IMPORTANCE OF PROPER COMMISSIONING OF STEAM PIPE SPRING HANGERS & SUPPORTS

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There are several pipings that connect various equipments in a power plant. These pipes are to be supported properly at regular intervals. Invariably the pipings are hot and hence there is thermal movement of piping in service. In order to take care of the movement and at the same time to offer proper support, a combination of rigid hanger, rigid support, roller support, guided supports, limit stops are provided. There is another important support system called spring supports. Spring supports are essential to take care of the movement and at the same time offer a support without straining the pipe / or the connected equipment. Boiler feed pump and turbine flanges are important connections that are not to be loaded beyond the allowable forces. Also there will be thermal movements to be taken care of. Spring supports can be variable spring support, variable spring hanger, constant load hanger, constant load support.

Equipment such as Turbine generator, Final SH header, Steam drum, main steam header , LP heater, HP heater , Condenser, Condensate pump, BFP are somewhat fixed to some locations. These equipments yet have thermal expansion at the connecting ends to piping.

The pipes have their self weight and imposed loads due to valves. Certain reaction loads due to opening/ closing of control valves and safety valves also act on the piping. Pipes are insulated and thus have additional loads.

Pipe lines like any other equipment used to be supported at regular intervals to prevent sagging. Pipes can be supported by pipe racks or hung or base supported from boiler supporting structure or building. The routing of pipes is done from aesthetic sense, accessibility for valves, instruments, and head room clearance and to make use of nearby structure.

Pipings are subjected to thermal expansion. If the piping is not designed for flexibility, we may have strained flanges, weld joints, strained bends, and strained branches. Ultimately pipe would rupture if the piping is not designed with flexibility. We often see break down of piping, header due to improper piping design and improper construction of steam pipings.

Piping failures are due to,

1) Layout changes executed by construction engineers either due to interferences or by their own decisions.
2) Improper commissioning of pipe support due to lack of knowledge.
3) Inadequate rigidity of the base support.
4) Failure to remove the temporary anchoring done for construction purpose.
5) Failure to locate the support with a shift based on expected thermal movement as per stress analysis report.

Recently I had come across a case of a main steam header crack which occurred within few months of commissioning of a power plant. The cause was identified as non-removal of temporary anchors of steam piping. But the construction manager showed an attitude of disagreement to the finding. He went ahead to say that their designer had verified that the header should not fail for this reason. It is unfortunate that the magnitude of thermal forces is not verified by calculation by the designer. The inspection made by the design engineer was not complete. The case study is presented below:

This is in the case of a 2 x 25 MW power plant. The main steam parameters are 105 kg/cm2g and 545 deg C. The newly commissioned 2 x 115 TPH boilers and two steam turbines are linked by the main steam header placed on the roof of control room. The steam pipings from boilers are of 250 nb OD x 32 thk. The steam piping to TG is also 250 nb pipe with 32 thk. The main steam header is of 400 nb dia & 44.45 thk. The main steam boiler is of 6.5 m long. It is anchored at one end allowed to expand in opposite direction. The steam piping model and arrangements are shown in figure 1. The customer had arranged for all the piping system drawings. I traced the piping for the correctness of spring hangers, spring supports, guides & rigid supports. While all the supports are found at the right places, certain additional temporary supports were seen inside the insulation. After the insulation was removed the piping was seen to have been locked at locations shown in the drawing.

The unit had several start / stops since there were teething troubles with the various equipments. There were totally about 20 stoppages. I had concluded that the large cyclic forces must have led to the failures. This led to the crack of pipe close to the weldments. Generally a weldment is stronger that the parent metal due to extra thick reinforcement at weld. In addition the heat affected zone is likely to have some minute hair line cracks. The cracks grow if sufficient force is made available. Cycling forces accelerate the growth of the crack.

Reasoning by forces / bending moment / stress analysis

To support the argument, the thermal forces were estimated. It can be seen from the calculations, the order of the forces were simply too high.

- The header is considered as a simply supported pipe with various loads acting on it. It has its own weight along with insulation. The bending stresses can be estimated for this case separately.
- Part of the weight of connecting pipes & valves will be acting on the header. Depending on the location of the support in the pipe, the bending stresses can be calculated.
- When the connecting pipes are restricted by locks, the restricted thermal expansion of pipe develops thermal stresses. The stresses transfer as forces on to the header. The forces are found to be of very high order. The order of the forces can be seen below.
- The above three stresses are added to the longitudinal stresses developed by internal pressure. The calculations proved the failure was bound to occur at the location where the failure had taken place.

<u>Estimation of forces on header by the restricted piping,</u>

Thermal Co-efficient For P22 Material α $= 14.35 \times 10^{-6}$ mm / mm / °C

Young's modulus For P22 Material E = 1.4342×10^4 kg/mm^2
Operating temperature T = 535°C
Thermal Stress (On complete restraint) = $\alpha * T * E$
= $14.35 \times 10^{-6} * 535 * 1.434 \times 10^4$
Thermal stress = 110.1 kg/mm^2

Assuming the pipe is flexible to absorb the thermal expansion to an extent of 90%, the actual stress can be taken as 10% of the above.

Therefore, Stress in the piping = 110.1* 10%
σ = 11.01 kg/mm^2
Converting stresses into forces:
Stress σ = F/A
Force at R (from boiler 1) = σ A
= 11.01 * π (273^2-209^2)/4
= 266750 kg

Force at S (to boiler 3) = 11.01* π (219^2-163^2)/4
= 185000 kg

Force at T (to TG3) = 11.01* π (273^2-209^2)/4
= 266750 kg

The forces act as bending moments on the header. Stresses due to bending moment add to the longitudinal stress developed due to internal pressure. It is found that allowable stresses have exceeded the value specified by the code.

Related case studies

In another installation, photographs 4 to 6 were taken. In photographs 4 & 5, we can see here how the inadequate structural support has yielded to load. The variable spring support close to these supports has got loaded heavily and it is no more a spring support. These developments which show up during commissioning have to be brought to the designer's notice to avoid major catastrophe in steam piping. Photographs 7 to 13 are from a new power plant. These photographs are not covering all the wrong installations at the plant. In general such mistakes are seen in several plants.

Recommendations for a proper piping support installation & commissioning

1. Hanger and supports are to be used only for the intended purpose. It is not to be used for scaffolding purpose.
2. The pipe routing is not to be altered by erection engineer. If done, it should be after the revision of stress analysis and load calculations.
3. The location of pipe support is not to be changed by the erector. If done, it should be after the

revision in stress analysis and load calculations.

4. Spring supports and assemblies should not be used for earthing.
5. Temporary supports used for piping should be removed finally after the complete insulation work also. Finally the insulation should be completed left over area too.
6. All spring supports are to be unlocked.
7. After hydro test, if the springs do not return to cold position, they have to be adjusted to match the pointer returns to cold position.
8. At the first heating of the piping, the spring supports are to be monitored till the piping reaches its rated duty condition.
9. After the construction activities are completed, piping engineer should “walk through” with the drawings and spring support data sheet to ensure that hangers and supports have been erected correctly unlocked and that no temporary support is preventing the free movement of piping.
10. Sliding supports should be properly designed and erected. The piping is placed centrally to the support in cold condition by many of us. Many times we can see the pipe is about to slip off from the support.
11. It is vital that no pipe line fouls with the structure, cable trays, walk ways etc, hand rails, which can cause serious damage and accident when thermal expansions start occurring.

Final word

It is a great set back if the piping fails in service. The steam force in the pipe can cause damages to unpredictable levels to power plant and the staff. It was to the luck of the plant that the damage was minimal when the header failed. There are so many plants, where piping supports are not commissioned by the engineers. For the readers’ information only, some photographs are attached with this article. A thermal expansion chart is attached with this article for reader’s information.

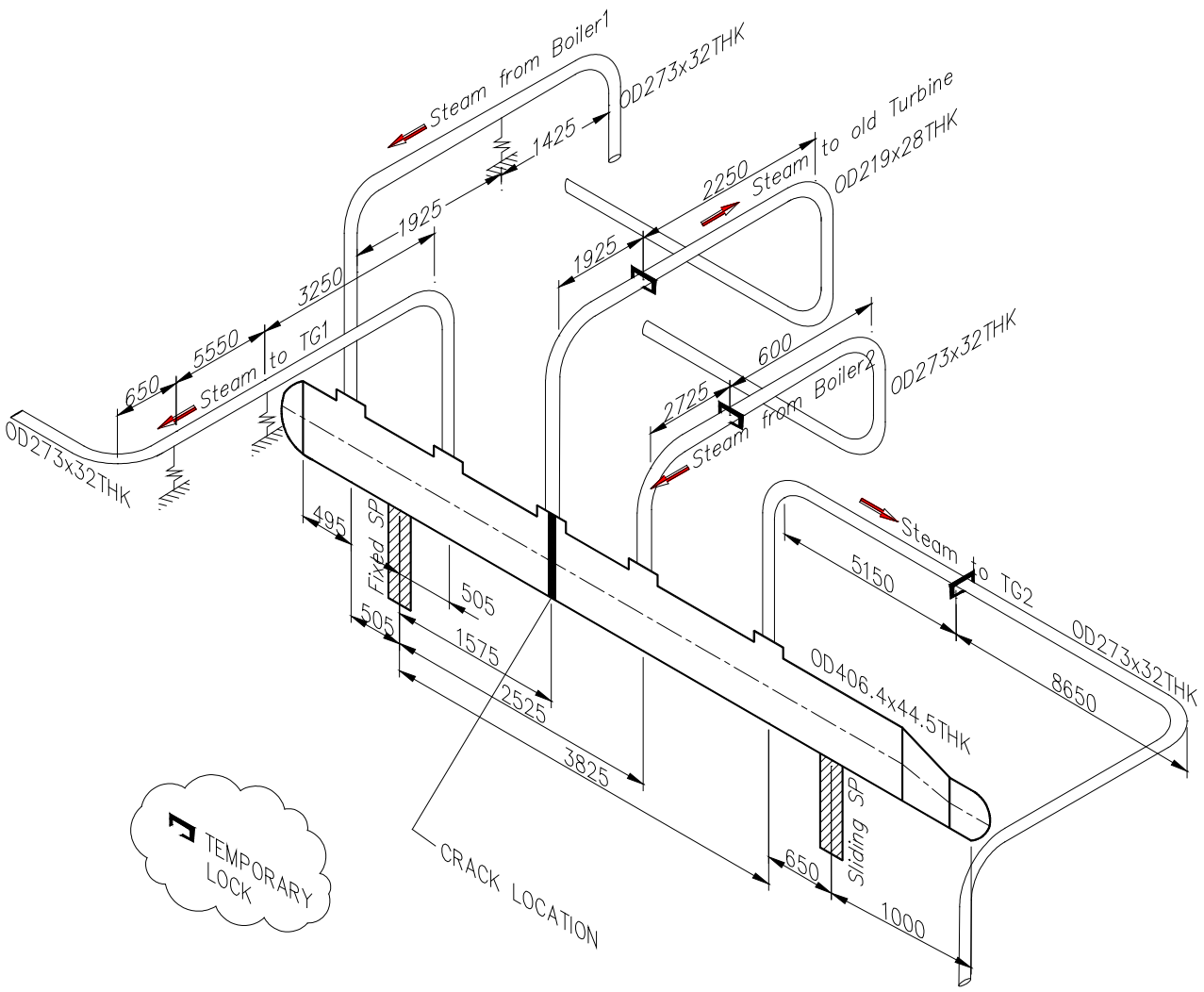


Figure 1: The drawing shows the piping arrangements connected to the main steam header. The drawing shows the location of temporary anchoring. The pipings & headers are meant for carrying steam at a pressure of 100 kg/cm2 & at 540 deg C.

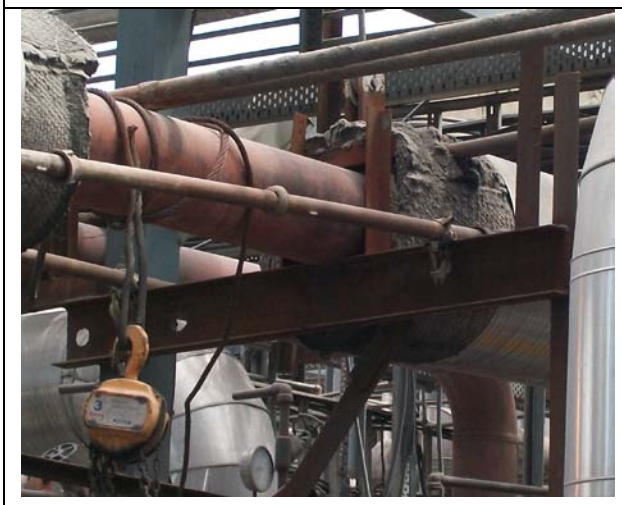


Photo 1: The steam piping from header to old TG is seen locked up. The insulation was removed to identify the temporary anchoring.

Photo 2: The steam piping from boiler no 2 to header is seen locked up. The insulation was removed to identify the temporary anchoring.

Photo 3: The header crack can be seen here very close to the weldment.

Photo 4: This is a mistake by a designer that a base support for hanger was not rigid enough. This is from another installation.

Photo 5: In the steam main steam piping, this is the status of the next support. The rigid hanger support base is not rigid enough.

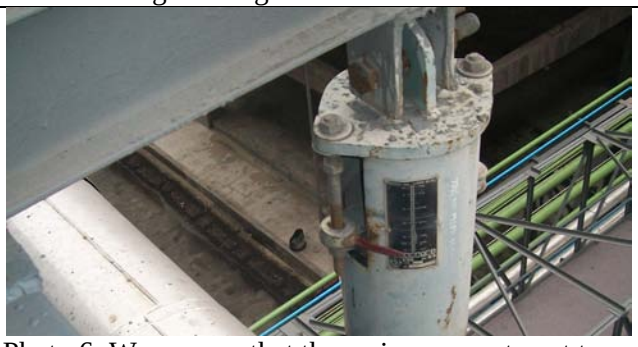


Photo 6: We can see that the spring support next to the above two supports has got overloaded.

Photo 7: A constant load hanger is seen with an improvised lock at a recently commissioned installation.

Photo 8: A spring support waiting to be loaded in the operating power plant.

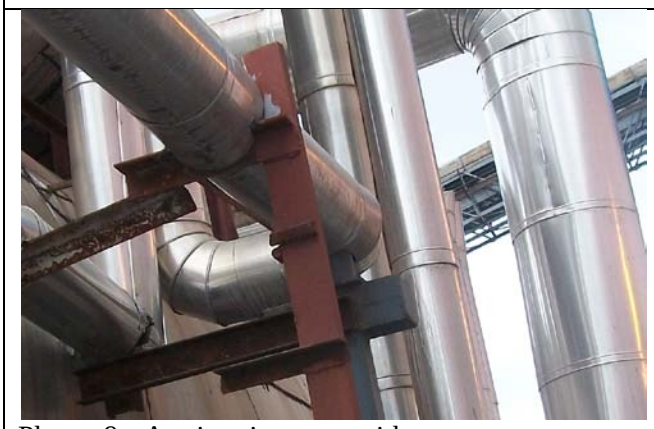


Photo 9: A pipe is seen with temporary support though the permanent support is installed nearby.

Photo 10: Pipe support partially commissioned by the commissioning team.

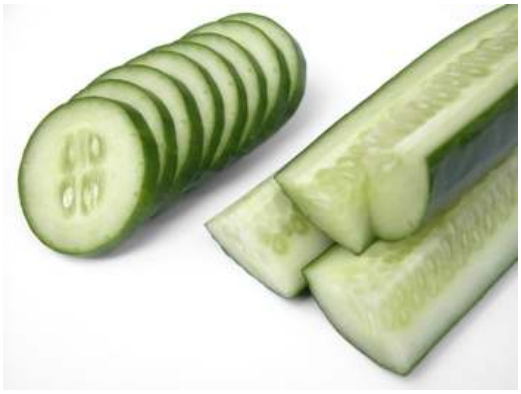
Photo 11: A rigid hanger in the boiler feed piping designed for 125 kg/cm2 is seen fallen due to poor welding at support.

Photo 12: Steam piping to TG is seen buried in the TG building wall. This is a common mistake seen.

Photo 13: Due to burying the steam line inside the TG wall, the pipe support gets lifted off it is sliding base.

THERMAL EXPANSION DATA FOR MATERIALS USED IN PIPING															
Material specification	Mean Coefficient of Thermal Expansion = A/10^6 (mm / mm / ^oC) Linear Thermal Expansion = B (mm/m)									IN GOING FROM 21^0C TO INDICATED TEMPERATURE					
	Coeff	**21**	**93**	**149**	**204**	**260**	**316**	**371**	**427**	**482**	**538**	**593**	**649**	**704**	**760**
Carbon Steel; Carbon-moly steel, low-Chromium steels (through 3Cr)	A	10.93	11.48	11.88	12.28	12.64	13.01	13.39	13.77	14.11	14.35	14.62	14.74	14.90	15.05
	B	0.00	0.82	1.52	2.25	3.02	3.83	4.69	5.58	6.51	7.41	8.37	9.25	10.18	11.11
Intermediate alloy steels(5Cr - Mo through 9Cr-Mo)	A	10.31	10.87	11.14	11.41	11.70	11.99	12.24	12.53	12.78	13.00	13.18	13.34	13.48	13.59
	B	0.00	0.78	1.42	2.03	2.79	3.53	4.28	5.08	5.89	6.71	7.54	8.33	9.21	10.04
Austenitic Stainless steels	A	16.40	16.81	17.05	17.26	17.46	17.68	17.86	18.09	18.29	18.52	18.70	18.86	18.97	19.08
	B	0.00	1.22	2.17	3.16	4.17	5.20	6.25	7.33	8.43	9.56	10.70	11.83	12.96	14.10
Straight chromium stainless steels (12Cr,17Cr and 27Cr)	A	9.43	9.90	10.19	10.46	10.73	11.03	11.27	11.50	11.74	11.93	12.10	12.20	12.33	12.42
	B	0.00	0.71	1.30	1.92	2.57	3.25	3.94	4.66	5.40	6.16	6.92	7.66	8.42	9.17
25Cr - 20Ni	A	13.46	13.97	14.26	14.54	14.80	15.08	15.34	15.62	15.86	16.06	16.20	16.34	16.42	16.52
	B	0.00	1.01	1.82	2.67	3.45	4.44	5.36	6.33	7.33	8.29	9.26	10.25	11.21	12.20
Monel (67Ni-30Cu)	A	13.46	14.11	14.44	14.76	15.12	15.44	15.80	16.13	16.49	16.81	17.14	17.46	17.78	18.07
	B	0.00	1.02	1.84	2.71	3.61	4.55	5.53	6.54	7.60	8.68	9.80	10.95	12.11	13.34
Monel (66Ni-29Cu-Al)	A	12.82	13.46	13.82	14.22	14.56	14.94	15.30	15.66	16.02	16.38	16.74	17.10	17.46	17.80
	B	0.00	0.97	1.77	2.61	3.45	4.40	5.36	6.35	7.38	8.46	9.58	10.83	11.93	13.15

HEALTH TIPS - CUCUMBER HEALTH BENEFITS



1. Cucumbers contain most of the vitamins you need every day, just one cucumber contains Vitamin B1, Vitamin B2, Vitamin B3, Vitamin B5, Vitamin B6, Folic Acid, Vitamin C, Calcium, Iron, Magnesium, Phosphorus, Potassium and Zinc.

2. Feeling tired in the afternoon, put down the caffeinated soda and pick up a cucumber. Cucumbers are a good source of B Vitamins and Carbohydrates that can provide that quick pick-me-up that can last for hours.

3. Tired of your bathroom mirror fogging up after a shower? Try rubbing a cucumber slice along the mirror, it will eliminate the fog and provide a soothing, spa- like fragrance.

4. Are grubs and slugs ruining your planting beds? Place a few slices in a small pie tin and your garden will be free of pests all season long. The chemicals in the cucumber react with the aluminum to give off a scent undetectable to humans but drive garden pests crazy and make them flee the area.

5. Looking for a fast and easy way to remove cellulite before going out or to the pool? Try rubbing a slice or two of cucumbers along your problem area for a few minutes, the phytochemicals in the cucumber cause the collagen in your skin to tighten, firming up the outer layer and reducing the visibility of cellulite. Works great on wrinkles, too!

6. Want to avoid a hangover or terrible headache? Eat a few cucumber slices before going to bed and wake up refreshed and headache free. Cucumbers contain enough sugar, B vitamins and electrolytes to replenish essential nutrients the body lost, keeping everything in equilibrium, avoiding both a hangover and headache!

7. Looking to fight off that afternoon or evening snacking binge? Cucumbers have been used for centuries and often used by European trappers, traders and explores for quick meals to thwart off starvation.

8.. Have an important meeting or job interview and you realize that you don't have enough time to polish your shoes? Rub a freshly cut cucumber over the shoe, its chemicals will provide a quick and durable shine that not only looks great but also repels water.

9. Out of WD 40 and need to fix a squeaky hinge? Take a cucumber slice and rub it along the problematic hinge, and voila, the squeak is gone!

10. Stressed out and don't have time for massage, facial or visit to the spa? Cut up an entire cucumber and place it in a boiling pot of water, the chemicals and nutrients from the cucumber will react with the boiling

water and be released in the steam, creating a soothing, relaxing aroma that has been shown to reduce stress in new mothers and college students during final exams.

11. Just finish a business lunch and realize you don't have gum or mints? Take a slice of cucumber and press it to the roof of your mouth with your tongue for 30 seconds to eliminate bad breath, the phytochemcials will kill the bacteria in your mouth responsible for causing bad breath.

12. Looking for a 'green' way to clean your faucets, sinks or stainless steel? Take a slice of cucumber and rub it on the surface you want to clean, not only will it remove years of tarnish and bring back the shine, but is won't leave streaks and won't harm you fingers or fingernails while you clean.

13. Using a pen and made a mistake? Take the outside of the cucumber and slowly use it to erase the pen writing, also works great on crayons and markers that the kids have used to decorate the walls!