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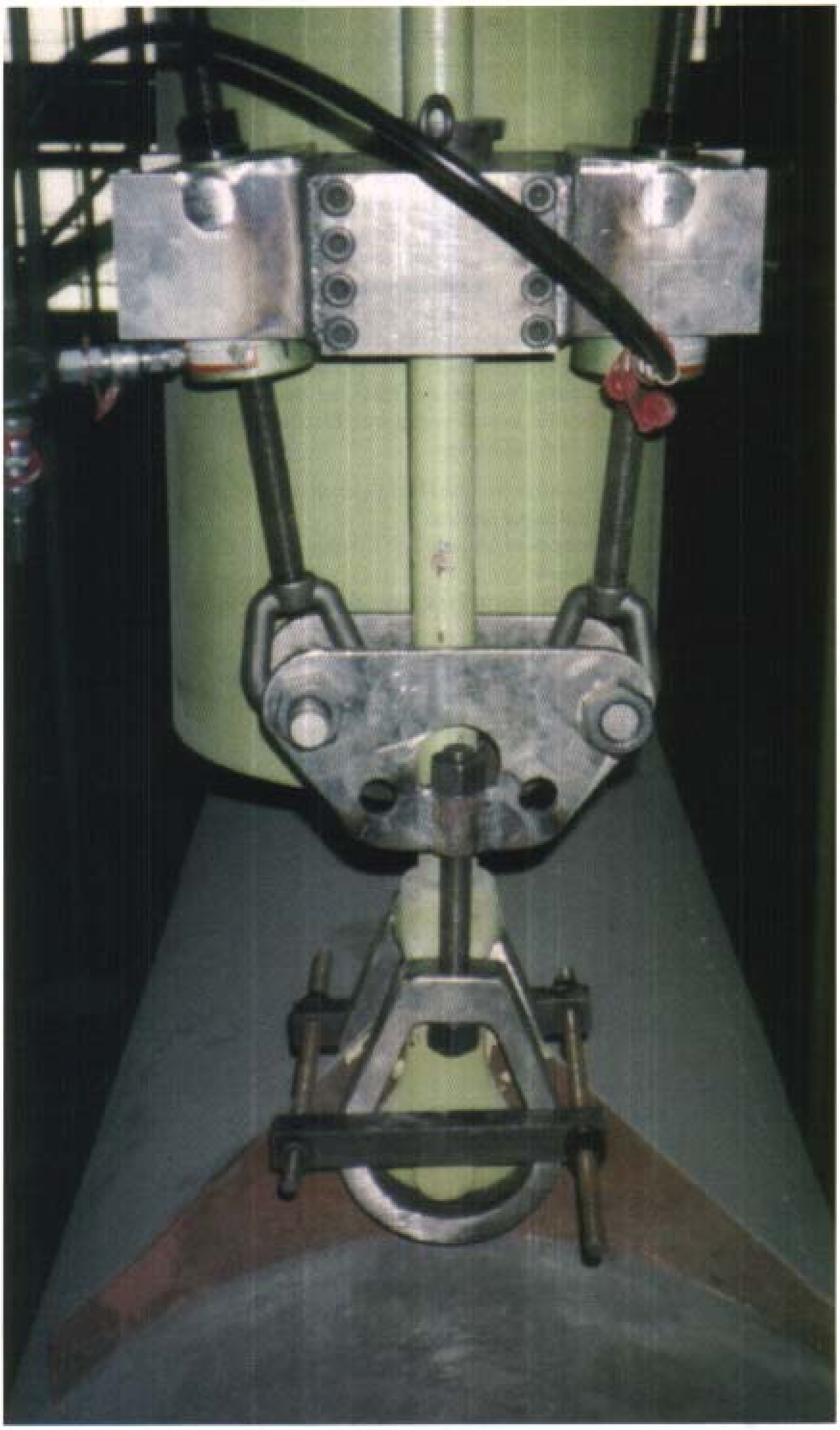
The Need For In-Situ Pipe Support Testing

by Gerry May



Pipe support functionality is critical to the long-term life of piping systems. Spring supports degrade with time due to flexing in the spring and wear in constant support bearings. It is not unusual to measure constant support hangers with resistance 25% to 50% different than the design load. This leads to excessive sustained pipe stress, pipe sag (or uplift), and in high temperature systems, accelerated creep damage. Supports may also not move properly from shut down to full operation, which can create excessive fatigue stress, failed hanger components, and other piping system damage.

In-situ hanger testing is a reliable and cost effective method to determine the functionality of pipe supports. Results are used as input to set revised recommended loads, and to determine if any hangers need to be replaced. This article provides examples of the types of problems that are often found in the field, the method to test, and typical resolutions to maximize the pipe life and minimize the risk of failure.

Initial Installation Pipe Support Issues

Piping systems are engineered with suitable flexibility to assure pipe stresses are less than ASME code allowable stresses[1,2], and that equipment connections are not overloaded. Variable spring and constant support hangers are used to properly support the pipe, while minimizing thermal displacement pipe stresses and equipment loads.

Figures 1 and 2 are outline sketches of typical constant support and variable spring cans. Variable springs are a helical coiled spring. As the length of the spring is varied by the pipe movement, the load also varies. Typically, variable springs are designed for less than 25% load variation between ambient and operating conditions. Constant support cans also have a helical spring coil, but are attached by lever arms to provide nearly the same support load throughout the travel range. Constant supports are typically installed when the movement results in too great a load variation to use a variable spring.

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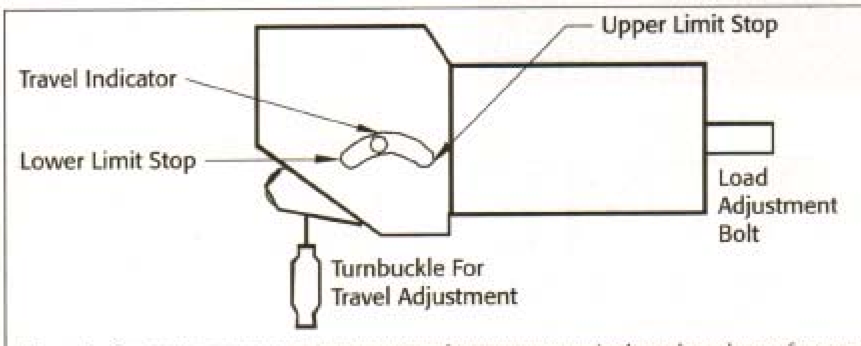

Figure 1: Constant support can. Arrangement of components varies by style and manufacturer

Constant support and variable springs should be factory tested to support a design load, but there are a number of variables that can cause this design load to be incorrect, compared to the actual installation:

- Pipe wall thickness greater than or less than nominal.
- Pipe diameter greater than or less than nominal.
- Constant support hanger loads can vary by plus or minus 6% and still be within industry standard requirements.[3]
- Variable spring travel/load scales incorrectly placed and thus do not indicate correct load.
- Insulation thickness and density not the same as assumed.
- Improperly designed support interface between different suppliers on the same piping system. (This sometimes occurs at interfaces between major equipment suppliers, such as between a boiler and balance of plant piping.)
- Incorrect support installed at a location, or incorrect support supplied by hanger supplier.
- Content weight not properly accounted for in the design for all operational conditions.

Causes of Pipe Support Degradation

As the pipe and pipe supports operate over several years, the following factors may cause an initially well-balanced system to become unbalanced:

- Wear of bearings increases friction and reduces free movement, sometimes to the point of locking a hanger in one position.
- Foreign matter in the spring or bearing increases resistance.
- Spring metal degrades due to corrosion and fatigue, resulting in a modified spring rate.
- Corrosion of bearings and springs increases friction and reduces movement.
- Interference of pipe or pipe support with adjacent equipment transfers loads to the supports in an unexpected manner.
- Damage to hanger components due to dynamic overload or other external factors.

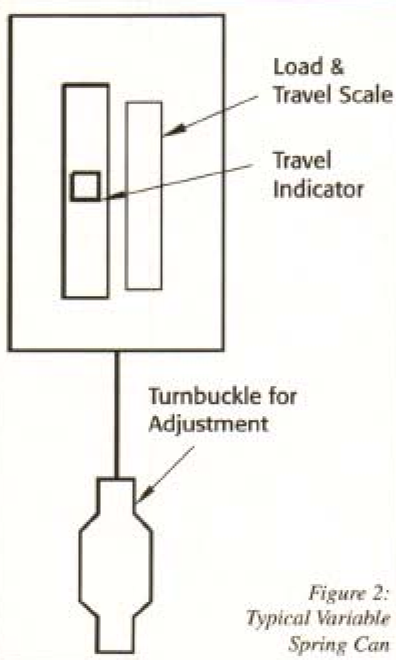

Figure 2: Typical Variable Spring Can

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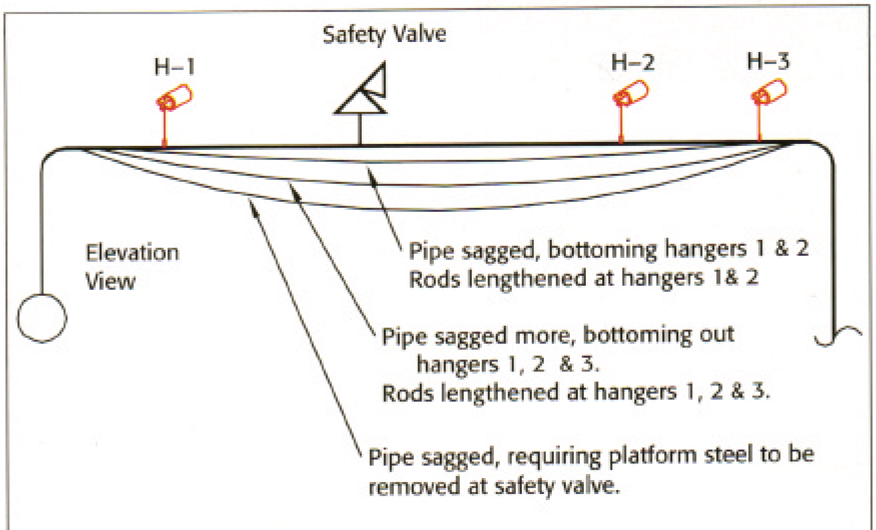


Figure 3: Example of Adjusting Travel Only.

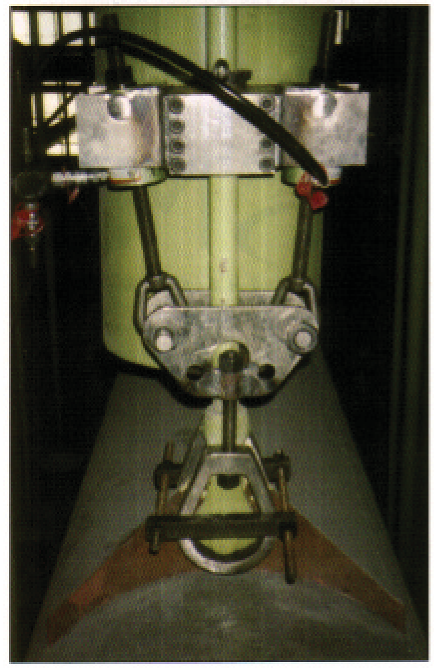
Pipe Support Initial Evaluation

A visual examination of the pipe and pipe supports in either the operating or shut down condition can often identify improperly balanced systems. Damaged supports, travel indicators bottomed out or topped out, bowed pipe, and sagging pipe are symptoms of some root cause(s). Some of the pipe support root causes are listed above, but there are other potential causes associated with damage to the pipe through operational conditions such as water hammer, steam hammer, erosion, corrosion, creep, and excessive thermal gradients.[4, 5, 6]

A second set of readings at a significantly different temperature from the first visual examination is required to determine actual pipe movements and hanger settings. This data allows comparison of actual movement to the design movement and an experienced field-piping engineer can evaluate probable root causes of any observed symptoms.

A common practice by some owners has been to adjust supports based only on the walk down data. An extreme case at a western U.S. utility involved a main steam line across the top of a boiler. The span between constant support hangers was very long, and the hangers bottomed out (Figure 3). The owner adjusted the travel by making the rods longer. A couple of cycles later, the hangers bottomed out again, and rods were again let out. The process continued for years. Eventually, the steel for an access platform had to be cut out to allow the pipe to drop further. The real problem was that the hangers were designed to support too low a load for the actual pipe weight. A hanger needed to be added; however, by letting the

Figure 4. An example of In-Situ Hanger Test Assembly.



pipe sag, a permanent set was put into the pipe requiring an extra drain, and the long-term life of the pipe was reduced.

In-Situ Pipe Support Load Testing

An approach that allows adjustments to be made based on knowledge of the cause(s) leads to corrective action that maximizes pipe life and avoids creating more problems. Certain contractors have developed methods to measure the load on the hangers, without having to remove the hanger.

One such method is shown in Figure 4. The hanger springs are floating within the travel range. An arrangement is made to bypass a portion of the rigid portion of the hanger assembly, usually at the clamp load bolt. The load is bypassed into hydraulic rams. Knowing the ram pressure and the area of the ram, the load on the rod is calculated. It is important that the hydraulic pressure is recorded just as the load is fully transferred to the rams. If the pipe is actually lifted, then an incorrect load is measured.

In-Situ Pipe Support Adjustments

The initial testing of the hangers provides data to start evaluation of the actual situation. With verification of the pipe wall thickness, diameter, and insulation thickness, a pipe stress analysis is performed to determine the significance of any deficiencies and develop recommendations. Hanger load and travel adjustments can then be made to attempt to bring the support system to its optimum condition. Support load testing is performed after adjustment to assure the pipe supports are set to the recommended loads.

Usually there are problems that preclude obtaining the optimum load and travel setting. These include:

- Insufficient adjustment remaining in hanger
- Inaccessible load adjustment bolt
- Load bolt will not turn
- Pivot bearings and other components are worn such that the adjustment is not consistent or reliable
- Insufficient rod length to adjust travel to recommended setting
- Rod threads damaged and will not turn

When one or more of these conditions occur, additional pipe stress analysis cases are run to determine if a different set of adjustments can be made that nearly achieve the desired result, without replacing pipe supports. In some cases, hanger replacements are required, but they are made only as a last resort.

CASE STUDY 1

Design Conditions: 1015°F, 725 psig: 39.00" O.D. x 2.125" wall pipe, A335 P22 Per ASME B31.[1] maximum allowable sustained stress, 7,300 psi

Figure 5 (page 23) is an isometric sketch of the piping system. Severe creep damage was found at several girth welds, primarily near the lower WYE fitting, prompting a root cause investigation and repairs.

Of the 19 constant support hangers, the load variations were as follows:

Percent Load Difference Measured to Design	No. of Constant Support Hangers
0% to 6%	7
7% to 15%	6
16% to 25%	3
26% to 35%	3

In addition, two rigid rod supports were measured to be supporting 80% more load than designed for at each location.

Based on the measured support loads, the maximum sustained stress was calculated at 9,150 psi, more than 25% greater than the allowable stress. The calculated high stresses were at the same locations as the damaged welds. Using the Larson-Miller Parametric curves, minimum time to failure for creep is calculated at 65,000 hours of operation.[7] The major weld damage was discovered at approximately 100,000 hours of operation.

With corrections made to the pipe support system, the maximum calculated stress in the system is reduced to 4,300 psi. Based on creep damage only, expected life of the pipe is estimated at more than 50 years. It is a reasonable inference that if the hangers had been tested and maintained properly, little or no damage would have been found in the pipe girth welds at 100,000 hours of operation.

CASE STUDY 2

Design Conditions: 1015°F, 725 psig: 33.25" O.D. x 1.93" wall pipe, A335 P22 Per ASME B31.[1], maximum allowable sustained stress, 7,300 psi

The system was evaluated shortly after installation, and it was determined that the weight of the pipe significantly exceeded the design assumptions. (See Figure 6 on page 23 for an isometric of the system.) Constant support hangers were adjusted to a "more optimum" setting by calculating the ratio of the actual pipe weight per foot divided by the design assumed weight per foot, and then turning the load adjustment bolt by the calculated percent change. However, no stress analysis was performed and no tests were performed to confirm the actual load adjustment in the hangers.

After about eight years of operation, it was observed that the pipe was not moving from ambient to operating temperature as expected, and the pipe appeared to sag in the same area that the major hanger adjustments were made. When measured, five of the hangers measured at 10% to 20% different than the expected load. Hanger 10 was more than 50% different than the expected load. Factoring the

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measured loads back into the analysis, the calculated maximum sustained stress that the pipe had been operating at was 8,030 psi, 10% greater than the allowable. Hangers were then adjusted and re-tested to balance the system and reduce the pipe stress to less than 4000 psi.

This case illustrates that adjusting loads without using a proper pipe stress analysis and actual load measurements can lead to serious errors. If engineering and testing had been performed when the problem was first noticed, significant degradation could have been avoided.

Conclusions

Pipe supports and the pipe should be considered a maintenance item by plant personnel. Supports degrade with time, and should not be expected to perform for decades without intervention. In many situations, periodic testing and adjustment is sufficient to maintain pipe supports near optimal conditions.

In both the cited cases, and many other documented hanger adjustment programs, properly functioning pipe supports are necessary to minimize pipe stresses. When material creep is a consideration, the life of the pipe may be greatly reduced by excessive stresses, resulting in the need for major repairs, including replacement of portions of the piping system. With proper pipe support design, installation, and maintenance, damage to the pipe should normally not develop for decades. However, improperly designed, adjusted, or maintained pipe supports can create very high pipe stresses resulting in premature damage. This can adversely affect plant safety, reliability, and financial performance.

Acknowledgements

The methods and tools to perform in-situ testing of pipe supports was developed by Rich Potter of Fastorq. The author gratefully acknowledges Mr. Potter's ability to develop the tools, and to accurately test the pipe supports at operating plants. The author also acknowledges the assistance of Lange Kimball of KBR who performed one of the case studies.

References

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NOTE: This paper, POWER2004-52031, was slightly edited from its original format. It was originally published in the Proceedings of ASME Power 2004, March 30-April 1, 2004, Baltimore, Maryland. These proceedings are available from ASME in both digital and print formats; for more details contact infocentral@asme.org. PDFs of individual papers can also be purchased at the ASME Digital Store.

Gerry May is a registered professional engineer with over 30 years experience in the design, testing, installation, and maintenance of piping, vessels, and tanks. He earned B.S. Aerospace Engineer and M.S. Mechanical Engineer degrees from the University of Kansas, and is currently Manager of the KBR Mechanical Integrity group based in Houston, Texas. Contact Gerry via editorial@magellanpubs.com

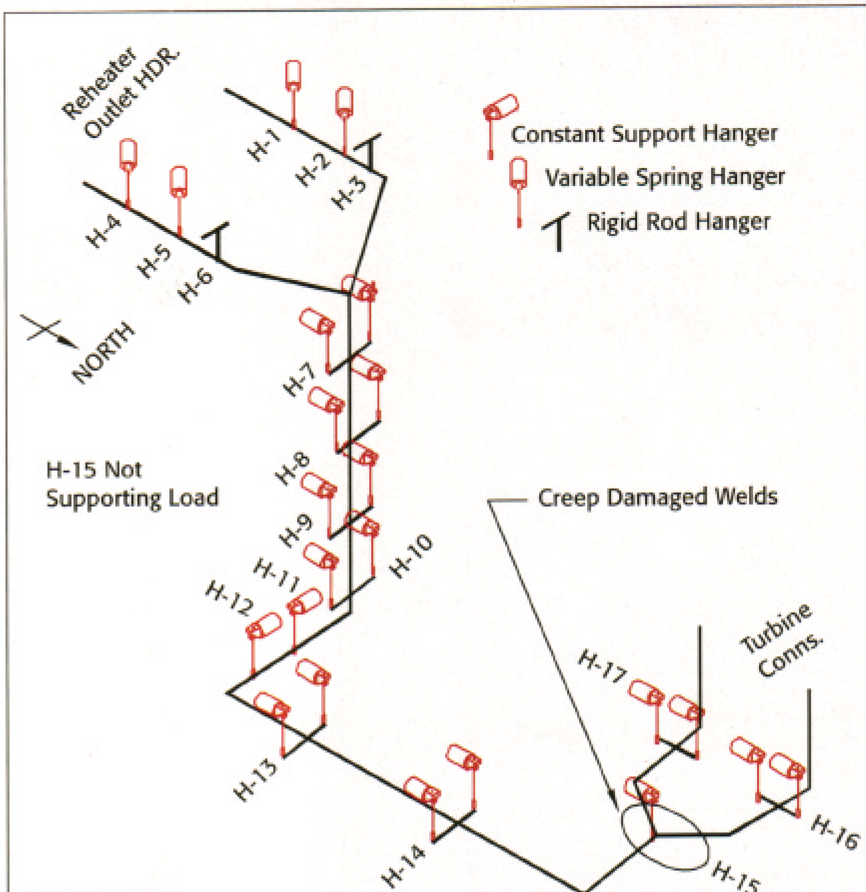

Figure 5: Case 1

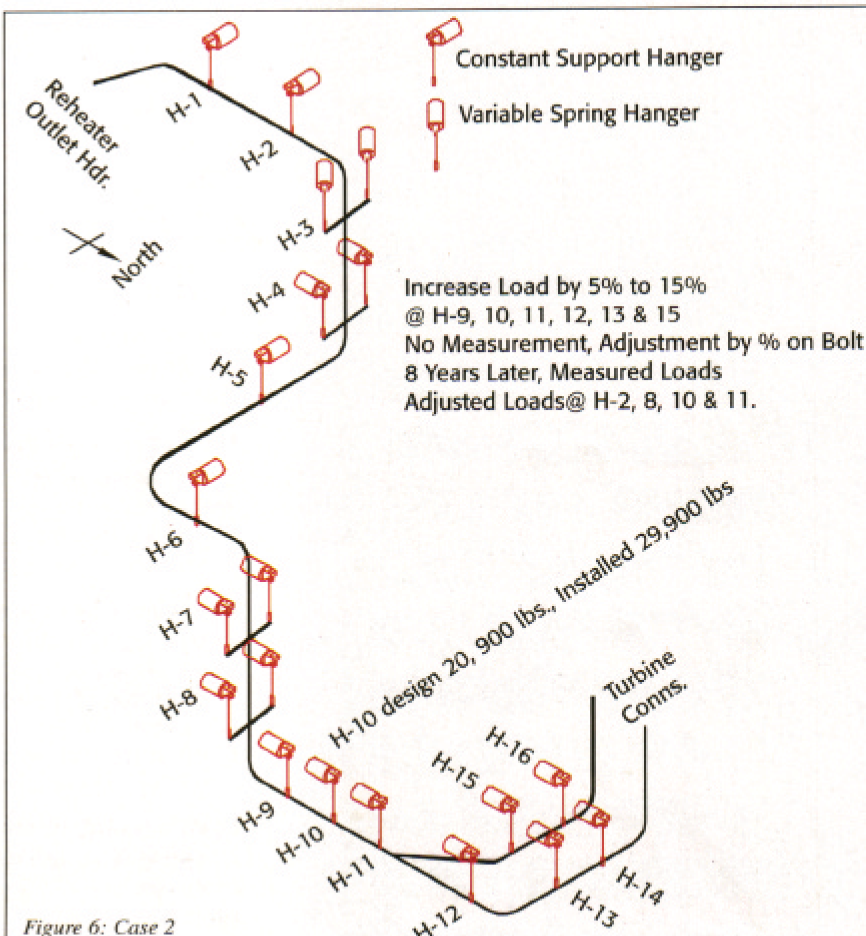

Figure 6: Case 2