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Pipe Hangers & Piping Loads

- **Comprehensive pipe support service**
- **In-service load determination and testing**
- **Detect non-functioning support members**
- **Weigh and adjust boiler heads and components**
- **Prevent steam leaks and major failures**
- **Detailed analysis and reporting**

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Load Testing
Piping Hangers and Systems

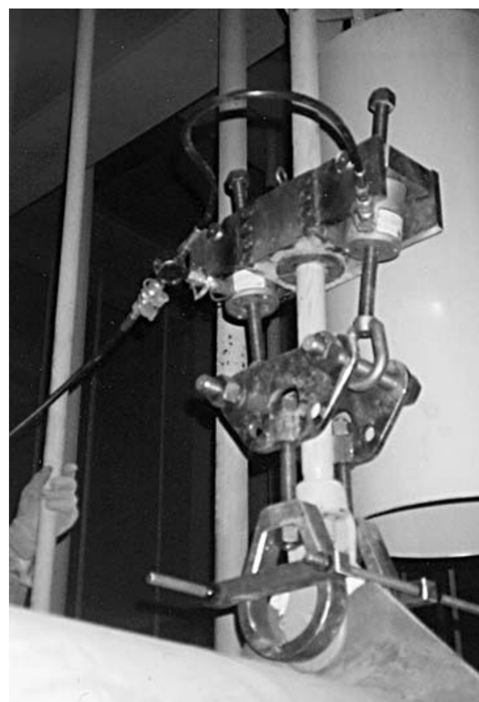
DO YOU HAVE…

- Bottomed out spring hangers
- Sagging high temperature steam lines
- Broken hanger components
- High energy steam lines "jumping" during startup/shutdown

High energy steam piping systems frequently operate at temperatures in excess of 900°F. These same systems are also typically exposed to variable support loading as a result of unit thermal cycling. The presences of these two items, when coupled with the standard mid-sized constant spring hangers, routinely result in increased system stresses, permanent creep deformation and reduced system operating life, with steam leaks and major failures possible.

ON-LINE TESTING

Fastorq has the methods and tooling to measure piping loads and spring hanger loads under plant operating conditions. This load testing will identify present loading conditions and what further evaluations may need to be performed i.e. NDT, "As Exists" stress analysis.



ON-LINE ADJUSTMENTS

After proper evaluations have been performed, the hydraulic tooling is used to load, adjust, and monitor field adjustments made to the hanger system. This allows the correct load to be applied at the "HOT" operating travel position.

ASSOCIATED SYSTEM TESTING

Fastorq tooling is also used to weigh and adjust boiler headers and components that directly influence piping loads and movement. These problems are frequently associated with symptoms of more severe problems which need exploration through "AS EXISTS" analysis.

An integral part of Fastorq's capability is a close working relationship with our clients and their technical staffs. As a specialty service contractor, we have the unique capability of performing in-service load determination and testing of spring hangers and other support systems. Such testing can also detect non-functional support members that show no outward sign of distress or failure.

CONTACT US FOR FURTHER INFORMATION ON TECHNIQUES OR FOR A DEMONSTRATION OF TOOL APPLICATION

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Piping and Piping Hanger Support Rod Analysis

Our comprehensive pipe support service offers the following advantages:

1. Measuring both the dead weight of the pipe, and the spring force at each location for comparison. This confirms the accuracy of the pipe hanger, and checks that all moving parts are functioning.
2. Weighing of all pipe supports along a complete steam line provides accurate input data for the analysts and the numerous pipe analyses programs available. (However sophisticated a piping analysis program is, it can only be as good as the input data).
3. Weighing carried out in both the cold condition and while the system is on-line, gives a complete picture of the loading distribution and fluctuation of the piping runs under the two extreme conditions of pressure and temperature.
4. Adjustments of the load, within the allowable range of each support unit, to achieve a satisfactory balance of loading along a piping run.
5. A comprehensive report upon completion of all contracts, commenting upon both the physical condition and loading condition of the pipe supports. Details of any adjustments made with the justification. All reports to include results tables, conclusions and recommendations for any further work that we deem necessary to maintain the system in optimum working condition.
6. An on-site engineering supervisor to work with the plant piping engineer and consulting engineer's, to identify any anomaly that may arise and resolve the situation to the satisfaction of all.

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Definition of Terms

WEIGH OPERATION

Transferring of load between the support hanger and pipe clamp to hydraulic load cells, where the hydraulic pressure is converted to load in lbs.

HANGER SPRING LOAD

The load being applied to the pipe while in the working travel range.

PIPE WEIGHT

The weight of the piping at the clamp support point. (This is achieved by locking the spring mechanism, in this form the hanger is effectively a ridged rod and the weight recorded will reflect the weight of the pipe).

BOTTOMED OUT

When the hanger reaches the limit of its downward travel. (In this condition the hanger becomes a rigid support and will induce stress not only in the pipe support but also into the piping system. The bottomed out load can at worst exceed the design strength of the support members).

DESIGN LOAD

The engineering design load for each support point.

LOAD ADJUSTMENT PERCENTAGE

The design load of the hanger can be adjusted generally within (ten) or (twenty) percent depending upon manufacture. This is stated in + or – of design hanger load. Should this range of adjustment be insufficient, then the cause of over/under load should be investigated. It will also identify that the hanger may need replacing.

WEIGHING AND ADJUSTING CONDITIONS

The operations can be carried out in the operating conditions. (The restraints being ambient temperatures to the personnel). Which slow down the normal activities.

Fastorq can normally weigh and adjust (7) seven to (12) twelve hanger locations per (8) eighthour shift. The crew size is normally a working supervisor and two technicians.

TOOLING

Fastorq tooling is sized to weigh support rods through 3 1/2” in diameter and load capacities of 120,000 lbs. (in all cases special tooling can be designed as required for a special application).

HANGER LOCATIONS

Fastorq tooling is designed to work at the pipe clamp location and access can be by ladder or scaffolding. If access to the hanger is required (as in the case of adjustments) then scaffolding must be erected as well. Fastorq personnel are provided with their fall protection and safety equipment. Our personnel will work out of customer supplied spider or other baskets.

LOCKING THE SPRING MECHANISM

Fastorq provides attachable locking devices in the weighing set of tools. In some cases it is required that a 1” or 7/8” nut be welded to the hanger frame, in most cases the customer will provide a welder.

HANGER ADJUSTMENTS

At times the hanger adjusting bolts become frozen in place and will strip out the threads, the hanger can not be adjusted further or at all.

PLANT SUPPORT

- Access to hanger locations, ladders and or scaffolding
- Plant air
- Major lighting
- Tool laydown area
- Welding & heating equipment, if required
- Pipe fitter support when major hanger adjustments are required
- Receiving & shipping of equipment container

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Support Rod Analysis of Piping Hangers and Piping Loads

by R.M. POTTER

INTRODUCTION

Many articles have been written on why high energy piping support loads are critical to the operating performance and safety of the piping system.

This paper will describe a method currently in use that will accurately measure the load that a hanger is applying to the pipe and will also measure the actual pipe load at the location of the hanger.

This method is performed while all components remain in place and can be carried out with the unit in the operating condition or in the cold shut-down condition.

R.M. Potter is an independent bolting technology consultant . . .

Based on a paper presented to the ASME B31.1 Code Committee on September 28, 1992.

SUPPORT ROD ANALYSIS

Support rod analysis is a comprehensive term describing the process of determining the loading in various types of equipment supports, (IE. Boiler support rods, Suspended equipment, Piping hangers, Etc.)

This paper is directed to the various pipe support hangers found in the power and process industries whether the hangers are rigid, variable or constant load type.

The initial effort was in developing tools and techniques to meet the needs of the utilities in the United States that have moved toward more analysis of high energy piping systems to provide accurate load data to replace assumed data in piping analysis programs.

The technology transfers the active load in the support rod or hanger to a precision load monitoring system without changing the configuration or disturbing existing load distribution.

This allows the analysis to be performed on operating systems under actual hot conditions, as well as in the cold maintenance condition.

THERE ARE THREE LOADS TO BE CONSIDERED

1) **Hanger spring load:** The load being applied to the pipe by the spring mechanism while in its travel range.
2) **Pipe load:** The weight of the pipe at the hanger support point. To determine the pipe load while the spring mechanism is in the operating range, the mechanism must be locked-out by mechanical means while also maintaining its location.
3) **Bottomed-Out loads:** When a hanger has reached its full travel range (in this condition, the hanger has become a rigid support) it will induce stress as the piping system tries to continue moving downwards.

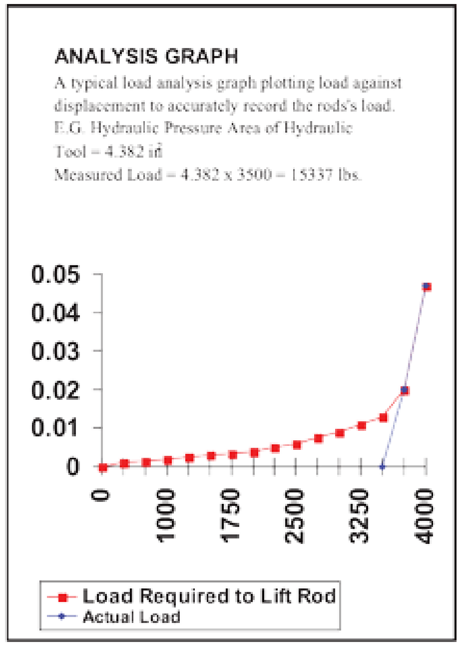

Figure 1 Load Analysis Graph

The Bottomed-Out load can at worst exceed the design strength of the hanger or supporting structures.

EQUIPMENT

The system consists of specialized clamps and adapters designed by Richard Potter to work with hydraulic load cylinders.

The clamps and adapters form a beam onto which two hydraulic cylinders are then attached. Two cylinders are required to maintain balance and eliminate any outside moments.

The tooling design provides economic as well as engineering benefits in that the piping components remain in place. A sufficient number of hangers can be weighed per shift to offset the labor and mobilization costs and, most important, provide accurate and useful data on pipe support mechanism performance.

WEIGHING THE LOAD

The specialized tooling is attached to the support rod below the hanger

Support Rod Analysis of Piping Hangers and Piping Loads Cont.

support point and to the pipe clamp. The attachment point at the pipe clamp is the pin or bolt securing the support rod to the clamp.

The hydraulic cylinders are connected to a pump & calibrated gauge.

As pressure is applied, the load transfers into the clamping device and is monitored by gauge pressure. When the gauge pressure stabilizes, the transfer is complete and pressure is converted to load in pounds.

HANGER SPRING LOADS

On spring mechanisms, the load must be transferred to the measuring system, keeping the spring active within the system.

PIPE LOADS

Weighing the pipe load uses the same tooling and normally the same tooling set-up, as presented for spring mechanisms. The important difference being the need to lock out the active spring mechanism.

The pipe load can be heavier or lighter that the supporting hanger, due to the pipe not being a free body but a beam.

For those hangers having built-in provisions, it is a somewhat simple process. Older hangers and other types that do not provide for locking (other than the pin provided for hydrostatic testing) must either be locked by some type of external clamp or by wielding a stop between the lever arm frame.

RIGID HANGER LOADS

It is important to note that rigid supports are found, at times, carrying loads exceeding the design strength of the components. On dual rod supports, rarely is the load evenly distributed between the two support rods.

HANGER LOAD ADJUSTMENTS

With the same tooling and measurement techniques it is now possible to adjust the applied load of the hanger(s) in the operating condition. I would like to caution that a sufficient piping load analysis be performed by qualified personnel prior to any random load adjustments.

CONCLUSIONS

The tolling procedures described provide the following benefits for piping industries.

1. To improve operating performance of the various components and support mechanisms.
2. To assist in problem solving.
3. To provide a margin of safety in knowing the piping system is operating as designed.
4. To eliminate the high labor costs associated with removing components for testing.

Hanger	Hanger Plate Load Stamp	Hanger Load Adj. % Setting	Actual Pipeload	Actual SPG. Load	Delta Percent		Elevation	
					+	-	MM	Inches
C19	5386	-15	474	4636		2	-9.4	-0.37
C20	11878	16	133358	13468		6.4	0.25	-1.10
C21	6406	4	5630	6624	15	-57.6	-2.26	-1.50
C22	7723	15	7728	7507		3	-28.0	-17.0
C23	5224	0	5961	5851		2	-38.0	-0.62
C24	8078	4	8390	8280		1	-43.7	2.87
C25	7466	8	7507	7397		1.5	-15.9	
C26	6633	10	*3864	6513			73.1	
C27	9808	12	10377	10543	1.5			
C28E	5986	4	6293	6070				
C28W	5986	7	6514	6348				
C28			12812	12420		3		
C29E	3986	16	4526	4250				
C26W	3986	14	4250	4140				
C29			8776	8390		4.3	-93.0	-3.60
C30E	N/A	N/A	9108	N/A				
C30W	N/A	N/A	8280	N/A				
C30			17388				-110.0	-4.3
**Totals			85286	85116	16.5	16.8		

NOTE: * HANGER IS PARTIALLY TOPPED OUT
** DOES NOT INCLUDE RIGID OR C26

Hanger	Hanger Plate Load Stamp	Hanger Load Adj. % Setting	Actual Pipeload	Actual SPG. Load	Delta Percent		Elevation	
					+	-	MM	Inches
D1	6575	10	7346	7452	<1		56.4	2.20
D2	10931	9	12806	12364		3.3	-37.6	-1.48
D3	6670	0	6734	6624		-1.5	27.6	-1.08
D4	6426	0	**6624				-1.6	-0.06
D5	4465	0	**6072				-29.6	-1.18
D6	7017	2	7176	7286	1.5		-81.0	-3.18
D7	7490	4	7452	7507	<1		-58.6	-2.30
D8	7625	10	8170	8170	0	0	-5.1	-0.20
D9	6623	12	7065	7065	0	0	-15.1	-0.59
D10	9748	14	100046	10488	4			
D11E	5975	14	6513	6513				
D11W	5975	14	6513	6624				
D11			13026	13137	<1			
D12E	3972	14	4140	4305				
D12W	3972	14	4361	4471				
D12	7944		8501	8776	3		60.0	2.30
D13S	N/A	N/A	***8170	N/A				
D13W	N/A	N/A	***9384	N/A				
D13			17554			-41.0	-1.60	
**Totals			88372	88869	10.5	5		

NOTE: * DOES NOT INCLUDE RIGID (D13) OR D4 & D5
** HANGER BOTTOMED OUT, LOAD = PIPE FORCE
*** RIGID SUPPORT

Figure 2 Typical Report of Loads

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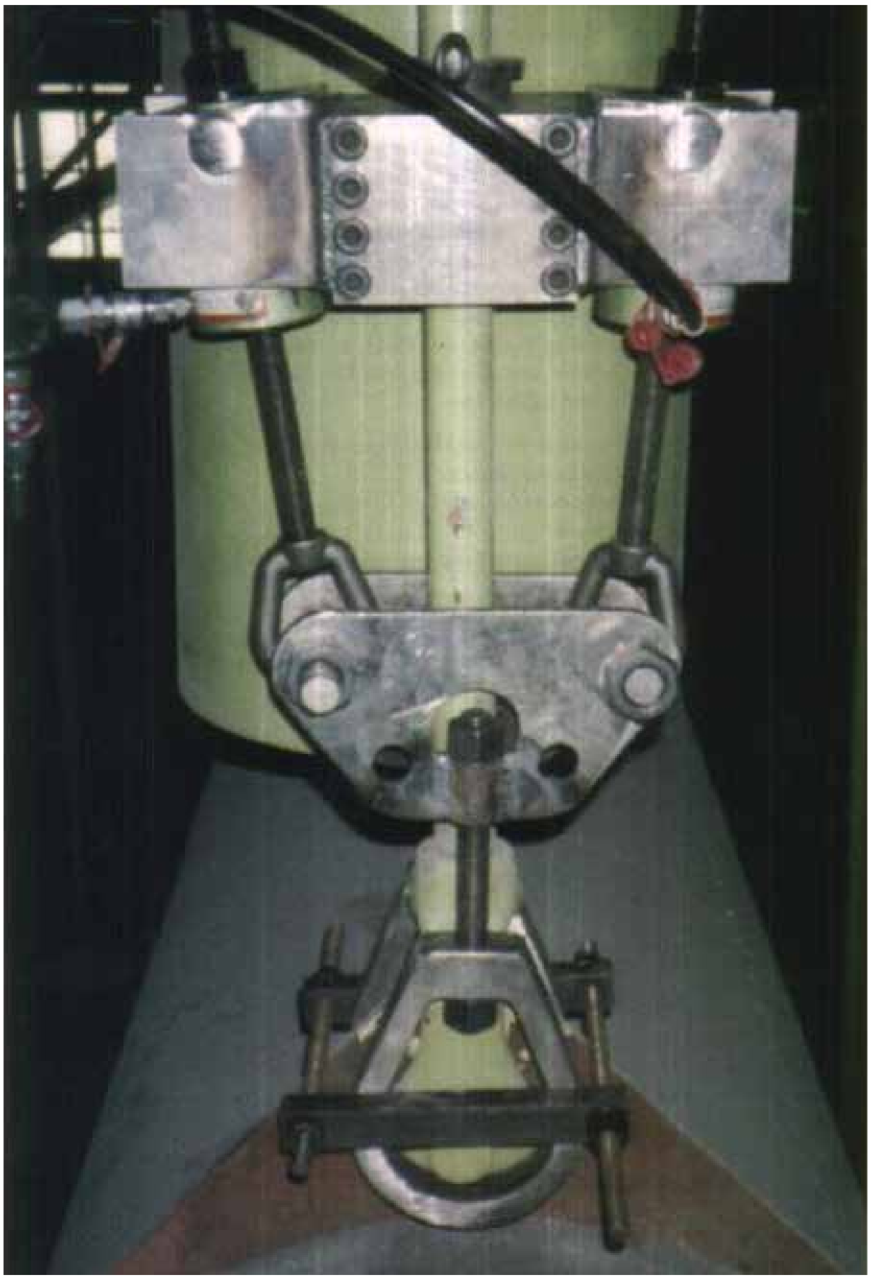
The Need For In-Situ Pipe Support Testing

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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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.

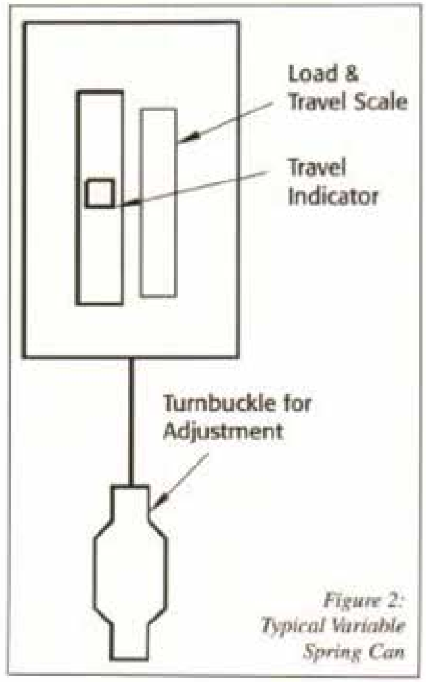

Figure 2: Typical Variable Spring Can

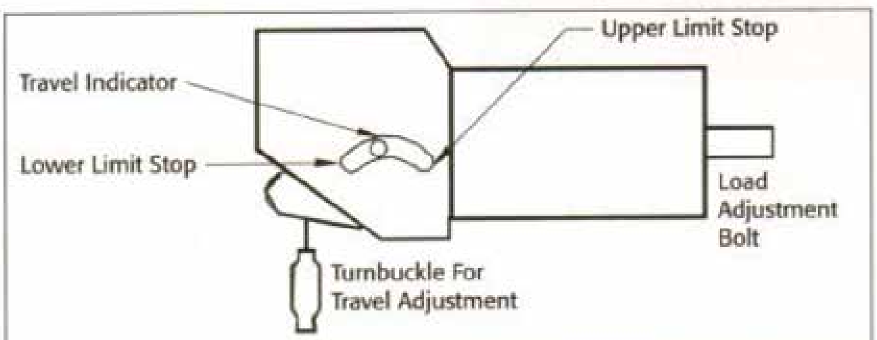

Figure 1: Constant support can. Arrangement of components varies by style and manufacturer

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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

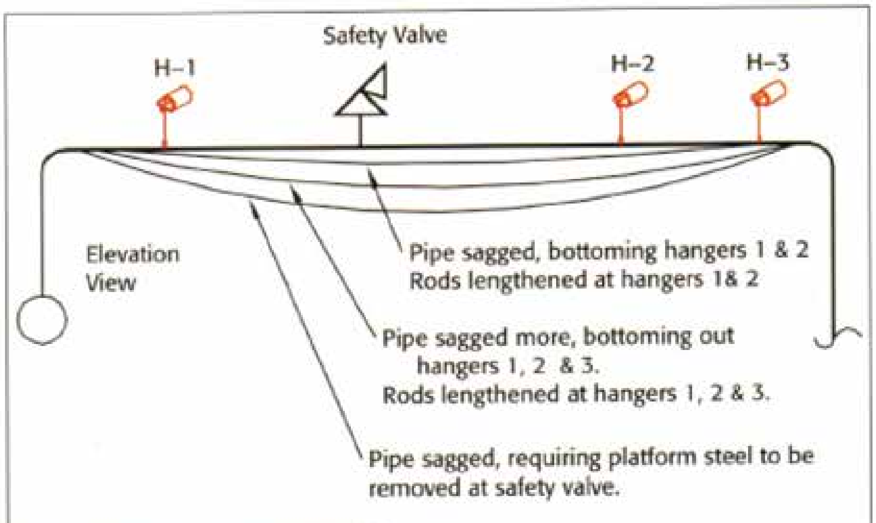

Figure 3: Example of Adjusting Travel Only.

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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.

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

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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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.

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.

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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.

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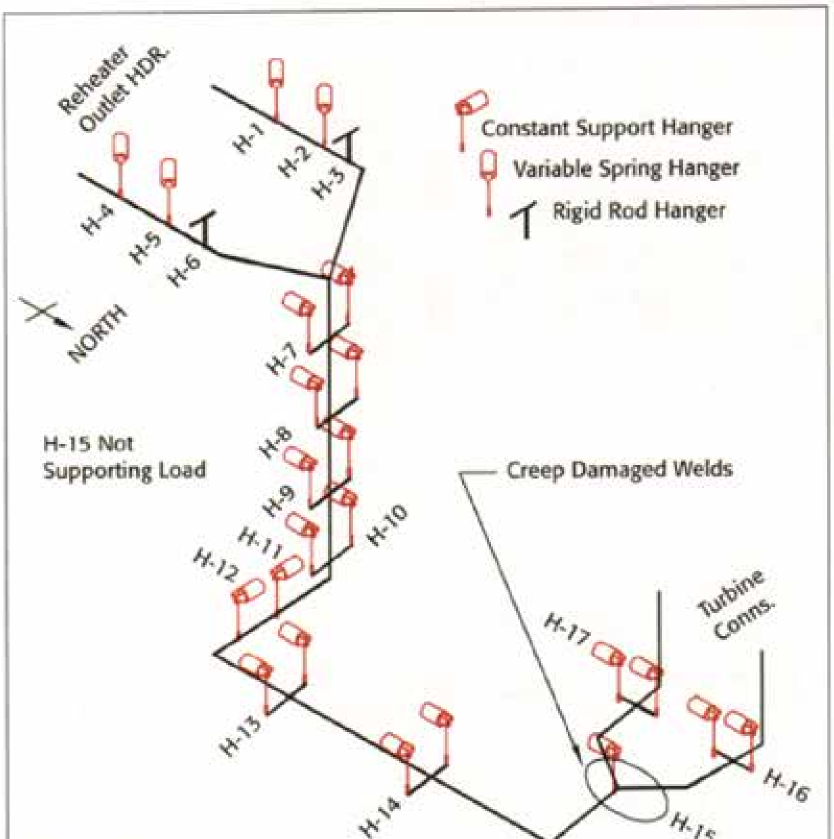

Figure 5: Case 1

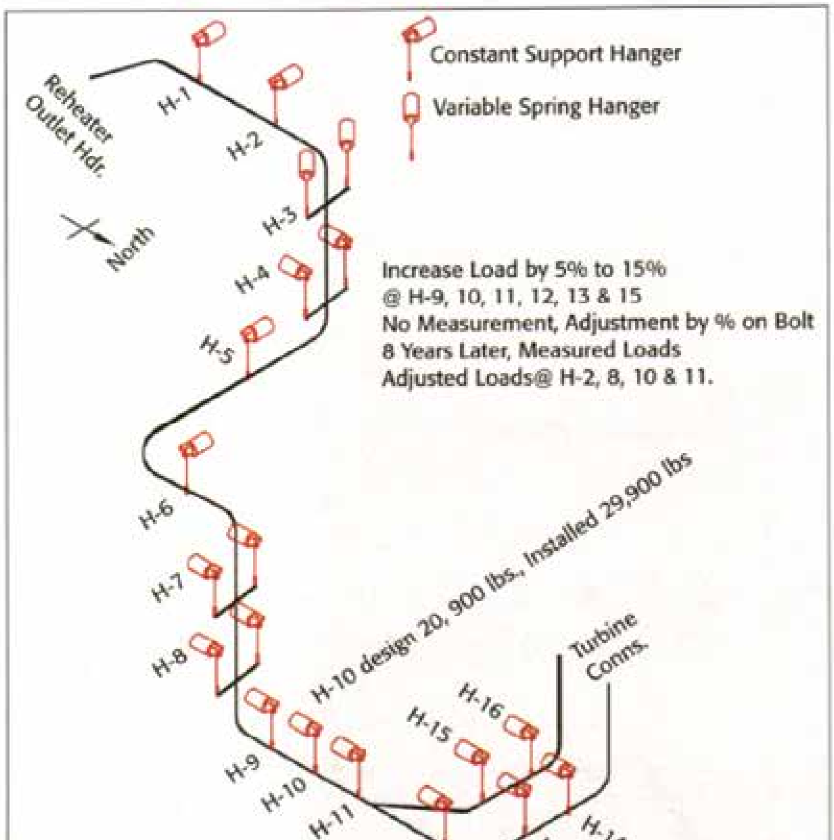

Figure 6: Case 2

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