

# Limitations in the modeling of spring hangers as rigid supports for deadweight analyses

M.Campens & M.Culot

*Westinghouse Energy Systems International Division, Brussels, Belgium*

## ABSTRACT

This paper describes the limitations in the modeling of spring hangers as rigid supports for deadweight analyses.

Factors which can invalidate the procedure of representing spring hangers by rigid elements with zero deflection in deadweight analyses are identified.

A case of application is described for the J.Cabrera NPP Reactor Coolant Loop analysis (Zorita - Spain).

In addition, the selected method for solving the problem of non-linear spring hangers by a superposition of linear cases is also presented along with the associated results for the same application.

## 1. GENERAL APPROACH

Spring hangers are in general preset in order to result in the piping occupying its reference position at full deadweight load. Consequently in a deadweight computer model, spring hangers are represented by rigid elements with zero deflection. The loads resulting from this analysis then serve to preset the spring hangers in the plant. Care must be taken in applying this procedure because, in certain cases, it can lead to the prediction of incorrect piping stresses and support loads.

A combination of the following circumstances can indeed invalidate the prediction procedure :

1. neighboring 'rigid' supports which, in the analysis, turn out to be more flexible than the springs for which truly rigid stiffness values have been entered
2. the stiffness of the piping is comparable with, or higher than the stiffness of the neighboring 'rigid' supports
3. concentrated deadweight loads are present (e.g. equipment water inventory) and act on the neighboring 'rigid' supports

The mechanism leading to incorrect results is as follows. When concentrated deadweight loads act on the contiguous 'rigid' supports, they will produce non-negligible displacements. In the case of stiff piping, the piping can furthermore act as a cantilever and introduce unrealistic high support loads on the spring hangers while the deadweight loads on the other supports are accordingly underestimated. Finally, the calculated stresses in certain parts of the piping are too low because the piping is better supported in the mathematical model than in reality.

## 2. DEADWEIGHT ANALYSIS OF THE J. CABRERA NPP REACTOR COOLANT LOOP (RCL)

The Reactor Coolant Pump (RCP) of the J. Cabrera NPP RCL is supported by three spring hangers, while the Steam Generator (SG) is suspended by a large and relatively flexible steel structure (Fig. 1). As the RCL piping is welded after installation of the primary equipment on its supports, the equipment dryweight (= without water inventory) does not contribute to the RCL piping stresses. The deadweight loads will therefore only consist of the RCL piping own weight plus the water inventory of the RCL piping and of the primary equipments. The most significant contribution of these to the deadweight piping moments and support loads comes from the water inventory of the SG and introduces a significant vertical displacement at the SG support.

### 2.1 RCP supports modeled as rigids

If, in the mathematical model, the RCP spring hangers are represented by restraints or by very rigid supports, the Cross Over Leg is pushed down on the SG side while it is restrained on the RCP side. The resulting analytical displacements can be seen on Fig. 2. The support loads obtained with this model are much too high for the RCP spring hangers and too low for the SG support (table 1). The piping maximum stresses are underestimated because of the perfect restraints at the RCP supports (Fig. 4).

### 2.2 Correct method

From the above, it appears that in this case the RCP spring hangers should not be modeled as rigid. However, as the spring hangers have been preset, it would not be correct either to simply enter the spring stiffness in the mathematical model. Instead, a non linear support model must be used (Fig. 5). As most piping codes do not have the possibility to model non-linear supports for static analyses, this problem has to be solved by superposition of linear cases as follows : Assume that under the dryweight load, the support has reached the position 1 on the typical force/displacement curve of a preset spring (Fig. 5). This means that the dryweight is less than the spring precompression load. Then, in the first computer run K1 is input as stiffness and a 1g downward load is applied. The calculated resultant downward displacement (say DISP\_RUN1) however is bigger than the displacement from position 1 to position 2 (say DISP12). Therefore the

results of this run (loads, moments, displacements) are to be ratioed by DISP\_RUN1/DISP12. For the second computer run, K1 is replaced by K2 and a total displacement of DISP\_RUN2 is obtained for a 1g downward load. Actually we should have applied a  $(1 - \text{DISP\_RUN1}/\text{DISP12})g$  load, therefore the results of this second run are to be multiplied by this factor.

If the displacement  $\text{DISP23} = (\text{DISP\_RUN2} * (1 - \text{DISP\_RUN1}/\text{DISP12}))$  is less than DISP24, the support has reached its equilibrium position under deadweight loading. The final results can be calculated as follows :

$$\text{Final result} = (\text{result RUN1}) * (\text{DISP\_RUN1}/\text{DISP12}) + (\text{result RUN2}) * (1 - \text{DISP\_RUN1}/\text{DISP12})$$

This formula can be extended to two or more non-linear supports and to more complicated stiffness curves.

The final displacements obtained by this method (four computer runs in total) are shown in Fig. 3. An important displacement at the RCP is observed which causes the moments along the Cross Over Leg to change sign and which induces high moments along the Cold Leg (Fig. 4). The support load distribution is shown in Table 1. For the rigid model the load on the RCP hangers is 59 KIPS. Following Fig. 5, this load should induce an important displacement at the RCP spring hangers while Fig. 2 however indicates a zero displacement. Therefore it can be concluded that the rigid model is not correct. The spring model results in a more realistic deadweight support load distribution.

Table 1. Equipment support loads

		Deadweight support loads *	
		(KIPS)	
		RIGID model	SPRING model
RCP	spring hangers	59	6
SG **	vertical hanger	90	110
RPV	vertical support	106	139
Total		255	255

\* without dryweight

\*\* RPV = Reactor Pressure Vessel

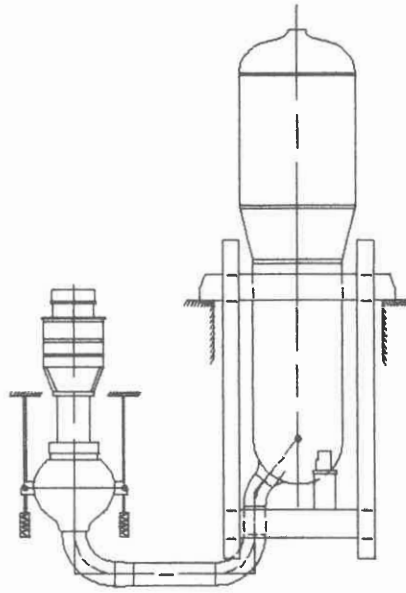


FIG.1 SUPPORT CONFIGURATION

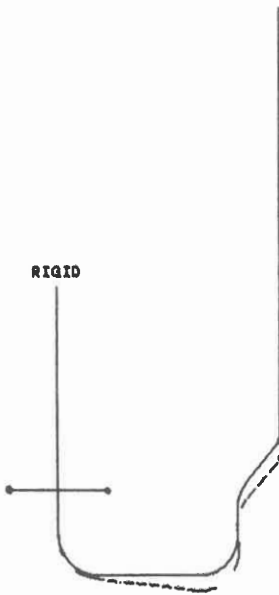


FIG.2 DISPLACEMENTS WITH  
RCP SUPPORTS MODELED  
AS RIGIDS

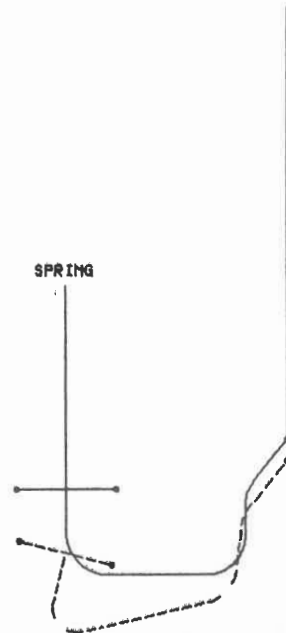


FIG.3 DISPLACEMENTS WITH  
RCP SUPPORTS MODELED  
AS SPRINGS

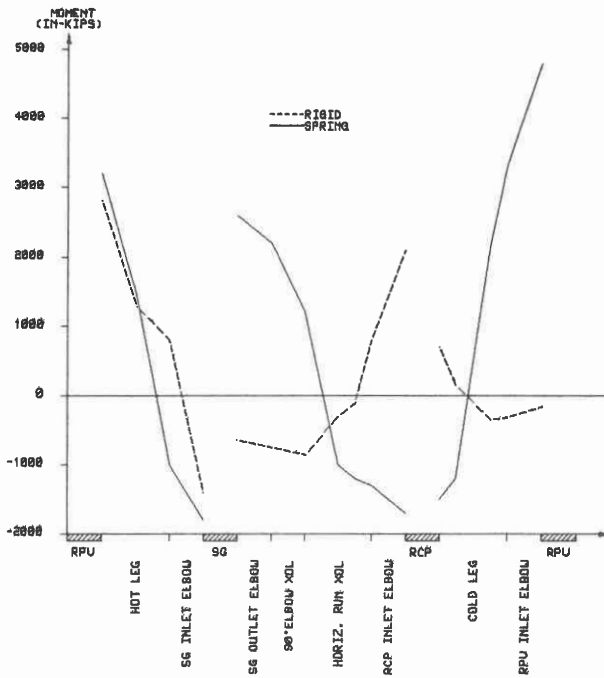


FIG.4 BENDING MOMENT DISTRIBUTION ALONG THE PIPING

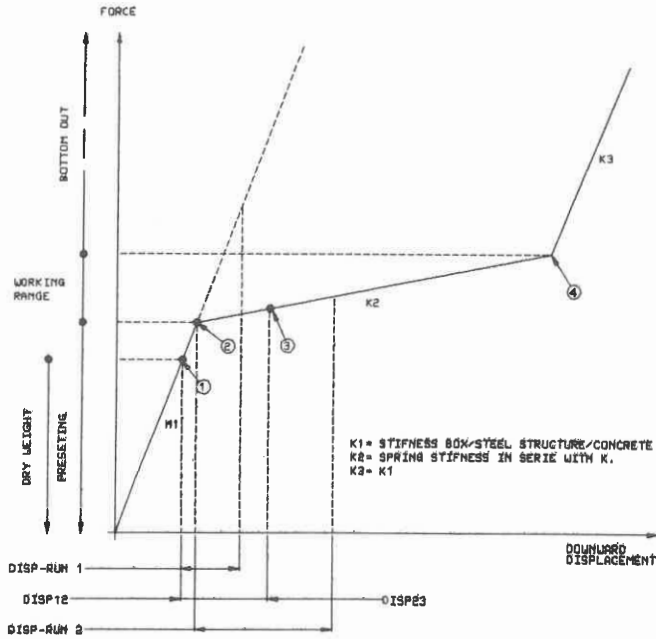


FIG.5 NON LINEAR SUPPORT CHARACTERISTICS