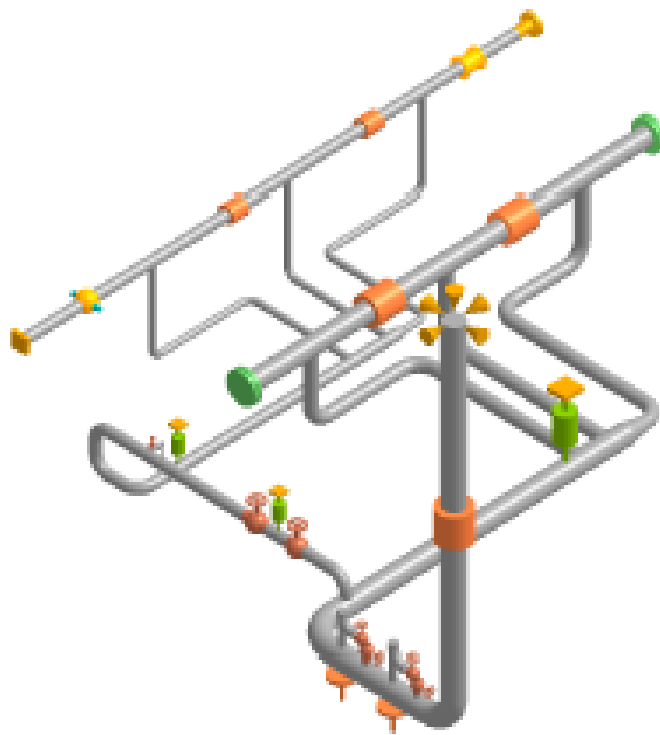


# CheckStress<sup>TM</sup> User's Manual



From the CAdvantage<sup>®</sup> Library



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Users must carry out all necessary tests to assure the proper functioning of the software and the applicability of its results.

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## 1.0 Introduction

It is common practice worldwide that piping designers/layout personnel route pipes with consideration given mainly to space constraints, process and flow constraints (such as pressure drop) and other requirements arising from constructability, operability and reparability. Unfortunately, often pipe stress requirements are not sufficiently considered while routing and supporting piping systems, especially in providing adequate flexibility to absorb expansion/contraction of pipes due to thermal loads. So, when “as designed” piping systems are given to pipe stress engineers for analysis, they soon realize that the systems are “stiff” and suggest routing changes to make the systems more flexible. The piping designers, in turn, make routing changes and send the revised layout to the pipe stress engineers to check compliance again. Such “back and forth” design iterations between layout and stress departments continue until a suitable layout and support scheme is arrived at, resulting in significant increase in project execution time, which, in turn, increases project costs.

This delay in project execution is further aggravated in recent years as operating pressures and temperatures are increased in operating plants to increase plant output; increased operating pressures increase pipe wall thicknesses, which, in turn, increase piping stiffnesses further; increased operating temperatures, applied on such “stiffer” systems, increase pipe thermal stresses and support loads. So, it is all the more important to make the piping layout flexible at the time of routing by piping designers. In order to substantially reduce the number of design iterations between the piping design and stress departments, which, in turn, results in huge time savings during design stage, the product “CheckStress” is introduced. CheckStress is add-on pipe stress check software to 3D Plant Design systems such as PDMS, CADMATIC, etc. It helps designers to decide “Code Complaint” pipe routing during layout stage and is meant for first level of stress check by designers.

So, by using CheckStress, the designer is able to send mostly “Code Complaint” piping systems to pipe stress engineers for detailed analysis and stress report preparation.

### 1.1 Basic Pipe Stress Concepts for Piping Designers

Piping systems experience different loadings, which can be categorized into three basic loading types, which are as follows:

#### **Sustained Load:**

It mainly consists of internal pressure and dead-weight. Dead-weight is from weight of pipes, fittings, components such as valves, operating fluid, test fluid, insulation, cladding, lining etc.

Internal design/operating pressure develops uniform circumferential stresses in the pipe wall, based on which pipe wall thickness is determined during the process/P&ID stage of plant design. In addition, internal pressure develops axial stresses in the pipe wall. These axial pressure stresses vary only with pressure, pipe diameter and wall thickness, which are already pre-set at the P&ID stage and hence cannot be reduced by changing the piping layout or the support scheme.

On the other hand, dead-weight causes the pipe to bend (generally downward) between supports and nozzles, producing axial stresses in the pipe wall (also called “bending stresses”); these bending stresses linearly vary across the pipe cross-section, being tensile at either the top or bottom surface and compressive at the other surface. If the piping system is not supported in the vertical direction (i.e., in the gravity direction) excepting at equipment nozzles, bending of the pipe due to dead-weight may develop excessive stresses in the pipe and impose large loads on equipment nozzles, increasing the susceptibility to piping “failure by collapse”. Various international piping standards/codes impose limits, also called “allowable stresses for sustained loads”, on these axial stresses generated by dead-weight and pressure in order to avoid “failure by collapse”.

For the calculated actual stresses to be below such allowable stresses for sustained loads, it may be necessary to support the piping system vertically. Typical vertical supports to carry dead-weight are:

- a) Variable spring hangers,
- b) Constant support hangers,
- c) Rod hangers and
- d) Resting steel supports.

Both rod hangers and resting steel supports fully restrain downward pipe movement but permit pipe to lift up at such supports.

In Appendix E titled "Sample Problems and Solutions using CheckStress", a couple of sample layouts are presented to illustrate how piping can be supported by spring hangers and resting steel supports to comply with the code requirements for sustained loads.

### **Thermal Load (also referred as Expansion Load):**

It refers to the "cyclic" thermal expansion/contraction of piping as the system goes from one thermal state to another thermal state (for example, from "shut-down" to "normal operations" and then back to "shut-down"). If the piping system is not restrained in the thermal growth/contraction directions (for example, in the axial direction of pipe), then for such cyclic thermal load, the pipe expands/contracts freely; in this case, no internal forces, moments and resulting stresses and strains are generated in the piping system.

If, on the other hand, the pipe is "restrained" in the directions it wants to thermally deform (such as at equipment nozzles and pipe supports), such constraint on free thermal deformation generates cyclic thermal stresses and strains throughout the system as the system goes from one thermal state to another. When such calculated thermal stress ranges exceed the "allowable thermal stress range" specified by various international piping standards/codes, then the system is susceptible to "failure by fatigue". So, in order to avoid "fatigue" failure due to cyclic thermal loads, the piping system should be made flexible (and not stiff). This is normally accomplished as follows:

- a) Introduce bends/elbows in the layout, as bends/ elbows "ovalize" when bent by end-moments, which increases piping flexibility.
- b) Introduce as much "offsets" as possible between equipment nozzles (which are normally modeled as anchors in pipe stress analysis). For example, if two equipment nozzles (which are to be connected by a pipeline) are in line, then the straight pipe connecting these nozzles is "very stiff". If, on the other hand, the two equipment are located with an "offset", then their nozzles will have to be connected by an "L-shaped" pipeline which includes a bend/elbow; such "L-shaped" pipeline is much more flexible than the straight pipeline mentioned above.
- c) Introduce expansion loops (with each loop consisting of four bends/elbows) to absorb thermal growth/contraction.
- d) Lastly, introduce expansion joints such as bellows, slip joints etc, if warranted.

In addition to generating thermal stress ranges in the piping system, cyclic thermal loads impose loads on static and rotating equipment nozzles. By following one or more of the steps from (a) to (d) given above and steps (e) and (f) given below, such nozzle loads can be reduced.

- e) Introduce "axial restraints" (which restrain pipe in its axial direction) at appropriate locations such that thermal growth/contraction is directed away from nozzles.
- f) Introduce "intermediate anchors" (which restrain pipe movement in the three translational and three rotational directions) at appropriate locations such that thermal deformation is absorbed by regions (such as expansion loops) away from equipment nozzles.

In Appendix E titled "Sample Problems and Solutions using CheckStress", a few sample layouts are presented to illustrate how loops/offsets, axial restraints and intermediate anchors are used to reduce thermal stresses in piping (and resulting nozzle loads).

## **Occasional Loads:**

These are the third type of loads, which are imposed on piping systems by occasional events such as earthquake, wind and water hammer. To protect piping from wind and/or earthquake (which normally occur in horizontal plane), it is normal practice to attach “lateral supports” to piping systems (instead of “axial restraints”). On the other hand, to protect piping for water/fluid hammer loads, both “lateral supports” and “axial restraints” may be required.

CheckStress, at present, assists piping designers to perform first level stress checks only for sustained (mainly dead weight and pressure) and thermal loads. Fortunately, to carry sustained loads, normally vertical supports are required. On the other hand, for thermal loads, zero supports give zero stresses. So, less the number of supports less the thermal stresses. Axial restraints and intermediate anchors are recommended only to direct thermal growth away from equipment nozzles.

## **1.2 Recommended Stress Check Procedure**

CheckStress is used to perform preliminary Stress Analysis during the layout stage. From the thermal stress contour plot and the deflected shape for thermal load case provided by CheckStress, designers could suitably route the pipe to make it more flexible and position axial restraints and/or intermediate anchors, if required, to direct thermal expansion/contraction away from critical locations such as equipment nozzles. Similarly, designers can decide the types and locations of vertical supports based on the stress contour plot and deflected shape for sustained (= weight + pressure) load case as well as the deflected shape for operating load case (= sustained load + thermal load).

The steps given below may normally be followed to perform first-level stress checks of piping systems designed using 3D plant design systems.

### **Step1:**

Apply CheckStress on the piping system under consideration in the 3D model, without exiting the 3D plant design system.

### **Step2:**

Review first stress contour plot for thermal stresses. The plot is color-coded such that “blue” region denotes areas with the least stress ratios (where stress ratio equals to actual computed stress divided by material allowable stress), “green” region with higher stress ratios, “yellow” region with even higher stress ratios, and “red” region with the highest stress ratios. Intermediate areas between these distinct colors will be of “bluish-green”, “greenish-yellow” and “orange” colors.

A designer’s goal is to arrive at a layout, which avoids “orange” and “red” zones in thermal stress plot so that there is sufficient thermal margin left for the pipe stress engineers to perform detailed piping analysis when the layout is finalized at the 3D-design stage. A designer may wish to avoid even “yellow” zone in the stress contour plot so as to provide additional thermal margin for pipe stress engineers.

Since thermal stresses generated are directly dependent on how “stiff” or “flexible” the layout is, in order to reduce thermal stresses, it may be necessary to make the layout “flexible” (by including bends, offsets, loops etc.). So, the first step is to make sure thermal stress ratios remain within “blue to yellow” range and not get into “orange” and “red” zones. For more “flexible” layout, even “yellow” zone can be avoided.

### **Step 3:**

In case thermal stress ratios exceed “yellow” zone (and are in “orange” and “red” zones in one or more areas of the piping system), it is important to study the deformed shape provided by CheckStress for “thermal” load case in order to understand how the piping responds to “pure thermal” load (where only temperature change is considered for CheckStress calculations). By studying such deformed shape, it is possible to arrive at a layout with appropriate bends, offsets and loops and/or with appropriately located axial restraints/intermediate anchors such that thermal stress ratios do not exceed “yellow” zone. This process may require a designer to perform several layout and/or restraint scheme iterations.

**Step 4:**

After finalizing piping layout under Steps 2 and 3 for thermal loading, the next task is to support the system vertically to carry its deadweight under operating condition. In this connection, first review stress contour plot for sustained stress ratios generated by deadweight and pressure for the system without any vertical supports excepting those provided by equipment nozzles, shown in color codes from “blue” to “green” to “yellow” to “red” (as in Step 2 above).

The designer’s goal is to arrive at a vertical support scheme consisting of (a) resting steel supports, (b) rod hangers, (c) variable spring hangers and (d) constant support hangers, at appropriate locations (where such pipe supports can be attached to adjacent concrete/steel structures, platforms etc.) so that stress contour plot for sustained stress ratios avoids “orange” and “red” zones and remains within “blue to yellow” range.

**Step 5:**

In case sustained stresses exceed “yellow” zone in one or more areas of the piping system, study the deformed shape provided by CheckStress for sustained load case in order to understand how the piping responds to its own deadweight: next, identify pipe locations in the 3D model where the pipe can be vertically supported by the support types listed under Step 4 above. Based on this information, it is possible to vertically support the piping such that sustained stresses do not exceed “yellow” zone. This step may require the designer to execute CheckStress on the system with several vertical support schemes.

In case resting steel supports are selected to provide vertical support for piping under sustained load, it is to be made sure that piping continues to rest on such steel supports even during operating condition (= weight + pressure + thermal) and does not lift off from these supports. If pipe lifts up at any of these resting supports during operating condition, then that support does not carry any pipe weight and hence will not serve its purpose. Similarly, at rod hanger locations, the tendency of piping should be to deform downward for operating load case, so that the rod hangers carry the pipe weight under tension. On the other hand, if pipe lifts up at any of the rod hangers, then that rod hanger goes into compression thereby not carrying the weight of the piping during operating condition. CheckStress displays the deflected shape of piping under operating load case. By viewing this deflection from different directions, the designer can make sure that piping is resting on steel supports and/or piping is not deforming upward at rod hangers.

**Step 6:**

Designers are to perform Steps 1 to 5 for all piping systems of the project. Systems, for which the layout and support schemes are finalized, can then be transferred to CAEPIPE stress models, which can then be sent to pipe stress engineers for detailed analyses and stress report preparation. This eliminates (a) generation of “stress isometric drawings” and (b) re-inputting the data into the pipe stress software CAEPIPE. Pipe stress engineers should check the CAEPIPE models so sent by designers and add additional input data into the models such as insulation thickness and density, corrosion allowance and mill tolerance of pipe sections, thermal anchor movements, seismic anchor movements, support conditions such as friction and gap, other loads such as wind, seismic and water/fluid hammer, multiple thermal and pressure cases, etc. and perform detailed analyses. It is most likely that the layout and support schemes sent by designers meet all other pipe stress requirements (such as meeting nozzle allowable loads) and hardly require any further iteration(s) between stress and layout departments.

This manual describes the operational details of CheckStress. It is assumed that the user is already familiar with the principles of Plant Design Software Piping Application and the practices followed in Plant Design Piping catalogue and specifications, and the user has used Plant Design Software to generate the piping by using available facilities in Plant Design Software.

The working sequence of the software is listed below.

1. The pipe branches modeled in the Plant Design Software are read and passed onto CheckStress.
2. CheckStress then, from the material mapping database (see Note 1) provided with CheckStress, identifies valid materials (which will be used for first level pipe stress calculations within CheckStress) that would correspond to the material specifications given for those branches in the Plant Design Software. This executable finally carries out stress analysis and displays contour plots of Stress ratios for Sustained and Expansion load cases. It also plots graphically the deflected shapes for Sustained, Expansion and Operating load cases.
3. Finally, this software has a provision to write CAEPIPE 5.xx mod file, which is used for carrying out detailed stress analysis and stress report preparation using CAEPIPE. See Note 2 below.

The sequence of CheckStress operation is shown diagrammatically in Figure 1-1.

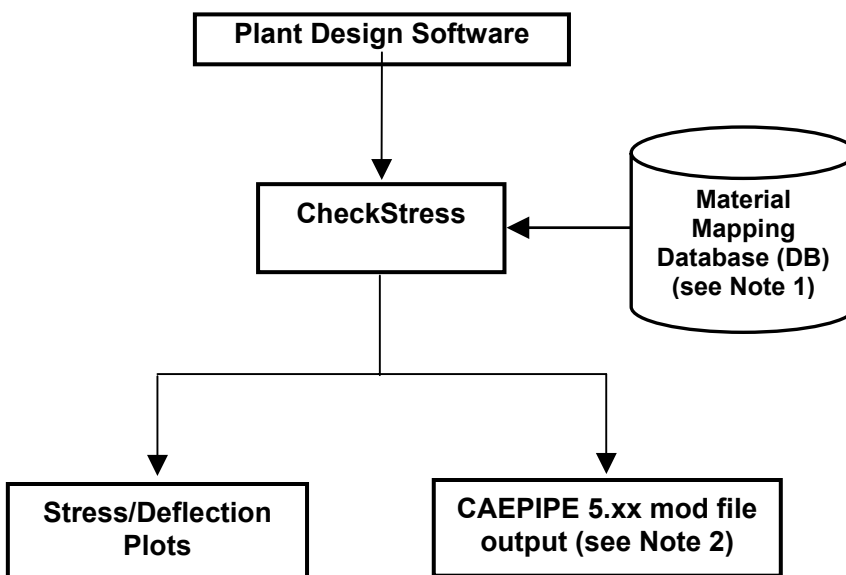


Figure 1.1

**Note 1:**

Refer **Appendix A** for more details on Material Property.

**Note 2:**

An optional software interface is available which converts the input (i.e., .mod file) of CAEPIPE Version 5.xx into the input file of CAESAR II Version 4.5.

## 2. Installing the Program

### 2.1 OS Requirement

CheckStress supports the following platforms with Internet Explorer 5.01 or later and Windows Installer 2.0 or later:

- a. Windows NT 4.0 (Workstation or Server) with Service Pack 6a
- b. Windows 2000 (Professional, Server, or Advanced Server)
- c. Windows XP (Personal and Professional)

### 2.2 Installing SST License Manager

Locate/Decide the computer that you want to use as a server for the CheckStress.

Insert the compact disc supplied by SST Systems to the CD-ROM drive of the computer, that you decided to use as a server for CheckStress. Wait for a few seconds to enable the “Auto play” of the CD. Please note, if the CD-ROM does not start automatically, simply browse the CD, and double-click on the “setup” application icon. You will see a typical window similar to that shown in the left figure below.

Click on “Install SST License Manager” option. You will be shown window similar to that shown in the right figure below.

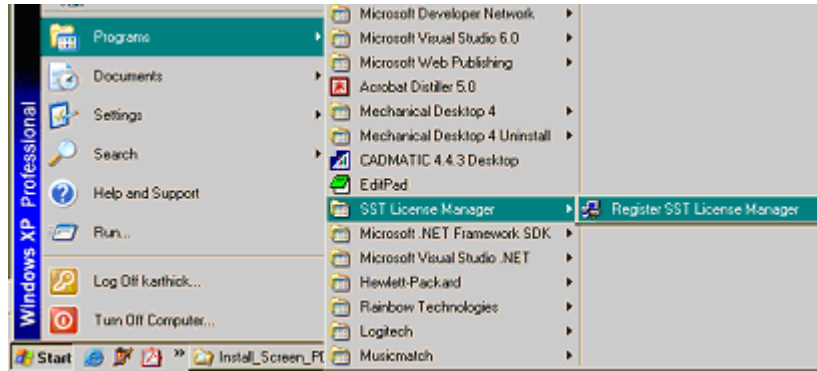


Follow the instructions as they appear on the screen.

### 2.3 Manually Registering Service

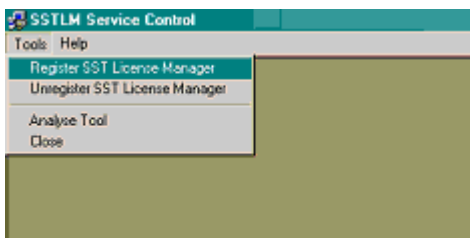
The SST License Manager setup program will register and start the service automatically, when you perform step 1.2. If the setup program fails to register the service automatically, then register the service manually as stated below.

After the successful installation of the SST License Manager, launch the program “Register.exe” by selecting Start Menu->Programs->SST License Manger->Register SST License Manager from the computer where the SST License Manager is installed. The details are shown graphically below.



Select the option “Register SST License Manager” through “Tools->Register SST License Manager” to register the window service as shown in the left figure below.

After successful registration of the service, you will see a message shown in the right figure below.



## 2.4 Installing the client program CheckStress

Locate/Decide the computers that you want to use as clients. The client program CheckStress can be installed in as many systems as you want.

To install CheckStress on the client computers, insert the compact disc supplied by SST Systems to the CD-ROM drive and wait for a few seconds to enable the Auto play feature. Please note, if the CD-ROM does not start automatically, simply browse the CD, and double-click on the “setup” application icon. You will see a window as shown in figure left of section 1, “Installing the SST License Manager”.

Click on “Install CheckStress” option and follow the instructions as they appear on the screen.

For sharing the license information, client computer needs to communicate with the server (computer where the SST License Manger is installed). The communication between the client computer and the server computer can be established by setting the Environmental Variable “SSTLM” on the client computers. Please note, the automated procedure for locating the server computer by the client computer for sharing license information is purposefully not given to avoid unnecessary clashes. However, the Environmental variable is set automatically for the machine where SSTLM is installed. In other words, if you install the client program in the same machine where the SST License Manager is installed, then there is no need to set the environmental variable “SSTLM”. If the client program is installed other than the machine where SST License Manager is installed, then follow the procedure listed below for setting the environmental variable under different operating systems.

1. SST License Manager is used as a security system for various SST Systems products and hence user can have different servers in the same network environment for different SST Systems products.
2. Can have one server for various SST Systems products installed in different client machines.
3. Can install both server/client in one computer.

Can have two different servers for one SST Systems product by splitting the number of users (not applicable for single user) and

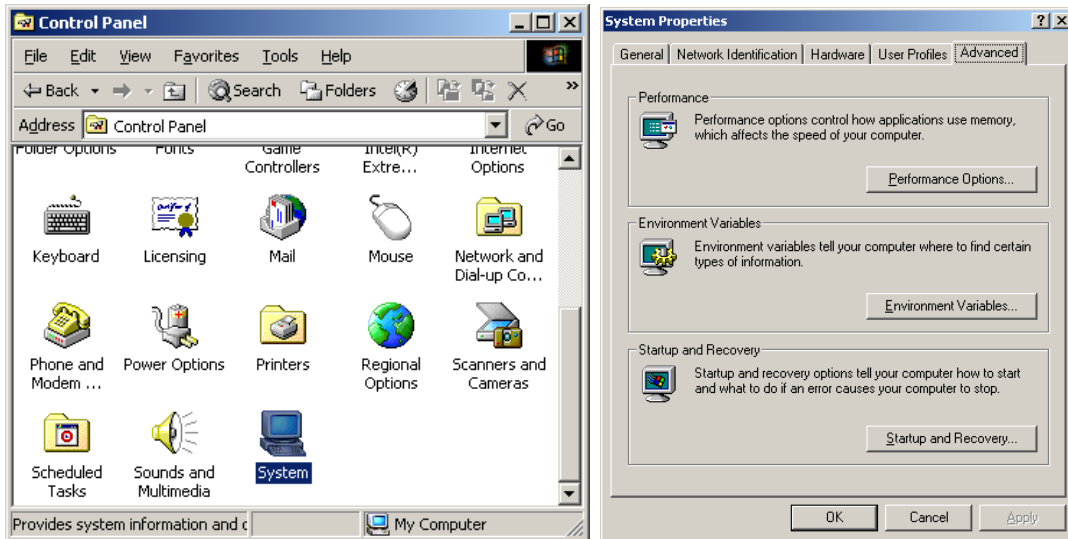
4. Locating the server automatically under a huge network environment is a time consuming process.

The procedure for setting the Environmental Variable “SSTLM” in the client machine under different operating systems is listed below.

#### 2.4.1 Windows 2000 (Server/Professional Edition) /Windows XP (Personal and Professional)

Open the “Control Panel” window through Start Menu->Settings->Control Panel.

Double-click on “SYSTEM” icon as shown in figure left below.

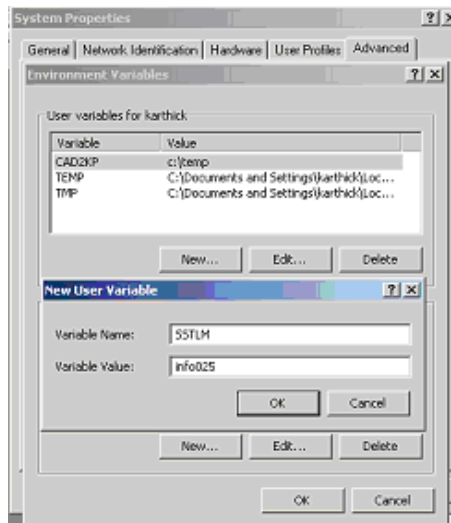


Select the tab “Advanced” and press the button “Environmental Variables” as shown in figure right above.

Click the button “New” under the “User Variables” as shown in figure below.

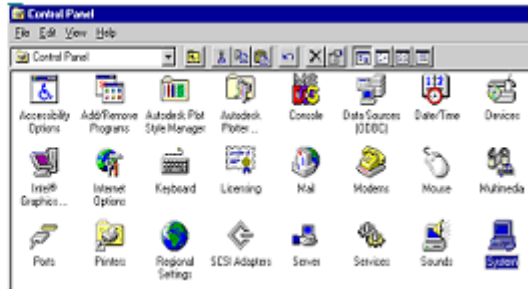
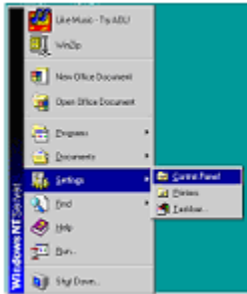
Type “SSTLM” under the variable name prompt and key in the name or IP Address of the computer where SST License Manager is installed (for e.g., info025 or 192.0.0.4) under the value prompt.

Press the button “ok” to complete the setting.



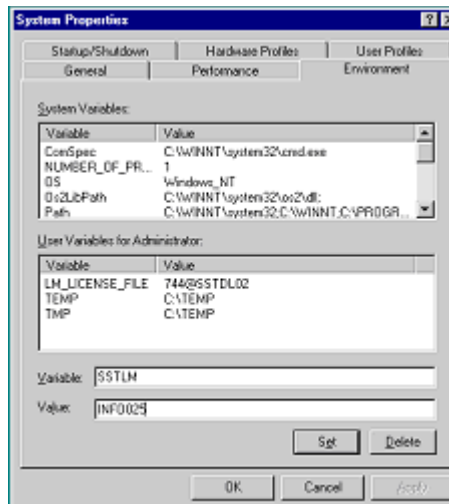
#### 2.4.2 Windows NT 4.0 (Server/Workstation)

Open the “Control Panel” window through Start Menu->Settings->Control Panel as shown in figure left below.



Double-click on “SYSTEM” icon as shown in figure right above.

From the window, select the tab “Environment”, you will see a window as shown in figure below.



Type “SSTLM” under the variable name prompt and key in the Name or IP Address of the computer where SST License Manager is installed (for e.g., info025 or 192.0.0.4) under the value prompt.

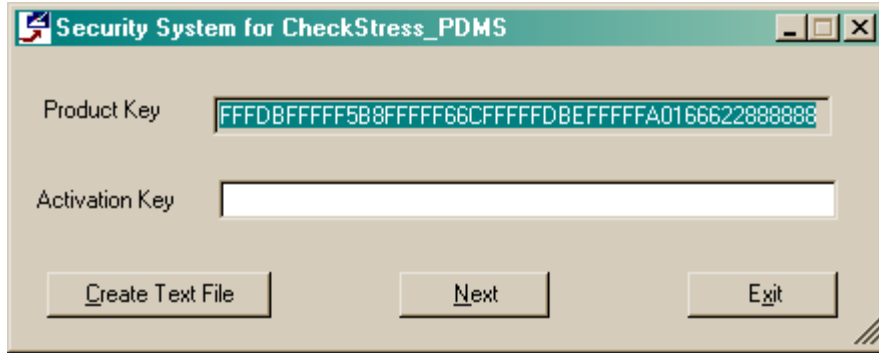
Press the button “set” and then “Ok” to complete the setting.

## 2.5 Product Key Generation

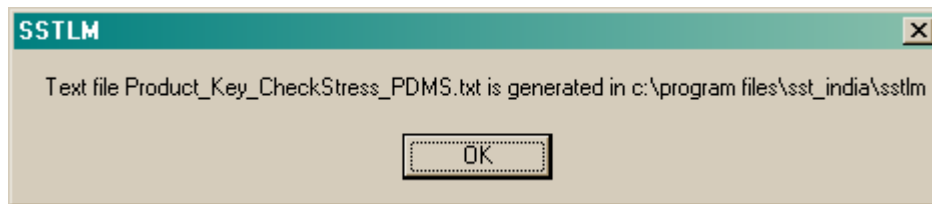
The procedure for creating the product key is explained in this section assuming the name of the module you own as CheckStress (for Aveva’s PDMS).

During the first run of the software, program communicates with the server computer and sends request to check for the availability of the license to use the product.

The server (SST License Manger) checks for the availability of the license in the windows registry. If not available, program automatically generates a Product Key and pops up the same on the server computer as shown in figure below.



Press the button “Create Text File” to store the details on a text file. After successful creation of text file, you will see a message as shown below.



Press the button “Exit” to send the response to client and to close the dialog. The client computer will receive a response as shown below until the Activation key is installed in the Server Computer.



Send the text file created above, which stores the Product Key information to SST Systems Inc. via e-mail. SST Systems Inc. will provide you the Activation Key with in the next working day.

Refer the document “security.pdf” for more information on Product Key generation and Activation Key installation.

### 3. Limitations

The present version of CheckStress has the following limitations.

- 3.1 By default, the pad thickness for reinforced tee is taken as 10mm.
- 3.2 In case of unavailability of material details, the program takes the material properties corresponding to the minimum index value of the selected material DB, corresponding to the "Piping Code for Analysis" (Refer Appendix A for details).
- 3.3 Instruments and filters are considered as rigid elements for Analysis.
- 3.4 Elbow components in Plant Design software are treated as bends in CheckStress.
- 3.5 Olet components in Plant Design software are treated as weld-olets in CheckStress.
- 3.6 If wall thickness for the section is not available in the Plant Design software, "Standard Schedule" thickness is considered in CheckStress. User can specify the wall thickness to be used for different Nominal sizes by editing the mdb file supplied along with this software. Refer Appendix A for more details on modifying the Wall thickness.
- 3.7 If the support type at a support location is not available, then the program assumes it as a Hanger.
- 3.8 Thermal movements at anchors, nozzles and supports are not currently considered for thermal stress calculations by CheckStress, as such movements are usually not specified by designers during layout.
- 3.9 The following items are currently not included for stress calculations in CheckStress.
  - a. Insulation Density and Insulation Thickness of the section.
  - b. Corrosion allowance and Mill tolerance of the piping section and
  - c. Lining Density and Lining Thickness of the piping section.

## Appendix A

### Material Mapping DB

This release of CheckStress assigns values for material properties as given below while transferring the information of piping model from PLANT DESIGN SOFTWARE to CheckStress.

The software uses the "Piping Code" for Analysis corresponding to the value "Default" defined in the field "KpCode" of table "code" in "Codedb.mdb".

If any of the Power piping codes B31.1 (1967), B31.1 (1998), ASME Class 2 (1980, 86, 92), BS806, EN13480, RCC-M, Stoomwezen and Swedish is selected while executing the CheckStress program, the material properties stored in the material library for B31.1 (2001) (B311.mdb) are used. Similarly, if any of the Oil and Gas piping codes B31.3 (1999), B31.4, B31.5, B31.8, Norwegian (1983, 1990) CODETI, Z183 and Z184 is selected, the material properties from the B31.3 (2001) library (B313.mdb) are used to perform the stress analysis.

User is allowed to create their own material table and can use the same by modifying the code Mapping DB (code.mdb) supplied along with this software. This db contains a table with name "code" and contains four fields viz. PdCode, KpCode, KpMat and Kpsect. The first field "Pdcode" contains the name of piping codes available in Plant Design Software. The Second field "KpCode" contains the name of piping codes available in CheckStress corresponding to Plant Design Software, the third field "KpMat" defines the name of the material DB to be used during transfer and the fourth field "Kpsect" defines the name of the standard schedule table to be used during transfer. Please note, the Material DB must exist before it is used in the Code Mapping DB.

### Material DB Creation

- a. Copy the existing file (B311.mdb or B313.mdb) and rename the file with the desired name.
- b. The DB created as explained in Step a above contains four tables viz. MaterialE, MaterialS, MdetailE and MdetailS. The MaterialE and MdetailE table in the DB are used to define material properties in English units whereas MaterialS and MdetailS tables are used to define the material properties in Metric units.
- c. Replace the contents of each table with new values and save the DB. Fill the table fields with the appropriate values available depending upon the type of piping code. Other fields can be left unfilled.
- d. Enter the name of the DB created as explained above in the third field "KpMat" in the table "code" of Code Mapping DB corresponding to the CheckStress Piping Code.
- e. A sample "Code" mapping DB with "Standard Schedule" table and Material DB is given below for reference.

## Sample “Code” DB

PdCode	KpCode	Year	KpMat	Kpsect
B31.4	B314	2002	B311	STDsch
B31.5	B315	2001	B311	STDsch
B31.8	B318	2003	B311	STDsch
BS3351	BS806	1986	B311	STDsch
BS806	BS806	1986	B311	STDsch
CODETI	SNCT	1995	B311	STDsch
EN 13480	EUROPEAN	2002	B311	STDsch

## Sample Standard Schedule Table

NPD_E	NPD_M	OD	THK
0.125	4	10.287	1.7272
0.25	8	13.716	2.2352
0.375	10	17.145	2.3114
0.5	15	21.336	2.7686
0.75	20	26.67	2.8702
1	25	33.401	3.3782
1.25	32	42.164	3.556
1.5	40	48.26	3.683
2	50	60.325	3.9116

Fields in standard schedule table and their descriptions are given below in detail.

NPD_E	- Nominal Piping Diameter in Inches
NPD_M	- Nominal Piping Diameter in Millimeters
OD	- Outside Diameter in mm
THK	- Wall thickness in mm

The procedure for creating the user defined Standard Schedule Table is listed below

1. Copy the table “STDsch” and then paste it as new table in the same “codedb.mdb” by specifying a new name for the table.
2. Modify the contents of the table with the new values.
3. Open the table “Code” and then enter the “Kpsect” field with the name of the table created above corresponding to the “PdCode”. For e.g. Assuming the name of the new Standard Schedule table created as “ENSch” corresponding to “European” PdCode, change the value of field “STDsch” as “ENSch”.

Note: Incase, the value of the field “Kpsect” is not defined in the table, then the CheckStress will use the “Standard Schedule (STD)” for ANSI standard by default.

If the “Piping Code” for Analysis” is not specified or specified as “Default” in the neutral file, then the software transfer the “Piping Code” into CheckStress as the value specified in the field “KpCode” corresponding to the value “Default” in the field “Pdcode” of table “code” in “Codedb.mdb”.

For e.g., If you wish to define the “Piping Code” into CheckStress as “EN 13480” by default, then change the value corresponding to “Default” in the field “PdCode” as “European” in the field “KpCode” as shown

below and leave the year as unchanged. You can also modify the name of the material table and the standard schedule table to be used during the transfer by modifying the values in the field "KpMat" and "Kpsect". Refer "Appendix D" of for the valid "Piping Code" names.

PdCode	KpCode	Year	KpMat	Kpsect
Default	European	2006	B311	STDsch

**Sample "Material DB" (B311.mdb)**

**Sample Table "MaterialE" for English Units**

Index	Mname	Density	Nu	Joint Factor	Material Type	Tensile	CircFactor	Yield
3	A106-A	0.283	0.3	1	CS	None	None	None
4	A106-B	0.283	0.3	1	CS	None	None	None
5	A106-C	0.283	0.3	1	CS	None	None	None
24	A268-TP405	0.282	0.3	1	SS	None	None	None
25	A268-TP410	0.282	0.3	1	SS	None	None	None
26	A268-TP446	0.282	0.3	1	SS	None	None	None
13	A312-TP304	0.289	0.3	1	AS	None	None	None
14	A312-TP304L	0.289	0.3	1	AS	None	None	None
15	A312-TP304N	0.289	0.3	1	AS	None	None	None
16	A312-TP309H	0.289	0.3	1	AS	None	None	None
17	A312-TP310H	0.289	0.3	1	AS	None	None	None
18	A312-TP316	0.289	0.3	1	AS	None	None	None
19	A312-TP316L	0.289	0.3	1	AS	None	None	None
20	A312-TP316N	0.289	0.3	1	AS	None	None	None
21	A312-TP317	0.289	0.3	1	AS	None	None	None
22	A312-TP321	0.289	0.3	1	SS	None	None	None
23	A312-TP347	0.289	0.3	1	CS	None	None	None
10	A335-P11	0.283	0.3	1	CS	None	None	None
8	A335-P2	0.283	0.3	1	CS	None	None	None

**Sample Table "MdetailE" for English Units**

Mname	Temperature	E	Alpha	A-Load	Yield	Design	Proof	Rupture	fh	fCR
A106-A	-20	29900000	0.00000587	12000	None	None	None	None	None	None
A106-A	70	29500000	0.00000607	12000	None	None	None	None	None	None
A106-A	200	28800000	0.00000638	12000	None	None	None	None	None	None
A106-A	300	28300000	0.0000066	12000	None	None	None	None	None	None
A106-A	400	27700000	0.00000682	12000	None	None	None	None	None	None
A106-A	500	27300000	0.00000702	12000	None	None	None	None	None	None
A106-A	600	26700000	0.00000723	12000	None	None	None	None	None	None
A106-A	650	26100000	0.00000734	12000	None	None	None	None	None	None
A106-A	700	25500000	0.00000744	11700	None	None	None	None	None	None
A106-A	750	24900000	0.00000755	10700	None	None	None	None	None	None
A106-A	800	24200000	0.00000765	9000	None	None	None	None	None	None
A106-B	-20	29900000	0.00000587	15000	None	None	None	None	None	None

Mname	Temperature	E	Alpha	A-Load	Yield	Design	Proof	Rupture	fh	fCR
A106-B	70	29500000	0.00000607	15000	None	None	None	None	None	None
A106-B	200	28800000	0.00000638	15000	None	None	None	None	None	None
A106-B	300	28300000	0.0000066	15000	None	None	None	None	None	None
A106-B	400	27700000	0.00000682	15000	None	None	None	None	None	None
A106-B	500	27300000	0.00000702	15000	None	None	None	None	None	None
A106-B	600	26700000	0.00000723	15000	None	None	None	None	None	None
A106-B	650	26100000	0.00000734	15000	None	None	None	None	None	None
A106-B	700	25500000	0.00000744	14400	None	None	None	None	None	None
A106-B	750	24900000	0.00000755	13000	None	None	None	None	None	None
A106-B	800	24200000	0.00000765	10800	None	None	None	None	None	None

Fields in each table and their descriptions are given below in detail.

**Fields in MaterialE Table:**

- Index - Unique Material Id
- Mname - Material Name
- Density - Density of the Material in English units
- Nu - Poisson Ratio
- Joint Factor - Joint Factor of the Material
- Material Type - Type of Material
- Tensile - Tensile Strength
- CircFactor - Circular Factor
- Yield - Yield Strength

**Fields in MDetailE Table:**

- Mname - Material name
- Temperature - Material Temperature
- E - Young's Modulus
- Alpha - Alpha value for material
- A-Load - Allowable Loads
- Yield - Yield Strength
- Design - Design Factor
- Proof - Proof Stress
- Rupture - Rupture Stress
- fh - Allowable Stress at Maximum Temperature
- fCR - Allowable Creep Stress

Material properties for the two piping code B31.1 and B31.3 are available in the DB (i.e. B311.mdb and B313.mdb). User has to feed the details in both "MaterialE" and "MdetailE" for English units and "MaterialS" and "MdetailS" for metric unit for using the same with CheckStress.

## **Adding User Material to the existing Material DB**

The program takes the material details automatically from the appropriate material DB corresponding to the Plant Design Piping Code.

The program checks for the availability of material in the material DB corresponding to Piping Code. In case of unavailability of the material detail for Plant Design Section, the interface program takes the material properties corresponding to the minimum index value of the selected material DB for “Piping Code for Analysis”.

User can add their own material with the existing DB by adding the appropriate value in tables available for English as well as Metric units. For example, A53-GradeB material can be added as default material in the B31.1 piping code by adding the properties in the corresponding material table (i.e. MaterialE and MdetailE for English units or MaterialS and MdetailS for Metric units) in B311.mdb.

## **Modifying Support Type DB**

CheckStress uses the support details (entered via attributes) and its location specified in the Plant Design software for performing stress check. The values of the attributes filled at support locations shall be in accordance with the values specified in the field #1 of tables “Zvertical” and “YVertical” of “Supportyp.mdb” built into this software. The values from field #1 of table “Zvertical” shall be referred and entered at the support locations (via attributes), if the Global Vertical Axis to be used in the Stress Model is “Z”. On the other hand, values from field #1 of table “Yvertical” shall be referred and entered at the support locations (via attributes), if the Global Vertical Axis to be used in the Stress Model is “Y”.

Fortunately, the values entered/available in the field #1 of tables “Zvertical” and “Yvertical” are kept identical, because most Plant Design software always consider the vertical direction as Z-axis. On the other hand, pipe stress engineers in different parts of the world use either z-axis as vertical or Y-axis as Vertical. So, the values entered in the field “CaepipeCode” are different for “Zvertical” and “Yvertical”. CheckStress always uses the value entered in the field “CaepipeCode” corresponding to the value entered in field “PDSupport”, for its internal stress calculations.

User can modify the values available in the field “PDSupport” of tables “Zvertical” and “Yvertical” to suit their requirements. It is recommended to keep the values entered in the field “PDSupport” of tables “Zvertical” and “Yvertical” identical as much as possible. This will help to avoid the user in reentering/changing the values at support locations for different Global Vertical Axis.

**Warning: Changing the values available in the field “CaepipeCode” without understanding the meaning of such support may lead to malfunction of the program. Refer to Appendix F of this manual for details on entering/modifying the values in the field “CaepipeCode”.**

## Appendix B

### Plant Design – CheckStress Component Mapping

The type of component available in Plant Design is mapped in CheckStress as tabulated below.

<b>Type of Component in Plant Design</b>	<b>Type of Component in CheckStress</b>
Rigid Components	Rigid Elements
Valves	Valves
Instruments	Rigid Elements
Elbows	Bends
Flanges	Flanges
Piping Types	Pipes
Supports	Hangers/Supports
Reducers	Reducers
Olets	WeldOlet
Welding Tees	Welding Tees
Reinforced Tees	Reinforced Tees
Unreinforced Tees	Unreinforced Tees
Welds	Welds
Cross	Welding Tees`

## Appendix C

### Errors and Descriptions

This Appendix presents the list of errors, their descriptions and the necessary actions to be taken.

#### **“Enter all the Necessary Data and Proceed”**

User has to enter the neutral file name, model batch file name and has to select hanger type from the hanger list.

#### **“Piping code B (n) is not available in the library”**

The “Piping Code for Analysis” for CheckStress corresponding to Plant Design Software is not available in the “code.mdb”. Program lets the user to select the piping code from the list.

#### **“Wrong Neutral File or Wrong MBF file given”**

This may occur, if the user enters the wrong file name or invalid path in the neutral file or model batch file field.

#### **“Select the Piping code”**

User has to select the default piping code available in the piping code list.

#### **“Element (Element\_Name) corresponding to the unique ID (Id Number) not found in the component table. Contact program vendors for more details”**

The element name is a piping component short code (max 4 char) described in to the component DB which identifies the type of component such as Pipe, Rigid Elements, Instruments etc., and their connection point details. The above said error message occurs, If the neutral file contains such short code which is not available in the component DB. At this time, the user is not allowed to add such details in to the component DB as it may lead to prevent the interface from working in case of any wrong entry. Hence the same can be added by notifying such component type and their details to the program vendor.

#### **“Information.txt not found. Program creates this file by restarting the application.”**

Program reads certain information from the file ‘Information.txt’ and hence pops up error message upon unavailability of this file.

#### **“Invalid file ‘Information.txt’. Restart the application to resume it.”**

Occurs, if the user modifies the content of this file.

#### **“The bore value is given as ‘<STRING>’ in the neutral file for unique ID (ID number)”**

Occurs, if the bore value is a string.

#### **“The UNIT section is not available in Neutral file. Check neutral file and proceed.”**

Occurs, if the record section “UNITS <Length\_Units> and <Weight\_Units>” (e.g. UNITS, IN, KG) which describe the length and weight measurement unit is not available in the neutral file.

#### **“The Bore value ‘Bore\_Value’ given in neutral file for unique ID (ID number) is not available in standard bore table.”**

Program tries to get the OD and Thickness of piping section from the standard table for the corresponding nominal size, in case, if the same is not available in the neutral file. This error occurs if the nominal size in the standard schedule table is not available.

## Appendix D

### Valid Piping Code

<b>Piping code</b>	<b>Description</b>
B311	ANSI B31.1
B311-67	USAS B31.1 (1967)
B313	ANSI B31.3
B314	ANSI B31.4
B315	ANSI B31.5
B318	ANSI B31.8
ASME	ASME Section III, Class 2 (1980)
ASME-86	ASME Section III, Class 2 (1986)
ASME-92	ASME Section III, Class 2 (1992)
BS806	British code
NORWEGIAN-83	Norwegian code (1983)
NORWEGIAN-90	Norwegian code (1990)
RCC-M	French code (1985)
SNCT	CODETI (1995)
SWEDISH	Swedish code (1978)
STOOMWEZEN	Dutch code (1989)
Z183	Z183 (1990)
Z184	Z184 (1992)
EUROPEAN	EN 13480 (2002)

## Appendix E

### Sample Problems and Solutions using CheckStress

This Appendix provides a few sample layouts (specifically, Sample 1, Sample 2, Sample 3 and Sample 5) to illustrate how bends, offsets, loops, axial restraints and/or intermediate anchors are used to reduce thermal stresses in piping (and resulting nozzle loads).

Sample 4 and Sample 5 illustrate how piping can be supported by spring hangers and resting steel supports to comply with the code requirements for sustained loads.

The CAEPIPE model files created using CheckStress for the sample problems listed in Appendix E are stored in the directory CheckStress\_installation\_path\Samples for reference.

#### **Sample: 1 (Loop\_00 and Loop\_01)**

This problem illustrates the use of expansion loops to reduce thermal stresses.

A 8" NB Schedule 80 pipe (see Fig. 1A) connects two equipment at nodes 10 and 30 with an offset of 4' (i.e., equal to distance between nodes 20 and 30). The pipe is of A53 Grade A carbon steel and is heated to 300 ° F.

Pipe between nodes 10 and 20 grows thermally to the right towards node 20, while pipe between nodes 30 and 20 grows up towards node 20, as illustrated in Fig. 1B.

This thermal deformation generates large thermal stresses (orange and red zones) in the bend at node 20 and at anchor node 30, as shown in Fig. 1C.

Fig.1D shows a revised layout with a loop, introducing 2 additional bends at nodes 14 and 18, thereby making the layout more flexible. So, thermal growth of X-directional pipes between nodes 10 and 14 and then between 18 and 20 as well as the growth of Z-directional pipe between nodes 30 and 20 are absorbed by the 3 bends at nodes 14, 18 and 20.

The corresponding stress contour plots for thermal and sustained load cases are shown in Fig.1E and Fig. 1F, confirming code compliance.

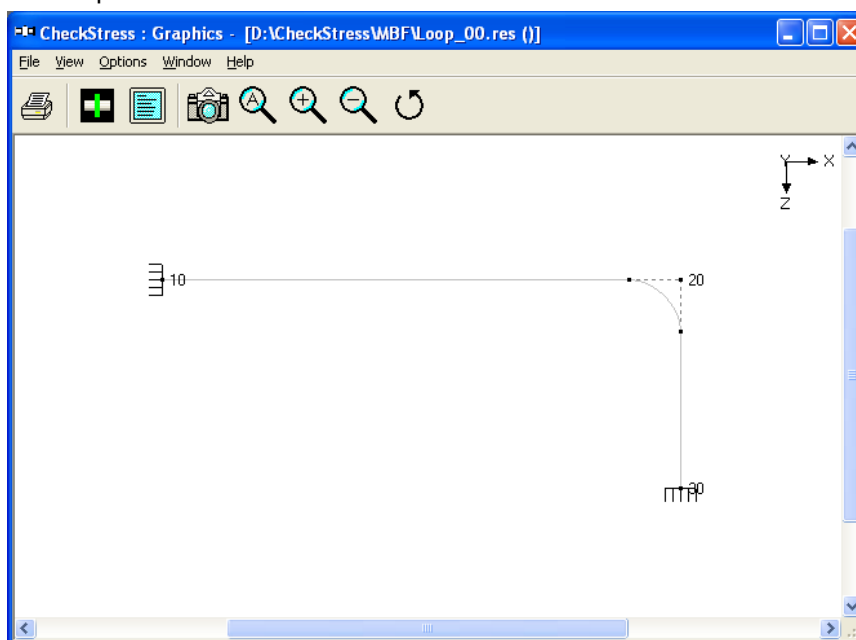


Fig. 1A. Layout with Node Numbers

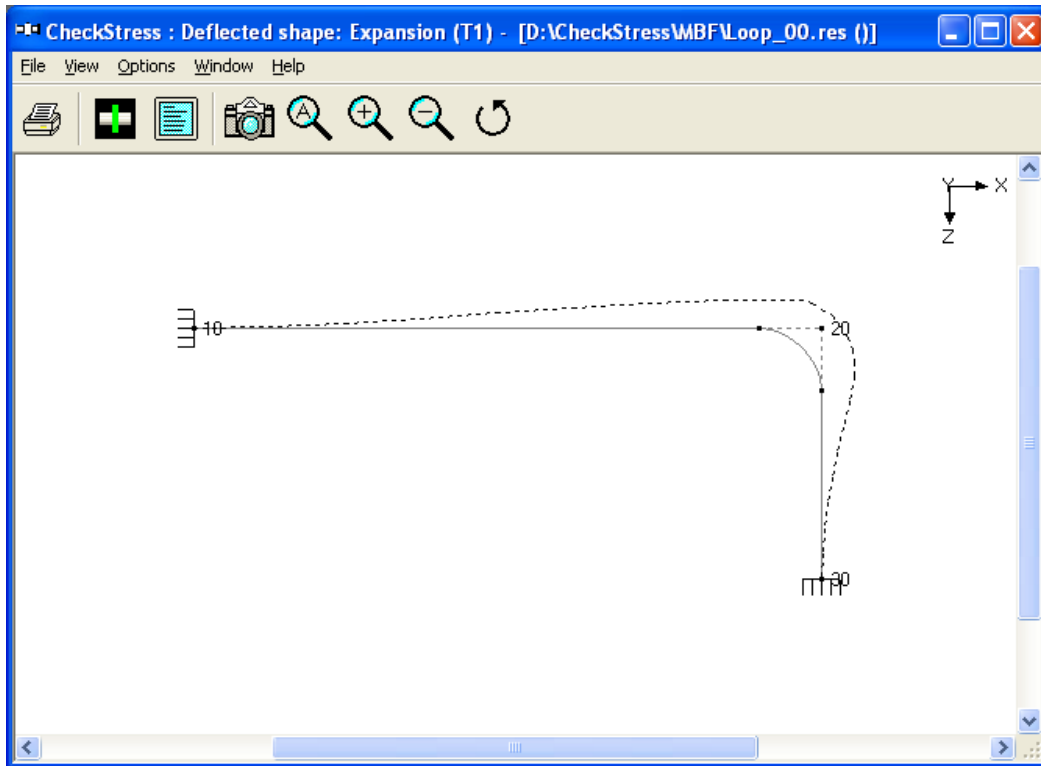


Fig. 1B Thermal Deformation Plot

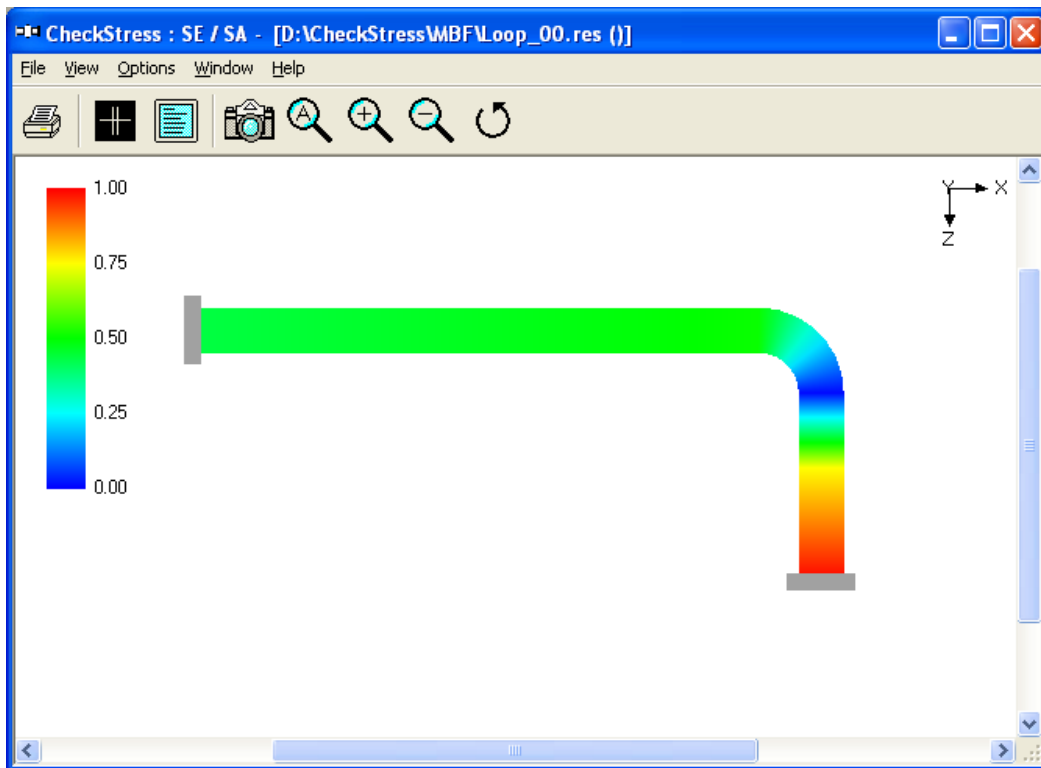


Fig. 1C Thermal Stress Contour Plot

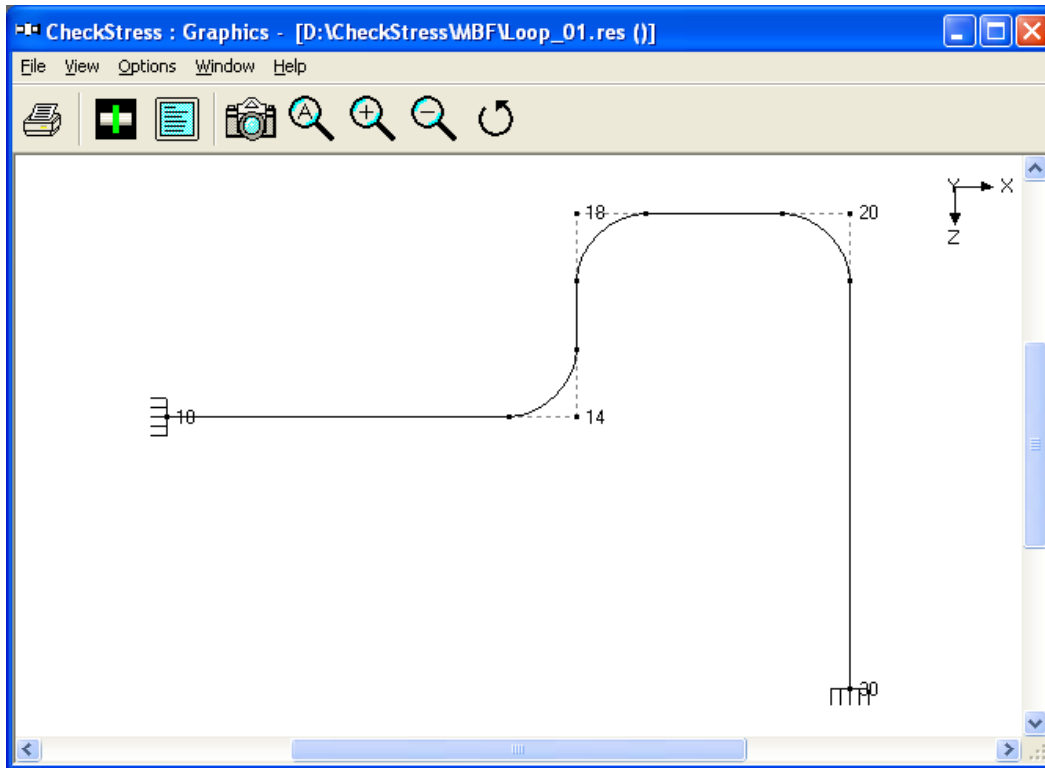


Fig. 1D Revised Layout with Node Numbers

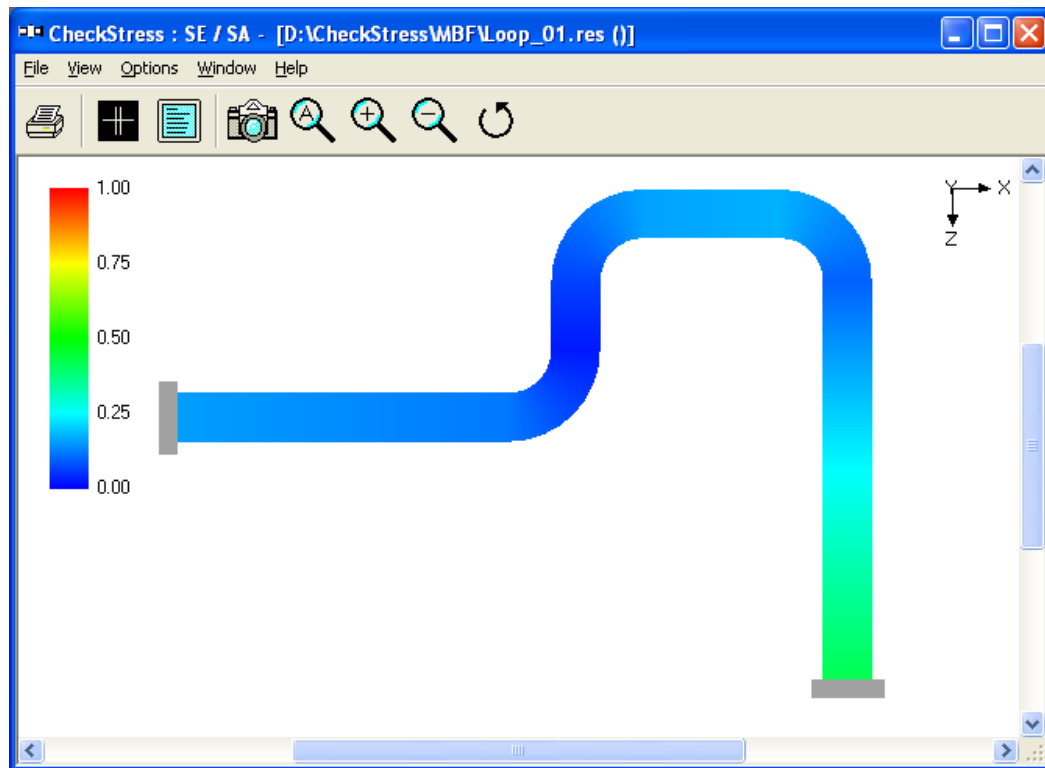


Fig. 1E Thermal Stress Contour Plot

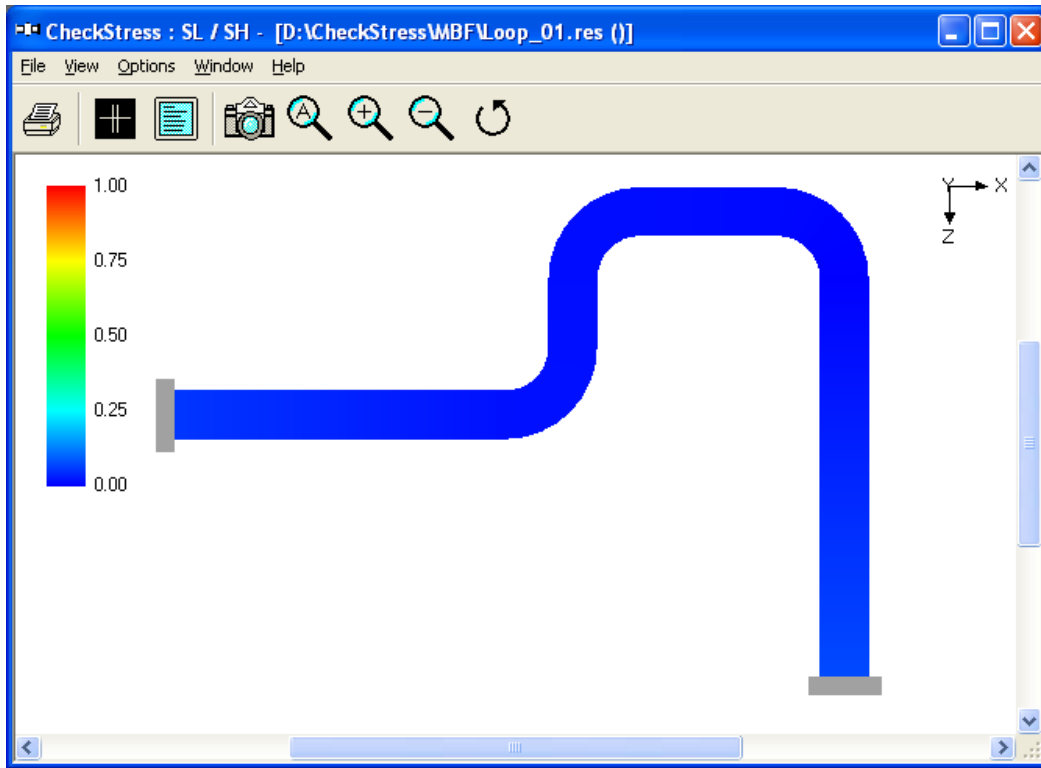


Fig. 1F Sustained Stress Contour Plot

### Sample: 2 (IntermediateAnchor 00 and 01)

This system shown in Fig. 2A is made of 3 pipe sizes, 4" NB Schedule 40 between the anchor node 10 and the first reducer starting at node 50, 6" NB Schedule 40 between the first reducer and the second reducer ending at node 90, and 8" Schedule 40 between the nodes 90 and anchor node 130. The system temperature is 470<sup>o</sup> F.

Since the loop between nodes 10 and 40 is much more flexible (as it is made of 4" NB pipe) than the loop between nodes 100 and 130, the straight pipe between nodes 40 and 100 will thermally grow mostly towards the 4" NB loop, as shown in Fig. 2B, straining the pipe between nodes 10 and 40; this, in turn, produces large thermal stresses (i.e., orange and red zones) in the 4" NB loop and at anchor node 10, as observed in Fig. 2C. In other words, the thermal growth of pipe between nodes 40 and 100 is mostly absorbed by the 4" NB loop and very little by the 8" NB loop, defeating the very purpose of the 8" NB loop.

In order to alleviate thermal stresses in the 4" NB loop, introduce an intermediate anchor at node 95 immediately after the second reducer, so that the thermal growth of straight pipe from node 95 to node 100 is absorbed by the 8" NB loop, while the thermal expansion of straight pipe between nodes 40 and 95 is absorbed by the 4" NB loop, thereby making both loops achieve their intended purpose. The corresponding thermal displacement and thermal stress contour plots are given in Fig. 2D and Fig. 2E respectively.

Fig. 2F confirms that for the deadweight of piping under operating condition, the present configuration with only two equipment nozzles at nodes 10 and 130 and an intermediate anchor at node 95 safely meet the code stress requirement for sustained load.

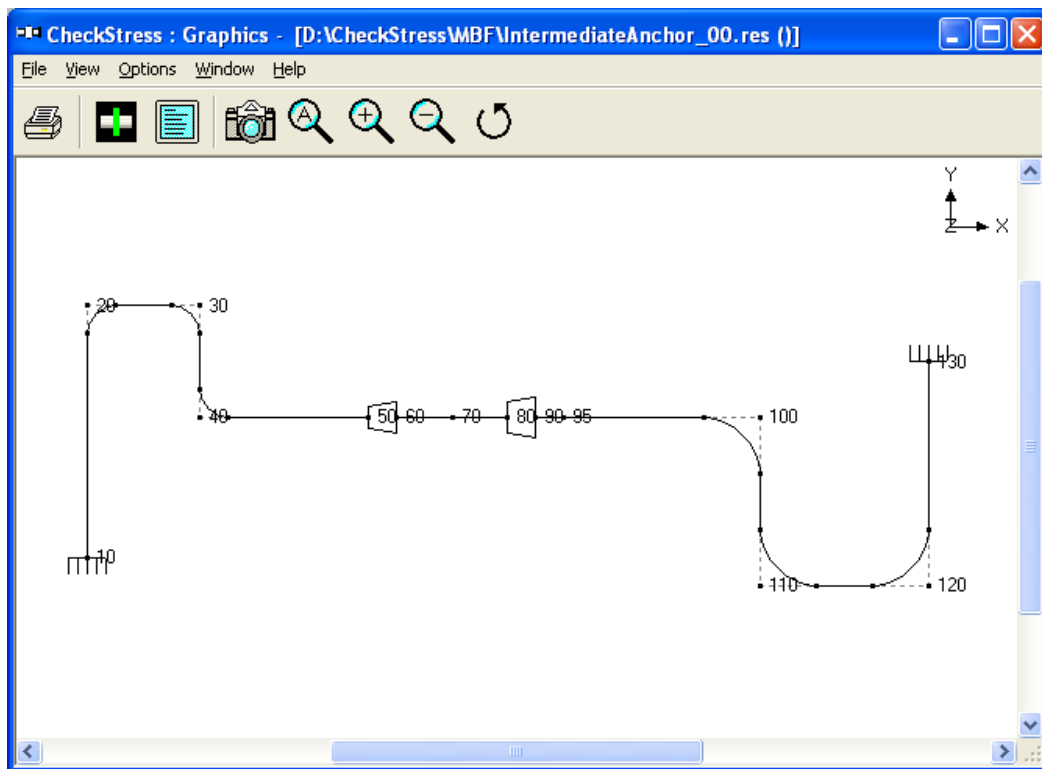


Fig. 2A Layout with Node Numbers

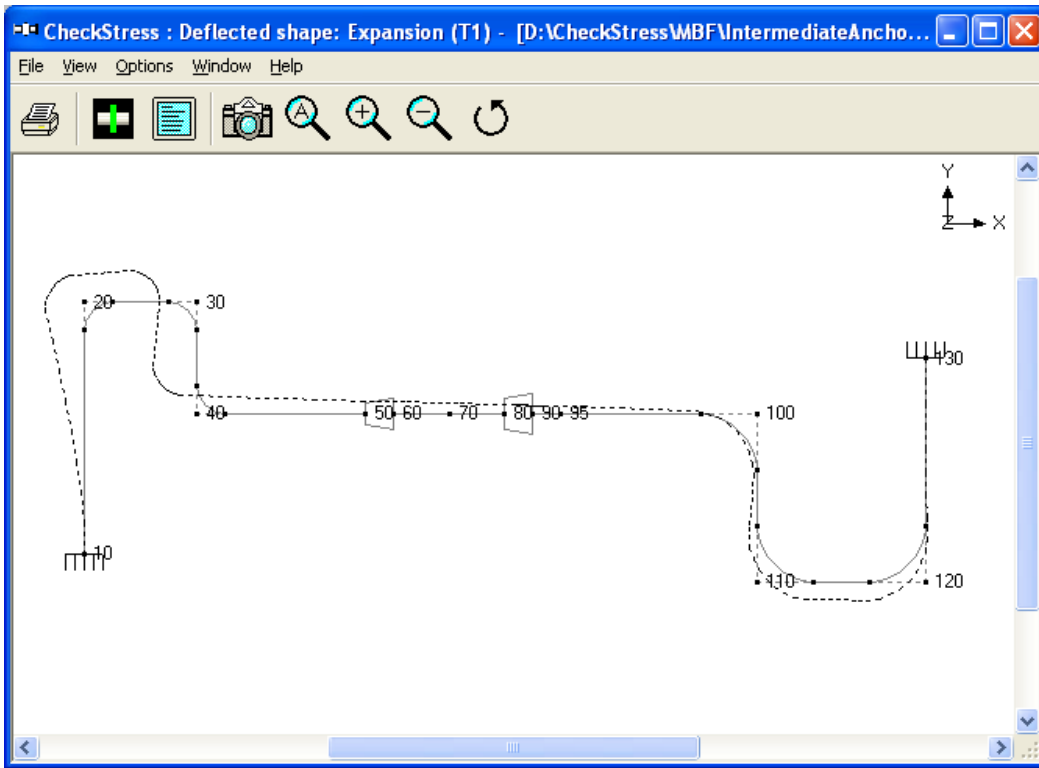


Fig. 2B Thermal Deformation Plot

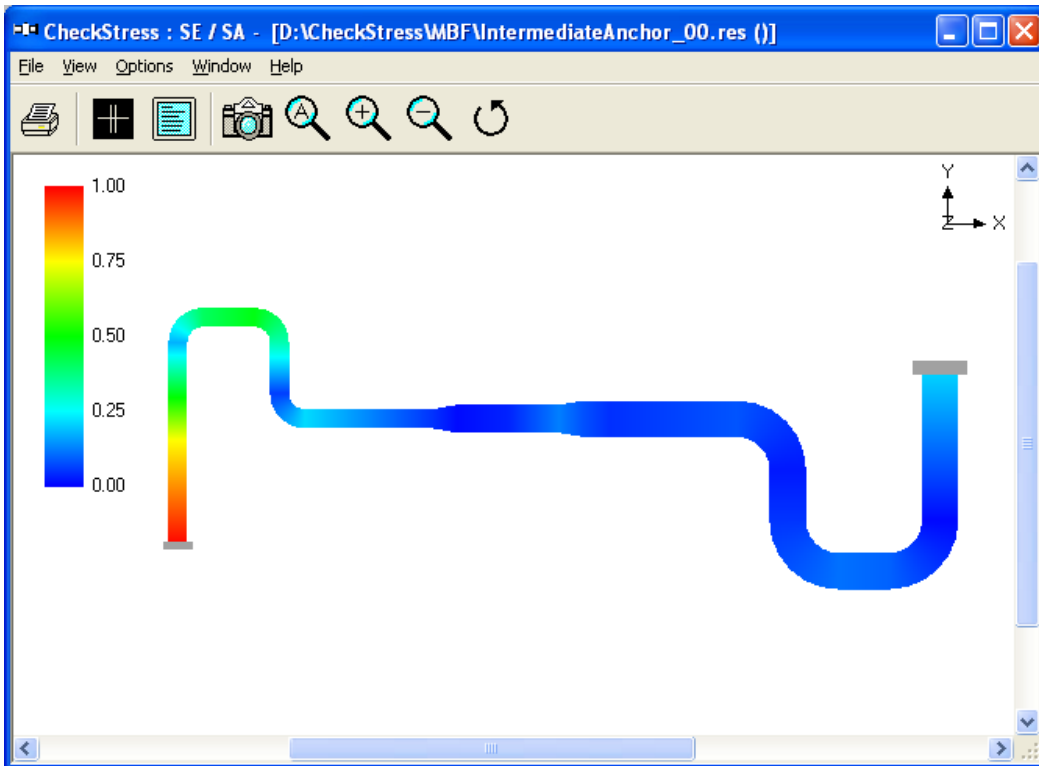


Fig. 2C Thermal Stress Contour Plot

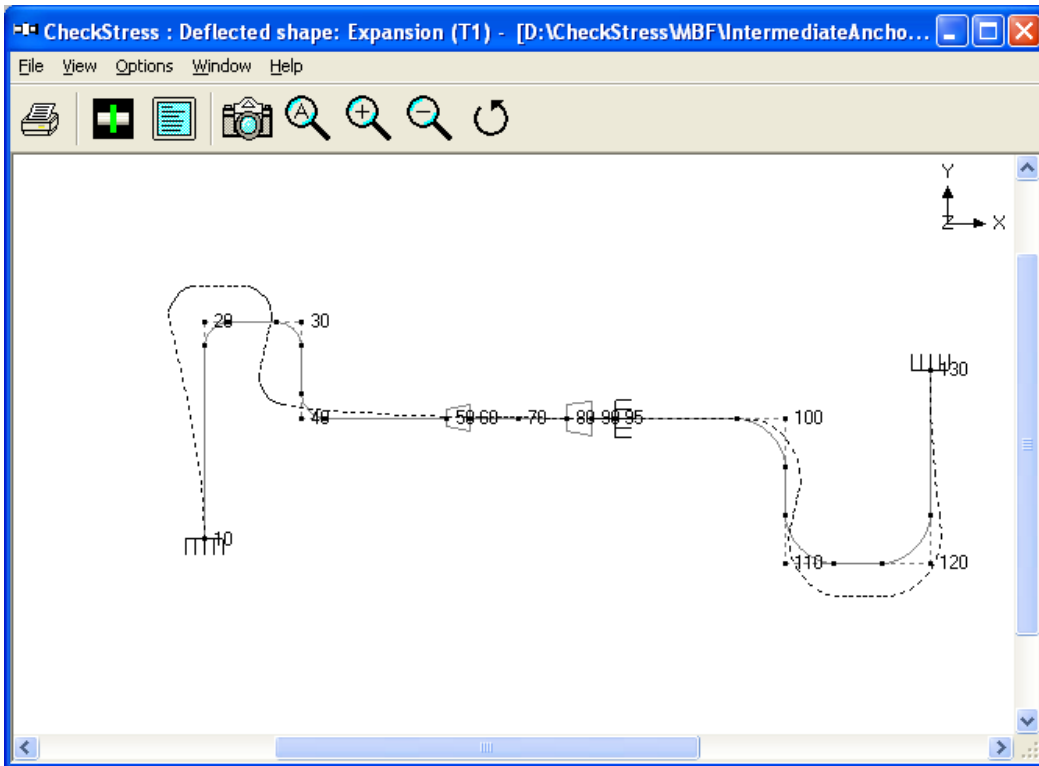


Fig. 2D Thermal Deformation Plot for Layout with Intermediate Anchor

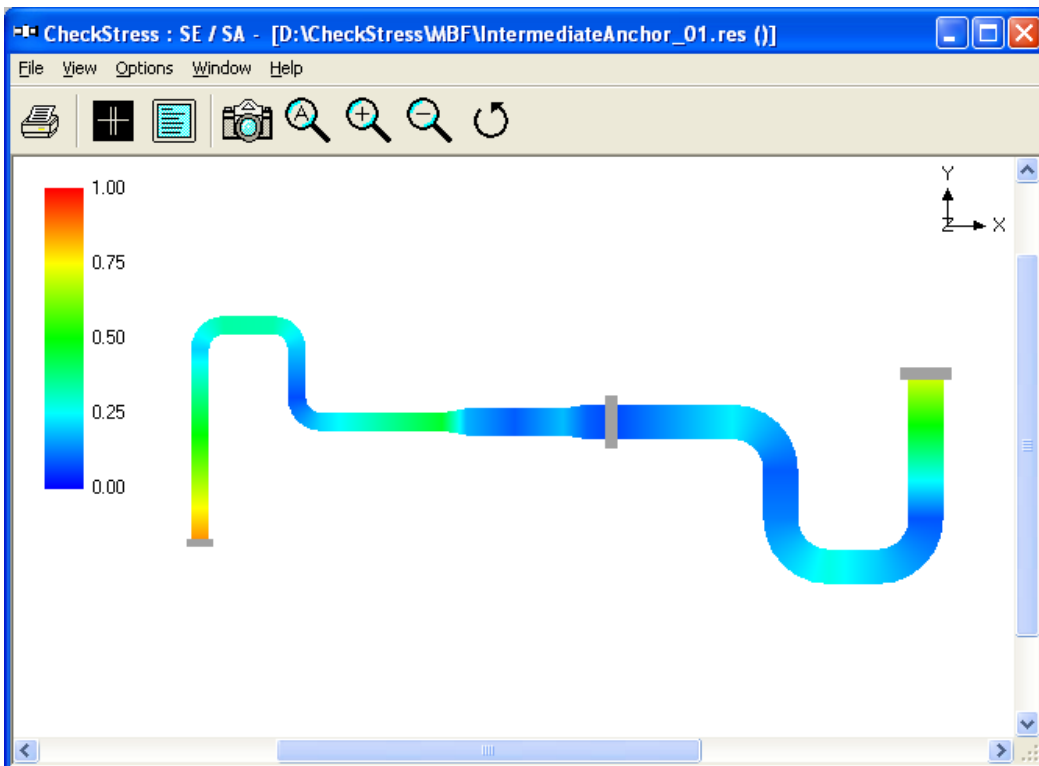


Fig. 2E Thermal Stress Contour Plot for Layout with Intermediate Anchor

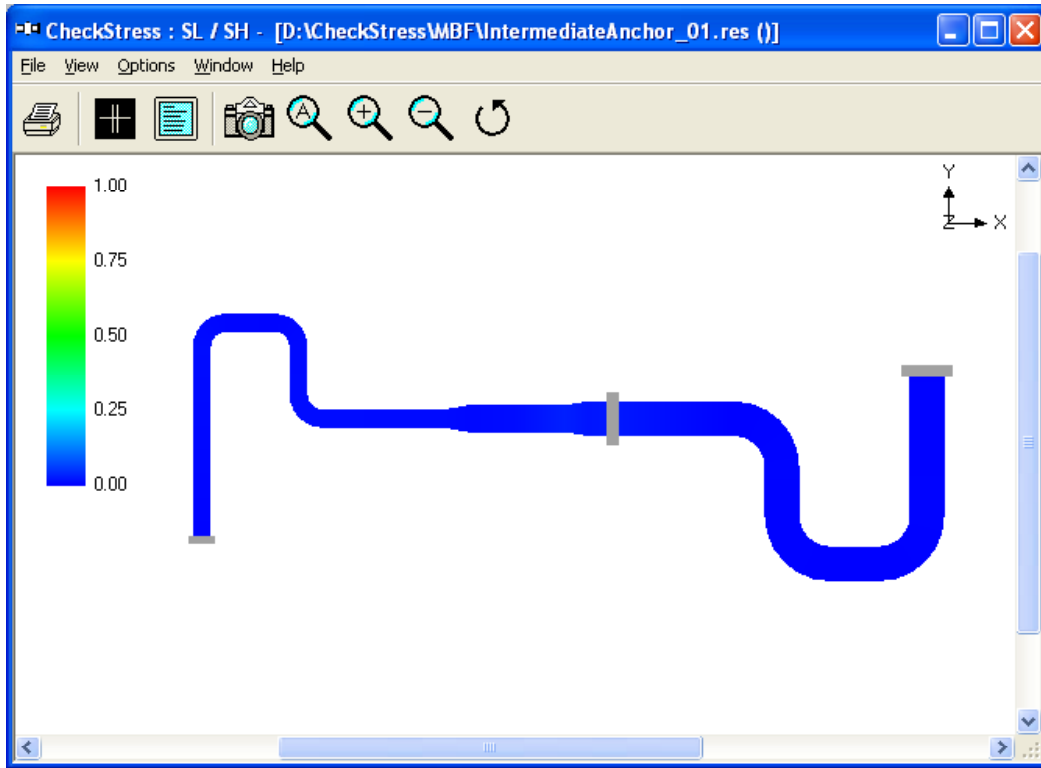


Fig. 2F Sustained Stress Contour Plot for Layout with Intermediate Anchor

### Sample: 3 (AxialSupport\_00 and 01)

This problem shows how axial restraints (i.e., supports that prevent movement in the pipe axial direction) can be effectively used to direct thermal growth towards expansion loops and to split thermal growth in a line such that the two piping portions grow in opposing directions.

Fig. 3A shows the same problem as in Fig. 2D, with a 6" NB branch line added at the welding tee at node 70 (i.e., from node 70 to node 240).

The deformed geometry for thermal load is shown in Fig. 3B, where it is observed that the tee node 70 does not move up in +Y-direction. Since the intermediate anchor at node 95 restrains the vertical riser (between bend node 220 and tee node 70) from thermally growing upward towards node 70, this riser grows downward producing large bending moments and stresses at and around equipment nozzle at node 240; in addition, since the upward growth of this vertical riser is effectively restrained at the tee node 70 due to presence of intermediate anchor at node 95, large localized thermal stress is generated at the welding tee. This is observed in the thermal stress contour plot given in Fig. 3C.

Fig. 3D shows the same piping system with the intermediate anchor replaced by two axial restraints; the axial restraint in the horizontal line at node 95 splits and directs its thermal growth towards the 4" NB and 8" NB loops and does permit the horizontal line to move up in +Y-direction at tee node 70, whereas the axial restraint at node 210 splits the thermal growth of the vertical riser between nodes 220 and 70. From the thermal deformation plot given in Fig. 3E, it is observed that such that much less forces and moments and hence stresses would be generated at the equipment nozzle node 240 and welding tee node 70. Fig. 3F and Fig 3G show the thermal stress and sustained stress (in this case sustained stress is due to only deadweight as pressure is zero) contour plots, confirming code compliant system for both loading cases.

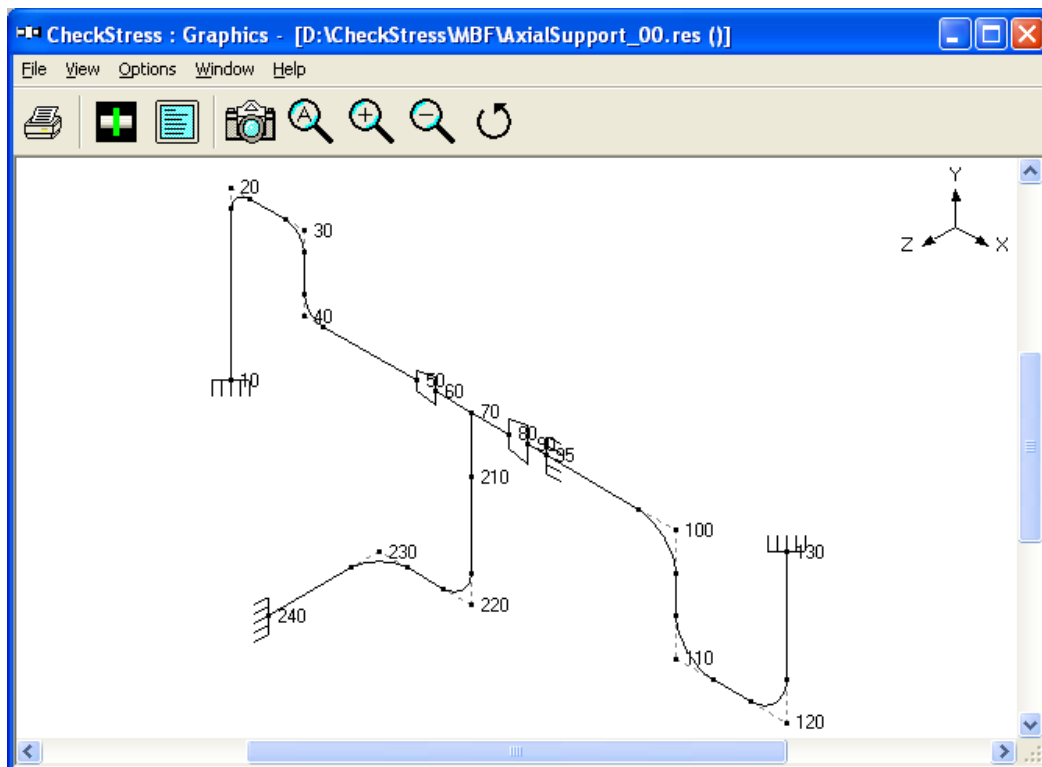


Fig. 3A Layout with Intermediate Anchor at Node 95

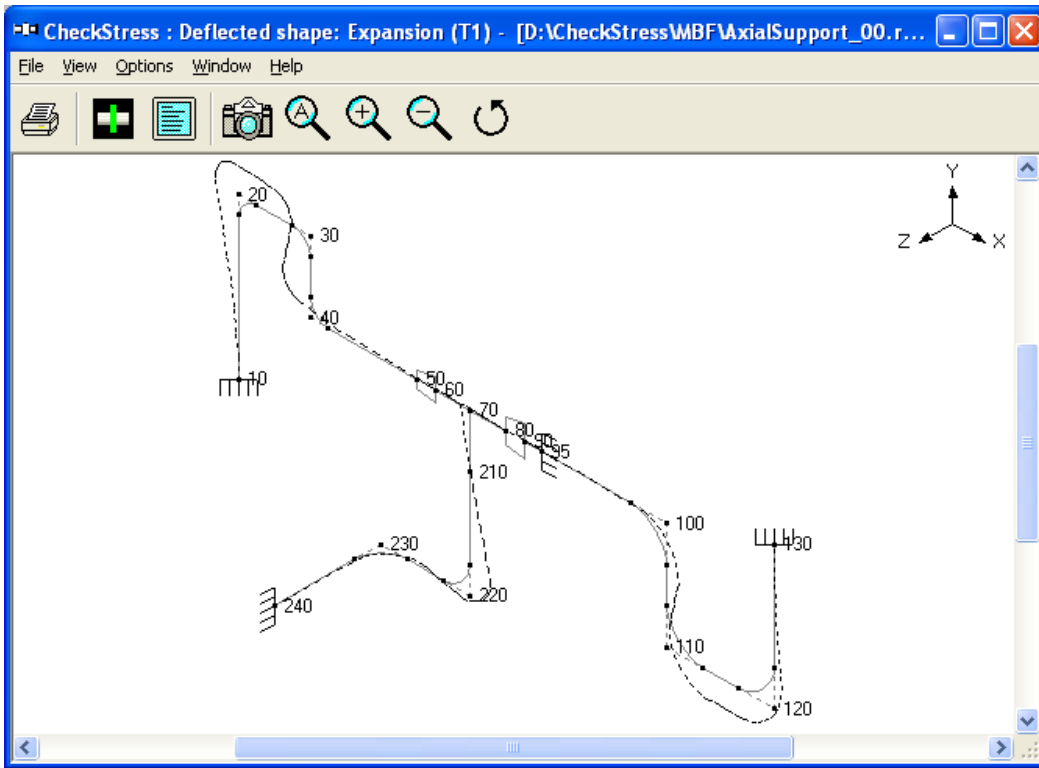


Fig. 3B Thermal Deformation Plot

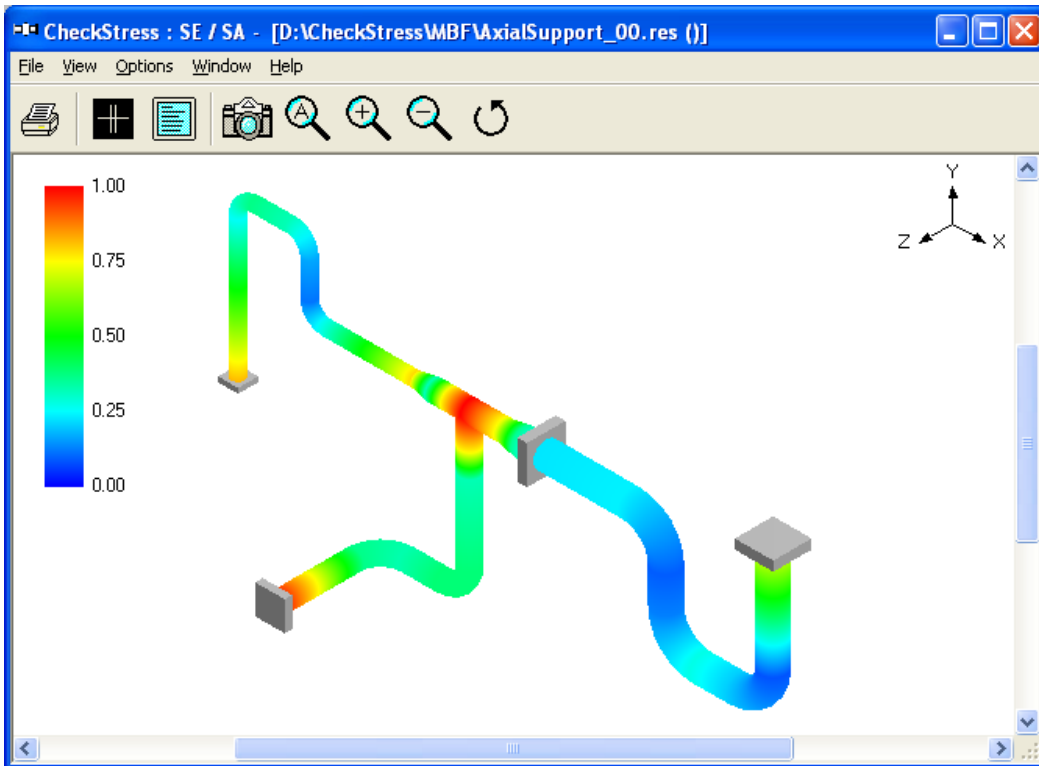


Fig. 3C Thermal Stress Contour Plot

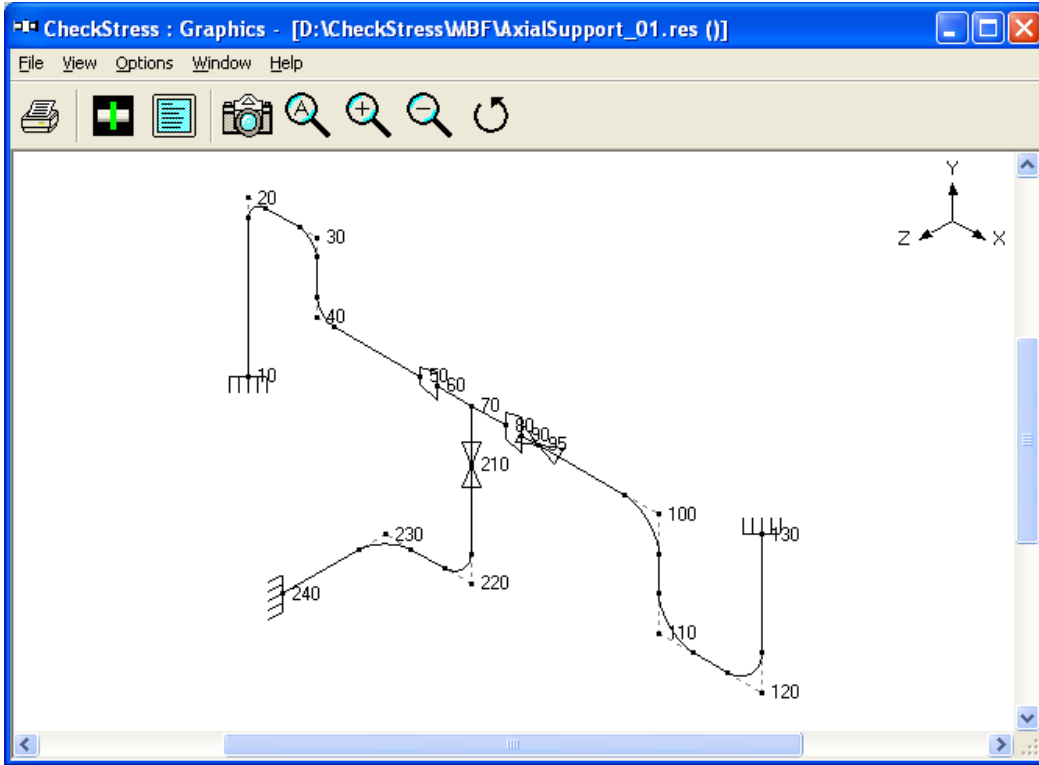


Fig. 3D Layout with Axial Restraints at Node 95 and 210

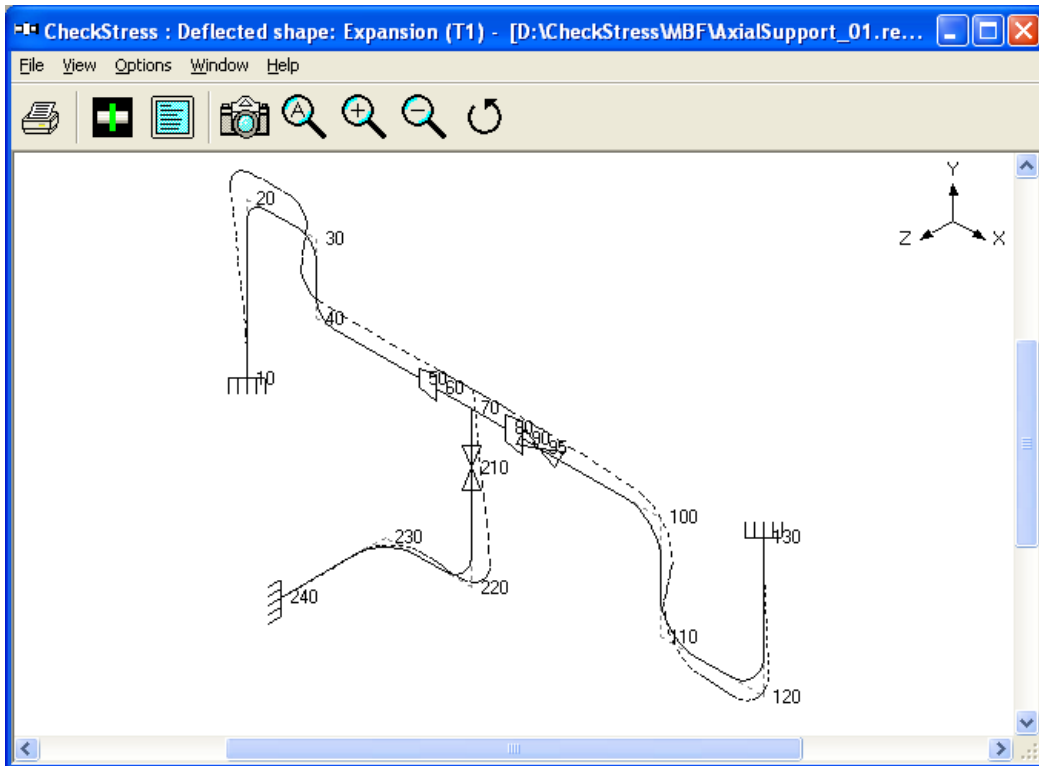


Fig. 3E Thermal Deformation Plot for Layout with Axial Restraints

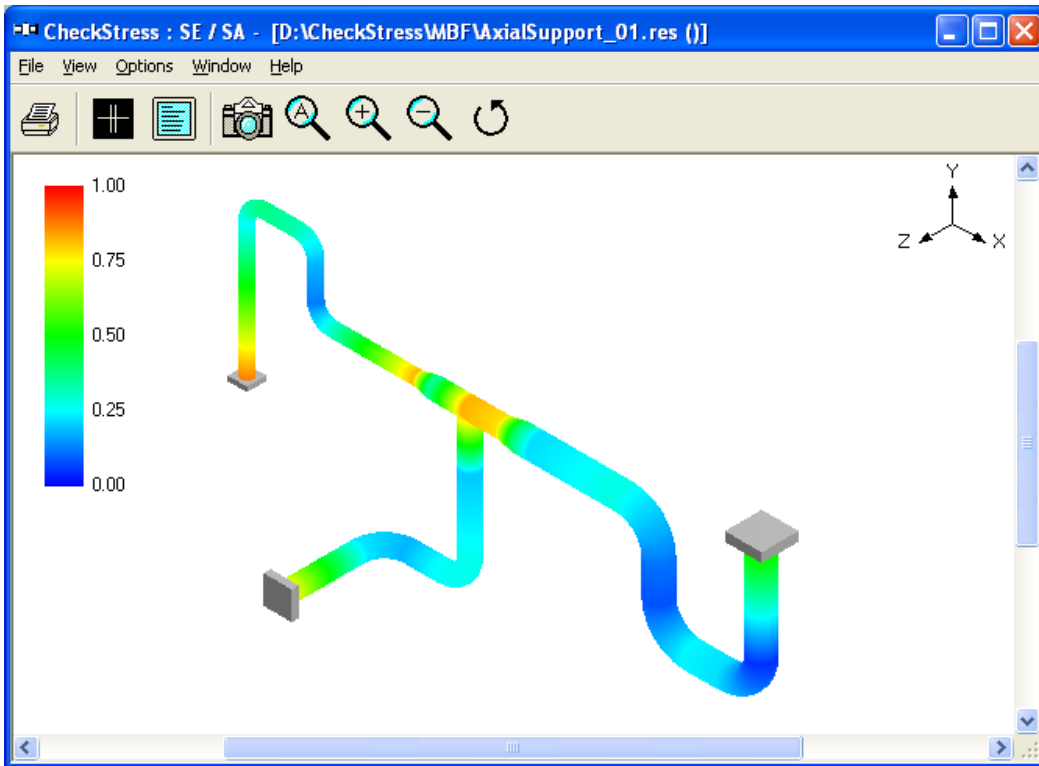


Fig. 3F Thermal Stress Contour Plot for Layout with Axial Restraints

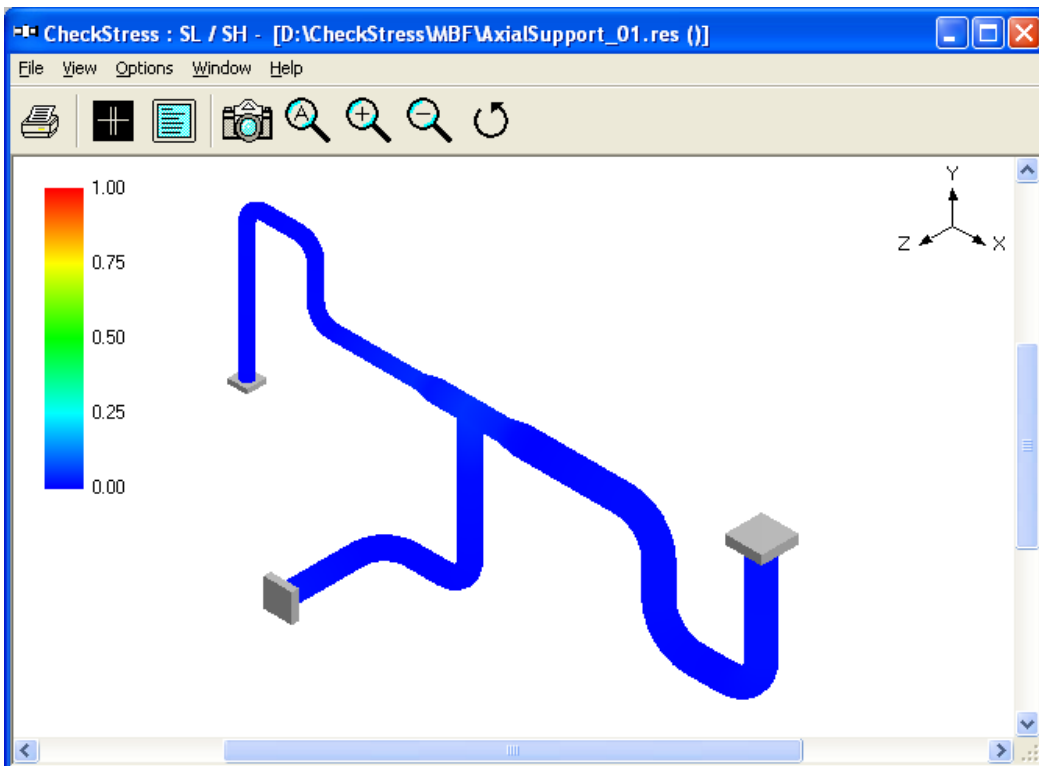


Fig. 3G Sustained Stress Contour Plot for Layout with Axial Restraints

#### **Sample: 4 (WeightSupports\_00 and 01)**

This problem illustrates how to select and locate vertical supports to carry piping deadweight at operating condition.

Fig. 4A shows a practical problem with 10" NB Standard schedule pipe from equipment nozzle at node 5 upto the reducer starting at node 30, 8" NB Standard schedule pipe from this reducer to the pump nozzle at node 40, and a 6" NB Standard schedule branch line from the welding tee at node 25 to the equipment nozzle at node 125.

The thermal stress contour plot given in Fig. 4B confirms that the piping system is highly flexible and hence meets the code requirement for thermal load. Fig. 4C shows the deflected shape for sustained load (i.e., mainly deadweight). It is observed that the weight of (i) the horizontal line from node 5 to node 15 and (ii) a major portion of the vertical riser from node 15 to node 20 is carried by the equipment nozzle at node 5; on the other hand, the pump nozzle at node 40 carries the weight of (i) the horizontal line from node 20 to node 40, (ii) the valve portion of the branch line from node 25 to node 125 and (iii) a small portion of the vertical riser from node 15 to node 20. The deformation response for deadweight, in turn, generates large forces and moments and hence large sustained stresses at nozzle nodes 5 and 40 as shown in Fig. 4D for sustained stress contour plot.

Fig. 4E shows the same layout with variable spring hangers attached at the bends at nodes 20 and 115, which carry piping deadweight and provide negligible restraint to thermal movement from cold to hot condition and vice versa.

The thermal stress and sustained stress contour plots given in Fig. 4F and Fig. 4G confirm that the piping system with hangers is code compliant for both sustained and thermal load cases.

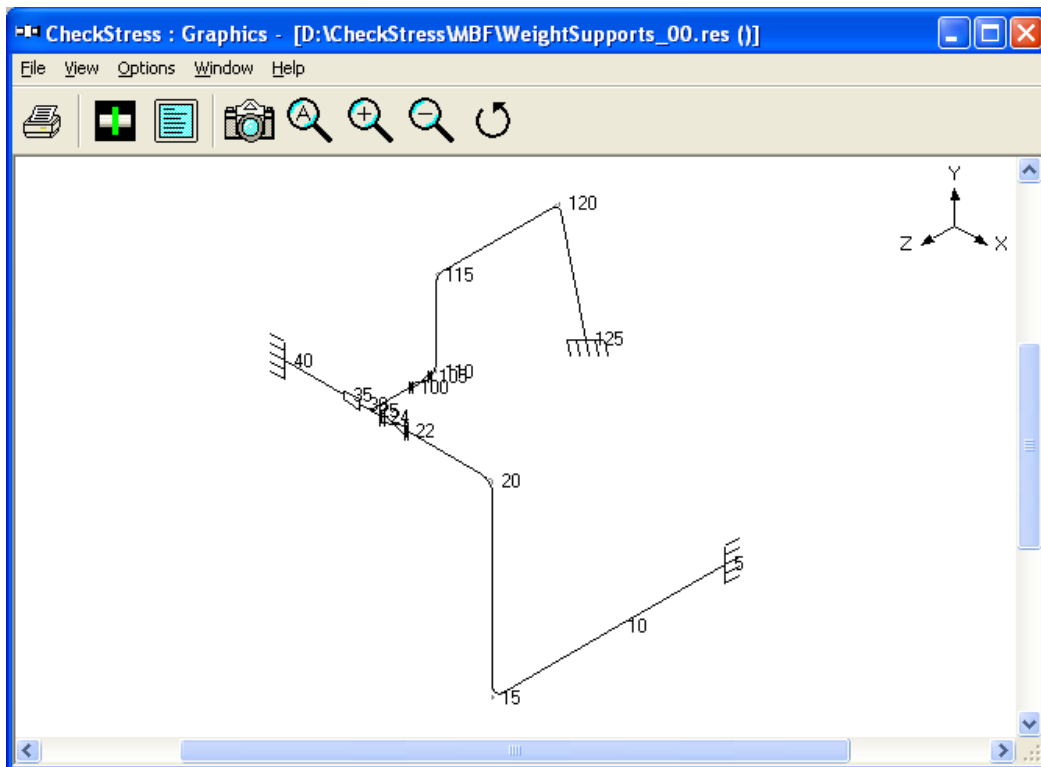


Fig. 4A Layout with Node Numbers

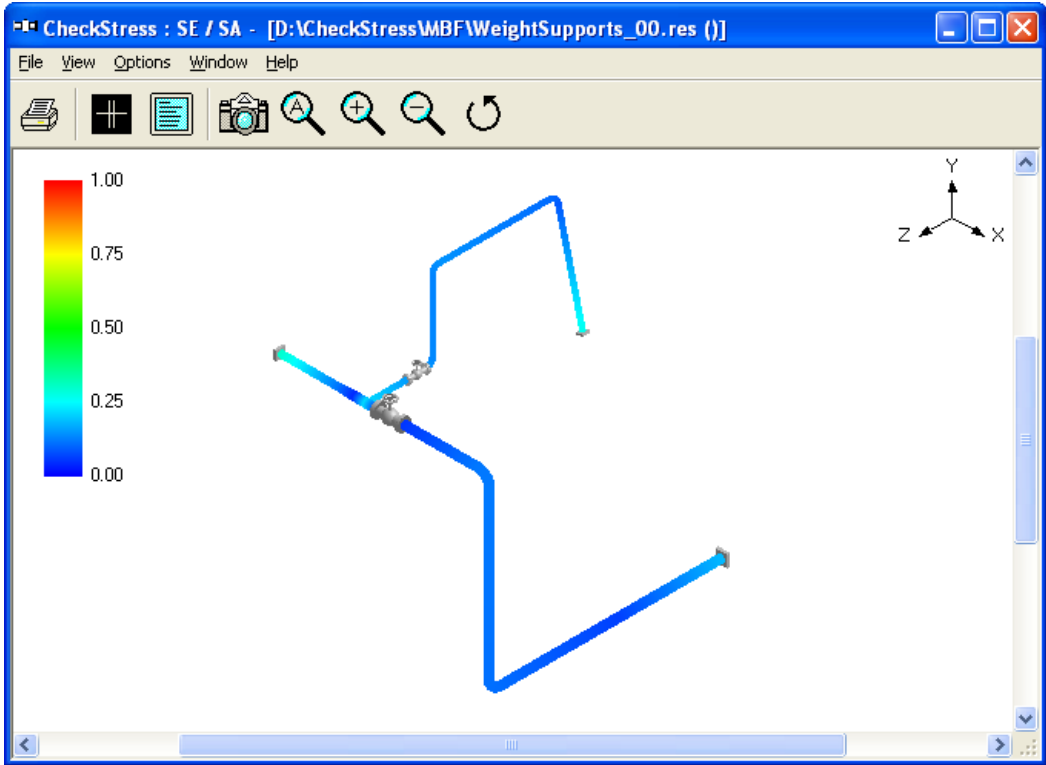


Fig. 4B Thermal Stress Contour Plot

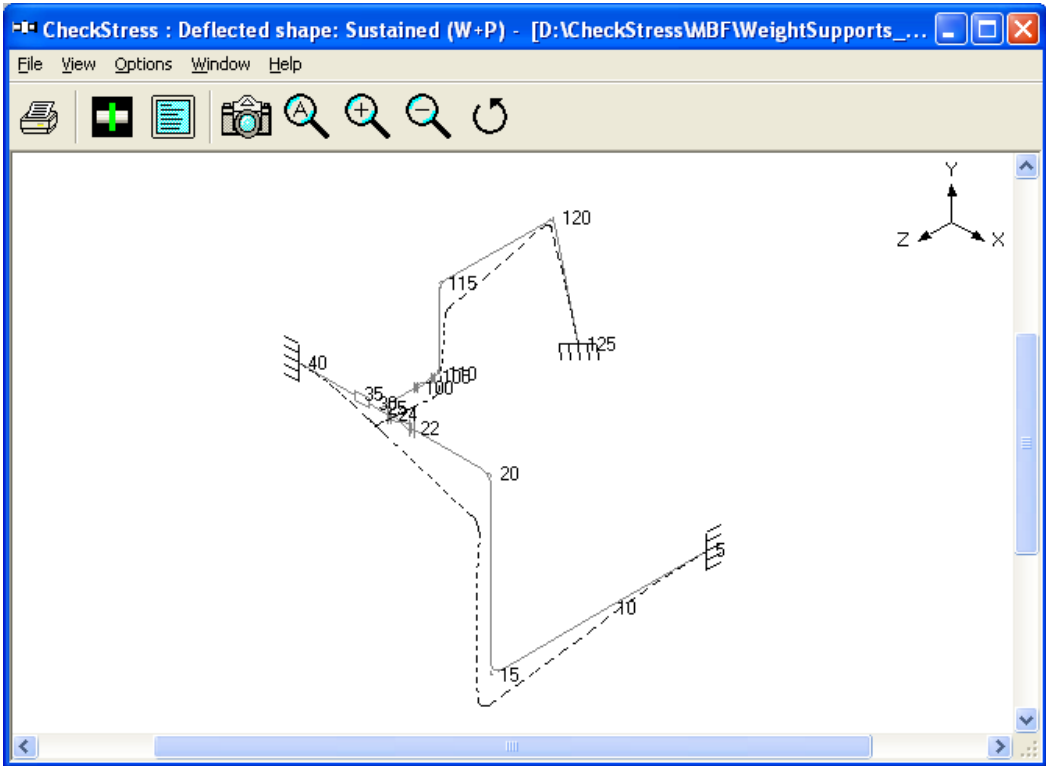


Fig 4C Sustained Load Deflected Shape

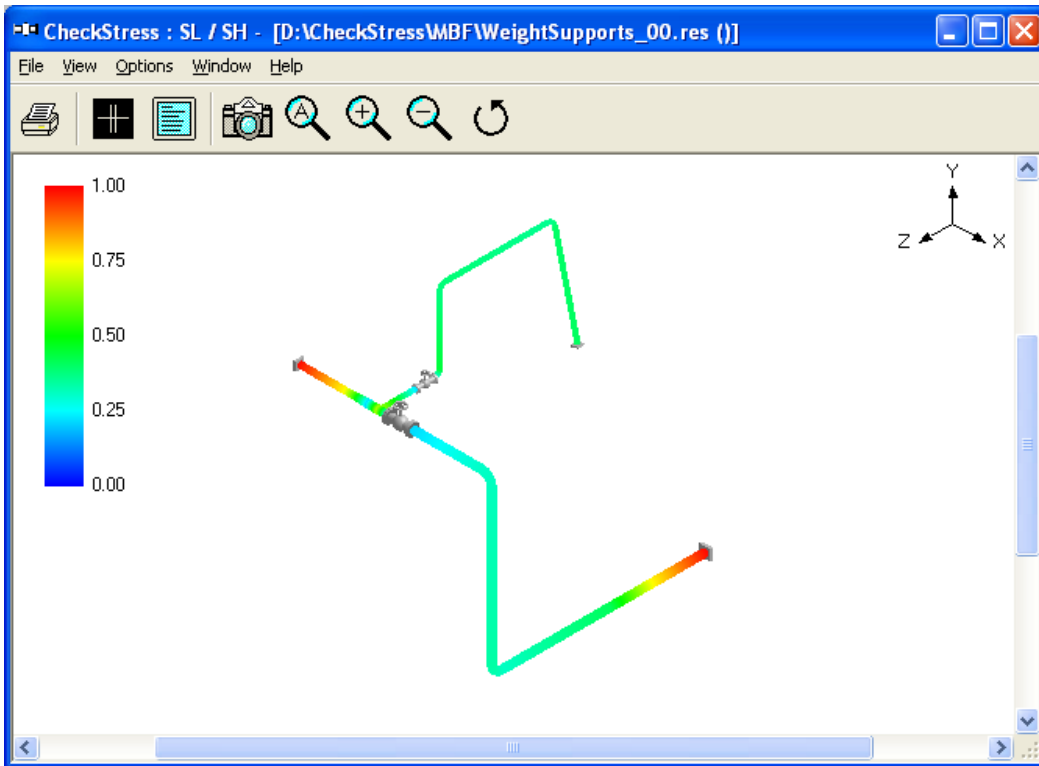


Fig. 4D Sustained Stress Contour Plot

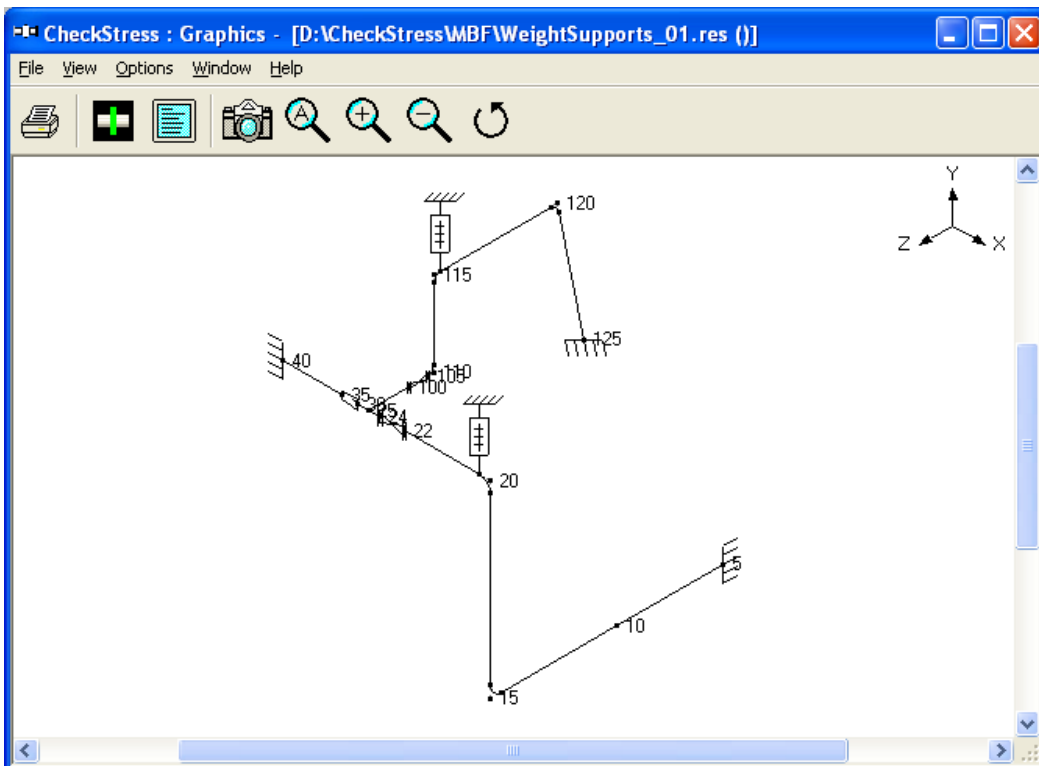


Fig. 4E Layout with Hangers

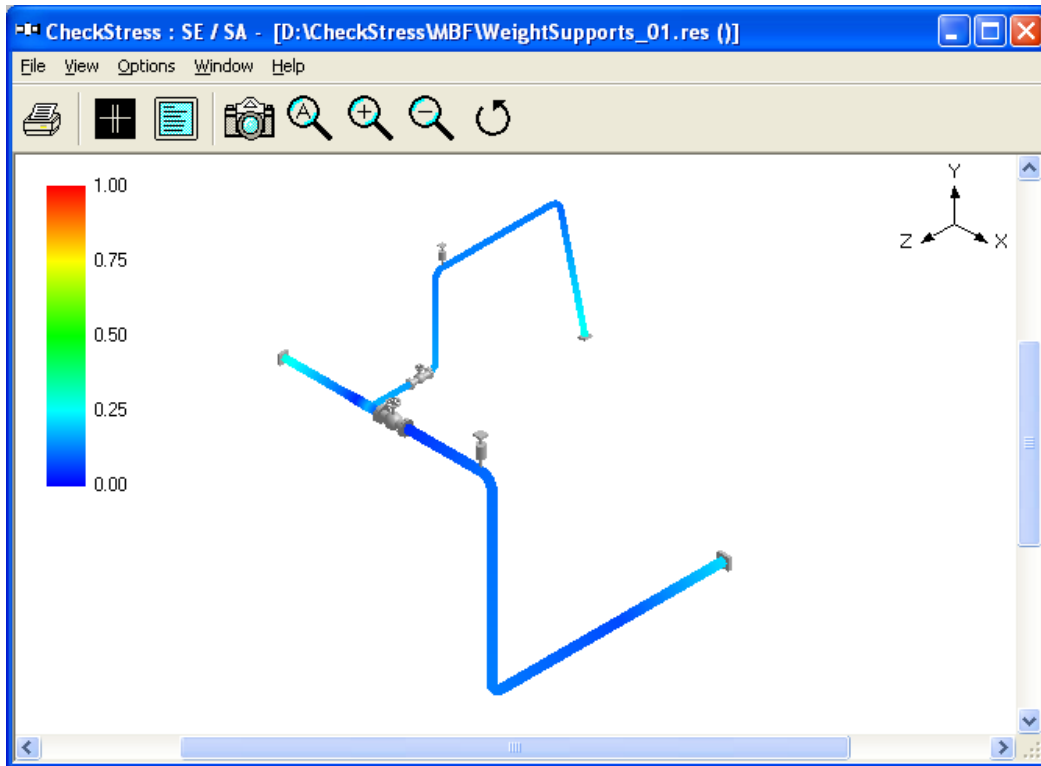


Fig. 4F Thermal Stress Contour Plot for Layout with Hangers

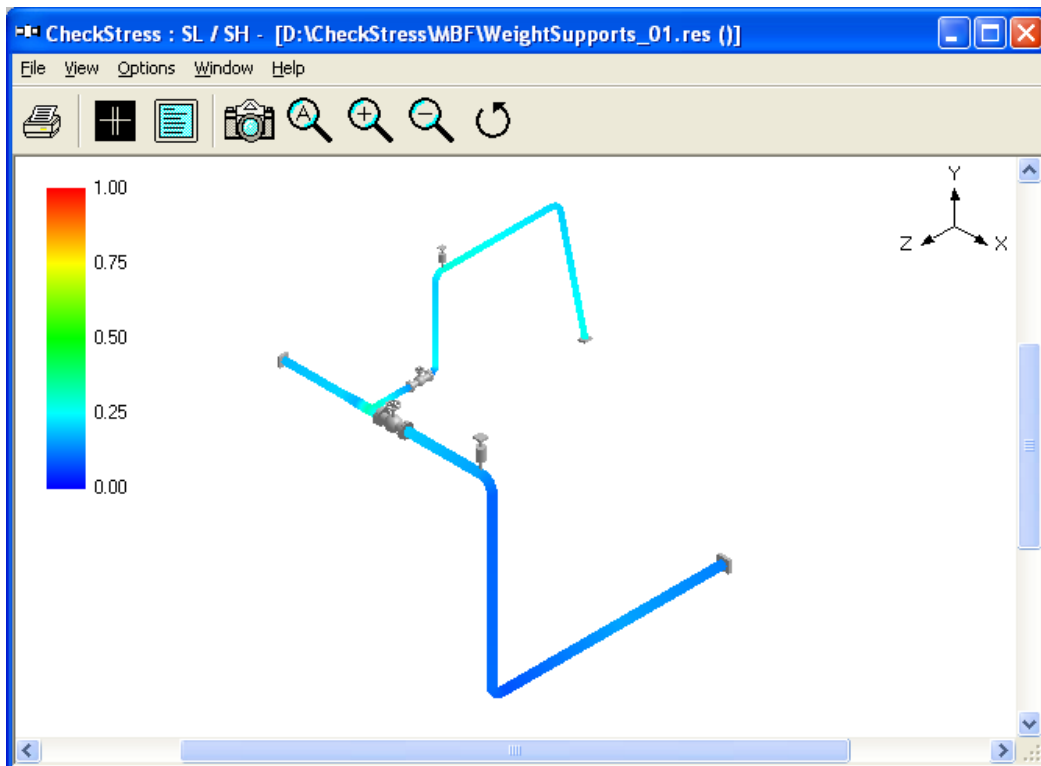


Fig. 4G Sustained Stress Contour Plot for Layout with Hangers

### **Sample: 5 (Condensate 00, 01 and 02)**

This practical problem illustrates how to place resting steel supports to carry the weight of the system with operating fluid as well as to modify the layout in order to re-direct thermal growth to comply with code stress requirements.

Fig.5A shows the initial layout where condensate from a tank is extracted by the pump suction lines. When one pump is operating, the other one is 100% standby.

It is observed from the Fig. 5B that the pipeline from node 10 to node 100 thermally grows in the  $-Z$  direction, whereas the two pump suction lines, one from node 120 to node 180 and the other from node 110 to node 250, thermally grow in the  $+Z$  direction. So, the straight pipe between nodes 100 and 120 (with a welding tee at node 110) experiences two opposing deflection patterns. The pipe portion between nodes 110 and 120 is being deflected in the  $+Z$  direction like a rigid stick; on the other hand, the portion between nodes 100 and 110 is being bent at tee node 110 as the node 100 deflects in  $-Z$  direction. This deflection response, in turn, produces high strains and thermal stresses locally at the tee node 110, as shown in Fig. 5C.

In order to reduce the high local thermal stresses at node 110, we cut the straight pipe between nodes 100 and 120 into two parts; one part is the pipe from node 100 to node 110 and the second part is from node 110 to node 120. We then shifted the second part downstream towards the two pumps, resulting in the modified layout shown in Fig. 5D. Fortunately, this shift of pipe downstream would not adversely increase the pressure drop between the tank at node 10 and the pumps at nodes 180 and 250.

From the thermal deformation plot for this revised layout shown in Fig. 5E, it is observed that the two pump suction lines from the suction nozzles to the welding tee at node 111 have almost equal thermal growth in the  $+Z$  direction, thereby moving the branch pipe between nodes 111 and 300 as a rigid stick resulting in low thermal stresses in that branch pipe as seen in Fig. 5F. In addition, it is observed that the pump suction lines from the bend node 100 to the pump suction nozzles thermally grow in the  $+Z$  direction, whereas the pipe from the tank node 10 to the bend node 90 grow in the  $-Z$  direction; this opposing deflections rotate the inter connecting pipe between nodes 90 and 100 like a "see-saw" in the horizontal XZ plane, resulting in low thermal stresses in this region, as observed in Fig. 5F.

Although the thermal stress criteria have been met, the weight stresses exceed the sustained stress allowable, as illustrated by many red and orange areas in the sustained stress contour plot given in Fig 5G. This is because there are no vertical supports (excluding the 3 nozzles and a variable spring hanger at node 52) to carry the weight of the system.

Now, vertical resting supports are introduced as shown in Fig.5H and the corresponding sustained stress (i.e., weight + pressure) contour plot (with most areas in blue) shown in Fig.5I confirms that the sustained stresses are well below the allowable values.

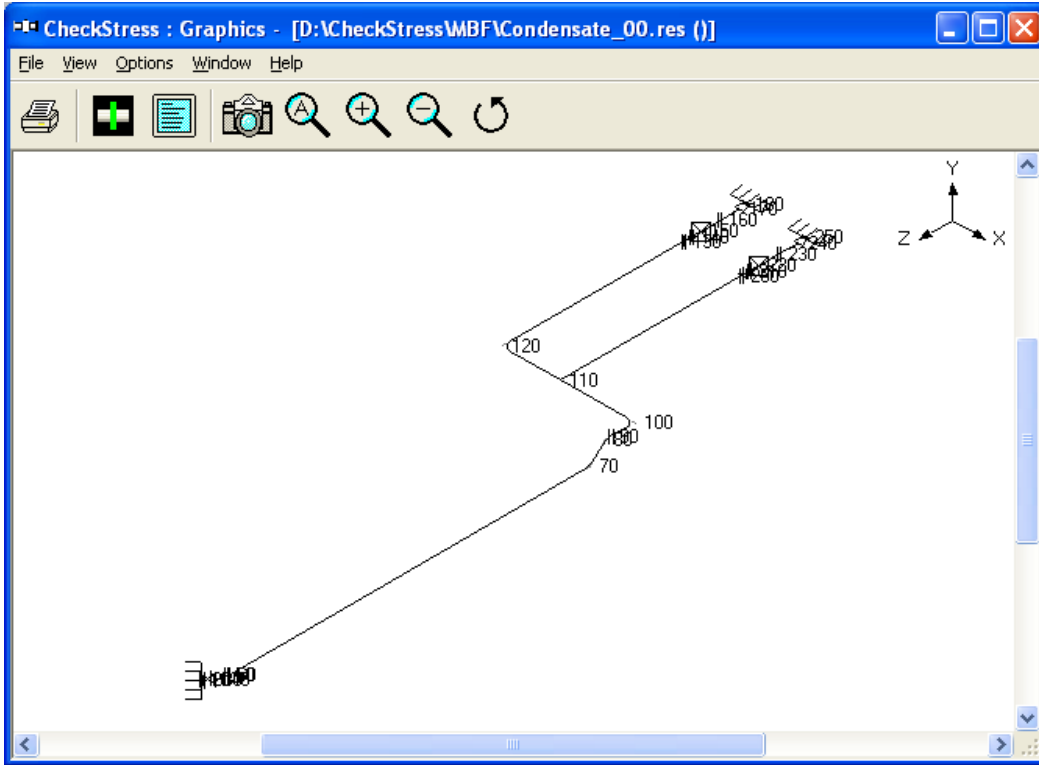


Fig. 5A Layout with Node Numbers

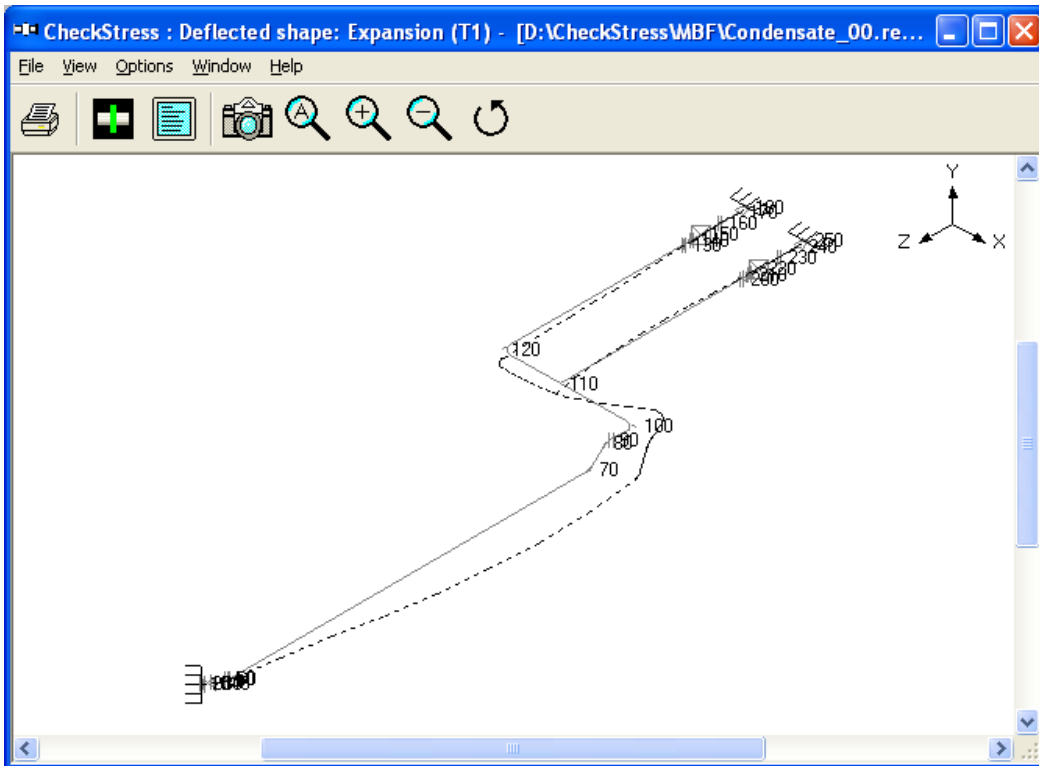


Fig. 5B Thermal Deformation Plot

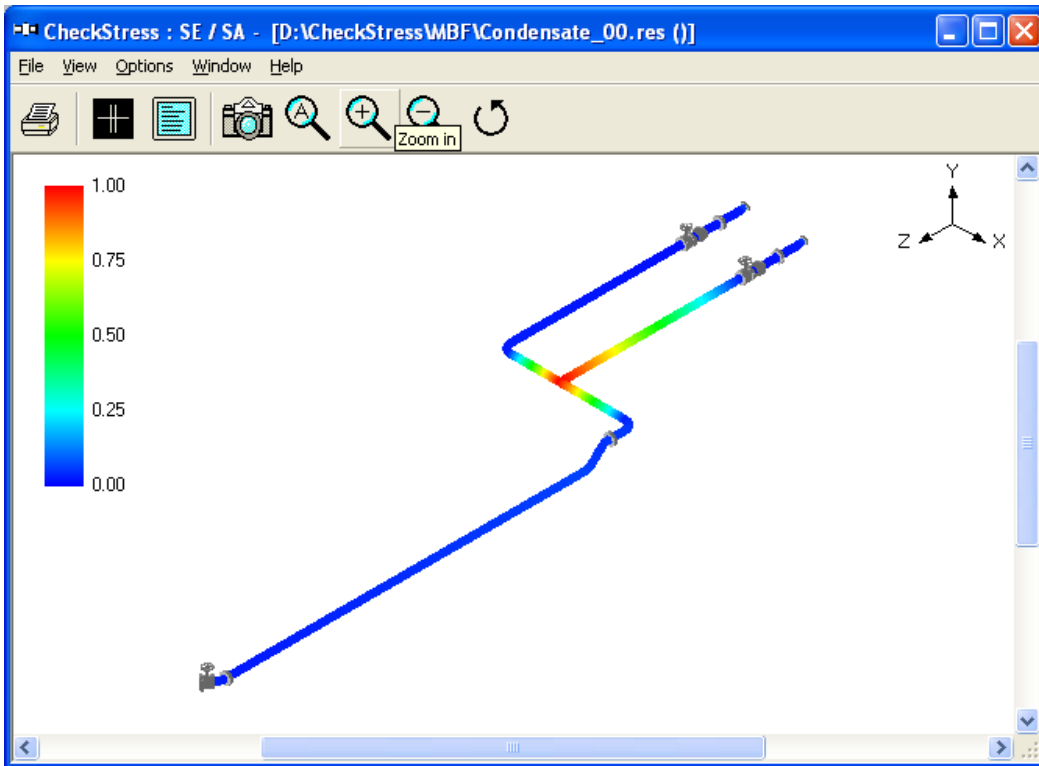


Fig. 5C Thermal Stress Contour Plot

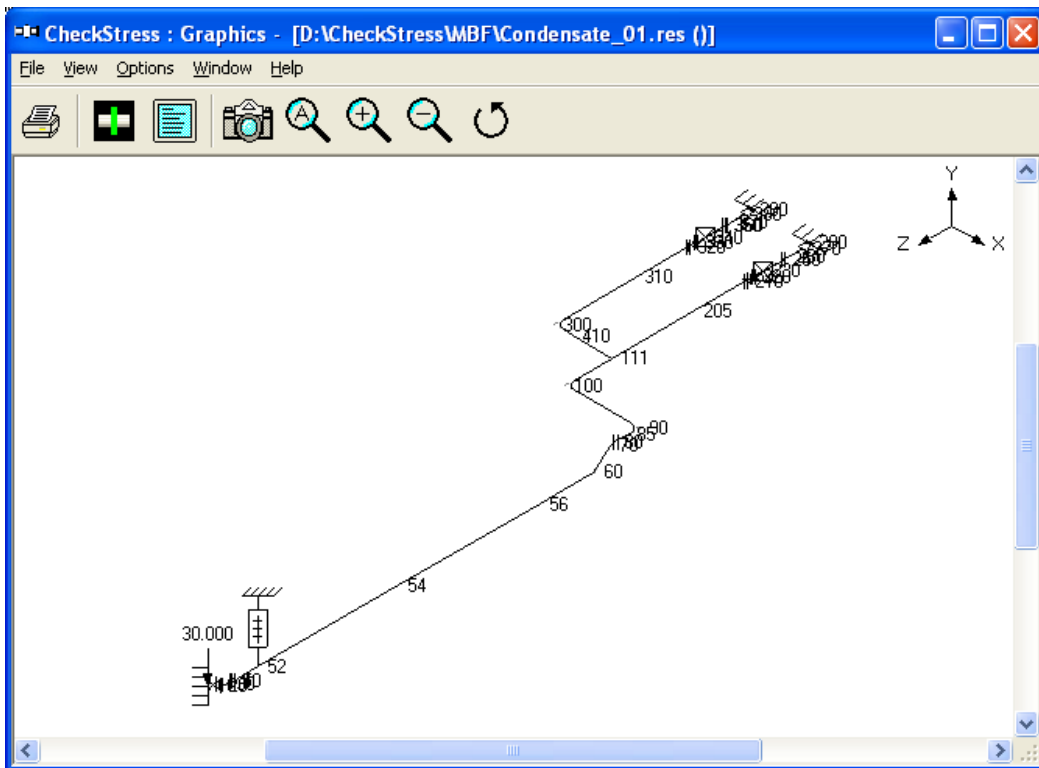


Fig. 5D Revised Layout with Node Numbers

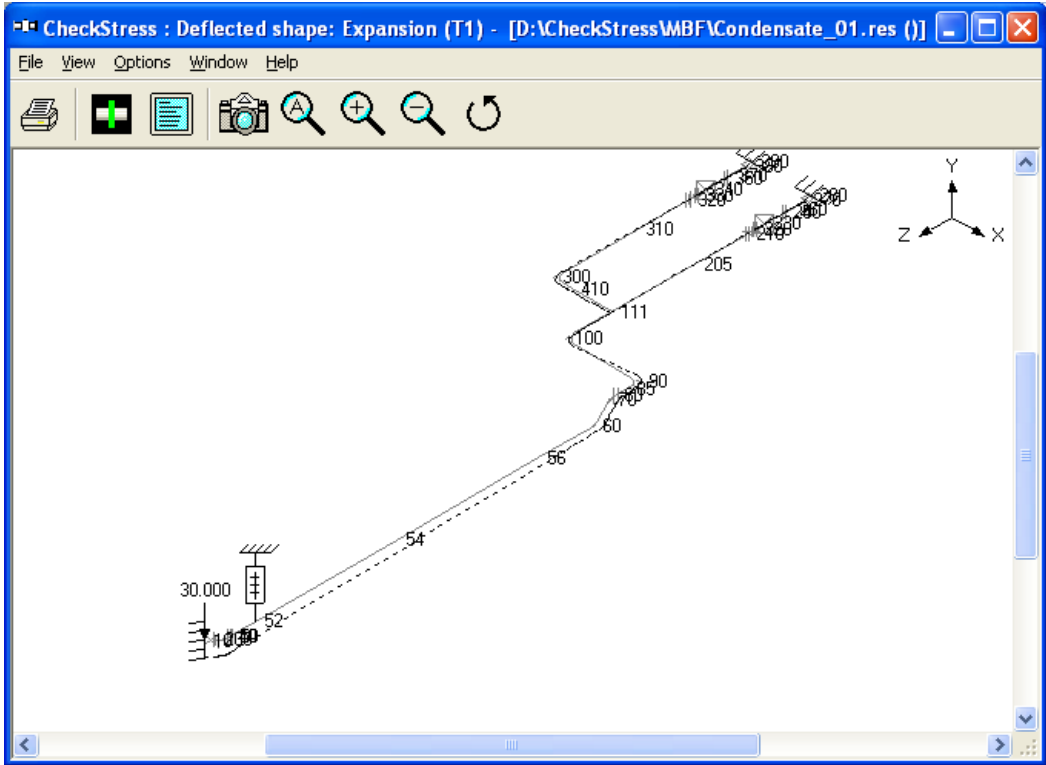


Fig. 5E Thermal Deformation Plot for Revised Layout

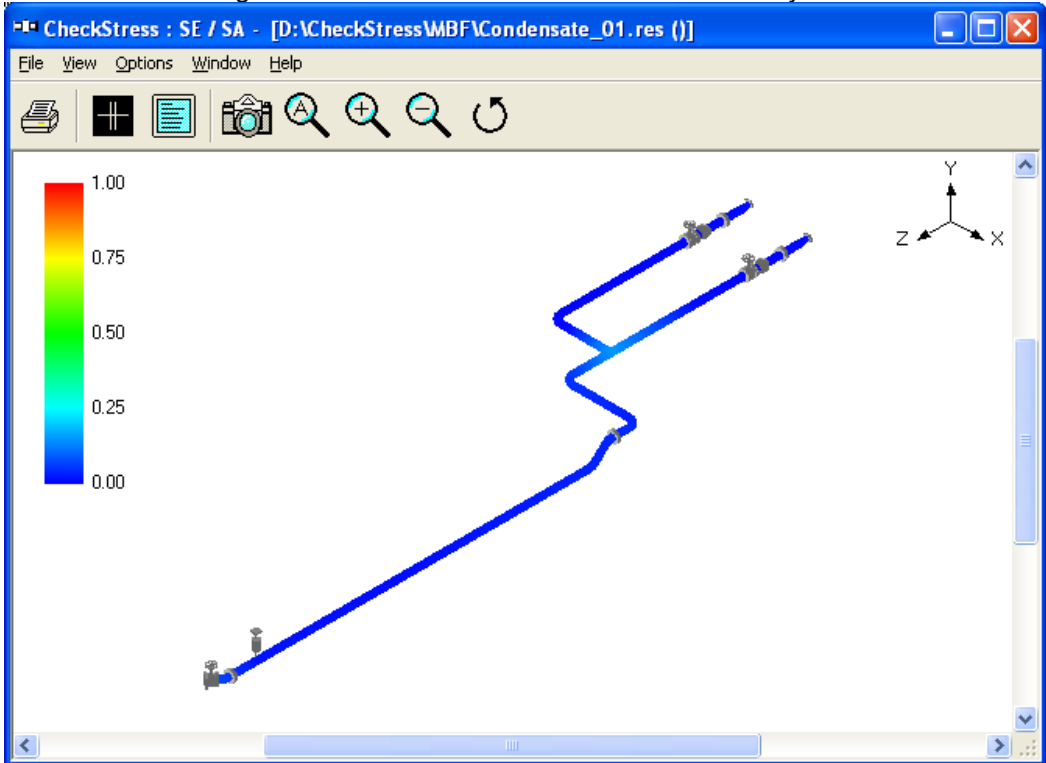


Fig. 5F Thermal Stress Contour Plot for Revised Layout

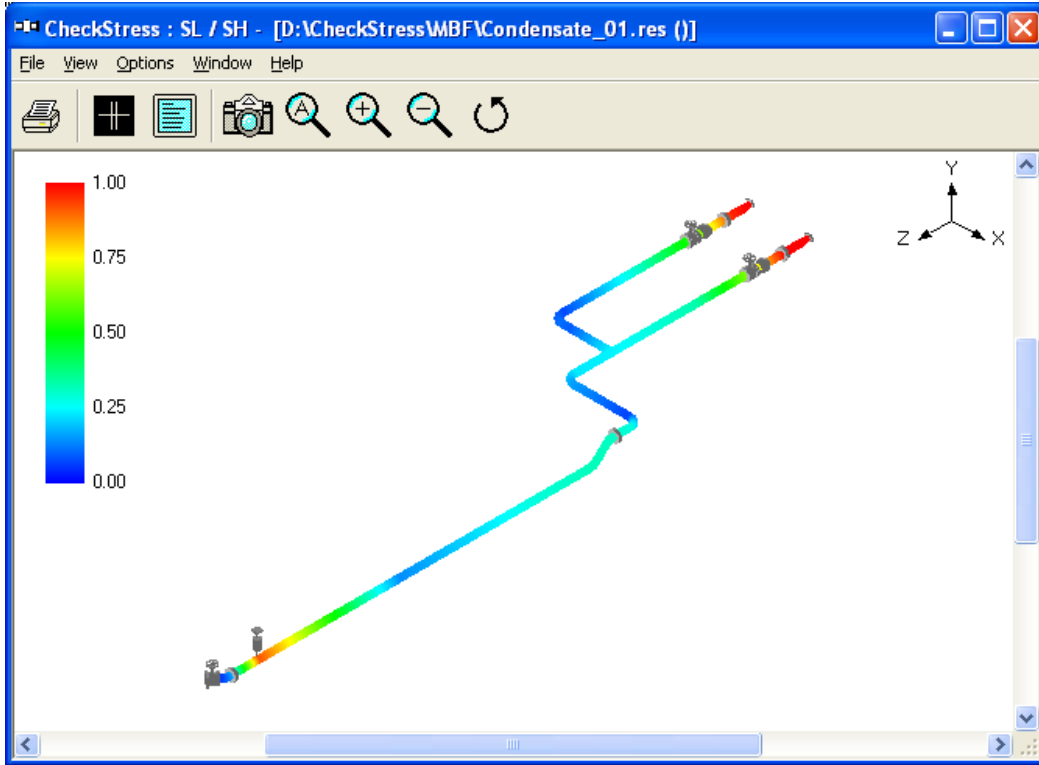


Fig. 5G Sustained Stress Contour Plot for Revised Layout

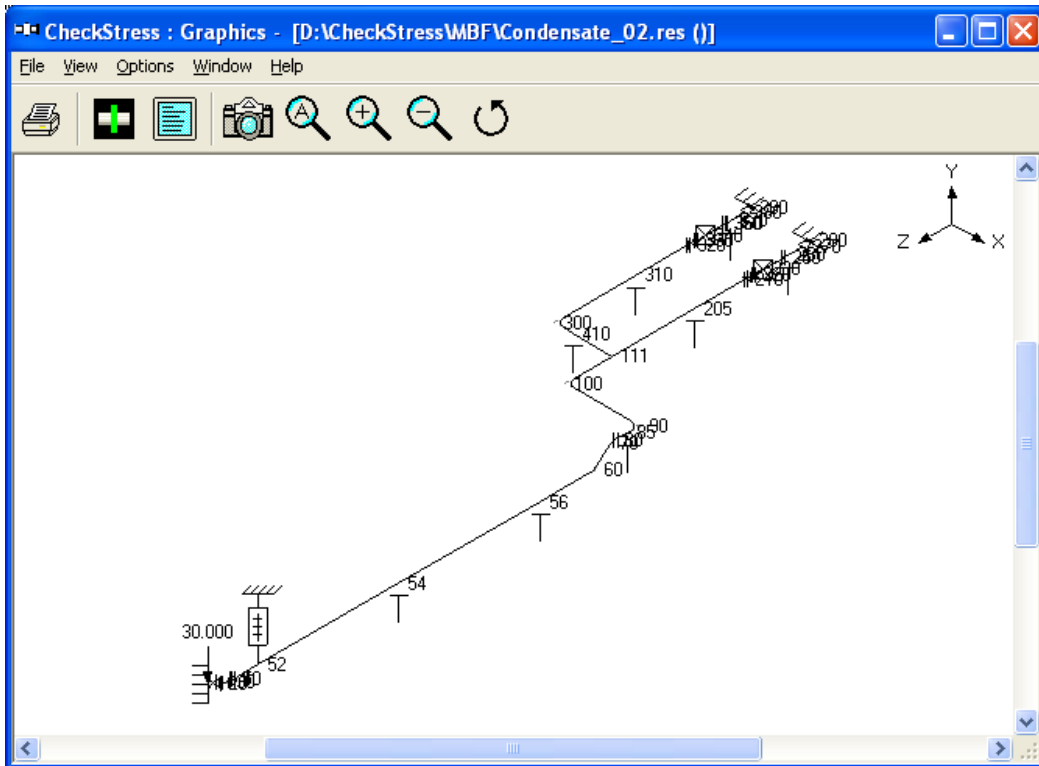


Fig. 5H Revised Layout with Resting Supports

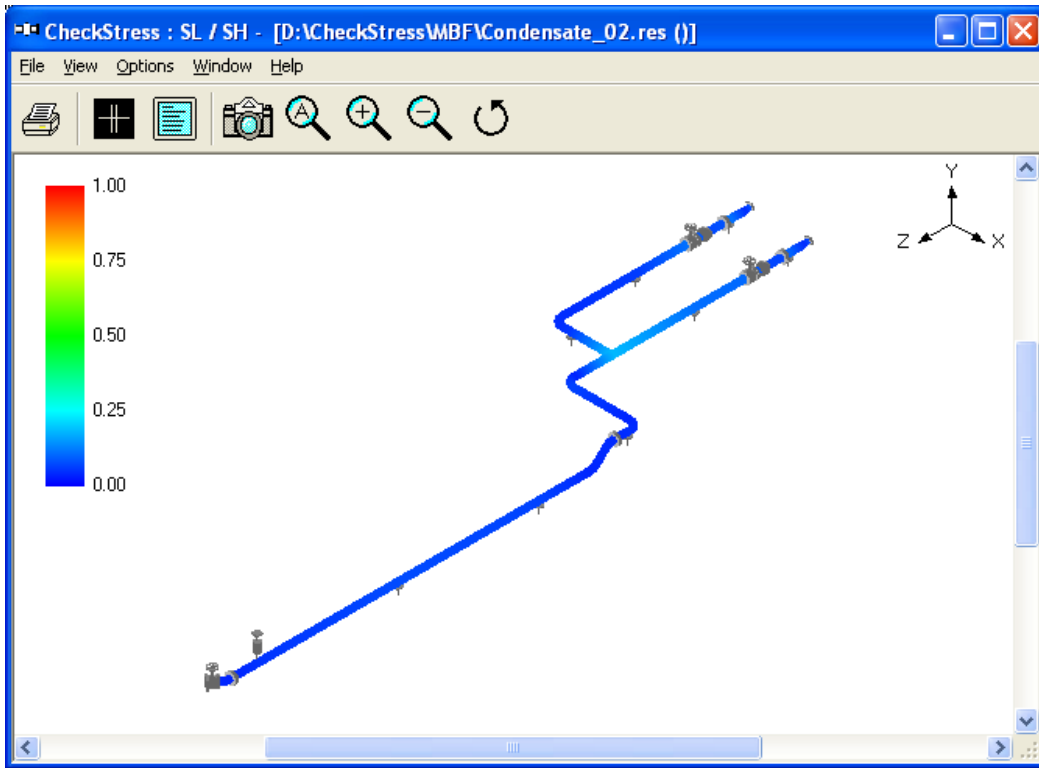


Fig. 5I Sustained Stress Contour Plot for Revised Layout with Resting Supports

## Appendix F

### Valid keywords to use in "CaepipeCode" field of Support Type DB

- F (From) From node is specified. When a new branch is started, the first node of the branch is specified as a "From" node. The X, Y and the Z fields are taken as coordinates rather than offsets from the previous node.
- T (To) To node is specified. This is a "To" node from the previous "From" node or the previous "To" node (but not from the previous "Location node").
- L (Location) Location node is used to input additional data at a node when the node has more than one data item such as a hanger/force, etc.

K (Code) The following codes may be used:

Code	Description
A	Anchor
B	Branch connection
H	Hinge (To node only)
M	Miter bend (To node only)
I	Tangent intersection (To node only)
T	Welding Tee
S	Sweepolet
W	Weldolet
F	Fabricated Tee
E	Extruded Tee
R	Radiused branch
P	Branch on thickened pipe

M (Material) A material is retained until altered. Another material should be entered only when there is a change.

P (Pipe) A pipe (section property) is retained until altered. Another section property should be entered only when there is a change.

J (Joint Code)

Code	Description
B	Ball joint
C	Cut pipe
D	Reducer
E	Expansion
I	Jacket bend
L	Elastic element
M	Beam
P	Jacket pipe
R	Rigid
S	Slip joint
T	Tierod
V	Valve

The weight of a rigid joint should be entered using a WGT comment. The stiffnesses of the expansion joint should be entered using an ES comment and the pressure thrust area should be entered using the TA comment.

X, Y and Z The offsets may be entered in combination of feet, inches and fractions of an inch for English units and mm for SI units.

Example: (English units)

Entry	Value
-10	-10 ft
10'8 or 10-8	10 ft 8 in
0'8 or 0-8	8 in
10.5	10 ft 6 in
1'6-3/8 or 1-6-3/8	1 ft 6.375 in

B (Bend Radius) The bend radius (inch or mm) is entered only if a tangent intersection (i.e, Bend, Jbend and Miter Bend) has been specified. The default is the long radius for the bend and jacketed bend.

C (Comment) The comment section allows entry of data related to a particular node or element. For example, a pipe end specified as a hinge would have the rotational spring constant and the direction vector entered in the comment section. A line temperature can be entered as comment and is retained until changed.

Multiple comments may be entered separated by commas. If a comma follows the last comment, the comment is continued on the next line.

\* (Model comment) The model comment section allows entry of notes relevant to analysis model. The model comment can be up to 70 characters.  
Example: \*Load cases considered for analysis are T1 and P1.

**The comments are as follows:**

- AMB Ambient or reference temperature (F or C)  
Default is 70 F.  
Example: AMB=80
- AWGT Additional weight for valve (lb. or kg)  
Use only for valve.  
Example: AWGT=100
- BTHK Bend thickness (inch or mm)  
Use for Bend and Jbend (core).  
Example: BTHK=6.01
- BMAT Name of Bend Material (Up to 3 characters)  
Should be defined in Material section before use.  
Example: BMAT=BM1
- BK Bending stiffness (in-lb/deg or Nm/deg)  
Use only for Bellows  
Example: BK=1000
- BSIF Bend SIF  
Inplane  
Outplane  
Example: BSIF(1.5,2.0)  
For Piping code with one SIF, use inplane=outplane=SIF  
Example: BSIF(2.0,2.0)
- BETA Beta angle for Beam (deg or rad)

	Use only for Beam Example: BETA=90
CONE	Cone angle for reducer (deg. or rad.)
CNOD	Connected to Node Use for Guide, Hanger, Limit Stop, Rod Hanger, Skewed Restraint, User Hanger and Constant Support Example: CNOD=150
CLD	Cold load Use only for User Hanger. Example: CLD=1
CRTCH	Crotch radius for an extruded tee (inch or mm) Example: CRTCH=1.25
CS	Constant support spring Example: CS=2: Two constant support springs
CWGT	Concentrated weight (lb or kg) Use only for concentrated weight. Example: CWGT=200
D or DIS	Specified displacements (Inch or mm) Note: Entry of zero is ignored and not treated as a specified displacement. Example: D(0.1,-0.25,0) or DIS(0.1,-0.25,0) DX=0.1,DY=-0.25 or DISX=0.1,DISY=-0.25
DV	Direction vector. DV(xcomp,ycomp,zcomp) Use for Hinge, Snubber and Nozzle Example: DV(1,-2,0)
DIS2	Specified Displacement for Temperature 2 (inch or mm) Use only for Anchor Note: Entry of zero is ignored and not treated as a specified displacement. Example: DIS2(1,-2,0)
DIS3	Specified Displacement for Temperature 3 (inch or mm) Use only for Anchor Note: Entry of zero is ignored and not treated as a specified displacement. Example: DIS3(1,-2,0)
E	Young's modulus (psi or Mpa) Use only for Nozzle Example: E=28E6
ES	Expansion joint stiffness Axial (lb/in or N/mm) Lateral (lb/in or N/mm) Torsional (in-lb/deg or NM/deg) Example: ES(1000,5000,200)
F or FIXD	Translational restraint Example: FIXD(1,0,1) : Restrain X and Z translations FIXDX=1 or FX or FIXDX
FF	Bend Flexibility factor Use for Bends and Miter bends Example: FF=1.5
FIXR	Rotational restraint

Example: FIXR(0,1,0) : Restrain Y rotation.  
 FIXRY=1 or FIXRY

FLANGE	Type	Description
	WN	Weld neck flange
	SO	Single welded slip on
	DW	Double welded slip on
	SW	Socket welded
	FW	Fillet welded
	LJ	Lap joint
	TH	Threaded
	Example: FLANGE=TH (threaded flange)	
FOR	Force (lb or N) Use for Force and Harmonic load. Example: FOR(100,0,-200) or FORX=100, FORZ=200	
FFOR	Friction force (lb or N) Use for Slip joint Example: FFOR=100	
FTOR	Friction torque (ft-lb or Nm) Use for Slip joint Example: FTOR=100	
FRCT	Bending and Torsional friction Torque (ft-lb or Nm). FCRT(Bending, Torsional) Use only for Ball joint Example: FCRT(100,150)	
FREE	Free anchor during hanger design Example: FREE: Free all directions FREEY: Free Y direction	
FRE	Frequency (Hz) Use only for Harmonic Load. Example: FRE=30	
G	Guide	
GAP	Tension and Compression gap (inch or mm) GAP(Tension, Compression) Use only for Tie rod. Example: GAP(10,15)	
GGAP	Guide Gap (inch or mm) Use only for guide Example: GGAP=5	
HSG	Hydrotest Specific Gravity Use only for Hydrotest Load Example: HSG=0.7	
HPRES	Hydrostatic Pressure (psi or bar) Use only for Hydrotest Load Example: HPRES=3	
HTYP	Defines the Hanger Type. Refer Appendix G of this doc for details. Use only for Hanger Example: HTYP=16 (Grinnell)	

IN1	Intermediate Node 1 for Bends Node Number (>1 and < 9999) Angle (deg or rad) Use for Bend and Jbend Example: IN1(300,30)
IN2	Intermediate Node 2 for Bends Node Number (>1 and < 9999) Angle (deg or rad) Use for Bend and Jbend Example: IN2(400,30)
INSF	Insulation factor Use only for Valve Example: INSF=3.0
JCAP	Jacked End Cap Defines the data type Jacked End Cap Example: JCAP
JMAT	Jacket Material (up to 3 characters) Use for Jpipe and Jbend Example: JMAT=A53
JSEC	Jacket Section (up to 3 characters) Use for Jpipe and Jbend Example: JSEC=N10
JLOAD	Jacket Load (up to 3 characters) Use for Jpipe and Jbend Example: JLOAD=L3
JTHK	Jacket Thickness (inch or mm) Use only for Jbend
JR	Jacket Radius (inch or mm) Use only for Jbend. Example: JR=6.75
K	Translational stiffness (lb/inch or N/mm) Use for Skewed restraint Example: K=500,DV(1.5,-0.75,0.25)
KR	Rotational stiffness (in.-lb./deg. or N-m/deg) Use for Skewed restraint Example: KR=1200,DV(1.2,2.5,0)
KTIE	Tension and Compression stiffness. KTIE(Tension, Compression) (lb/in or N/mm). Use only for Tie rod Example: KTIE(1000,1500)
LS	Limit stop LS(M1,M2) M1=allowable movement in negative direction (in. or mm) M2=allowable movement in positive direction (inch or mm) Example : LS(-1.0,1.5), DV(0,1,0), MU=0.3
LOAD	Beam load reference (up to 3 characters) Note: Beam load should be defined in BLOADS section before use. Example: LOAD=B1

LEN	Length (inch or mm) Use only for Branch SIF with type Branch on Thickened Pipe Example: LEN=5
L1	Length 1 (ft-in or mm) Use to define "L" for API 650 Nozzle and "L1" for WRC 297 Nozzle Example: L1=3'0" or L1=900
L2	Length 2 (ft-in or mm) Use only for WRC 297 Nozzle to define "L2" Example: L2=4'0" or L2=1200
LONG	Cut long (inch or mm) Use only for Cut pipe. Example: LONG=100
LXAX	Local X axis. LXAX(xcomp, ycomp, zcomp) Use only for Elastic Element Example: LXAX(1,0,0)
LYAX	Local Y axis. LYAX(xcomp,ycomp,zcomp) Use only for Elastic Element Example: LYAX(0,1,0)
MAT	Beam material reference (up to 3 characters) Note: Beam material should be defined in Beam material (BMATERIALS) section before use. Example: MAT=M1
MM	Mismatch (inch or mm) Use only for weld Example: MM=5
MLV	Maximum load variation (%) in hanger design Default is 25%. Example: MLV=30
MOM	Moment (ft-lb or NM) Example: MOM(200,-100,0) or MOMX=200, MOMY=-100
MU	Friction co-efficient Example: MU=0.3
NOD	Nozzle outside diameter (inch or mm) Example: NOD=104
NTHK	Nozzle thickness (inch or mm) Example: NTHK=6.01
NOZZLE	Defines the Nozzle data type. (650 or 297) Example: NOZZLE=650 (API 650) or NOZZLE=297 (WRC 297)
OD1	Outer diameter at from end for the reducer (inch or mm)
OD2	Outer diameter at to end for reducer (inch or mm)
OFFSET	Offset of concentrated weight from node or additional weight of valve from the center of valve (inch or mm). OFFSET(X offset, Y offset, Z offset). Example: OFFSET(0,18,0)
PAD	Thickness of reinforcement for fabricated tee (inch or mm)

	Example: PAD=0.25
PH	Phase (deg or rad) Use only for Harmonic Load Example: PH=10
P or PRES	Pressure (psig or bar) Example: P=500
ROT	Specified rotation (deg or rad) Note: Entry of zero ignored and not treated as a specified rotation. Example: ROT(1.5,0,-0.25) ROTX=1.5,ROTZ=-0.25
RLIM	Rotation limit (deg or rad) Use only for Hinge Example: RLIM=10
ROTL	Rotational limit in Bending and Torsion ROTL(Bending, Torsion) (deg or rad) Use only for Ball joint Example: ROTL(10,20)
ROTK	Rotational stiffness. ROTK(kxx,kyy,kzz) (deg or rad) Use for Anchor and Elastic element Example: ROTK(5,6,3)
ROT2	Rotational Displacement for Temperature 2. (deg or rad) ROT2(kxx,kyy,kzz) Use only for Anchor Example: ROT2(10,15,10)
ROT3	Rotational Displacement for Temperature 3. (deg or rad) ROT3(kxx,kyy,kzz) Use only for Anchor Example: ROT3(10,15,10)
R	Fillet radius (inch or mm) Use only for Branch SIF (Radiused Branch and Branch Connection) Example: R=10
RPAD	Reinforcing Pad (0 or 1) Use only for Nozzle (API 650) Example RPAD=1
RK	Rotational Stiffness in Bending and Torsion. RK(Bending, Torsion) (ft-lb or Nm) Use only for Ball joint Example: RK(100,150)
SG	Specific Gravity Example: SG=0.8
SIF	Stress intensification factor at node. SIF=value or SIF(inplane, outplane) Example: SIF=1.3 or SIF(1.5,2.0)
SHORT	Cut short (inch or mm). Use only for Cut pipe. Example: SHORT=100
SEC	Beam section reference (up to 3 characters) Note: Beam section should be defined in Beam section (BSECTIONS) before use.

	Example: SEC=BS1
STIFF	Stiffness (lb/in or N/mm) Use for Guide, Limit stop and Snubbers Example: STIFF=1000
SR	Turn on the option Short range. Use only for Hanger. Example: SR
SPIDER	Defines the data type SPIDER Example: SPIDER
T or TEMP	Temperature (F or C) Example: T=650
TA	Pressure thrust area for bellows and Slip joints (in <sup>2</sup> or mm <sup>2</sup> ). Example: TA=12.3
THK	Thickness (inch or mm) Use only for Branch SIF (Radiused Branch & Branch on Thickened Pipe) Example: THK=10
THK1	Thickness at from end for reducer (inch or mm).
THK2	Thickness at to end for reducer (inch or mm).
THKF	Thickness factor Use only for Valve. Example: THKF=3.0
TRAK	Translational Stiffness (lb/in or N/mm). TRAK(kx,ky,kz) Use for Anchor and Elastic element. Example: TRAK(1000,1500,2000)
TJOINT	Defines the Threaded Joint Example: TJOINT
U or UNIF	Uniform load (lb/ft or Kg/m) Example: U=200
US	User defined spring hanger US(No.of hangers, spring rate(lb./inch or N/mm), hot load(lb. or N)) Examples: US(2,600,1540) US(1,0,2300) : Constant support
VS	Variable spring hanger Example: VS, VS=2: two variable spring hangers
VOD	Vessel outside diameter (inch or mm) Use only for Nozzle. Example: VOD=250
VTHK	Vessel thickness (inch or mm) Use only for Nozzle Example: VTHK=10
VWGT	Valve weight (lb or kg) Example: VWGT=100
WGT	Weight of an item (ball joint, flange, Slip joint, etc.) (lb or kg) Example: WGT=50

WS Widely Spaced  
Use only for Miter bend  
Example: WS

WTYPE Weld type  
Example: WTYPE=1  
(1 = Butt weld, 2 = Fillet weld, 3 = Concave fillet weld, 4 = Tapped Transition)

## Appendix G

### Hanger Type

This section describes the hanger type number to be used for defining variable spring hanger type.

Hanger Description	Type Value
ABB-PBS	1
Basic Engineers	2
Bergen Paterson	3
Bergen Paterson (L)	4
BHEL Hyderabad	5
BHEL Trichy	6
Borrello	7
Carpenter & Paterson	8
Corner & Lada	9
Dynax	10
Elcen	11
Fee and Mason	12
Flexider (30-60-120)	13
Flexider (50-100-200)	14
Fronek	15
Grinell	16
Hydra	17
Liseqa	18
Mitsubishi (30-60-120)	19
Mitsubishi (80-160)	20
Myricks	21
NHK (30-60-120)	22
NHK (80-160)	23
Nordon	24
NPS Industries	25
Piping Services	26
Piping Tech & Products	27
Power Piping	28
Sanwa Tekki (30-60-120)	29
Sanwa Tekki (85-170)	30
Sarathi	31
Spring Supports	32
SSG	33
Comet	34

## Appendix H

### Release Notes on CheckStress 5.14

1. Adds anchors automatically at all free ends of the piping model.
2. Facility to create and define Standard Schedule table(s) corresponding to different Piping Codes.
3. Transfers the variable spring hanger type to CheckStress, if the same is defined in Plant Design software.
4. Transfers the weight of flange, valve, rigid element, etc., to CheckStress, if the same is defined in the database of Plant Design software (standard setup).

### Release Notes on CheckStress 5.14A

1. Specific Gravity of operating fluid is included in stress check.