

## Load Case Definition in CAESAR II

The CAESAR II Load Case Editor is a very versatile instrument for combining native and combination loads in nearly any manner required by the various piping codes supported by CAESAR II. To enter the Static Load Case Editor from the CAESAR II Main Menu select Analysis->Statics. The Static Load Case Editor is shown in the figure below.

<c2agxxx.bmp>

The Technical Reference Manual describes the method for adding or deleting load cases. Here we will concentrate on which load cases to use to describe a variety of situations. For assistance in load case definition for an application not covered here or for clarification of the load cases described below please contact COADE Technical Support by e-mail at [techsupport@coade.com](mailto:techsupport@coade.com).

### **Standard Load Cases for B31.1, B31.3, ASME SECT III Class 2 & 3, NAVY 505, B31.4, B31.5, B31.8, B31.11, Canadian Z662, RCC-M C & D, Stoomwezen, CODETI, Norwegian, FDBR, BS 806 piping codes:**

Use these load cases (as recommended by Caesar II) for cases where you have weight, temperature, and pressure.

L1	W+T1+P1	(OPE)
L2	W+P1	(SUS)
L3	L1-L2	(EXP) *

\* Use algebraic combination method under the Load Case Options tab.

Note: Some of the above piping codes perform a code stress check on the operating case and some do not. See the CAESAR II Quick Reference Guide for the equations used for obtaining code stress and allowable stress for the various piping codes.

The expansion case is a combination case that results from subtracting the sustained case from the operating case. As such the expansion case represents the change in the piping system due to the effect of temperature, *but in the presence of other loads*. This is important because the restraint status of the operating and sustained cases can be different if there are nonlinear restraints (such as +Y, -Z, any restraint with a gap, etc.) or boundary conditions (friction).

### **Standard Load Cases for B31.4 Ch IX, B31.8 Ch VIII, and DNV codes:**

L1	W+T1+P1	(OPE)
L2	W+P1	(SUS)

No expansion stress is calculated for these piping codes.

### Standard Load Cases for BS7159 and UKOOA piping codes:

L1 W+T1+P1 (OPE)

No expansion or sustained stress is calculated for these piping codes.

### Load Cases with Hanger Design:

When CAESAR II designs spring hangers 2 additional load cases are required as recommended by CAESAR II. The letter H is used to designate the hanger installation load (pre-load) that is always present in a spring hanger.

L1	W	(HGR)	*HS = Rigid
L2	W+T1+P1	(HGR)	*HS = Ignore
L3	W+T1+P1+H	(OPE)	*HS = As Designed
L4	W+P1+H	(SUS)	*HS = As Designed
L5	L3-L4	(EXP)	**

\*HS is the Hanger Stiffness defined under the Load Case Options tab.

\*\* Use algebraic combination method under the Load Case Options tab.

When using only pre-defined spring hangers there is no need for the first two load cases above, however the letter H is still required in the operating and sustained load cases. When using multiple load case design other hanger load cases are required. In such instances it is suggested that the User first allow Caesar II to recommend the load cases, then add/edit the non-hanger design load cases as appropriate.

### Load Cases with Thermal Displacements:

Generally Thermal Displacements are associated with specific operating conditions (D1 is applied with T1, D2 with T2, etc.). When one temperature is below ambient and one is above ambient we will want to determine the full expansion stress range as described below:

L1	W+T1+D1+P1	(OPE)	
L2	W+T2+D2+P1	(OPE)	
L3	W+P1	(SUS)	
L4	L1-L3	(EXP)	* effects of D1 and T1
L5	L2-L3	(EXP)	* effects of D2 and T2
L6	L1-L2	(EXP)	* full expansion stress range

\* Use algebraic combination method under the Load Case Options tab.

Note: For piping codes with no expansion stress computation simply include the thermal displacements in the operating cases as shown above.

### Load Cases with thermal displacements and settlement:

For settlement, use a Cnode on any affected restraints. This Cnode must be a node number not used elsewhere in the model. Then place the settlement on the Cnode using a displacement vector not already used for thermal displacements. We will use D3 to describe restraint settlement in this example.

L1	W+T1+D1+D3+P1	(OPE)
L2	W+T2+D2+D3+P1	(OPE)
L3	W+P1	(SUS)
L4	L1-L3	(EXP) * effects of T1, D1, and settlement
L5	L2-L3	(EXP) * effects of T2, D2, and settlement
L6	L1-L2	(EXP) * full expansion stress range with settlement

Settlement is evaluated as an expansion load because it is strain-related with a half-cycle.

Note: For piping codes with no expansion stress computation simply add the thermal and settlement displacements to the operating cases as shown above.

### Load Cases with Pitch and Roll:

In offshore piping evaluation there is often platform movement or relative movement between two platforms with inter-connected piping. This also applies to FSPO and other ship-board piping systems. For these applications the pitch and roll displacements are applied to Cnodes on each affected restraint similar to settlement. Use displacement vectors not in use to describe thermal displacement boundary conditions. Usually there is a positive displacement and a negative displacement to describe the peak pitch and roll conditions. Consider the state of the platform at its peaks to determine the worst two conditions for relative displacement between piping separated by the largest distance along the line of wave travel. D3 and D4 are used in this example to describe two peak pitch conditions. D1 is thermal displacement.

L1	W+T1+D1+D3+P1	(OPE)
L2	W+T1+D1+D4+P1	(OPE)
L3	W+P1	(SUS)
L4	L1-L3	(EXP) *
L5	L2-L3	(EXP) *

- Use algebraic combination method under the Load Case Options tab.

It is likely that because of the large number of displacement cycles common in pitch and roll situations that the user will want to perform a fatigue analysis. Select the appropriate fatigue curve on the first piping input spreadsheet under the Allowable Stress auxiliary

data area. Then in the load case editor add the following two cases for the example above and add the number of cycles for each pitch condition.

L6	L1-L3	(FAT)	21000000
L7	L2-L3	(FAT)	21000000

The 21000000 above represents 21 million load cycles during the life of this piping system.

For large displacements such as those that occur during a one-year, 30-year, or 100-year event, simply use a low number of cycles as would occur during the life of such a storm multiplied by the number of such storms likely to be seen during the lifetime of the piping system. These displacements ARE NOT considered as occasional loads because occasional loads only involve primary loads and are not strain-related.

### **Load Cases for Static Seismic:**

While in piping input select Kaux->Special Execution Parameters and check the box for Uniform Load in Gs. Then on the first input spreadsheet activate the Uniform Loads field and type in the seismic load in Gs. Typically you should input the X-direction acceleration in vector 1, Y-direction acceleration in vector 2, and Z-direction acceleration in vector 3. This makes load case generation easier.

Since any seismic event is likely to occur while the piping system is in operation this is the load case that we want to consider. The operating case should have all operating loads plus the seismic load. This load case is then used in conjunction with the standard operating case to segregate the effect of the seismic load, which then is combined with the static sustained load case for code compliance considerations.

L1	W+T1+P1	(OPE)
L2	W+T1+P1+U1	(OPE)
L3	W+T1+P1-U1	(OPE)
L4	W+T1+P1+U2	(OPE)
L5	W+T1+P1-U2	(OPE)
L6	W+T1+P1+U3	(OPE)
L7	W+T1+P1-U3	(OPE)
L8	W+P1	(SUS)
L9	L1-L8	(EXP)
L10	L2-L1	(OCC)
L11	L3-L1	(OCC)
L12	L4-L1	(OCC)
L13	L5-L1	(OCC)
L14	L6-L1	(OCC)
L15	L7-L1	(OCC)
L16	L8+L10	(OCC)
L17	L8+L11	(OCC)

L18	L8+L12	(OCC)
L19	L8+L13	(OCC)
L20	L8+L14	(OCC)
L21	L8+L15	(OCC)

In load cases 2 through 7 above we include all the loads and call these operating cases. The subtracted uniform load vectors simply reverse the direction of the uniform load applied. Use these load case results for occasional restraint loads and occasional displacements. Load Cases 10 through 15 represent the segregated occasional loads. Even though we designate these as occasional load cases we don't need a code stress check here as these are only part of the final solution for code compliance. Therefore under the Load Case Options tab we can select Suppress for the Output Status. Also these combination load cases all use the Algebraic Combination Method under the Load Case Options tab. Load cases 16 through 21 are all used for code compliance. We add the segregated occasional results to the sustained case results and use either the Scalar or ABS (Absolute Value) Combination Method under the Load Case Options tab. Both scalar and absolute will give us the same code stress results although the displacements, forces, and moments could be different. Since we don't really use any results except the stresses for combination cases it really doesn't matter which combination method you use.

Sometimes we want to combine the results of vertical g-loads with horizontal g-loads. Often a factor is applied to the vertical g-load component of the combined load. This can be accomplished initially when entering in the Uniform Load on the input spreadsheet for the vertical component or you can do this directly in the load case editor as shown below. Using the example above we will combine .67 vertical g-load with each horizontal component.

L1	W+T1+P1	(OPE)
L2	W+T1+P1+U1+0.67U2	(OPE)
L3	W+T1+P1-U1+0.67U2	(OPE)
L4	W+T1+P1+U1-0.67U2	(OPE)
L5	W+T1+P1-U1-0.67U2	(OPE)
L6	W+T1+P1+U3+0.67U2	(OPE)
L7	W+T1+P1-U3+0.67U2	(OPE)
L8	W+T1+P1+U3-0.67U2	(OPE)
L9	W+T1+P1-U3-0.67U2	(OPE)
L10	W+P1	(SUS)
L11	L1-L10	(EXP)
L12	L2-L1	(OCC)
L13	L3-L1	(OCC)
L14	L4-L1	(OCC)
L15	L5-L1	(OCC)
L16	L6-L1	(OCC)
L17	L7-L1	(OCC)
L18	L8-L1	(OCC)

L19	L9-L1	(OCC)
L20	L10+L12	(OCC)
L21	L10+L13	(OCC)
L22	L10+L14	(OCC)
L23	L10+L15	(OCC)
L24	L10+L16	(OCC)
L25	L10+L17	(OCC)
L26	L10+L18	(OCC)
L27	L10+L19	(OCC)

At times it is required to combine the horizontal and vertical components of seismic loading together. This can be easily accomplished in the load case editor. First, set up the static seismic load cases as shown in the first example above. Then combine the segregated horizontal and vertical load cases together using the SRSS Combination Method under the Load Case Options tab. Then add these last results to the sustained case as shown below:

L1	W+T1+P1	(OPE)
L2	W+T1+P1+U1	(OPE)
L3	W+T1+P1-U1	(OPE)
L4	W+T1+P1+U2	(OPE)
L5	W+T1+P1-U2	(OPE)
L6	W+T1+P1+U3	(OPE)
L7	W+T1+P1-U3	(OPE)
L8	W+P1	(SUS)
L9	L1-L8	(EXP)
L10	L2-L1	(OCC) *
L11	L3-L1	(OCC) *
L12	L4-L1	(OCC) *
L13	L5-L1	(OCC) *
L14	L6-L1	(OCC) *
L15	L7-L1	(OCC) *
L16	L10+L12	(OCC) **
L17	L10+L13	(OCC) **
L18	L11+L12	(OCC) **
L19	L11+L13	(OCC) **
L20	L14+L12	(OCC) **
L21	L14+L13	(OCC) **
L22	L15+L12	(OCC) **
L23	L15+L13	(OCC) **
L24	L8+L16	(OCC) ***
L25	L8+L17	(OCC) ***
L26	L8+L18	(OCC) ***
L27	L8+L19	(OCC) ***
L28	L8+L20	(OCC) ***
L29	L8+L21	(OCC) ***

L30	L8+L22	(OCC) ***
L31	L8+L23	(OCC) ***

- \* Use algebraic combination method under the Load Case Options tab.
- \*\* Use SRSS combination method under the Load Case Options tab.
- \*\*\* Use ABS or Scalar combination method under the Load Case Options tab.

Note: For piping codes that do not perform a sustained code stress check simply change the operating load cases that include seismic loads to OCC and use these for code compliance. In such cases the combination cases described above will be unnecessary.

### Load Cases for other types of occasional loads:

#### Wind and Wave:

The methodology is the same for all occasional loads regardless of the source. So for a Wind analysis simply replace the U1 and U3 above with Win1 and Win2 (there is not likely to be a vertical component of wind considered) in the load cases. For Wave loading replace U1 and U3 above with Wav1 and Wav2 (there is not likely to be a vertical component of wave considered) in the load cases.

#### Relief Valve:

For relief valve firing, calculate the thrust force of the relief valve and place a concentrated load equal to the thrust force at the appropriate place downstream such as the first bend node or intersection node of a tee. Also place an equal force, but in opposite direction on the back of the relief valve. Then simply replace U1 above with F1 in the load cases. The example below has two relief valves that fire independently. They may fire individually or both together.

L1	W+T1+P1	(OPE)
L2	W+T1+P1+F1	(OPE)
L3	W+T1+P1+F2	(OPE)
L4	W+T1+P1+F1+F2	(OPE)
L5	W+P1	(SUS)
L6	L1-L5	(EXP) *
L7	L2-L1	(OCC) *
L8	L3-L1	(OCC) *
L9	L4-L1	(OCC) *
L10	L5+L7	(OCC) **
L11	L5+L8	(OCC) **
L12	L5+L9	(OCC) **

- \* Use Algebraic combination method under the Load Case Options tab.
- \*\* Use ABS or Scalar combination method under the Load Case Options tab.

**Snow and Ice Load:**

Snow load is simply a uniform load in units of weight per length (lb/ft, N/m, etc.). Multiply the depth/thickness of snow/ice on the piping by the density of snow/ice and the pipe outside diameter to calculate the uniform load. If the piping enters a building or will otherwise have no snow/ice load simply re-activate the uniform load at that node and enter all zeroes. For snow/ice loads the uniform load will always be negative in the vertical direction. The load cases are the same as described earlier for seismic, wind, and wave, but with only one uniform load vector they are simplified somewhat.

**Waterhammer loads, Seismic loads with anchor movements:**

It is not recommended to attempt to simulate waterhammer loads statically. See the example in the Technical Reference Manual for dynamic analysis of a system undergoing waterhammer.

It is not recommended to attempt a static seismic analysis when anchor movements are present. Rather a dynamic analysis should be done using the Spectrum analysis method. See the example in the Technical Reference Manual for Earthquake Spectrum analysis of a system undergoing anchor movements.