MECHANICAL ENGINEERING NEWS

COADE® Engineering Software

For the Power, Petrochemical and Related Industries

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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**.

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PC HARDWARE FOR THE ENGINEERING USER (PART 8)

Many of our users have experienced problems with Everex computers refusing to accept our keydisks. A copy of **CAESAR II** was forwarded to Everex for testing purposes, and they have narrowed the problem down to a specific chip on the floppy disk controller card. The questionable chip is a *National Semiconductor* EP8473N or EP8473V.

The current remedy for this problem is to replace the controller card, with one that does not use this *National Semiconductor* chip. A word of caution is in order--we don't know what other manufacturers are also using this chip series.

There are many other points to be discussed when reviewing hanger sizing performed by **CAESAR II**. The list of optional design parameters, actual cold loads, rigid Y stiffness in the initial weight case, partial hanger sizing, pre-loading, and the actual thermal loads due to changing spring loads will all be discussed in future articles. In the meantime, call COADE if any questions about hanger selection arise. Also, refer to the User Guide Section 16 pages 75 through 98 for many examples of spring selection and specification.

STATIC & DYNAMIC ANALYSIS OF HIGH PRESSURE SYSTEMS

The following article has been submitted for publication by Mr. R. Hruska (Principal Pipe Stress Engineer) of John Brown Engineers & Constructors B.V., Bredewater 4, P.O. Box 5254, 2701 GG Zoetermeer, The Netherlands. As previously mentioned in Mechanical Engineering News (November 1988), users with unusual applications of our software are invited to write an article for discussion in this newsletter.

Recently John Brown Engineers & Constructors B.V., The Netherlands, fulfilled engineering support on the revamp of an LDPE plant in Belgium. This plant operates under extremely high pressures, up to 55000 psi, with reasonable temperature conditions up to 300°C to reach the required polymerization reaction condition. This made the pipe stress engineering more than an ordinary job.

With **CAESAR II** we have been able to simulate piping system behaviors, which will occur during start-up and operating conditions. Since the project was an extensive revamp, we were able to check our modelling procedure with existing piping systems. Comparing FFT measurements, on a system in operation, to the **CAESAR II** output results proved our pipe stress engineering capability.

A correct simulation model of a high pressure piping system, which has been used for both static and dynamic analysis, requires not only accuracy but also special **CAESAR II** features. In addition to the standard modelling of such a piping system, it is essential to implement the following points:

- Add a sufficient number of nodes between restrained nodes to allow **CAESAR II** to set pipe element masses on the free pipe element itself. An intermediate element length of 10 to 15 times the outsider diameter of the pipe is a good practice.

- The actual restraint stiffness of the different types of hold down supports, which have to be obtained from a finite element analysis of the hold down support itself, have to be entered.

- For hold down supports (e.g. node 210) which can slide, the appropriate data should be entered as follows:

  a. Link node 210 to node 1210 using a CNODE with the appropriate hold down stiffness in all six degrees of freedom.

b. Introduce an element 1210 to 2210 of one unit length (e.g. 1mm). At node 2210 the actual sliding surface condition should be entered. This will normally be rotational stiffnesses in all three directions, translational friction restraints in two directions, and a stiffness in the other translational direction upon which the clamped hold down force acts.

- Be sure that rigid anchor blocks are located in the longer runs of the piping system in order to control the friction free static behavior and the dynamic pressure pulsation forces, as will be discussed later.
- Activate the Bourdon effect (Kaux 4). Due to the extremely high pressure, high strength pipe material (ASTM A-723 or equivalent) has to be selected and will be loaded up to its maximum capacity, resulting in relatively large elongations.

Now a friction free simulation (representing the continuous operating condition) and a friction restrained simulation (representing the start-up condition) can be executed. After comparing the output results to previously set limits for maximum allowable stresses, nozzle loadings and reaction forces on the hold down supports and anchors, the dynamic calculations can be started. Here a split should be made between the mode shape analysis, the dynamic pressure pulsation loading, and the exciting forced nozzle deflection.

It is obvious, that the natural frequencies of the piping system should be out of the range of pressure pulsation frequencies produced by the connecting compressor. For this reason, the gas pulsation analysis performed should contain a digital frequency/pressure pulsation report. From this report the minimum required natural frequency for the piping section can be obtained as being:

Wn_{min} = 1.2 * the highest harmonic which still produces a pressure pulsation of 0.5% peak to peak.

The only additional parameters **CAESAR II** needs--to calculate the natural frequency of the piping system--are as follows, and should be entered on the control parameters spreadsheet as:

M -	For mode shape analysis.
Case No -	To identify the static loading case to be used for non-linear restraints. In general the operating case, which should have been run previously is specified.
100000 -	The stiffness factor for friction.
100 -	The frequency cut off (Hz).

If the calculated frequencies are within the limits, it is unlikely that resonance will occur during operating conditions due to the gas compression pulsations.

The actual dynamic loading of the piping system still has to be analyzed. Due to the complexity of the gas pulsation, we have to deal with several loading conditions at one individual frequency. The gas pulsation study should have been supported in such a way that all required data for each straight length in the piping system becomes available in a free shaking force/pressure report.

First of all, nozzle excitation and free shaking forces at the first harmonic should be analyzed by **CAESAR II** by entering:

Under B - Control Parameters

H -	For harmonic analysis.
Case No -	To identify the static loading case to be used for non-linear restraints. In general the operating case, which should have been run previously is specified.
100000 -	The stiffness factor for friction.
SRSS -	Use the spatial combination method.

Under 8 - Harmonic Loads

1 - To select the first load case, the first harmonic.
2 - Specify the harmonic forces: force, direction, phase, and node number.
3 - Specify the harmonic displacements: displacement, direction, phase, and node number.

For the total loading, we can limit ourselves to all the loadings within the frequency range of ±20% of the natural frequency of the piping system and all harmonics with a significant pressure force loading. Individual calculations should be performed for each frequency by entering the corresponding free shaking forces for all straight sections, as described above.

To come to the overall picture, a manual summation of forces and stresses at the critical nodes should be carried out by using the square root of the sum of the squares (SRSS) method. These results should be compared to the allowable forces (on nozzles and supports) and stresses using the limitations as per ASME Section VIII, Division 2, Appendix 5.

It should be emphasized that **CAESAR II** performs harmonic analysis for undamped systems. If damping must be considered, we support the philosophy as described in the April 1989 issue of COADE's Mechanical Engineering News, with the addition that the damping factor should not exceed 2%.

CAESAR II SPECIFICATIONS

Several clients have expressed an interest in a security method other than a keydisk. This possibility has been investigated, and we have found a hardware key that will perform the same functions as the current keydisk. This hardware key is a small connector which attaches to the parallel port of the computer. If there is enough interest in this type of security protection, we will make these keys available for a charge of $150 per client, per key. If you are interested in this form of security, please contact the COADE Development staff.