

So before any costly system modification is made, the model will be refined to incorporate these WRC 297 nozzle flexibilities. It is possible that a more thorough and accurate model of the system will show that re-design is not needed. To assist in this model update, CAESAR II provides a processor, which will calculate and insert these flexibilities into the system. This change will constitute the second analysis of this layout.

Return to the input processor for the job Tutor. Go to the spreadsheet that contains the nozzle node (40) and double click the **Nozzle** check box. Enter the correct data in the **Auxiliary Data Area** as illustrated in the figure below.

The nozzle pipe size is imported from the spreadsheet. If this nozzle connection had no associated thermal growth, the vessel node number need not be entered. Since this vessel has thermal growth, the vessel node number must be identified and the thermal displacements previously assigned to node 40 must be re-assigned to this new node number. Enter the vessel node number as node 6000. The calculated nozzle flexibilities will be applied between nodes 40 and 6000. The vessel dimensions are entered here in terms of OD, wall thickness, and reinforcing pad thickness. WRC 297 flexibilities are also sensitive to the proximity of stiffeners to the nozzle. Here, a tray in the vessel is closest to the nozzle and is 4 ft above the nozzle. On the other side of the nozzle, the bottom head tangent and skirt connection is 6 ft below. The vessel orientation, based on a direction vector, is entered next. Enter 1 in the Y direction to indicate a vertical vessel. This Z nozzle and Y vessel will define the orientation of the local stiffnesses assigned through WRC 297. This completes the definition of the nozzle. There will be no piping element defined between nodes 40 and 6000. Now the displacements provided at node 40 must be moved to node 6000. Simply click on displacements and change node 40 to 6000.

**Nozzles**

Type

WRC 297

API 650

PD 5500

Nozzle Node: 40

Vessel Node (optional): 6000

Nozzle Outer Diameter: 8.625

Nozzle Wall Thickness: 0.322

Vessel Outer Diameter: 60.000

Vessel Wall Thickness: 0.250

Vessel Pad Thickness: 0.188

Distance to Stiffener or Head: 48.000

Distance to Opposite Stiffener: 72.000

Vessel Centerline Direction Cosine VX:

Vessel Centerline Direction Cosine VY: 1.000

Vessel Centerline Direction Cosine VZ:

Vessel Temperature (optional):

Vessel Material (optional):

**Displacements**

Node 1: 6000

	Vector 1	Vector 2	Vector 3
DX	0.0000		
DY	0.2800		
DZ	-0.1000		
RX	0.0000		
RY	0.0000		
RZ	0.0000		

**Displacement on Vessel Node**

### WRC 297 Input

## WRC 297 Calculations Completed at End of Error Checking

With the nozzle specification and the node number change for the vessel deflections, the job is ready for analysis. Click start run to launch the error checker. The error checker again produces the two notes regarding the hanger sizing. Additionally there is a warning generated regarding the specification of a vessel node number in the WRC 297 input when this node number is not included on any piping element. This warning message (75) is shown in the following figure. There is no trouble with this job since the displacements of the vessel node (node 6000) are defined.

The following report reviews the nozzle flexibility calculations performed by the **CAESAR II** error processor.

```
WARNING 75E      At NOZZLE node   40, the VESSEL/TANK node 6000 could
                  not be found.  Be sure that DISPLACEMENTS are
                  defined for the vessel connecting node.
```

```
WRC NOZZLE DATA FOR NODE   40
```

### TERMINOLOGY:

```
D1 - distance to stiffener or head
D2 - distance to opposite side stiffener or head
L  - unsupported length of cylindrical shell,
    L = 8(D1)(D2) / [ sqrt(D1) + sqrt(D2) ] ** 2
D  - mean diameter of vessel
T  - wall thickness of vessel
d  - outside diameter of nozzle
t  - wall thickness of nozzle
ε  - capital "lambda", ε = L / sqrt( DT )
j  - "lambda", j = (d/D) * sqrt(D/T)
D1 =   48.000      D2 =   72.000
L  =  116.376     T/t =   1.359
D  =   59.562     T  =   0.438
d  =   8.625      t  =   0.322
ε  =   22.797     j  =   1.690
```

### WRC 297 NOZZLE CALCULATIONS

```
WRC NOZZLE NODE   =   40
VESSEL Dmean(in.) =  59.562      VESSEL THK. (in.) =   0.438
NOZZLE O.D. (in.) =   8.625      NOZZLE THK. (in.) =   0.322
AXIAL TRANSLATIONAL STIFFNESS ( lb./in. ) =  318640.
LONGITUDINAL BENDING STIFFNESS (in.lb./deg) =  290366.
CIRCUMFERENTIAL BENDING STIFFNESS (in.lb./deg) =  58498.
ANGLE BETWEEN NOZZLE ε VESSEL CENTERLINES(deg) =  90.0000
LENGTH (L) (in.) =  116.376      THICKNESS RATIO =   1.359
CAPITAL LAMBDA   =  22.797      SMALL LAMBDA   =   1.690
```

The previous report lists the flexibilities extracted from WRC 297 — an axial stiffness of 318,640 lb./ in., a longitudinal bending stiffness of 290,366 in.lb./deg, and a circumferential bending stiffness of 58,498 in.lb./deg. These three numbers are certainly much less than the magnitude of the default rigid stiffness, which is 10E12. The local coordinate system is defined by the nozzle/vessel orientation. With the nozzle in the Z direction and the vessel in the Y direction, this new axial stiffness is in the global Z direction (the nozzle centerline), longitudinal bending is about the global X axis (bending into the vessel centerline or long axis), and circumferential bending is about the global Y axis (about the vessel centerline).

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## Conclusion

The pump discharge loads are now within their allowable limits. The vessel loads from the nozzle at node 40 should also be checked to ensure they are not too high. These loads cannot be compared to a fixed load limit as with the pump. Instead, these loads must be converted to local stresses on the vessel and these stresses compared to their limits as defined by ASME Section VIII, Division 2. As a very rough guide for evaluating local vessel stresses, one can check the code defined stress on the pipe connected to the vessel. If those stresses are below about 6000 psi, the vessel stresses should be ok. Looking at the operating, sustained, and expansion stresses at node 40, the maximum stress is less than 2500 psi. The vessel loads seem fine. If the stresses are to be checked, the Welding Research Council Bulletin 107 (WRC 107) can be used to convert the applied forces and moments to the appropriate local stresses. **CAESAR II** provides a processor to convert these loads into WRC 107 stresses and a second processor to combine the different stress categories (general or local primary membrane stress intensity, primary membrane plus primary bending stress intensity, and primary plus secondary stress intensity) for comparison with their design limits.

Final reports should now be made to document this design change. As shown earlier in this tutorial, the input listing could be generated from the Input Processor or from the Output Processor. It would be wise to include the current status of the program's default settings in this input echo. A hard copy of a few input plots would also help in defining this model and analysis. Structural and stress results from the Output Processor will substantiate the current design. Structural output includes the system displacements and restraint loads for both the operating and installed cases. The code-defined pipe stresses are generated for the sustained and expansion cases. The hanger report should also be generated from the **Output** Menu. The data files for and from this analysis may also be archived with the hard copy reports. Copy the files Tutor2.C2 and Caesar.cfg to a CD to archive a copy of the **CAESAR II** input, load case definition, **CAESAR II** output, and program default settings. Note that often upon release of a new version of **CAESAR II** that archived files will have to be converted to the new version and subsequently re-analyzed. This is primarily due to frequent format changes within **CAESAR II** as new features are added. To avoid this, limited-run users are encouraged to keep the old version of the software available to them and use newest version for new jobs.

Any questions or comments about this tutorial may be directed to the **COADE** support staff. We may be reached in Houston, Texas at (281)890-4566. Our fax number is (281)890-3301. We can also be reached via E-mail at [techsupport@coade.com](mailto:techsupport@coade.com).