

# Mechanical Engineering News

COADE, Inc.

For the Power, Petrochemical and Related Industries

Volume 21  
February, 1996

The COADE Mechanical Engineering News Bulletin is published periodically from the COADE offices in Houston, Texas. The Bulletin is intended to provide information about software applications and development for Mechanical Engineers serving the power, petrochemical, and related industries. Additionally, the Bulletin will serve as the official notification vehicle for software errors discovered in those Mechanical Engineering programs offered by COADE. (Please note, this bulletin is published only two to three times per year.)

## Table Of Contents

PC Hardware for the Engineering User (Part 21) .....	1
What's New at COADE	
Internet FTP Site Established .....	2
<b>CADWorx/PIPE</b> Introduction .....	3
<b>PVELite</b> Version 1.00 Released;	
Version 1.15 Out Soon .....	4
<b>CAESAR II</b> Version 3.22 Released;	
Version 3.23 Out Soon .....	5
<b>CodeCalc</b> Version 5.40 Released .....	6
<b>TANK</b> Version 1.30 Released;	
Version 1.31 Out Soon .....	7
Technology You Can Use	
Mechanical Engineering News Article Index .....	7
Combining Models in <b>CAESAR II</b> .....	8
<b>CADWorx/PIPE</b> Capabilities .....	9
Hillside Nozzle Angle Calculations -	
Revisited .....	12
Modeling Spring Cans with Friction	
in <b>CAESAR II</b> .....	16
<b>CADWorx/PIPE</b> -- A Model for CAD/Analysis	
Integration .....	16
A Review of ASME's External Pressure	
Calculations .....	20
Program Specifications	
<b>CAESAR II</b> Notices .....	22
<b>TANK</b> Notices .....	23
<b>PVELite</b> Notices .....	24
<b>CodeCalc</b> Notices .....	25

## *PC Hardware & Systems for the Engineering User (Part 21)*

### Windows 95

As everyone knows, Windows 95 was officially released in late August of 1995. What sort of ramifications does this event have to the average PC user? For starters, 8 Mbytes of RAM and a 486 are necessary for acceptable performance. Depending on the software packages utilized, the RAM requirement could jump to 16 or even 32 Mbytes.

*COADE introduces CADWorx/PIPE,  
a full featured Piping Drafting/Design program  
with a bi-directional data link to CAESAR II.  
See articles on pages 3, 9, and 16 for details.*

The October 10 issue of PC Magazine contained a partial listing of "Windows" programs that do not currently run under Windows 95. A more extensive list is available on the World Wide Web. Anyone contemplating a move to a new operating system should check such lists against the software currently in use for compatibility problems.

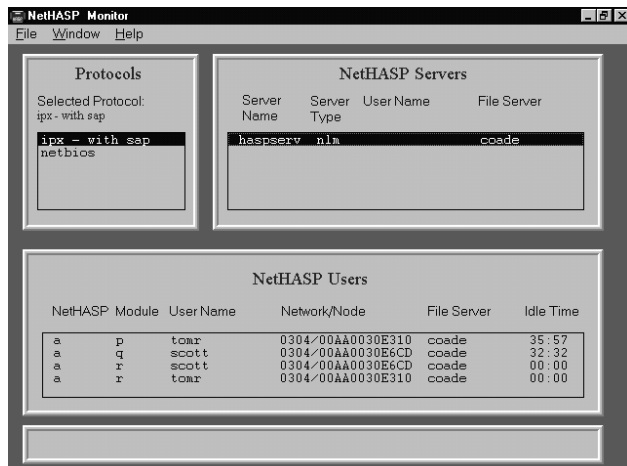
Two of the most common Windows 95 induced problems are: the inability to print from applications, especially over networks, and driver replacement. One of the drivers replaced by Windows 95 is WINSOCK.DLL, used for on-line communications. The new version works only with Microsoft's Internet access software. Insure you have a backup of your current version before installing Windows 95!

Closer to home, Windows 95 has been installed on three COADE computers - and subsequently removed from two of them. The problems experienced include: unable to print over a Novell network, data base access crashes system, COM ports unavailable, and Plug & Play hardware not detected. (Other software vendors have also experienced printing problems with Windows 95.)

On a positive note, all COADE software products do run on this operating system. Our printing problem was traced to an error in the WATCOM Fortran compiler, which resulted in a patch from WATCOM. (**CAESAR II** 3.22 Patch F, **CodeCalc** 5.40 Patch D.)

### Network ESLs

(Note, the following discussion applies to Network ESLs only, i.e. the red ones.) In late October, Aladdin Software Security (one of our ESL vendors), distributed the latest release of the software. This release includes updates to all of their network drivers and includes a **License Monitoring Program**. This License Monitoring Program provides network administrators with the ability to see which users have licenses locked to their workstations. The monitoring program produces a Windows display similar to the figure below.



Currently, this monitor program supports NETBIOS and IPX protocols. (TCP/IP will be supported in a future release.) Network administrators should use this software as follows.

- 1) Place all Monitor related files in an accessible directory.
- 2) When necessary, start the Monitor program, either from the Files/Run box or by clicking on the icon.
- 3) In the "protocol" window, select (double click) the desired protocol.
- 4) In the "server" window, select (double click) the desired network server.

The software then displays (response times may vary and take up to 10 seconds) a list of all users who have licenses locked on the selected server. (Download ASSIDRV.EXE to acquire this.)

### Pathworks Ver 5.1

A conflict between Pathworks 5.1 networks and the ESL code from Software Security causes all COADE software to lock-up. The ESL vendor, SSI, is researching the problem and hopes to have it resolved soon. In the mean time, **if you have a Pathworks network, do not upgrade to version 5.1.**

### Internet FTP Site Established

At the request of many users, COADE has established an Internet FTP (File Transfer Protocol) site and an E-Mail address on the Internet. The structure of this FTP site is intended to mimic the structure of our Bulletin Board System, providing access to patches and enhancements made to our software products.

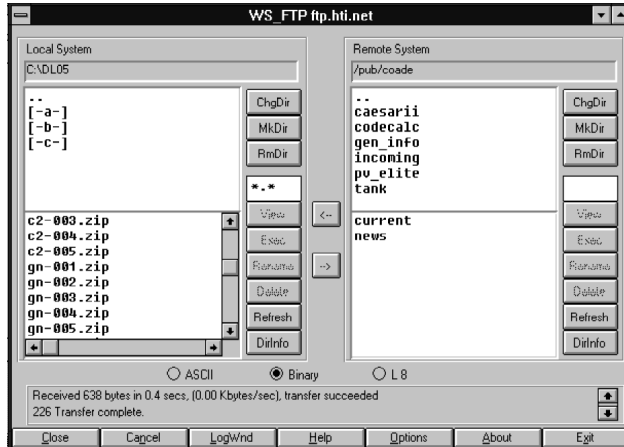
### FTP Site

To access our FTP site, you need access to the Internet, and Internet software. Internet access is available from local providers for a monthly charge - typically \$20 to \$30 for **unlimited** access. Some providers distribute the necessary software, others recommend retail packages. These are both items to consider when evaluating Internet providers. Internet access is also available from many on-line services, such as CompuServe and America On Line.

Once connected to the Internet (via your software and your provider), initiate your FTP software and log on to our FTP site (the host name is **ftp.hti.net**). **Logon with the user name "anonymous" and specify your E-Mail address as the password.** This will place you in a public directory on the host, with COADE as a subdirectory. Change directories to COADE and you will see the various program and information directories from which you can download files. Note that in these directories, anonymous users have **"read only"** access rights.

To upload a file to our FTP site, you must change to the INCOMING directory (beneath COADE). Anonymous users have **"read"** and **"write"** access rights to this directory only.

The actual mechanics of transferring a file depend on your FTP software. Typically, FTP software provides a view of both a local directory and the remote directory. Left and Right buttons initiate a transfer of selected files in the indicated direction. An example screen depicting the COADE directory is shown in the figure below.



In most directories of most FTP sites, an index file exists. This index file is named FILES.LST on the COADE FTP site. This index file contains a description of the other files available for transfer from current directory of the FTP site. The index file can be viewed, usually with NOTEPAD.

FTP sites (like Bulletin Boards) are very useful in keeping users up to date on the latest developments, news, and patches available from software vendors. Once you have a vendor's network address, you should check the FTP (BBS) site at least once every other week to stay current. COADE uses this forum to post notices regarding errors between issue of this newsletter, so it is very important to check it periodically.

For users with a **CompuServe** account, it is possible to access Internet FTP sites also. From the CompuServe Information Manager, click on the Internet icon. The display will change and present another group, in which an icon to access a "specific site" can be seen. Click on this icon to obtain the login form. On this login form, all you need to do is fill in the FTP site address, which is: ftp.hti.net, as stated above. The default user name of "anonymous" and the default password are acceptable. Once on the FTP site, you can access the directories and files as described above.

### E-Mail

COADE's E-Mail address on the Internet is: **coade@hti.net**. Directing correspondence to this address (from an Internet source) routes your mail to COADE. To send E-Mail to COADE's Internet address from CompuServe, the proper form of the address is: **INTERNET:coade@hti.net**. To send E-Mail to COADE's CompuServe address from the Internet, the proper form of the address is: **73073.362@compuserve.com**.

All users of COADE software products should note that on both our BBS and FTP sites, a *NEWS* file is maintained. This file contains the latest status of all our products, as well as general news and developments. You should check the contents of this file at least once every other week to see if any software errors have been discovered that may affect your work. In addition, on both the BBS and FTP sites, a *CURRENT* file is maintained. This file lists the current version (including patch level) of our software products as well as the date of the latest issue of *Mechanical Engineering News*.

### *CADWorx/PIPE Introduction*

By Richard Ay

For many years, **CAESAR II** users have been requesting CAD Interfacing capabilities. What exactly is meant by "CAD Interfacing"? To some, this means simply transferring the geometry of a piping system from a Designer's CAD workstation into **CAESAR II**. Other users want, in addition to the geometry, the loading conditions, the material properties, and the support definitions - essentially a complete, ready to analyze, stress model. Still other users want a way to take a **CAESAR II** model and generate drawings on a CAD system, including output details such as stress information and restraint loads. Finally, there is the manager's dream - build a CAD model, send it to **CAESAR II**, allow the stress analyst to modify it, then send the modified model back to the CAD system, with output results.

To date, all attempts to address the above requirements have met with limited success. For example, in a simple geometry transfer, there are still problems such as element connectivity, element orientation, gasket lengths, "olet" locations, and engagement lengths to be resolved. Some CAD packages generate sorted elements, some do not. Some CAD packages generate node numbers, some do not. Even if node numbers are present, their values and ordering are poorly chosen for stress analysis purposes. Additionally, most CAD models do not include sufficient node locations for a complete stress analysis, especially if dynamics must be considered. In more complex data transfers, the CAD neutral file must contain the required material property values, support types, and intersection types which correctly match those expected by the Stress package. This is never the case unless external mapping files are generated and maintained for each project.

Sending model data from a Stress package into a CAD systems presents a different set of problems. Most CAD systems are *specification* driven, so there are certain rules governing what can be in the drawing model. (The creation

of the specification is another lengthy exercise which may require hours at the initiation of each project.) Attempting to send data, which violates the specification, from a Stress package into a CAD system invalidates the transfer. Additionally, most Stress packages don't care about the details of valves, flanges, and equipment (stresses are not computed on these items). However, this information is required by the CAD system to build a correct model.

On top of these problems are the logistical issues of: where and when is the first model built, are the CAD and Stress systems on the same type of computer, when are details (insulation thickness, tee type, etc.) determined, where are data conflicts resolved, and where is the model verified. Each of these issues, if not properly addressed, is significant enough to cripple any attempt to transfer data between a CAD system and a Stress system.

These problems are so widespread that, at a recent **CAESAR II** seminar, one attendee stated "*Everyone claims to have a CAD interface to a certain stress program - none of these interfaces work!*" This statement reflects the poor state of existing interfaces and the difficulties that actual users face when attempting to implement them. Once you cut through the marketing hype, the deficiencies in the neutral files and interfaces reveal a large chasm between drafting/designing and analyzing a piping system. (To make matters worse, some CAD vendors charge anywhere from several hundred to several thousand dollars for the module which generates the neutral file for stress analysis.)

In order to resolve the shortcomings discussed above, COADE has spent several man-years planning and developing a CAD package and the necessary bi-directional data transfer link to **CAESAR II**. With this issue of *Mechanical Engineering News*, COADE introduces this CAD system, formally called **CADWorx/PIPE**. The bi-directional data transfer link has the built-in intelligence to make the necessary assumptions regarding model refinement, depending on the direction of the transfer. Relying on AutoCAD for the drawing engine and input-output operations, **CADWorx/PIPE** provides both the Designer and Stress Engineer with an easily accessible platform to produce piping drawings and stress isometrics. Developed by Designers, for Designers, with strong influence from the COADE Stress group, **CADWorx/PIPE** provides a drafting system which will meet the requirements of a production environment.

The accompanying articles (see pages 9 and 16) discuss the features and capabilities of **CADWorx/PIPE**, as well as its data transfer link to **CAESAR II**.

For a *limited* time, **CADWorx/PIPE** can be acquired by "*current*" **CAESAR II** users at a 40% discount. (In this sense, the word "*current*" means users who are current on the Maintenance, Update & Support Plan. Note that bi-directional linking to **CADWorx/PIPE** requires **CAESAR II** Version 3.23, while **CADWorx/PIPE** can import from earlier versions of **CAESAR II**.)

### *PVElite Version 1.00 Released; Version 1.15 Out Soon*

As discussed in the last issue of *Mechanical Engineering News*, COADE has been developing a new pressure vessel package. This new Vessel package, officially named PVElite, has replaced PROVESSEL.

PVElite was designed to provide additional analytical abilities to the vessel designer. One of the major topics addressed is in the area of available load cases. The figure below illustrates the load case combinations available for a typical run in PVElite.

The screenshot shows the PVElite software interface with the following data and options:

Design Data	Load Case
Design Internal Pressure: 202 psig	Load Case 1: NP+EW+HI
Design Internal Temperature: 300 F	Load Case 2: NP+EW+EQ
Hydrotest Type: UG99c	Load Case 3: NP+OW+HI
Hydrotest Test Position: Horizontal	Load Case 4: NP+OW+EQ
Projection from Top: 8 in.	Load Case 5: NP+HW+HI
Projection from Bottom: 8 in.	Load Case 6: NP+HW+HE
Min. Metal Temperature: -20 F	Load Case 7: IP+OW+HI
Flange Distance to Top: 0 ft.	Load Case 8: IP+OW+EQ
Construction Type: Welded	Load Case 9: EP+OW+HI
Special Service: None	Load Case 10: EP+OW+EQ
Degree of Radiography: RT 1	Load Case 11: HP+HW+HI
Miscellaneous Weight: 5 %	Load Case 12: HP+HW+HE
Use Higher Long. Stresses?: Y	
Hydro. Allow. Unmodified?: Y	

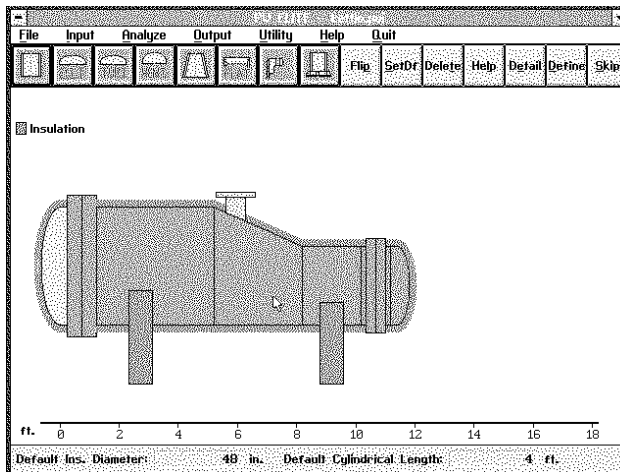
  

Design Modification	Nozzle Design Modification
<input checked="" type="checkbox"/> Select Wall Thickness for Internal Pressure	<input type="checkbox"/> for MAWP + static Head
<input type="checkbox"/> Select Wall Thickness for External Pressure	<input checked="" type="checkbox"/> for Design P + static Head
<input type="checkbox"/> Select Stiffening Rings for External Pressure	<input checked="" type="checkbox"/> Consider MAPNC
<input checked="" type="checkbox"/> Select Wall Thickness for Axial Stress	

The screen above displays 4 main windows of global data. Global data apply for the entire vessel. One unique feature of PVElite is the load case design option feature. The load cases are displayed in the upper right box. By default, PVElite sets up twelve load cases. These combinations allow the vessel engineer to examine every possible combination of weight, wind and seismic loads for a particular vessel. Of course the load cases can be edited. For example, if the stress evaluation on the vessel due to wind only was needed, a load case with WI could be entered on a line by itself. During the analysis, the program would compute this stress component and display the stress results in the "Stresses Due To ..." report. Typical definitions for the load cases are shown below:

NP	=	No Pressure
IP	=	Internal Pressure
EP	=	External Pressure
HP	=	Hydrostatic Test Pressure
EW	=	Empty Weight
OW	=	Operating Weight
HW	=	Hydrotest Weight
WI	=	Wind Load
EQ	=	Earthquake Load
HE	=	Hydrotest Earthquake
HI	=	Hydrotest Wind

Another feature of PVElite is its easy to use graphical interface. The following is an example of a kettle type reboiler with a hillside nozzle in the eccentric reduction section of the boiler. This example was entered in just a few minutes.



Version 1.0 was released last July and replaced PROVESSEL 2.81. Version 1.15 is slated for release early in 1996. Version 1.15 will be shipped to all PVElite users who are current on the Maintenance, Update and Support Plan. Some features of this new version are :

- India's IS:875 Wind Code and IS:1893 (RSM and SCM) Seismic Design Codes have been added.
- The TEMA and ASME tubesheet component programs have been added as well as the Thick Walled Expansion Joint and Floating Head Programs.
- Nozzle Input has been moved into the Input processor.
- Center of Gravity Calculations have been added.
- Eccentric Reducing Sections have been added.

- Cone Discontinuity Stress Calculations have been added.
- The Material Database has been sorted by material name.
- Ability to specify the nozzle elevation directly.
- Automatic Nozzle calculations in both planes ( for Hillside Nozzles )
- An Insulate All feature has been added.
- A Liquid Level To... feature has been added.
- Section Type Stiffening Rings with selection from the structural steel database has been added.
- and several others.

Many users have inquired about a Windows 95/NT version of PVElite. PVElite is being ported to that platform. The graphic input processor has already been converted along with some of the utility modules. A full Windows 95 version may be ready by the end of the year. The next version will include a new solver which uses the matrix solution method to explicitly solve for the exact forces and moments on legs, lugs and of course the elements themselves (similar to how **CAESAR II** solves piping models) as well as any other ASME changes. As always any suggestions for new features are always welcome.

Some of the other abilities PVElite offers the Vessel Engineer are:

- The ability to construct a vessel graphically, through the selection and placement of vessel components.
- On screen, instant, computations for certain deterministic quantities.

### *CAESAR II Version 3.22 Released; Version 3.23 Out Soon*

In late April 1995, **CAESAR II** Version 3.22 was released. This version incorporates many suggestions and requests from the user community. A few examples of the changes incorporated into Version 3.22 are:

- The Harmonic solver has been updated to provide damping. Harmonic analysis can now include or exclude damping as the user deems necessary.

- The following codes have been reviewed (and any necessary changes made) for compliance to the latest editions: B31.1, B31.3, B31.4, B31.5, B31.8, NC, ND and BS-806.
- The following additional piping codes have been added: RCCM-D, CODETI, Norwegian (TBK 5-6).
- Center of Gravity and a Bill of Materials reports have been added.
- Automatic node numbering abilities have been added to the piping input module.
- Expansion Joint data bases from IWK (Germany) and Senior Flexonics are provided.
- The Restraint Summary in the static output processor has been modified to include the translational displacements of the restrained nodes (when printing in 132 column mode).

Work is progressing for Version 3.23, which is targeted for release this month. This version will include:

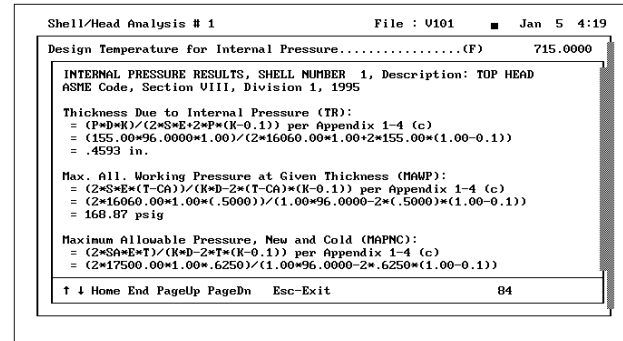
- Mouse Support
- **CADWorx/PIPE** bi-directional link
- FBDR Piping Code
- BS 7159 Piping Code for FRP
- Interface to Sunrise System's PIPENET
- Low DOS RAM reduction to 420 Kbytes
- South African Structural Steel Table

*CodeCalc Version 5.40 Released*

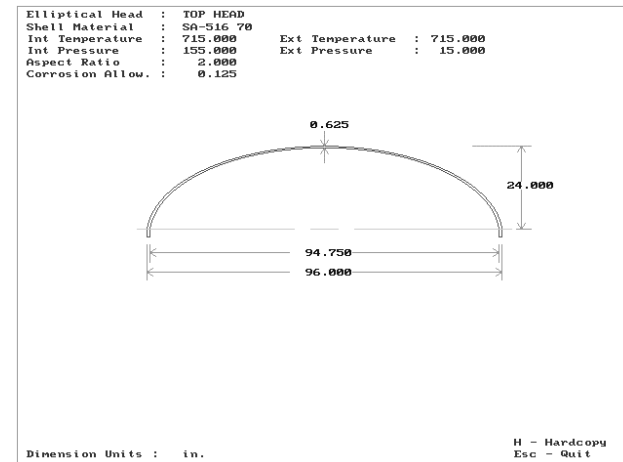
In late June 1995, Version 5.40 of **CodeCalc** was released. The 5.40 version of **CodeCalc** includes a number of enhancements which provide the analyst with better techniques to evaluate vessel components. Additionally, the A94 addendum/95 Edition of the code is incorporated.

One of the changes for **CodeCalc** 5.40 is the conversion of the input processor from 16 bit to 32 bit code. This conversion allows the input processor to utilize extended memory. Once extended memory is available, this processor can provide "on-screen" calculations and graphics of the components currently specified.

On screen calculations provide the analyst with immediate calculations. Once the data is typed in, a function key is pressed (F9) and the results appear in a window that overlays the input window. By having this capability, iterative designs can be processed in a quick and efficient manner. These on screen calculations provide a great convenience and are independent of the input processor. A typical on screen calculation is shown in the figure below.



Version 5.4 now has graphic capabilities. A typical plot is shown in the figure below.



*TANK Version 1.30 Released;  
Version 1.31 Out Soon*

In late August 1995, Version 1.30 of **TANK** was released. The 1.30 version of **TANK** includes many enhancements suggested by program users. A summary of the more important enhancements is shown in the table below:

- API-650 Addendum 1 updates incorporated.
- Mouse support has been added to all modules.
- A tank sizing/costing scratch-pad is available.
- A material data base editor is provided.
- Structural element checks per API-650 Section 3.10.3 are implemented for the design of Supported Cone roofs.
- Wind girder size selection per API-650 Table 3-22 has been added.
- API-653 service/maintenance considerations added by allowing individual shell course joint efficiencies, critical length locations, and  $t_1$  and  $t_2$  thicknesses to be specified.

The use of the measured thicknesses,  $t_1$  and  $t_2$ , allows the program to compute the allowed fluid heights for each measurement extreme. This information can be used to aid in deciding whether it is more profitable to repair a tank now, or reduce the product volume and continue operations.

The sizing scratchpad, in addition to estimating material costs, can be used to optimize course heights and thicknesses. A sample report screen from this scratchpad is shown in the figure below.

```

TANK SIZING SCRATCHPAD
Required Volume .....(FT3) 500000.0000
Fluid Specific Gravity ..... .8500
Cost/Unit Weight of Plate ..... 10.0000
Plate Allowable Stress .....(lb./sq.in.) 20000.0000
Average Course Height .....(ft ) 8.0000
Minimum Tank Height .....(ft ) 48.0000
Maximum Tank Height .....(ft ) 64.0000
Minimum Tank Diameter .....(ft ) 96.0000
Maximum Tank Diameter .....(ft ) 160.0000

---TANK SIZING RESULTS---
      VARIATION BY TANK HEIGHT
Heights  (ft ):   48.0   53.3   58.7   64.0
Diameters (ft ):  115.2  109.3  104.2  99.7
Circumferences(ft ): 361.8  343.2  327.3  313.3

Thk. Course 1(in.): .5981  .6318  .6638  .6943
Thk. Course 2(in.): .4963  .5352  .5717  .6061
Thk. Course 3(in.): .3945  .4386  .4796  .5180

[Esc]-Menu [F1]-Compute [F2]-Print [?] -Help [Alt-C]
    
```

*Mechanical Engineering News  
Article Index*

The following article index updates the initial index published in December of 1993. This index is intended to aid clients in finding reference articles from past newsletters quickly.

Title	Issue	Page
<i>Subject: Code Requirements</i>		
AISC Unity Checks on Pressure Vessel Legs	8/92	8
Expansion Case for Temperatures Below Ambient	5/93	32
A Review of ASME's External Pressure Calculations	2/96	20
Sustained & Expansion Stress Cases	5/88	4
Sustained & Expansion Follow Up	11/88	10
<i>Subject: Dynamics</i>		
An Introduction to Time History Analysis	12/93	9
Dynamics Basics	11/87	3
Dynamics, Damped Harmonic Motion	4/89	7
Dynamics, The Range Check	11/88	4
Dynamic Questions & Answers	7/90	8
Missing Mass Correction in Spectral Analysis	5/93	8
Pulse Table Generator	11/94	9
Seismic Analysis of Tall Vertical Process Towers	4/95	15
Time History Input (Establishing ...)	6/94	8
<i>Subject: Hardware</i>		
ESL's and Multiple Computers	8/92	2
Machine Times	5/88	2
Memory Requirements	5/88	2
Network Questions & Answers	4/95	5
Network Versions	6/94	1
Printer Configuration	6/94	13
Virus Infections	7/90	1
Virus Infections (Revisited)	6/94	13
Virus Update	10/90	2
<i>Subject: General Information</i>		
API-650 Addendum 1	4/95	7
API-650 Nozzle Flexibilities	12/93	6
ASME B31G Criteria	5/93	27
ASME External Pressure Chart Name Changes	12/92	6
FE/Pipe-CAESAR II Transfer Line Study	3/92	6
FE/Pipe-CAESAR II SIFs & Flexibilities	12/92	8
Finite Elements in Practice	3/92	16
Flange Allowable Stresses	10/91	6
Flange Design (Influence of Corrosion On ...)	6/94	6
Flange Leakage	10/91	3
Flange Rigidity Calculations	6/94	5
Flange Stresses	12/92	7

*Subject: General Information (Continued)*

Incorrect Results From Piping Analysis	11/88	8
Numerical Sensitivity Checks	11/87	9
Rectangular Vessel Computations	6/94	7
Static & Dynamic Analysis of High Pressure Systems	3/90	6
What Makes Piping/Finite Element Jobs Big?	5/87	2

*Subject: Life Extension & Failures*

Applying API-653	4/95	7
Evaluation of Creep Stresses	5/93	18
Evaluation of Fatigue Stresses	12/92	12
Fine Tuning & Sensitivity Studies	11/94	6
Piping Failure Caused by Elastic Follow-Up	8/92	10

*Subject: Designing/Drafting*

CADWorx/PIPE Introduction	2/96	3
CADWorx/PIPE Capabilities	2/96	9
CADWorx/PIPE-A Model for CAD/Analysis Integration	2/96	16

*Subject: Modeling*

Bend Elastic Models	3/87	3
Buried Pipe Analysis	4/89	3
Buried Pipe, The Overburden Compaction Multiplier	3/92	3
Calcium Silicate (Density)	11/94	4
Cold Spring Discussion	10/90	11
Combining Models in CAESAR II	2/96	8
Double Rod Modeling	7/90	11
Global vs Local Coordinate Systems	12/92	3
Global vs Local Coordinate Systems (Bends)	11/94	4
Expansion Joint Modeler (Part 1)	5/93	29
Estimation of Nozzle Loads	12/93	14
Hanger Design Discussions (Part 1)	3/90	4
Hanger Design Discussions (Part 2)	10/90	7
Hillside & Off Angle Nozzles	12/93	7
Hillside Nozzle Angle Calculations - revisited	2/96	12
Large Rotation Rods and Hangers	11/87	9
Plastic Pipe Modeling	4/91	5
Relative Rigid Stiffnesses	11/88	11
Selecting & Evaluating an Expansion Joint Assembly	12/93	12
Some Nuances of Spring Hanger Design	5/87	7
Spring Hanger Design	10/90	4
Spring Cans with Friction	2/96	16
Slip Joint Modeling	4/91	9
Tees & SIFs	3/92	4
Tee Types	3/92	14
Underground Pipe Modeling Philosophies	4/91	8
User Specified Wind Profiles	3/92	14

*Subject: Quality Assurance*

Benchmarking CAESAR II & ANSYS	10/91	3
CAESAR II Quality Assurance Manual	5/93	5
Software Quality Assurance	10/90	7

*Subject: Strength of Materials*

Maximum Shear Stress Intensity	8/92	4
Octahedral Shear Stress	3/87	4
Torispherical Head Equations	12/92	6

Combining Models in CAESAR II

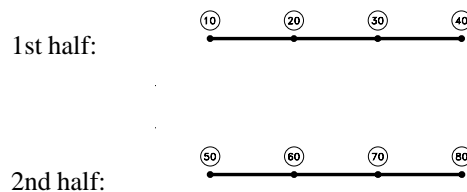
By Richard Ay

There are instances where a single **CAESAR II** input file contains several, separate pipe models (runs). Possibly, these runs are from different lines, or possibly they are part of the same line and need to be connected. This article discusses the later condition, how to properly connect separate models in a single input file.

The situation of separate models can occur in several ways:

- The model consists of piping and structural steel elements.
- The model consists of piping and vessels, where the vessels are actually modeled.
- Several pipe runs are being combined into a single model, possibly from a CAD interface.

To begin, assume all elements (pipe, structure, or vessel) are available in the current input file. At this point, there is no connection between these distinct models. Attempting to run the analysis will result in the solution for distinct (i.e. not connected) models. Attempting to plot the input shows all models emanating from the plot origin (the start node of the first model). These results are correct and predictable, because **CAESAR II** has not been informed as to how the models connect to each other. For example, consider a cantilever composed of two halves, anchored at 10. In this model, nodes 40 and 50 are supposed to connect to each other, i.e. they are the same point in space.



If the user plots this model, as it is, the result is:

Result: 

because both sections plot on top of each other, starting at node 10. If the user specifies the coordinates of 50, such that they are the same as 40, the resulting plot is:

Result: 

Specifying the starting coordinates for each distinct model will produce correct plots - **however, the analysis still sees distinct unconnected models.** Positioning models in space relative to each other has no effect on the global stiffness matrix! The models must be tied to each other from a “stiffness” point of view. The above model of the cantilever is still incorrect.

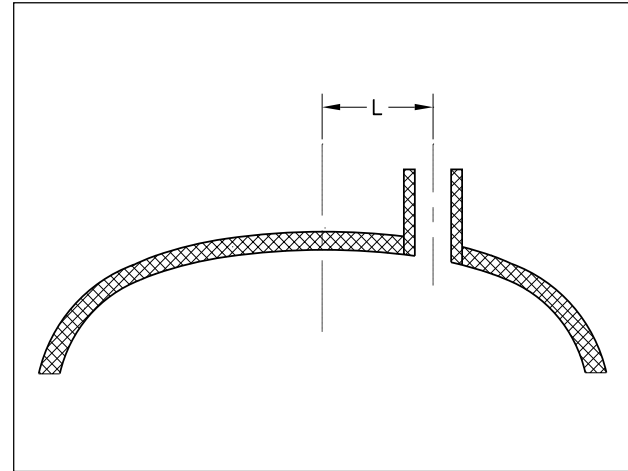
There are two ways to properly tie models together, from both a geometric (plotting) and a stiffness (computation) point of view. The first and easiest method is to change one of the node numbers. For the example cantilever, changing node 40 (on the 1st half) to node 50 will produce the proper connection. Similarly, (on the 2nd half) changing node 50 to node 40 will also produce the proper connection. The connection formed in this manner is as if the two halves are welded together, all six degrees of freedom are connected.

The second, and more powerful way of connecting two models is via the “Restraint with CNODE” option. This option will connect the geometry for plotting purposes, but the stiffness connection can be specified individually for each of the six degrees of freedom. For the above cantilever, restraining 40 with a CNODE of 50 in [A]ll directions produces the same, proper connection as changing the node numbers did. (Note, [A]nchor is the usual interpretation of restraint type [A]. However, in this sense it means All Degrees of Freedom). A hinge could be defined by restraining 40 with a CNODE to 50 three times, once in the X direction, once in the Y direction, and once in the Z direction. (Note that a hinge in a cantilever is an unstable model!) The “Restraint with CNODE” option is most useful when connecting pipe to steel using “resting” (+Y) supports.

The “Restraint with CNODE” option is a very powerful, flexible feature. This subject is discussed in detail in the **CAESAR II** manuals. *The important thing to remember about connecting models is that a correct geometry plot is a necessary, but not a sufficient condition for a correct stress analysis.*

## CADWorx/PIPE Capabilities

By Robert Wheat

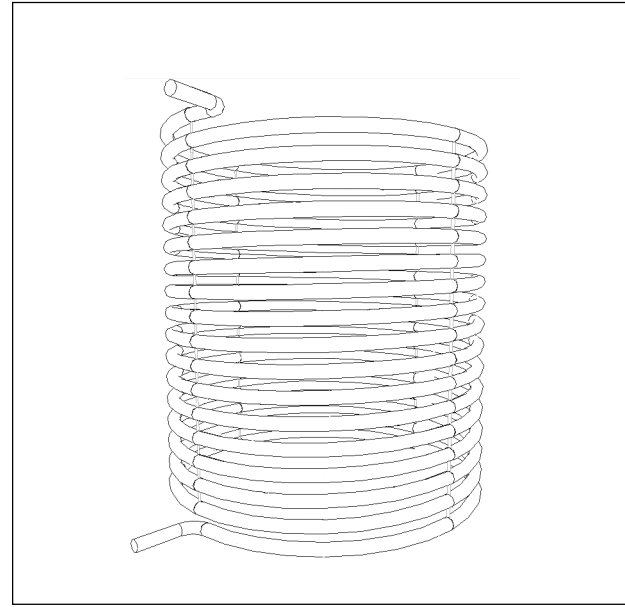
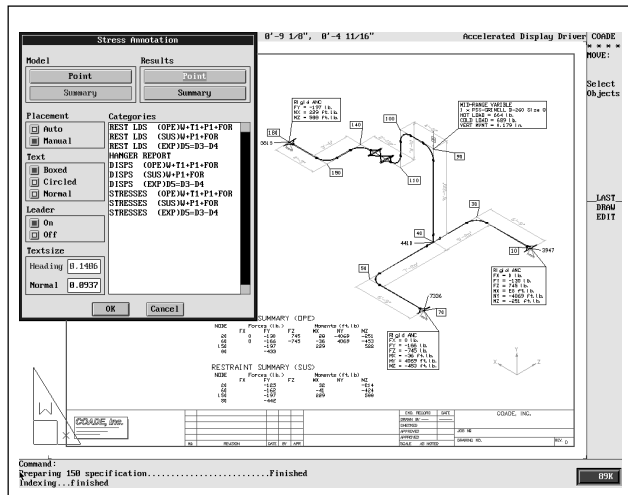


**CADWorx/PIPE?** Another CAD piping package? Yes, and as with our other software, **CADWorx/PIPE** will prove to be a valuable PC based commodity due to its simplicity, ease of operation and power.

The primary reason COADE developed **CADWorx/PIPE** was to provide the **CAESAR II** user with a link to the CAD environment. So many CAD packages on the market claim to have interfaces with **CAESAR II**, whereas most only provide inadequate transfers if any at all. These transfers often require as much intervention as keying the information directly into **CAESAR II**. Whenever an error occurs, it is usually blamed on **CAESAR II**. No link or transfer utility to date has been worthy. This has changed with the introduction of **CADWorx/PIPE**. Simple operation and a truly “bi-directional” link to **CAESAR II** makes this CAD piping software exceptional.

By selecting components from the drawing environment, an instant input file for **CAESAR II** can be created. The stress analyst will not need to be concerned with node numbering and other transfer problems found in other CAD links. Node numbers and locations will be exactly as the engineer would like to see them. The CAD operator will not need to be concerned with any aspect of the stress model. Just select and send. When the analysis is completed, if any changes or additions are made, send it back to the drawing and **CADWorx/PIPE** will automatically update your drawing. Remaining for the CAD operator will be a skeleton of the new piping components. The information regarding the stress analysis will be preserved with the drawing for future analysis. Stress isometrics can also be

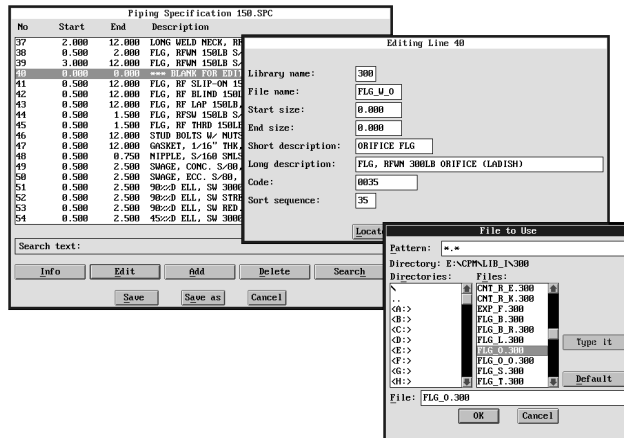
easily created and the **CADWorx/PIPE - CAESAR II** link provides all annotation required for the results and model summaries. Available information is presented in an annotation dialog with many placement options.



Many current CAD packages have grown from simplistic to very complicated. In fact, the average designer has difficulties running these monstrosities. Many weeks may be required for training. Many more weeks may be required to create specifications. Why are the tools for the designer becoming so complicated? Are there designers out there drawing in 2D? Yes! Are we to forget these people and continue on in the 3D world regardless? No! The tools for each need to be there without compromise. If orthographics are the only drawings produced, then advanced features such as automatic isometric, automatic sections and elevations may not be available. These choices need to be made available.

For designers modeling in 3D, all the necessary functions are required. Component placement needs to be relaxed, so that beginners can create 3D models. Must vertical placement of components be so difficult? Need the elevation be set each time a component is placed? Why can't we just draw components at different elevations? 3D piping design is surely an important aspect and can be an economical approach. 3D design must be easy for the designer - make it complicated and any budget will be exceeded.

From the startup of **CADWorx/PIPE**, all that's required to draw pipe components is to set a specification and size. 2D, 3D or isometric drawing can be created without costly setup time. If company standard specifications are required, modification to a template specification is easily accomplished. 150, 300, 400, 600, and 900 pound metric and English specifications are readily available. These can be modified to reflect the requirements of any job. Ease of modification can be accomplished with a specification dialog editor available right in the drawing environment. This editor has easy to use editing capabilities. Need to change all A-106 to A-333? No problem. Complete search and replace functions are available. Need to add another pipe grade? Just add or delete entries. Instant library modification can be achieved while in the drawing environment when a component size is not available. Instead of having to exit and find the necessary data files, library modification routines allow instant access and modification. Over one thousand component data files are provided. Each of the component files are provided in metric and English dimensions. Access to the components is as easy as a flip of a switch. The **CADWorx** input system includes English units with nominal inch pipe sizes and metric units with nominal metric and inch pipe sizes.



**CADWorx/PIPE** provides all modes for excellent pipe drawings. 2D double line can be used to provide conventional orthographic drawings. Single line mode can be combined with a 3D model to provide the industry's best isometrics. Isometrics can be mirrored, manipulated, etc., with unprecedented ease by taking advantage of AutoCAD's paperspace. Actually the whole drawing can be created in an Isometric mode, then converted to double line plans and elevations, then converted to 3D faces for rendering and presentation drawings. Solid modeling provides perfect sections and elevations. This mode can also be used for interference checks.

Components placed in the drawing are as easily modified. Full dialog editing will allow any type of modification. Indicators show all pertinent information, such as whether insulation is attached. Line numbers, annotations, etc., are all available for easy modification. Any of this information can be easily removed.

Automatic isometrics are a snap. Isometric data is written to exterior files where they can be collected in job directories. Global configuration can be assigned to each one of these. The configuration is presented in well laid out dialogs. During the creation of an isometric, the user will be presented with different views, allowing any selection from four predefined view points. All can be complimented with automatic dimensioning, bill of material generation or bolting assignment. Border annotation is handled automatically with a few guide lines as directed in the configuration. Isometrics are created in a real 3D environment allowing easy modification.

The industry's simplest method of UCS (User Coordinate System) manipulation is provided with the "Point and Shoot UCS" available with **CADWorx/PIPE**. Any piping system in any plane can be drawn with ease. 3D modeling has never been easier. Removed are the restraints of other CAD piping

packages which require setting an elevation every time a component or run is added. With **CADWorx/PIPE**, choose any working plane (north, south, east, west and flat), pick an origin, now you are free to work at this location. Forget about present elevation constraints that are associated with other CAD piping packages. **CADWorx/PIPE** provides the easiest placement of components at different elevations and in the vertical positions. This user enhanced control will prove to be a valuable tool.

Orthographic elevations can easily be generated from developed plans. Modify the elevations and re-insert it back into the plan. Draw your elevation and make plans from these or vice-versa. Draw a simple 2D or 3D routing line with the simplistic router function and easily attach pipe and elbows to this line. Changes in elevation through a rolling offset will provide the necessary trimmed elbows at these locations. Piping at any angle, in any direction can be applied to the routing line. Use butt weld (short or long radius), socket weld or threaded components. The provided router function covers all options for logical pipe layout (sloped, elevation change, etc.).

Tanks, vessels, pumps, and various heads are readily available. This type of equipment can be drawn in 2D or 3D. In 3D, options providing solid modeling are available. Equipment routines are designed to be exact for detailing purposes. Examples are F&D heads which prompt for each important parameter such as dished radius, knuckle radius, straight flange lengths, etc. Pressure vessel detailing is easily accommodated.

Other important features:

- Bill of Material generation
- Center of Gravity generation
- Automatic dimensioning
- Node placement controls
- Single line and fitting width control
- Customizable line numbering system
- Extended data (xdata) use for component information
- Automatic gaskets
- Restraints
- Miters
- Bends
- Rolled pipe
- Bleed rings
- Gage valves
- Spectacle blinds
- Expansion joints
- Long weld necks
- Reinforcing pads, and saddles
- Weld gaps and many more

At present COADE continues to work on **CADWorx/PIPE** along with **CADWorx/P&ID** and **CADWorx/STEEL**. **CADWorx/P&ID** will provide functional links with the piping module, databases and required material reports. **CADWorx/STEEL** will have a bi-directional link to **CAESAR II** similar to **CADWorx/PIPE**.

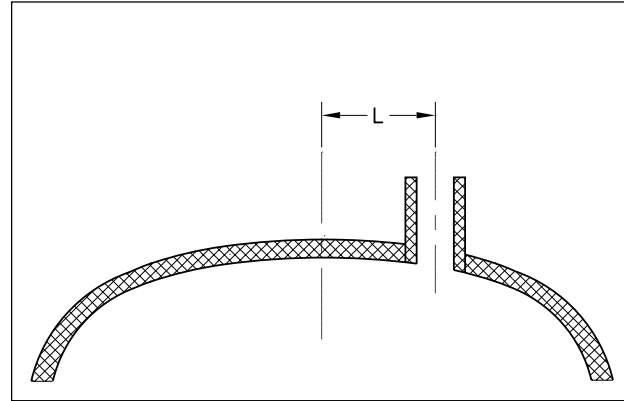
**CADWorx/VESSEL** and **CADWorx/TANK** drafting software will follow these and closely interface with the COADE's current **PVelite** and **TANK** engineering software. We look forward to working on these modules to provide more detailed equipment for the pipe drafting environment. This will probably produce a new module called **CADWorx/EQUIPMENT**. After these have been finished, **CADWorx/ELECTRICAL** drafting software will be created and should round out the complete **CADWorx** line of drafting software.

### *Hillside Nozzle Angle Calculations - Revisited*

By Tim Curington

In the initial release of **CodeCalc** version 5.4, the nozzle program included an angle calculator for hillside nozzles. The calculator computed the angles per the method recommended in the Code, and in particular the method described in an article written for the December, 1993, issue of Mechanical Engineering News. After the initial release, based upon comments and suggestions from the users of our software, the **CodeCalc** Development Staff decided to develop a more exact method of computing the angle. Using a numerical integration scheme, **CodeCalc** first determines the exact area needed to be replaced, and then, based upon the arc length of this area, **CodeCalc** determines the corresponding angle. (This new method of computing the angle is included in Patch D to current users of the software via our BBS, or Internet FTP site. Interested users should contact the COADE **CodeCalc** Development Staff.)

The following discussion shows by example the improved accuracy of the numerical integration method utilized by the Patch D version of the **NOZZLE** program. Various calculations will be performed by both methods, and the results shall be compared. In addition to being more accurate, the new method only requires the user to enter the distance from the nozzle to the head centerline (See Figure 1). In the initial release, the relative position of the nozzle in the head was also necessary.

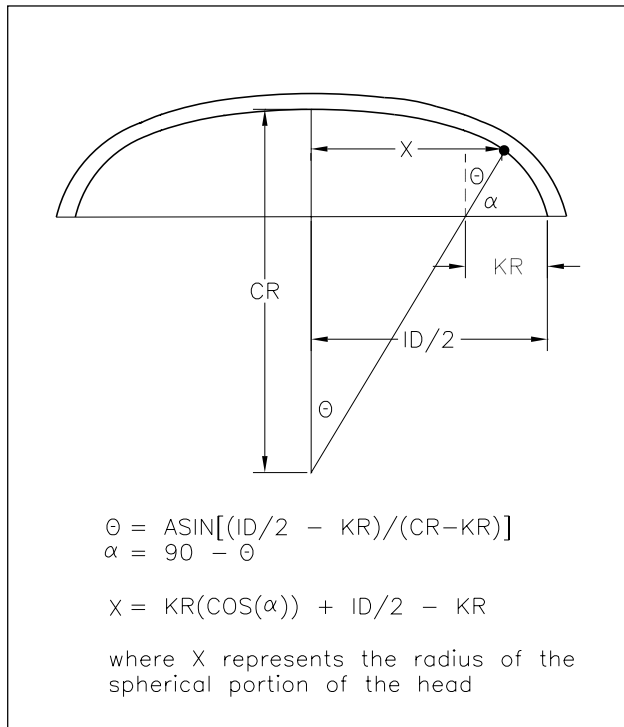


**Figure 1**

Distance from nozzle centerline to head centerline.

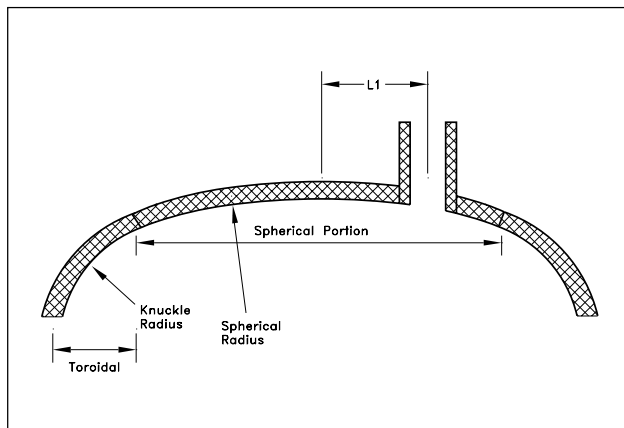
As stated previously, several example problems will be explored. For the first two examples, a nozzle of varying size will be located on a torispherical (F&D) head. The third example problem shows a nozzle located on a spherical head. The progression through the example problems illustrates the possible inaccuracy of the Code method of computing the angle.

Before proceeding to the first two example problems, the Code method of computing the angle along a torispherical head is addressed. One of the problems with calculating the nozzle angle along a torispherical head, is knowing how to define the nozzle location. In order to do this, the spherical portion of the head must be computed. For a torispherical head, the spherical portion is determined based on the head inside diameter, the crown radius, and the knuckle radius entered by the user. Figure 2 shows the calculations used to determine this value. In the figure,  $X$  represents the distance to the knuckle,  $CR$  represents the crown radius, and  $KR$  represents the knuckle radius.



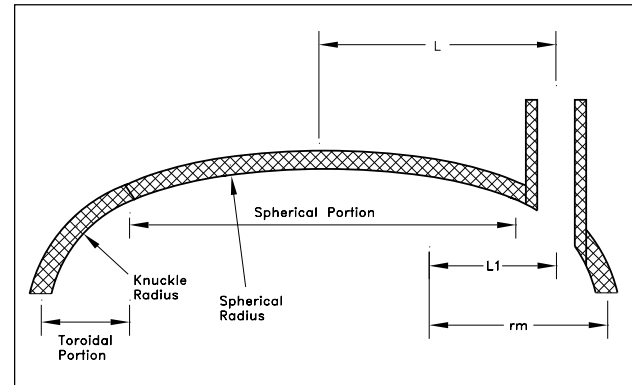
**Figure 2**  
Spherical Portion of a Torispherical Head.

After determining the location of the nozzle, the offset distances have to be determined. For torispherical heads, if the nozzle is located on the spherical portion, the offset distance is the distance L1 shown in Figure 3.



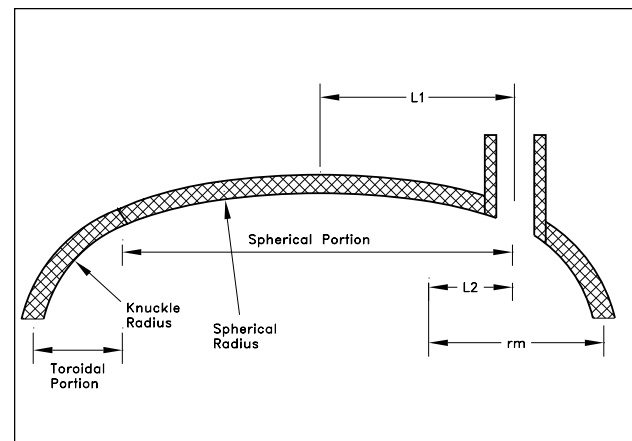
**Figure 3**  
Nozzle Located on Spherical Portion of Head.

If the entire nozzle is located on the toroidal portion of the head, the offset distance L1 is the offset distance from the mean knuckle radius. This distance is shown in Figure 4.



**Figure 4**  
Nozzle Located on Toroidal Portion of Head.

The final possible location is on the knuckle. This implies that the nozzle centerline lies on the toroidal portion of the head, but the nozzle lies partially on the spherical portion and partially on the toroidal portion of the head. The initial release required entries of L1 and L2 are shown in Figure 5.



**Figure 5**  
Nozzle Located on Knuckle Portion of Head.

Once the location and offset distances were known, the angle could be calculated as described in the December, 1993, issue of *Mechanical Engineering News*. The computation was performed using the following three equations:

$$\alpha_1 = \cos^{-1} \left( \frac{L-r_n}{r_m} \right)$$

$$\alpha_2 = \cos^{-1} \left( \frac{L+r_n}{r_m} \right)$$

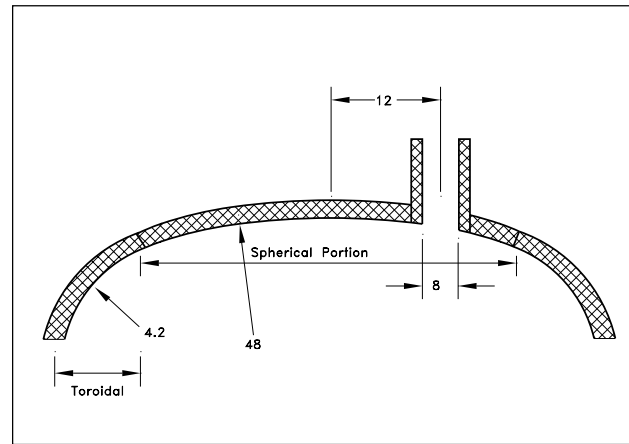
$$\alpha = \frac{\alpha_1 + \alpha_2}{2}$$

To summarize the December article, if the nozzle is located on the spherical portion of the vessel, the value L is the value L1 shown in Figure 4, and the value  $r_m$  is the mean radius of the vessel. If the nozzle is located on the toroidal portion of the vessel, the value L is the value L1 shown in Figure 5, and the value  $r_m$  is the mean knuckle radius. Finally, if the nozzle is located on the knuckle, compute  $\alpha_1$  as if the nozzle were located on the spherical portion, and  $\alpha_2$  as if the nozzle were located on the toroidal portion.

Now that we have established the basis for the Code based method, let's explore briefly the numerical integration method. To understand why this method is more accurate, it is important to understand what the angle is being used for. In the nozzle reinforcement calculations, the Code uses an area replacement method, meaning that the area of the head removed by the nozzle must be computed. In order to obtain this, the Code uses the nozzle angle to obtain the area. As will be shown in later examples, this method breaks down for larger diameter nozzles where the area computed using this angle is no longer valid. The numerical integration method, on the other hand, calculates directly the area to be replaced and then back calculates the corresponding angle. This simply boils down to knowing a radius and an arc length, and then computing the angle. Thus, the Code method should be viewed as an approximation that loses accuracy with increased nozzle diameter.

The following example problems illustrate the improved accuracy of the numerical integration method incorporated in Patch D. For the purpose of the illustrations, the first two example problems use a torispherical head with a 48 inch crown radius, a 48 inch head diameter, a 4.2 inch knuckle radius, and a wall thickness of 0.5 inches is used. There is no corrosion allowance used.

The first example is an 8" ID nozzle located on the spherical portion of the shell. The distance from the nozzle centerline to the head centerline is 12 inches, as shown in the following figure.



**Figure 6**  
8" Nozzle With a 12" Offset.

Looking at the Code method (the initial release of 5.4 method), the angle is computed as follows:

$$\alpha_1 = \cos^{-1} \left( \frac{12''-4''}{48.25''} \right) = 80.456^\circ$$

$$\alpha_2 = \cos^{-1} \left( \frac{12''+4''}{48.25''} \right) = 70.634^\circ$$

$$\alpha = \frac{80.456''+70.634''}{2} = 75.54^\circ$$

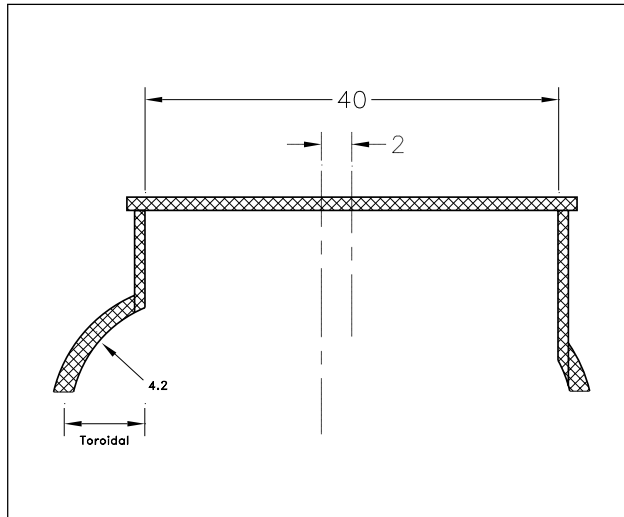
The computation of the arc length, which is really what we want, is then calculated as follows:

$$d = DLR = \frac{d_n}{\sin \alpha}$$

$$d_n = \frac{8''}{\sin 75.54^\circ} = 8.262''$$

Comparing this to the results obtained from the numerical integration method utilized by Patch D, an angle of **75.19 degrees** with an arc length of **8.275** is obtained. As can be seen, for the 8 inch nozzle, the results are essentially the same.

Although the results can be considered accurate using either method for the first example, the second example illustrates a case where the Code method begins to lose accuracy. The following example uses the same torispherical head, with a 40 inch nozzle attached. The nozzle has an offset of 2 inches as shown in the following figure.



**Figure 7**  
40" Nozzle With a 2" Offset.

First, looking at the results from the Code method, the following angle is calculated:

$$\alpha_1 = \cos^{-1}\left(\frac{2''-20''}{48.25''}\right) = 111.904^\circ$$

$$\alpha_2 = \cos^{-1}\left(\frac{2''+20''}{48.25''}\right) = 62.873^\circ$$

$$\alpha = \frac{111.904^\circ + 62.873^\circ}{2} = 87.388^\circ$$

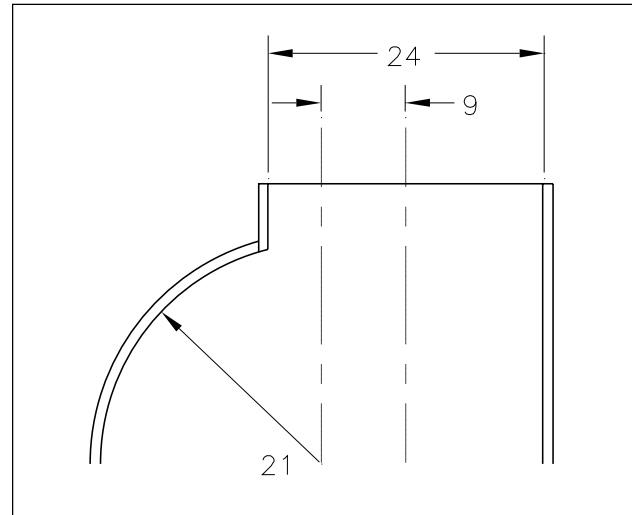
Using this angle, the following arc length is computed:

$$d = \frac{40''}{\sin 87.388^\circ} = 40.04''$$

Comparing this to the arc length of **41.31 inches** with its corresponding angle of **75.52 degrees**, an inaccuracy of 3% is introduced.

While 3% is not too significant, the final example illustrates a case where the results become far less reliable. The final example consists of a 24 inch nozzle located on a 42 inch ID

spherical head with a 9" offset (See Figure 8). The head thickness is .1316 inches, and the nozzle thickness is .25 inches.



**Figure 8**  
24" Nozzle With a 9" Offset.

First looking at the Code method, the following arc length and angle are computed:

$$\alpha_1 = \cos^{-1}\left(\frac{9''-12''}{21.066''}\right) = 98.187^\circ$$

$$\alpha_2 = \cos^{-1}\left(\frac{9''+12''}{21.066''}\right) = 4.536^\circ$$

$$\alpha = \frac{98.187^\circ + 4.536^\circ}{2} = 51.362^\circ$$

thus,

$$d = \frac{24''}{\sin 51.361^\circ} = 30.725''$$

Next, using the numerical integration method, an arc length of **35.8 inches** and a corresponding angle of **42.06 degrees** is computed. In this example a more significant error of nearly 16% is introduced.

In closing, for reasons of simplicity and accuracy, COADE has introduced PATCH D of **CodeCalc** which includes these new nozzle angle calculations. As stated previously, PATCH D is available for download from the BBS, and the Internet. Interested users should contact the **CodeCalc** Development Staff.

### Modeling Spring Cans with Friction in CAESAR II

By Richard Ay & Tim Curington

In many systems, portions of the pipe are supported by spring cans. These spring cans perform the same function as spring hangers, only they are below the pipe, pushing up.

In some models, these spring cans are allowed to slide on their foundation, subjecting the system to friction forces. How can this type of support be modeled in **CAESAR II**?

Basically, each support of this type needs:

- A rigid element from the pipe center to the top of the can. Length equals pipe radius + insulation thickness + shoe height + any trunnion height.
- A CNODE to connect to the spring. Except for the vertical spring stiffness, all other DOFs are rigidly connected.
- A rigid element representing the spring can height.

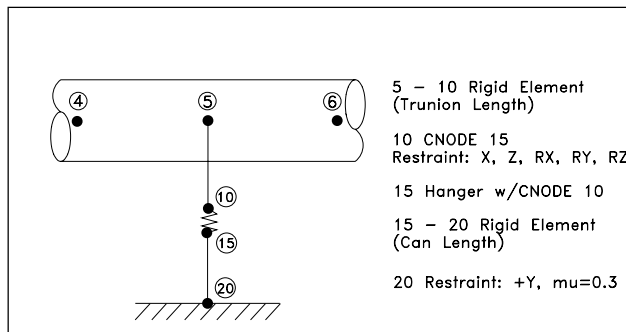
These points are illustrated in the model below.

```

CAESAR I I  VERS 3.22  JOBNAME:HGRCAN  MAY 31,1995  9:12am  Page 1
Licensed To: COADE Engineering Software, Inc.DEALER/DEMO COPY  ID: 10001

PIPE DATA
-----
From 4 To 5  DX= 5.000 ft.
PIPE
Dia= 8.625 in.  Wall= .322 in.  Insul= .000 in.
GENERAL
Mat= (1)LOW CARBON STEEL  E= 29,500,000 lb./sq.in.  v = .292
Density= .2899 lb./cu.in.
-----
From 5 To 6  DX= 5.000 ft.
-----
From 5 To 10  DY= -.749 ft.
RIGID Weight= .00 lb.
RESTRAINTS
Node 10 X  Cnode 15
Node 10 Z  Cnode 15
Node 10 RX Cnode 15
Node 10 RY Cnode 15
-----
From 15 To 20  DY= -.999 ft.
RESTRAINTS
Node 20 +Y  Mu = .30
Node 10 RZ  Cnode 15

```



This modeling technique can also be applied to situations where the shoe or trunnion slides on top of a bolted spring can.

### CADWorx/PIPE — A Model for CAD/Analysis Integration

By Thomas J. Van Laan

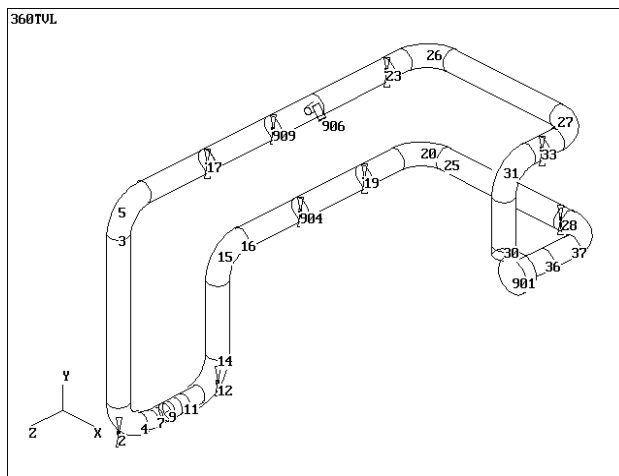
The first revolution caused by the mass availability of personal computers within the last fifteen years has been evidenced in the automation of manual tasks, improving productivity of repetitive activities. The second revolution, currently in progress, is the elimination of duplicate activities, through the sharing and reuse of data among disparate applications. For example, a financial spread sheet prepared by a company's accounting department can be inserted directly into a desktop publishing document or whisked off onto the Internet without having to be retyped or reformatted. In fact, the "hook" to these other software packages can be a logical link, which permits the automatic update of the data in the other applications as it is changed in the primary application.

The engineering community has, to date, lagged in this ability to share data between applications — but not for lack of wishing. A typical piping design project is initiated by the designer, often using CAD software, laying out the pipe routing from P&IDs, specifications, equipment drawings, and steel drawings. Once a preliminary layout is achieved, prints of the pipe routing are sent to the stress engineers, who then key the model into their pipe stress program. The stress model usually requires a certain amount of refinement, as well, in order to produce the best analytical model of the restraints (and other boundary conditions), fitting stress intensification factors, and other non-standard components. Often, modifications will be required to the piping configuration in order to meet the stress analysis criteria. At this point, the analyst must notify the designer of the changes considered in the analytical model, and hope that sufficient controls exist that these changes get re-incorporated into the design layout. The process repeats itself as further modifications are made to the piping layout; at each stage of the cycle, the engineer must re-key the model (or some portion thereof), re-tweak the specialized components, and communicate any required changes back to the responsible designer. Obviously, any portion of this process which can be eliminated by automation or data sharing offers a boon to the design/analysis process.

#### Existing interfaces not the answer:

In answer to this need, there has been a proliferation of interface programs between CAD and stress analysis — **CAESAR II** has long provided interfaces from the CADPipe, ADev, and Intergraph systems, to name a few. In many cases, this has proved to be an inadequate answer, due to an important deficiency inherent to the CAD/analysis interfaces

of today — the interfaces are usually CAD-driven, and based upon a neutral file which is intended to be a “do-all” interface (rather than one tailored to the needs of the analytical model), which often ends up insufficient for all. For example, much of the CAD information is not needed by the stress analyst, and must be discarded by any interface program. More importantly, much of the analytical information (boundary conditions, temperatures and pressures, code related data, applied loads, etc.) is not considered necessary for the CAD model, and must be entered manually by the analyst after each conversion (often many times in the design cycle, leading to the potential omission of a key modeling step at some point in the process). Also, since the interfaces are CAD-driven, the stress models usually appear as though they were generated by a machine, rather than a human stress analyst — for example, element breaks are often located at the actual component breaks, points which are largely irrelevant to the stress analyst, and numbering systems are often illogical (see Figure 1 for a **CAESAR II** model created from a typical CAD interface). One major developer of piping CAD systems (and pipe stress interfaces) confirms this through the statement: “Ideally, the transferred (stress analysis) model should result in a model that would be generated if the analyst entered the model manually. However, that would require the computer to simulate human intelligence, which in the foreseeable future, seems unlikely.” The resulting unorthodox modeling style can make it more difficult for the analyst to recognize coding errors and solve overstress problems.



**Figure 1**

Note multiple nodes at elbow breaks and illogical node number scheme

The typical CAD/analysis interface of today is not really a great labor saver, either. Use of the interface will surely eliminate the bulk of the initial system modeling, but from that point, its value is questionable. Since the interface produces a CAD-oriented model, the stress analyst must

still tweak the model to provide the stress-related nuances — not just on the first pass, but *after any subsequent conversions as well*. Since the interface is uni-directional (CAD to analysis only), any changes made to the stress model must still be communicated back to the designer for incorporation into the piping layout. The potential for missing a change in the repetitive design cycle still exists to the same degree as it does in the manual (non-automated) process.

A further problem arises when the CAD and analytical packages do not come from the same vendor (or the same development groups within a single vendor) — the maintenance of version compatibility. The interface can only work to its best effect when the interface is updated simultaneously on both sides of the fence. Changing neutral files, delayed developments schedules, and mis-guided internal commercial decisions (to cease distribution of existing stress analysis interfaces, for example) can cripple the production of users who have come to rely on a specific interface.

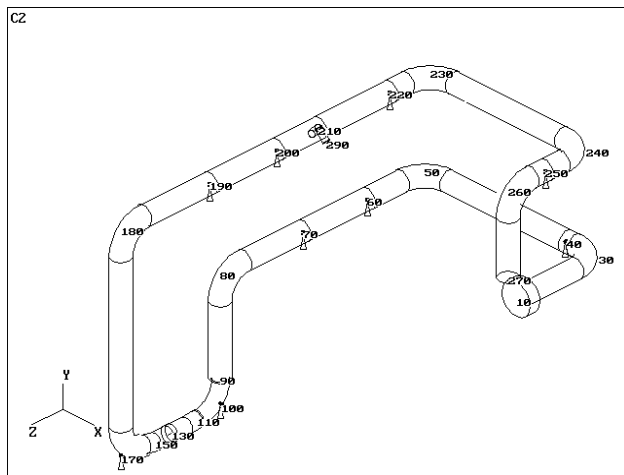
#### The promise of CADWorx/PIPE:

COADE approached the development of **CADWorx/PIPE**, our full-featured, AutoCAD-based piping design and drafting program, with the intent of providing a seamless data link to **CAESAR II** which eliminates all of these deficiencies. Our charge was to deliver a true labor-saving tool with the following specifications:

- 1) The program is fully bi-directional. Piping drawings can be developed from stress analysis models, or stress analysis models can be developed from piping drawings. Changes made in **CADWorx/PIPE** can be automatically transferred to the **CAESAR II** model, and changes made to the **CAESAR II** model can be automatically transferred back to the **CADWorx/PIPE** model. This can be repeated through any number of cycles.
- 2) The program retains nuances entered in either one of the programs, as the model is passed back and forth between the two environments. For example, a piping model may be transferred to **CAESAR II**, and the analyst may spend some time tweaking restraint models (friction coefficient, direction cosines, gap, etc.), operating conditions, element mesh, piping layout, and node numbering schemes. After transferring back the modified model to **CADWorx/PIPE**, these changes will be stored in the piping drawing, to be returned *exactly as entered by the analyst* the next time the model is returned to **CAESAR II**. Likewise, upon return from the pipe stress model, the piping drawing will appear exactly

as originally designed, even where potential ambiguity exists (for example, use of bent pipe vs. standard piping elbows).

- 3) Wherever possible, the program uses artificial intelligence so that, when initially creating a stress analysis model from a piping drawing, or vice versa, it appears to have been done by an experienced stress analyst or piping designer, not by a machine. In the stress model, element breaks are located as expected in a **CAESAR II** model, stress intensification factors are correctly generated, and the automatic node numbering scheme appears logical (see Figure 2 for a **CAESAR II** model created from the **CADWorx/PIPE** interface). In the piping drawing, the components are also broken correctly, and are chosen on a most likely basis from the selection of components which can represent each specific portion of the **CAESAR II** model.



**Figure 2**  
Single Nodes at elbows and logical node numbering scheme

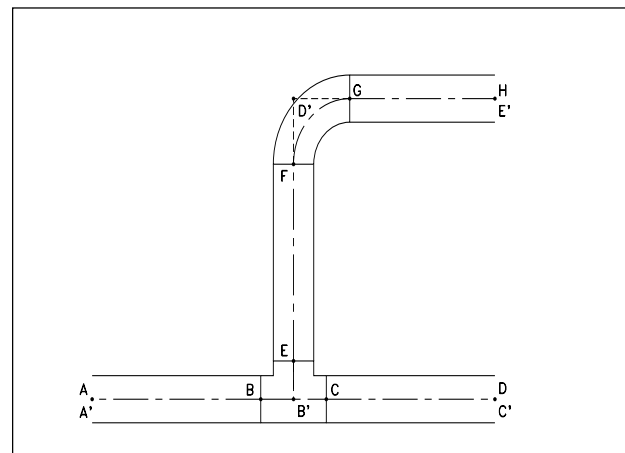
- 4) There will never be a mismatch between the **CADWorx/PIPE** and **CAESAR II** development cycles, leading to a crippling of the interface. Where **CADWorx/PIPE** does require **CAESAR II** Version 3.23 in order to use the stress analysis models created from the piping drawings, **CADWorx/PIPE** can create piping drawings and stress isometrics from earlier versions of **CAESAR II**. Development of the data link is the responsibility of the developers of **CAESAR II**, and critical releases will be done in tandem in the future. As has been true with all versions of **CAESAR II**, all updates of **CADWorx/PIPE** will always maintain upward

compatibility with both piping drawings and stress analysis models. There are no neutral files to be lost (or become outdated), and no secondary processes to be maintained current — the data link operates on a simple select and send basis.

This promise has been delivered with COADE's first release of **CADWorx/PIPE**.

#### **An intelligent interface — the underlying model:**

A certain portion of the specifications outlined above can be implemented through a rigorous data tracking system — attaching stress analysis information to the CAD components and CAD information to stress analysis elements. However this is not sufficient, due to the fact that designers and analysts “speak a different language” as far as the models are concerned. For example, the configuration in Figure 3 (tee, 90° bend, and four straights) would usually be broken by the piping designer at points A, B, C, D, E, F, G, and H, creating six components, while the stress analyst would typically break it at A', B', C', D', and E', creating four elements. It is easy to see how the first configuration could be automatically converted to the second, or the second converted to the first — the problem develops due to the fact that there is a “many-to-many” mapping of design layouts to stress analysis configurations (see Figure 4). This makes it difficult to return, on subsequent bi-directional passes, exactly what was originally sent on the first conversion. Continuing the linguistic analogy, it is easy to translate “Pleased to meet you!” into French as “Enchanté de faire votre connaissance!”, but isn't there the chance that it might get translated back as “I'm enchanted to make your acquaintance!”?



**Figure 3**

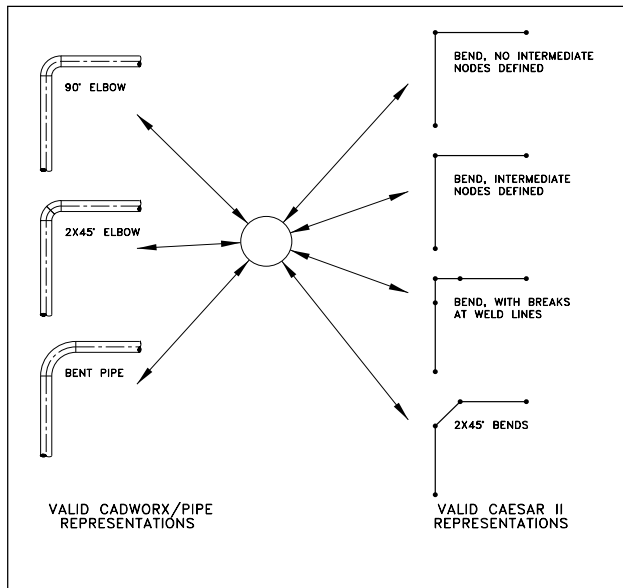


Figure 4

**CADWorx/PIPE**'s solution to this problem is to store all elements as a set of sub-elements, with references to both the **CADWorx/PIPE** piping component, and the **CAESAR II** element to which they belong. For example, the configuration shown in Figure 3 is actually broken, unseen by the user, at points A", B", C", D", E", F", G", H", I", and J" (as shown in Figure 5). Pointers designate element A"-B"; elements B"-C", C"-D", and C"-F"; element D"-E"; element F"-G", elements G"-H" and H"-I"; and element I"-J" as belonging to distinct **CADWorx/PIPE** components; when working in **CADWorx/PIPE**, the user would only see these groups of sub-elements as the six virtual components. Likewise, pointers designate elements A"-B" and B"-C"; elements C"-D" and D"-E"; elements C"-F", F"-G", and G"-H"; and elements H"-I" and I"-J" as belonging to distinct **CAESAR II** elements. Accordingly, when the user is working in **CAESAR II**, these groups of sub-elements are displayed and processed as four virtual elements. In this way, by breaking the system into elements representing the lowest common denominator, the data always retains exact information on its external representation in both programs.

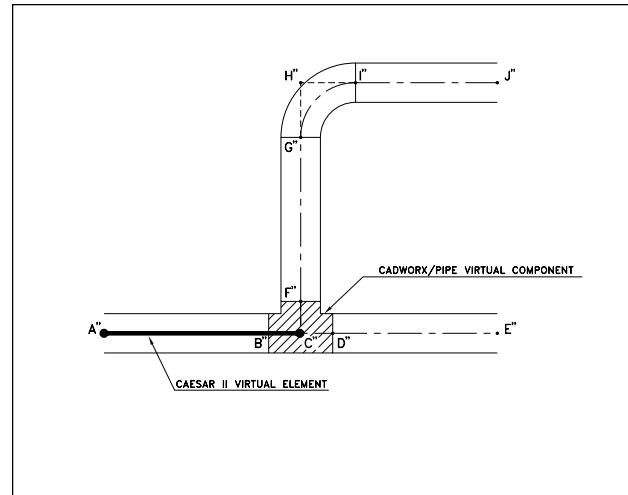


Figure 5

Of course, there is still the potential for problems to occur upon initial conversion from one program to another. A good example occurs with the conversion of a rigid element from **CAESAR II** to **CADWorx/PIPE** — a truly ambiguous situation. In the stress analysis model, a single rigid element could represent a fictitious construction element, an actual rigid piping component (flange or valve), or even a series of rigid piping elements (flange pair, or flange-valve-flange, with gaskets). Even if the number of components and type (flange vs. valve) were known, there is still a wide variation of flanges (weld neck, slip on, etc.) and valves (gate, globe, check, etc.) which could represent the analyst's intent.

These ambiguous situations are solved through artificial intelligence algorithms which attempt to find the most likely representation. For example, when determining how a **CAESAR II** rigid element should be converted to **CADWorx/PIPE**, the following process takes place:

- 1) The system is examined for clues indicating what configurations are possible — for example, if a fillet weld is designated at one end of the rigid, this indicates a socket fitting (valve or flange), which cannot be the face of a flange; if the two adjacent elements are normal pieces of pipe, the rigid element cannot represent a single flange, or a flanged-end valve, and the fitting must be of a butt weld type; if an adjacent element is a flange face, this element cannot be a flange pair (but could be a valve, valve-flange, or flange); etc.

- 2) All potential combinations of flanges, valves, and other rigid elements which could be consistent with the system clues are then checked for best fit. This is done by using the **CADWorx/PIPE** component data files to get the lengths of the postulated configurations; these lengths are then compared to the length of the **CAESAR II** rigid element. The configuration with the closest fit (in terms of length) is then selected for representation on the **CADWorx/PIPE** side.

Similar processes are followed when converting other potentially ambiguous components, such as sizing expansion joints, and of course, in the event that the conversion program guesses wrong, the user is given the chance to overrule its decision. This procedure does point to what the **CAESAR II** analyst can do in order to get the best representation when converting to **CADWorx/PIPE** — model the **CAESAR II** elements with properties (length, SIFs, etc.) as close as possible to the **CADWorx/PIPE** components which they are supposed to represent (and vice versa).

**CADWorx/PIPE — the future:**

These are just a few of the types of intelligent process implementations found in **CADWorx/PIPE**, which we expect will provide not just a true time and work saver to the engineer, but also will set the standard for interfaces between design and engineering software for the foreseeable future. COADE remains committed to continue its development, adding the latest in artificial intelligence to improve its interface to **CAESAR II** wherever possible, providing the skill of the trained stress analyst to the designer, and vice-versa. Also, it is our intent to expand the scope of the program, currently limited to piping design, to include P&ID, steel design, vessels, and tanks within the near future. With each new module, we will strive to provide the same quality interface between **CADWorx** and our other analytical software — **PVELite**, **CodeCalc**, and **TANK**.

*A Review of ASME’s External Pressure Calculations*

By Scott Mayeux

In many typical petrochemical applications, pressure vessels are designed not only to withstand stresses due to internal pressure but also external pressure. External pressure will cause a cylindrical cross section to displace laterally or form a lobed pattern when the stresses in the vessel wall become greater than the stress the material can withstand (see figure 1 below). The ASME Code Section VIII Division 1 has a set of requirements in paragraph UG-28 which are used to determine the required thickness of cylindrical shells and heads under external pressure. In this article we will discuss an apparent inconsistency in the ASME Code for the design of cylindrical shells under external pressure.

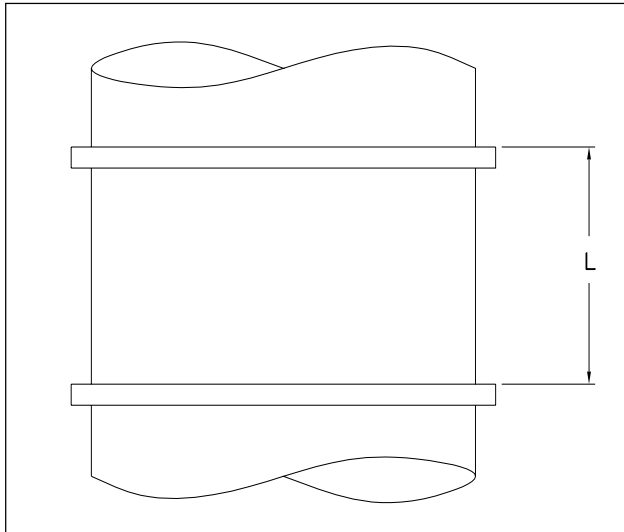
Buckling Mode				
Characteristics				
k = Number of lobes (k is the number of full sine waves around the periphery)	1	2	3	4
P <sub>e</sub> = Critical pressure the elastic Buckling or collapse	0 (No elastic buckling occurs, only sideways displacement of undistorted circle)	$\frac{3E}{4}$	$\frac{9E}{4}$	$\frac{15E}{4}$

In order to design a cylinder for external pressure, the following data are required :

- 1 - the modulus of elasticity of the material at design temperature E
- 2 - the outside diameter of the cylinder Do
- 3 - the length in between stiffeners or tubesheets L
- 4 - the external pressure chart for the material from Section II Part D CS-2
- 5 - the design temperature for external pressure T
- 6 - the design external pressure P
- 7 - the thickness of the cylinder ts

For our example we will use the following design data :

Design External Pressure	15 psig
Cylinder OD	103 in.
Cylinder Length ( between stiffeners )	141.375 in.
Cylinder Thickness ( Corroded )	0.375 in
Design External Pressure Chart ( SA 516-70 )	CS-2
Design External Temperature	335°F



The computation proceeds as follows :

- Step 1- Compute the value of  $Do/t$  ( $103/.375 = 274.666$  )
- Step 2- Compute the value of  $L/Do$  ( $141.375/103 = 1.3726$  )
- Step 3- Open Section II Part D to Figure G and determine Factor A ( .0002081 )
- Step 4- Read the external pressure chart CS-2 with the value of A and Determine B (stress ) 2980.53 psi
- Step 5- Compute the allowable pressure at this thickness using the equation  $P_a = 4B/(3(Do/t)) = 14.47$  psi

In our case, the required external pressure is greater than 14.47, therefore this geometry is inadequate.

In a similar iterative fashion we determine that the maximum length between stiffeners  $L$  is **136.38** in. and the required thickness is **0.3805** in. Thus we can conclude that this cylinder is too long and too thin for 15 psig external pressure.

As it turns out, the Code also provides tabular values for Figure G. These values appear in Section II Part D table G. When table G is read, discrete values of  $Do/t$  and  $L/Do$  are given. In order to arrive at the solution for a particular set of values an appropriate interpolation scheme must be used. The values from table G are used to determine Factor A as follows :

For  $Do/t$  of 250 and  $L/Do$  of 1.3726 Factor A is approximately equal to 0.000270913.

For  $Do/t$  of 300 and  $L/Do$  of 1.3726 Factor A is approximately equal to 0.000205562

By inspection we can immediately tell that Factor A will be larger than 0.0002081. Now we need to compute the overall value of factor A by using logarithmic interpolation. The computed factor A is equal to 0.000235, which yields a Factor B that is equal to  $(AE/2) = 3359.62$  psi. Using this value of B and the equation above the allowable external pressure is 16.30 psig. Thus by using Table G instead of Figure G, our initial geometry is acceptable.

#### What does all of this mean ?

So far we have calculated the allowable external pressure on a cylinder by the same method using the “same” set of data, one in chart form and one in table form. The difference between these two is that several people were given the task of reading and converting Figure G into Table G. Since Figure G is difficult to read within 10% and is logarithmic, there is some amount of error in Table G. **CodeCalc** and **PVElite** have Figure G in equation form and as a result the factors derived from these charts are both consistent and accurate. One should also understand that there is a much smaller factor of safety built into the Code where external pressure is concerned.

#### Conclusion

At this point we must determine which answer is correct. In reality, since both are ASME Code calculations, both should be valid. In this particular case the use of a stiffener can be avoided and thus the cost of the vessel could be cut by a slight amount at the expense of a non-conservative analysis. In short, one should only use table G as a last resort, since it generally produces a non-conservative result. Additionally, when comparing results from hand calculations (or other programs) to **CodeCalc** or **PVElite**, be aware of the underlying data used in the computations.

Hopefully the ASME Code committee on external pressure has recognized this problem and will furnish a suitable set of equations and examples that would simplify the design of cylinders and heads under external pressure.

CAESAR II Notices

Listed below are those errors & omissions in the **CAESAR II** program that have been identified since the last newsletter. These items are listed in two classes. Class 1 errors are problems or anomalies that might lead to the generation of erroneous results. Class 2 errors are general problems that may result in confusion or an abort condition, but do not cause erroneous results.

**Class 1**

- 1) Stress Computation Module: An error was discovered in the B31.4 code stress computation for “restrained” lines. The initial implementation for this condition did not include the addition of the hoop stress to the final value.

This error exists in all 3.x versions, up to Version 3.22, which corrected the error.

- 2) Piping Error Checker: An error was discovered in the generation of the nodal coordinates - the “*user specified global*” coordinate values were not converted from User Units to English Units.

This error exists in only Version 3.22 and only applies to jobs not using the default units file. This error is corrected in Patch A to 3.22.

An error was discovered in the Center of Gravity report when working in non-English units systems and the model contained rigid elements. The weight of these elements was not converted to “user” units for the report presentation.

This error exists in only Version 3.22 and only applies to jobs not using the default units file. This error is corrected in Patch F to 3.22.

- 3) Input Units Conversion Module: An error was discovered in the conversion of input files between units systems - the “*user specified global*” coordinate values were not converted.

This error exists in only Version 3.22 and only applies to jobs not using the default units file. This error is corrected in Patch A to 3.22.

- 4) Equipment Module: An error was discovered in the API-610 printed output reports. Even though the numeric values indicated failure, the status was reported as PASSED.

This error exists only in Version 3.22, and was corrected in Patch B to 3.22.

- 5) Structural Steel PreProcessor: A limitation of the structural steel preprocessor, with regards to “G” loads has been discovered. The structural preprocessor assumes uniform loads are “force per length” loads. No consideration is made in the structural preprocessor for uniform loads to represent “G” loads as in the piping preprocessor.

This limitation can lead to incorrect results when a structural model is combined with a piping model which includes “G” loads. The structural modeler always divides the uniform load specification by the uniform load conversion constant (to convert to English units), while the elemental load generator follows the “G” flag set in the piping preprocessor.

This limitation is only a problem when non-English units files are used. This limitation exists in all 2.x and 3.x versions, up to 3.22 Patch E.

- 6) Structural Data Base File GERM91.BIN: A formatting error was discovered in the German structural data base file which affected the cross sectional area of 18 members. The cross sectional area of the following members was incorrect.

1/2IPEV550	1/2IPEV600	
1/2IPB450	1/2IPB500	1/2IPB550
1/2IPB600	1/2IPB650	1/2IPB700
1/2IPB800	1/2IPB900	1/2IPB1000
1/2IPBI550	1/2IPBI600	1/2IPBI650
1/2IPBI700	1/2IPBI800	1/2IPBI900
1/2IPBI1000		

This error exists in Versions 3.18, 3.19, 3.20, 3.21, and 3.22. A corrected data base is available in Version 3.22 Patch E.

**Class 2**

- 1) AISC Unity Check Module: A logic error in the verification of the material yield stress prevented the program from evaluating partially compact members. The program displayed an error message instead, and skipped the member.

This error exists in all 2.x and 3.x versions, up to Version 3.22, which corrected the problem.

- 2) Loader/Manager Program: An incorrectly sized buffer prevented the software from running when installed in a directory whose full pathname exceeded 18 characters.

This error exists in Versions 3.21 and 3.22. This problem is corrected in Patch A to 3.22.

- 3) Intergraph Interface Module: Several data management errors have been discovered, which are related to the ordering of the Intergraph elements. This caused to interface to place Tee and Restraint nodes on improper spreadsheets, in some jobs, causing errors in the Error Checker.

This error exists in all 3.x versions. This error is corrected in Patch A to 3.22.

- 4) Miscellaneous Processor: An initialization error in a character buffer caused this module to always assume the user had changed/updated the input. This disabled the output print option *if the output had been scrolled on the screen*.

- 5) Static Output Processor: A presentation error was discovered in the reporting of the "hanger load variation" value, for user defined springs. (This value is not computed for user defined springs, and remains uninitialized.) This value overwrote the user's value of the spring rate in the output reports.

This error exists only in Version 3.22 and is corrected in Patch A to 3.22.

- 6) Piping Error Checker: A units conversion error in the "center of gravity" routine caused the weight values to be converted twice. This error is significant for non-English units files only.

A memory allocation error has been found and corrected in the "center of gravity" routine. This error caused asterisks to be displayed in the CG report.

These errors exist only in Version 3.22 and are corrected in Patch C to 3.22.

- 7) Dynamic Output Processor: An error was discovered in generating the titles for the dynamic input echo. This caused the output module to abort.

This error exists only in Version 3.22a, 3.22b, and 3.22c. This error is corrected in Version 3.22 Patch D.

- 8) Input Echo/Report Writer: An error in the ESL routine which acquires the "client name" aborted the program if a network ESL was accessed while a local ESL was also present.

This error is corrected in Version 3.22 Patch D.

- 9) 32 Bit Output Modules: In January of 1996, a fix was obtained from WATCOM which patches their FORTRAN compiler, to current network printing problems for some Novell, Windows 95, and Windows NT systems. The appropriate **CAESAR II** Modules have been recompiled and are available in Version 3.22, Patch F.

**TANK Notices**

Listed below are those errors & omissions in the **TANK** program that have been identified since the last newsletter. These items are listed in two classes. Class 1 errors are problems or anomalies that might lead to the generation of erroneous results. Class 2 errors are general problems that may result in confusion or an abort condition, but do not cause erroneous results.

**Class 1**

- 1) Seismic Computations: An oversight was discovered in the seismic routines - the specified weight of shell attachments was not included.

This error exists in all versions up to 1.20d, which corrected the problem. Version 1.20d was distributed to all users.

- 2) Seismic Computations: A variable assignment in the Error Checker inadvertently passed the "Importance Factor" through an integer variable. This truncated the value to 1.0.

This error exists in all versions up to 1.20e, which corrected the problem. Version 1.20e was distributed to all users.

- 3) Wind Stability Checks: An error was discovered in the use of the “% Roof Weight Supported by the Shell”. This value was used as entered by the user, instead of being converted to a percentage.

This error exists in all 1.10x and 1.20x versions. This error is corrected in Version 1.20f and Version 1.30. The 1.20f patch is available for download from the COADE BBS or FTP site.

- 4) Shell Course Thickness: An error was discovered in the implementation of Table 3.6.1 for 120 ft diameter tanks. For this exact diameter, the program set the thickness to 0.25 inches instead of 0.3125 inches.

This error exists in all version up to 1.30a, which corrected the problem. The 1.30a patch is available for download from the COADE BBS or FTP site.

- 5) Seismic Computations: The computation for the minimum required anchorage according to E.6 is incorrect if the pressure uplift face is included.

This error exists in versions 1.10, 1.20, and 1.30. This error will be corrected in version 1.31.

#### Class 2

- 1) Input Title Page: Several buffer pointers were improperly updated when editing the title page, which resulted in erratic behavior.

This error exists in all versions up to 1.20d, which corrected the problem. Version 1.20d was distributed to all users.

- 2) Loader/Manager Program: An incorrectly sized buffer prevented the software from running when installed in a directory whose full pathname exceeded 18 characters.

This error exists in Versions 1.10 and 1.20. This problem is corrected in Patch E to 1.20.

- 3) Output Preprocessor: A units labeling error has been discovered in the output generation module. This error presented the required thickness of cone roofs with the wrong units label. The unit was labeled as force instead of thickness, the numeric value reported is correct.

#### PVELite Notices

Listed below are those errors & omissions in the **PVELite** program that have been identified since the last newsletter. These items are listed in two classes. Class 1 errors are problems or anomalies that might lead to the generation of erroneous results. Class 2 errors are general problems that may result in confusion or an abort condition, but do not cause erroneous results.

#### Class 1

- 1) In some cases the insulation thickness was ignored for the computation of the overall diameter for wind calculations. This problem did not occur on every analysis. This was corrected in Patch A.
- 2) For Nozzle calculations when external pressure governed and it was a large nozzle, the large nozzle calculations were incorrect. This also effected the UG45b1 calculation and the MAWP. This was corrected in Patch A.
- 3) For the Canadian Seismic design code, the factors  $Z_a$  and  $Z_v$  were switched. These factors are used in computation of the design base shear. If the values for  $Z_a$  and  $Z_v$  are different the results may not be conservative. This was corrected in Patch A.
- 4) The values for percent wind and percent hydro were always being taken as 100 in the analysis part of the program. This always led to conservative results for load cases involving those values. This was corrected in Patch A.

#### Class 2

- 1) A display/printout error for the MAWP of torispherical heads existed. The summary table displayed the correct value while the equation printout displayed a value that did not include the hydrostatic head. This was corrected in Patch A.
- 2) When more than one user defined material was added to the database, the input program would abort when that material was selected. This was corrected in Patch A.
- 3) The analysis program would abort when the class of an attached flange was blank. This was corrected in Patch A.

### *CodeCalc Notices*

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Listed below are those errors & omissions in the **CodeCalc** program that have been identified since the last newsletter. These items are listed in two classes. Class 1 errors are problems or anomalies that might lead to the generation of erroneous results. Class 2 errors are general problems that may result in confusion or an abort condition, but do not cause erroneous results.

These errors have been corrected in version 5.40D. Users of version 5.40 or 5.40B can download the self-extracting patch file CC54D\_U.EXE from our BBS ( 713-890-7286 ) or FTP through the Internet ( ftp.hti.net under subdirectory Pub/Coade/CodeCalc ). Copy this patch file to the CodeCalc directory ( \CC5 ) and type **CC54D\_U -O** <enter>. The new version 5.40D will be generated and replace your 5.40 or 5.40B version.

#### **Class 1**

- 1) Nozzle Reinforcement Calculation: In the Large Nozzle case and if case 2 or 3 (external pressure or N&C) dominates, the nozzle reinforcement calculation was incorrect. Also in case 3 (N&C) the program calculated the minimum nozzle neck thickness using the corrosion allowance.
- 2) Conical Section with Knuckles: The half-apex angle and some related calculations were not accurate. CC5.40D can now calculate the half-apex angle correctly based on the given geometry.
- 3) Flange Rigidity Index Calculation: Flange rigidity index calculation did not include the corrosion allowance.
- 4) Tubesheet Thickness for U-tube exchangers: If the U-tube tubesheet is extended as flange, the required thickness calculation did not iterate. Also a minor error existed in calculating one of the terms in Tubesheet Shear Design Pressure per RCB-7.164.
- 5) Floating Head Design: The backing ring ID was not corroded.

#### **Class 2**

- 1) Flange Analysis and Design: Flange module now is able to compute gasket seating MAWP along with operating MAWP independent of design pressure.
- 2) Conical Section with Knuckles: For the external pressure case if the cone is not a line of support, the calculation would abort.
- 3) Unit Conversion for Non-English Unit in Intermediate Calculations: Some printouts during intermediate calculations for non-English Unit did not convert properly, but the final results are correct (for Tubesheet and Horizontal Vessel modules, etc.).
- 4) Tubesheet Not Extended as Flange: The program checked inputs and did some non-relevant calculations that were only needed for flanged tubesheets for angle leg geometry.
- 5) Legs & Lugs: The program could not properly perform on screen calculations (using F9). Also the program would abort if using help at "Legs cross braced Y/N".
- 6) Printing under Window 95, Window NT and Novell VLM systems: The program is recompiled with WATCOM 10.5a-Printer, to allow printing on these systems — particularly graphics.

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*Clarification Regarding COADE, Paulin Research Group, and Algor*

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As many of you may recall, in August of 1991, COADE split into two corporations; COADE, Inc. and Paulin Research Group (see Mechanical Engineering News 3/92 and 4/95). Unfortunately, Paulin Research Group (PRG) operated under the name COADE Research Services for several years, causing confusion among users and dealers. *In actuality, COADE and PRG were two distinct corporations, with different offices, with different staffs, with no joint business activities.* COADE, Inc. develops and markets **CAESAR II**, **CodeCalc**, **PVElite**, **TANK**, and **CADWorx/PIPE**. PRG develops (and until recently marketed) **FE/Pipe**. Repeat ... the staff of PRG has had no input to **CAESAR II** development since 1991.

Last October, PRG signed a marketing agreement with Algor. According to our information, Algor will market all software developed by PRG, i.e. **FE/Pipe**. In addition, PRG will devote some time to the maintenance of PipePlus, Algor's Pipe Stress program.

Some of our users have expressed confusion due to Algor's recent marketing claim that they intend to integrate **CAESAR II** into their products. The purported integration of **CAESAR II** into Algor software is in actuality a simple interface that reads the **CAESAR II** neutral file, described in the **CAESAR II** User's Manual. There will be no merging or integration of software, since in reality Algor and COADE are competitors, and neither Algor nor PRG has access to, or control over, the **CAESAR II** source code.

Engineers in the Power and Process Industries can continue to expect the most complete, robust, and best supported software from COADE. The Development/Support staff of COADE has an *average* tenure of six years, with several exceeding 10 years. Anyone with questions or concerns on this topic should feel free to contact the management of COADE at any time.

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*COADE Current Software Versions and Pricing*

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**CADWorx/PIPE** - Version 1.00

- Full License: \$2,500
- Full License (for current **CAESAR II** users): \$1,500

**CAESAR II** - Version 3.23

- Full License: \$11,000
- Limited Use (50 runs): \$600
- Monthly Lease: \$650

**CodeCalc** - Version 5.40d

- Full License: \$2,000

**PVElite** - Version 1.15

- Full License: \$4,500
- Limited Use (50 runs): \$500

**TANK** - Version 1.31

- Full License: \$1,500

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*Software Development Survey*

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As an aid to the further development of COADE software, we would appreciate it if you could take the time to complete the following survey and fax it back to the COADE Development Staff at 713-890-3301.

- 1) What operating system do you use now: (DOS, Windows95, WindowsNT)? \_\_\_\_\_
- 2) What operating system would you prefer: (DOS, Windows95, WindowsNT)? \_\_\_\_\_
- 3) Are you expecting to change operating systems in the near future, and if so to what? \_\_\_\_\_
- 4) Are you connected to a network, and if so what type? \_\_\_\_\_
- 5) What type of CPU processor do you have: (386, 486, Pentium, Pentium Pro)? \_\_\_\_\_
- 6) Do you have access to a modem to acquire software patches? \_\_\_\_\_
- 7) Do you have Internet access? \_\_\_\_\_
- 8) Do you have a CD-Rom drive in your computer? \_\_\_\_\_

**Comments / Suggestions:**

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\_\_\_\_\_  
Name (optional)

\_\_\_\_\_  
Company (optional)

\_\_\_\_\_  
Phone (optional)

\_\_\_\_\_  
Fax (optional)



*AutoCAD model created using CADWorx/PIPE  
Rendering created by AccuRender2 (by Robert McNeel and Associates)*

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### COADE Engineering Software

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