MECHANICAL ENGINEERING NEWS

COADE® Engineering Software

For the Power, Petrochemical and Related Industries

April, 1991

BULLETIN POLICY

The **COADE** Mechanical Engineering News Bulletin is published on a quarterly basis 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 Programs offered by **COADE**.

Please note that the "**CAESAR II** Specifications" section of this issue contains all of the software errors discovered since the 3.1 release of **CAESAR II**. Users should pay special attention to these error lists, and make sure they obtain up to date versions which correct these deficiencies.

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PC HARDWARE FOR THE ENGINEERING USER (PART 11)

Many of the newer computers support advanced keyboard functions. These functions depend on the type of computer (i.e. laptop or desktop) and on the keyboard driver loaded (i.e. with KEYB). The following list of keyboard commands applies to COMPAQ computers:

calculations. Automatic finite element model generation and code stress post processing will be available for 90 degree intersection models. These models can optionally have reinforcing pads and/or nozzle/pipe transition areas. Man time required to build these extensive models is measured in minutes, and post processing results are compiled in an easy to read ASME Section VIII Division 2 form. Full fatigue calculations in accordance with Appendix 5 are included. The graphics capability available with this product is extremely descriptive, and no special finite element expertise is required. Pre-defined templates select element types, mesh gradients, etc. to insure that proper model building is achieved. Automatic mesh generation is available for d/D ratios from 1.0 to 0.05.

The next issue of Mechanical Engineering News will be dedicated to FE/PIPE, and much more information will be forthcoming at that time.

PLASTIC PIPE MODELING

A number of users have recently asked for guidelines when analyzing plastic pipe. The following discussion was prepared for this reason.

There are many types of plastic pipe available on the market today. The problem with some types of plastic pipe materials is that they are not isotropic in nature. PVC pipe is an example of plastic pipe that is isotropic. PVC pipe can be analyzed using the standard **CAESAR II** pipe element model. Wrapped FRP pipe is not isotropic, and needs the special orthotropic material model in **CAESAR II** (that is activated by Material #20) to be analyzed properly.

Wrapped FRP pipe contains layers of glass and matrix wrapped at several pre-specified angles about the pipe axis to build up the wall thickness of the pipe. 20-30 layers wrapped at different angles are used by the manufacturer to obtain the desired pressure carrying capacity and bending strength. Because the layers are at different angles, and because the glass/matrix sheets have only axial load carrying capacity, the resulting pipe has different strength properties in the hoop and longitudinal directions. For example, if the pipe was only wrapped at 90 degrees to the pipe axis, the resulting pipe could only contain hoop pressure stresses and essentially zero bending or longitudinal pressure stresses, and would of course be worthless. Because there is no standard for the angle or degree of wrap, the properties of the final pipe must be specified by the manufacturer. Obtaining these properties is fairly straight forward, as there are typical relationships that are used to get global properties from the local characteristics of the glass and matrix, given the angle and the degree of wrap.

Today there is also FRP pipe that is not wrapped in sheets. In this FRP pipe the glass, in very small pieces, is enclosed in the matrix, and then sprayed onto a mold of the pipe. This method of construction provides for essentially isotropic properties, as the glass fibers are oriented at random in the matrix. In this instance the standard **CAESAR II** pipe element can be used, just like for PVC pipe.

When analyzing plastic pipe we are primarily looking for points where the pipe is under supported both horizontally and vertically. Steel pipe designers tend to under support plastic pipe because they use "rules-of-thumb" and a "design-eye" for the much stronger steel pipe. As a result supports on vertical risers are placed too far from the vertical leg, and leakage occurs at weak elbow joints. Horizontal supports should be provided liberally because they are inexpensive and lightly loaded, and because they prevent the pipe from moving into a position that is potentially dangerous. In fact any horizontally unsupported line can "walk" its way off of supports, into other lines, etc. if the designer is not careful. These types of problems seem to be exacerbated when working with plastic pipe. **CAESAR II** evaluates the under supported nature of the pipe.

Vertically unsupported pipe, the most dangerous condition, is revealed by a static weight+pressure+thermal analysis. Horizontally unsupported pipe is revealed by a quick modal dynamic analysis.

Practically, the pressure stresses in plastic pipe should be considered **before** any flexibility analysis. These pressures determine the thickness of the pipe, and the degree of the wrap. **CAESAR II** includes the effect of elongation due to pressure and the additional bending stresses due to weight and thermal. These bending stresses are compared to the bending stresses allowed in straight plastic pipe subject only to weight and fluid loads. If the thermal+pressure+weight bending stresses are less than the allowable bending stress in the longest permissible span then the pipe is properly supported. This has tended to be a very practical approach to determining allowable stresses for plastic pipe. This method is outlined in the steps below:

1 - Look up the allowable span for plastic pipe filled with water from a manufacturers catalog. Use the diameter of the pipe in the system to be analyzed.

2 - Using **CAESAR II**, build a plastic pipe model that is comprised of straight pipe sitting on vertical Y supports. Include at least 6 equally spaced supports, with free nodes at the ends. Place a node at the midpoint of the middle span. The lengths between supports should be equal to the maximum allowed pipe span obtained from the manufacturers catalog.

3 - Make sure that the pipe is filled with water, and run the weight plus operating pressure analysis on the pipe.

4 - The largest code stress, and the largest bending stress on the middle span are the limits to the bending and code stresses that should then be allowed in the operating system.

The flexibility of plastic pipe for bends is taken to be 1.0 times the flexibilities of a typical curved pipe. This is reasonable given that elbow fittings are typically much thicker than the attached pipe. The sif's for all plastic fittings are taken as 2.3. This value was recommended by Ciba-Geigy plastic pipe systems here in the US. If the user has some more accurate SIF for his plastic pipe bends he may enter this value in the "SIF auxiliary" field after entering the parameter ALLOW_USERS_BEND_SIF=YES in the SETUP.CII file.

The **CAESAR II** plastic pipe model is for fiberglass wrapped pipe. In this pipe sheets of matrix with glass fibers in a single direction are wrapped around a pipe mold. The sheets are wrapped at varying angles to get the desired hoop and longitudinal strength effects. This multidirectional wrapping produces a pipe that has different strength properties in the hoop and longitudinal directions, i.e an orthotropic material. Orthotropic material models for "beam-type" finite elements are very straightforward in formulation, requiring only a few additional input parameters, (which **CAESAR II** requests once the user has entered material type 20.)

The real benefit of **CAESAR II** as far as plastic pipe is concerned is that it helps eliminate poorly supported systems that will eventually leak (weepage), or that will cause distortion problems with the line. The analysis is quick and painless, and points out areas where inexpensive supports should be added. Whereas hot steel pipe can be easily over supported, plastic pipe typically cannot. The tendency is to under support it, which is shown in the analysis, or to over support it incorrectly producing large thermal moments at the intermediate elbow. Both of these basic design flaws are discovered very easily with the **CAESAR II** analysis of the system.

COADE OFFICE LOCATIONS

Many people do not know that COADE has an office in Calgary, Alberta Canada. In fact that office has been in place for over two and one-half years. The office is staffed by one mechanical engineer and one programmer. The engineer is Mr. Jim Wilcox. Jim is very familiar with **CAESAR II, PROVESSEL**, and **CodeCalc**, and is a little bit like the Maytag repair-man. If there are any **CAESAR II** questions, comments or suggestions, or if any of COADE's Canadian users would simply like to have someone more regional to discuss **CAESAR II** applications with, Jim is readily available. Users should find Jim very knowledgeable, congenial and quite helpful. Jim often finds himself coordinating the interaction between different COADE users.

The programmer is Mr. Kelly Chikmoroff. Kelly is the developer of the new **CAESAR II** graphics, and in fact coordinates all of the graphic development activity for COADE's engineering products. Kelly accepted the position at COADE over a similar offer by Nintendo to write video games. Kelly willingly accepts comments and suggestions on how to improve the **CAESAR II** graphics and interfaces, and can be very helpful when it comes to just about any question concerning PC's, or their operating software or hardware.

COADE has also just opened an office in Caracas, Venezuela. The director of that office is Mr. Reinaldo Pinto. Reinaldo is a graduate mechanical engineer from I.U.P.F.A.N. (Venezuela) and has worked extensively in the petrochemical industry in Caracas. Joining Reinaldo will be Mr. Jose Brito Kennedy. Mr. Kennedy has considerable experience with pressure vessels and piping. Addresses for the respective offices follow:

spring stiffnesses over the buried part of the piping system. This is probably the most useful part of the **CAESAR II** buried pipe modeler. Properly breaking down and distributing springs over the piping system is a very time consuming task to do accurately by hand, and **CAESAR II** does in just seconds. The distribution of the stiffnesses over lateral bearing lengths, transition lengths, and over axial bearing lengths is described in detail in the **CAESAR II** User's Guide.

Seldom are soil properties known very accurately. Often there is absolutely no quantative data available on the soil at the site. In these situations, the **CAESAR II** soil modeler will probably provide as good an estimate of the soil properties as is possible. The **CAESAR II** soil model is based on a combination of data available on the subject of soil properties from a variety of sources. (Many from analyses on driven piles.) When this data was evaluated, and the variance in estimated values considered it was decided that there was insufficient accuracy to differentiate between the horizontal and the two vertical soil restraining stiffnesses. Intuitively we know however that the downward stiffness of a buried pipe will be greater than both the lateral and upward stiffnesses, and that the lateral stiffnesses will be greater than the upward stiffness, (of course as a function of the depth.)

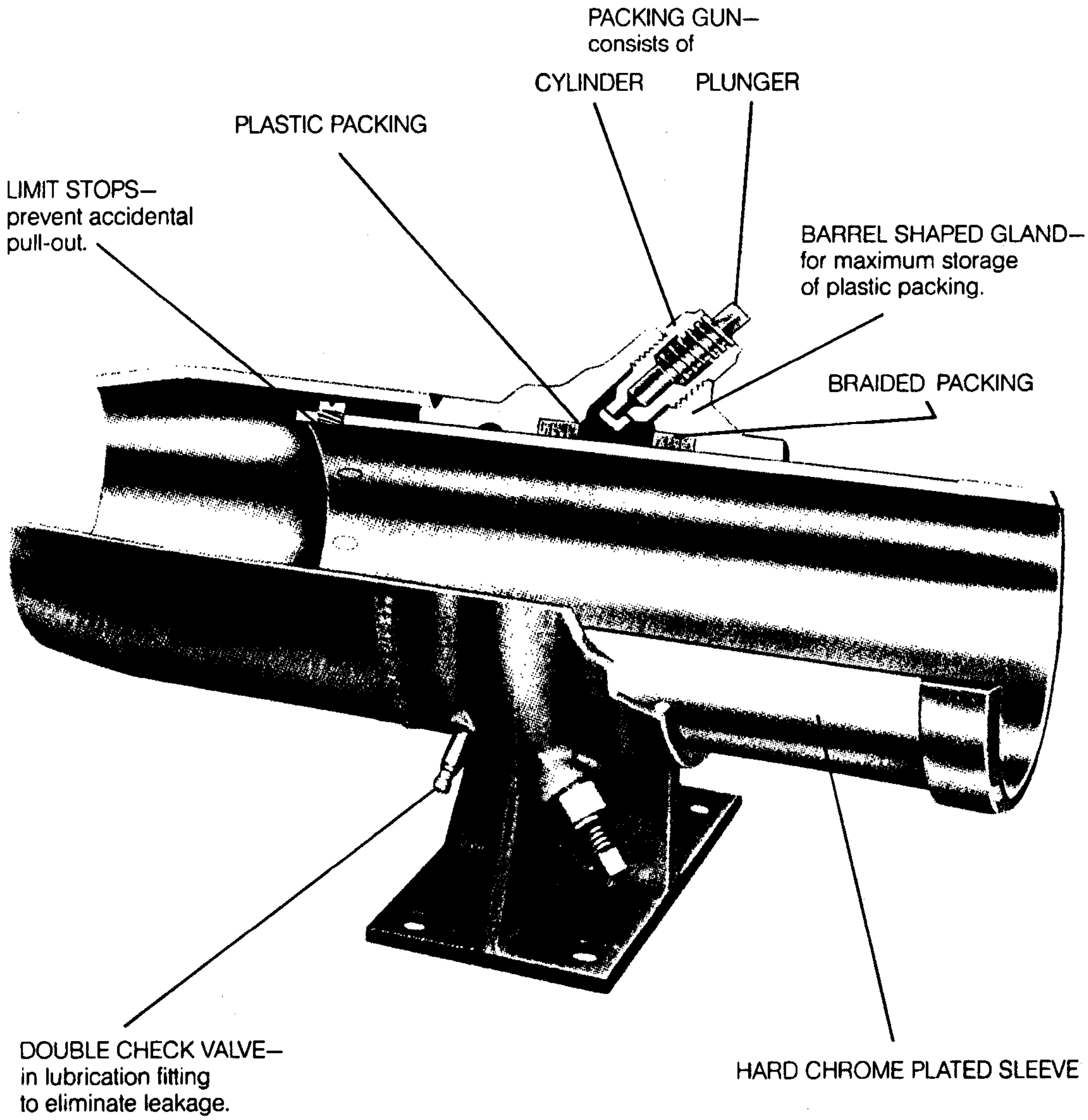
When there is good soil data and a good soil model available, it should be used in place of the **CAESAR II** soil model. (**CAESAR II** Soil Model Type 1.) Soil stiffnesses should be generated using this better model on a stiffness per length of pipe basis. These numbers can be input directly to the **CAESAR II** buried pipe analysis. The users improved soil model can take into consideration the difference between lateral, upward and downward distributed stiffnesses due to soil.

Users having improved soil models, that are better than the **CAESAR II** model for certain applications, are requested to submit a portfolio describing the model to COADE. Should the application be sufficiently broad based COADE will install the additional soil model into the **CAESAR II** buried pipe program for direct, and automated access. Users interested in having their respective soil model installed into **CAESAR II** should contact a member of the COADE support staff.

Because buried pipe technology is changing so rapidly today, anyone with recommendations or suggestions on ways that the software can be improved are encouraged to call or write COADE with the suggestions. These suggestions are very much appreciated.

SLIP JOINT MODELING

This article discusses how to model a slip joint in **CAESAR II**. A slip joint is a pipe connection which essentially only allows axial movement, after a certain "break away" force is reached. An example slip joint is shown in the figure below, with its corresponding **CAESAR II** model.

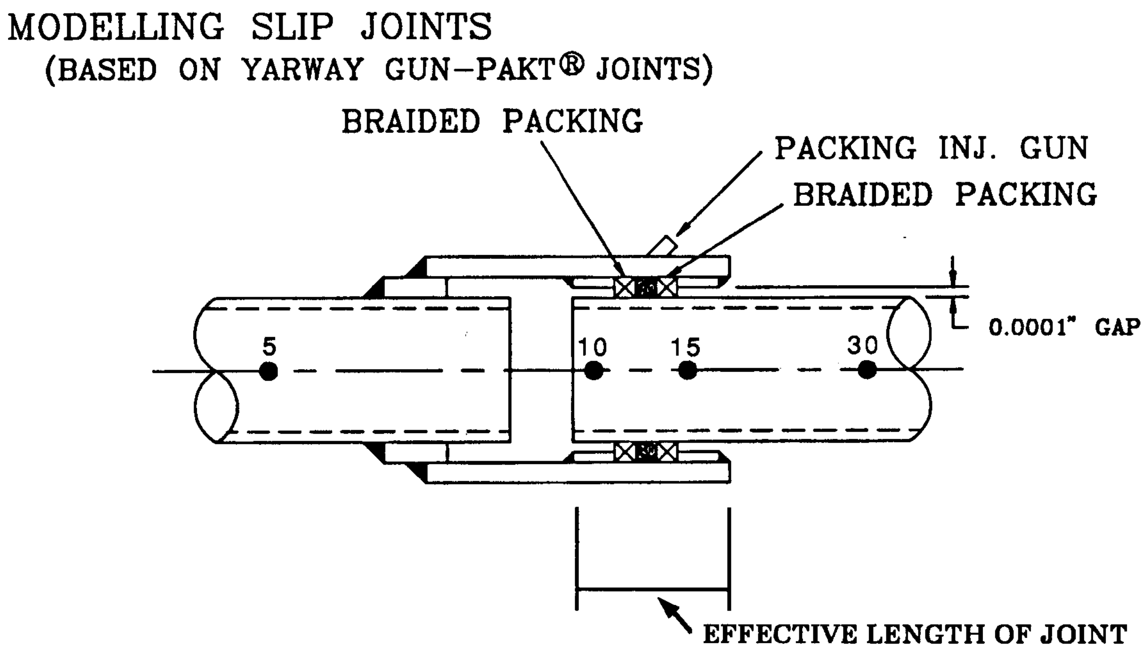


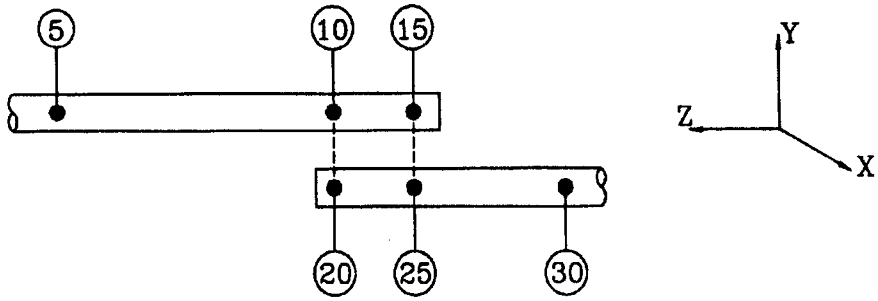
(Figure courtesy of Yarway Corporation, Blue Bell, PA 19422, 215-825-2100 x 500)

These joints are often used in low pressure, high temperature applications, and for this reason accurate load calculations are important because the relatively thin walled attachments can not take appreciable punching load. (As usually determined by a WRC 107 analysis.)

The figure below shows a center line model which can be used in **CAESAR II** to model a slip joint. Nodes 10 and 20 are at the same point in space, as are nodes 15 and 25. The slip joint model will be constructed by associating the degrees of freedom between nodes 10 and 20 and between 15 and 25 with a variety of restraints. The appropriate **CAESAR II** spreadsheet entries are listed below.

Horizontal guides are recommended to keep the pipe and slip joint properly aligned. Guide spacing is recommended by the manufacturer as a function of nominal pipe size. In the model below, the guides would be placed at nodes 5 and 30.





FROM	5	RESTRAINTS Y	NODE 10	CNODE 20
TO	10		DIRS X	
			STIF	(Note 5)
DX	see note 1		GAP 0.0001	(Note 6)
DY	see note 1		MU	
DZ	see note 1			
			NODE 10	CNODE 20
			DIRS Y	
			STIF	(Note 5)
			GAP 0.0001	(Note 6)
			MU	
FROM	10	RESTRAINTS Y	NODE 15	CNODE 25
TO	15		DIRS X	
			STIF	(Note 5)
DX	see note 1		GAP 0.0001	(Note 6)
DY	see note 1		MU	
DZ	see note 1			
			NODE 15	CNODE 25
			DIRS Y	
			STIF	(Note 5)
			GAP 0.0001	(Note 6)
			MU	
			NODE 15	CNODE 25
			DIRS Z2	
			K1 (blank)	see note 2
			K2	see note 3
			FY	see note 4

NOTE 1: Typical delta dimensions are:

5 - 10 The distance from the closest guide or support to the end of the joint. (Same values would also be used for 25 - 30.)

10 - 15 The effective length of the joint if known, or the travel expected plus 4", or a 12" estimate if nothing else is known.

NOTE 2: K1 is the spring stiffness for forces below the yield force, FY. Leaving this value blank indicates a rigid stiffness, hence the joint will not compress until FY is reached.

NOTE 3: K2 is the spring stiffness (for joint compression) for forces greater than FY. The best estimate for this resistance is cumulative friction effects of guides and supports, given by the vendor. Typical values of 100 lbs times the nominal pipe size per 100 ft of pipe span have been used. The spring rate conversion (in lbs per inch of movement) can be achieved by dividing the previous value by the rate of expansion (in inches per 100 ft of pipe span) at the operating temperature, i.e.

K2 = (100) (N) / (a),

where (N) is the nominal pipe diameter in inches, and (a) is the thermal expansion at the operating temperature in inches per 100 ft.

NOTE 4: FY is the joint friction thrust from the vendor catalog. Typical values are given as 400 lbs times the nominal pipe size.

NOTE 5: Packing provides some horizontal stiffness. Typically these stiffnesses are not a critical part of the model. Should the user have a tight system where these stiffnesses become important they can be estimated from:

DWE / t where D is the diameter, W is the width of the packing, E is the approximate modulus of elasticity of the packing, and t is the thickness of the packing.

NOTE 6: These gaps may be considerably larger for bigger diameter slip joints. Gaps this small may be omitted from the model if convergence problems result.

CAESAR II INTERFACES

Through 1990, many of the **CAESAR II** external interfaces were enhanced and several new interfaces were written. These interfaces are not part of the standard distribution diskettes that COADE distributes to users. These interfaces are available on request, for users current on their updates.

Anyone using the following interfaces should check their version number and .EXE size to insure that they are using the latest version of the interface software.

Interface To	EXE Name	File Size	File Date	Version Number
CADPIPE	CADPIP	135k	3/21/91	1.1
COMPUTERVISION	CVISON	78k	12/2/90	2.0
INTGRAPH	INTGRPH	153k	10/5/90	1.5
ISOMET	ISOMET	81k	10/5/90	1.1
PRO-ISO	ADEV	81k	10/5/90	2.0

The above interfaces all operate in a similar fashion. Each CAD package has a piping module wherein the user defines the piping system. Then this piping system is reduced by the CAD package to some type of neutral file. This neutral file is then transferred into the **CAESAR II** subdirectory on the PC. The final step is to invoke the **CAESAR II** half of the interface which translates the neutral file into a standard **CAESAR II** input (spreadsheet) file.

COADE SEMINARS

The following pipe stress seminars have been scheduled for 1991:

April 15-19	Houston, Texas
October 21-25	Houston, Texas