COMPACT SPRING SUPPORT WEBINAR

Presented by DST
Hosted by PT&P

www.springsupportsolutions.com
Klaus was born and raised in Lingen, Germany. After receiving his Masters in Chemical Engineering in 1977 from the Wilhelms University in Münster, Germany, his first job assignment brought him to the U.S., where he resided in Richland, Washington, for the past 36 years.

Besides the DST – Quality functions, Klaus is the Owner & President of Redmann Quality Engineering Services, Inc. Primary focus of the RQES - Consulting Business is the performance of Fuel Fabrication & Inspection Surveillances during the fabrication of entire commercial Nuclear Fuel - Reload Campaigns. As a Consultant to the U.S. - Nuclear Utilities, RQES assures the product compliance to the Utility / NRC – Nuclear Fuel Design and Licensing requirements. By review of the applied fabrication and inspection processes, RQES verifies the adherence to all Fuel Fabricator and Utility - Technical Specifications and Drawing requirements for the final acceptance of the nuclear fuel.

In addition, as an ASQC - Certified Quality Engineer and ANSI 45.2.23 / ISO certified Lead Auditor, Klaus performs both national, as well as international Quality Systems and NUPIC Audits.
<table>
<thead>
<tr>
<th>Webinar Criteria</th>
<th>Presenter</th>
<th>Slide #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Klaus P. Redmann</td>
<td>1-9</td>
</tr>
<tr>
<td>Leading Industry Problems creating the Basis for DST Formation</td>
<td>Kirk V. Leonardi</td>
<td>10-20</td>
</tr>
<tr>
<td>Industry Standards &amp; Regulatory Codes</td>
<td>Bart V. Makadia</td>
<td>21-30</td>
</tr>
<tr>
<td>Catastrophic Failures &amp; DST Solutions, Tools &amp; Catalog</td>
<td>James O. Taylor</td>
<td>31-47</td>
</tr>
<tr>
<td>Pipe Stress Analysis Examples - Load Reductions through the use of DST Support Systems</td>
<td>Kirk V. Leonardi</td>
<td>48-59</td>
</tr>
</tbody>
</table>
• Introduction of DST patented compact Spring Support Systems to be marketed, build and sold by PTP.

• Discussions to show the benefits by the use of the DST – Spring Support Systems in the following areas:
  1. Piping Design & Regulatory Code Compliance
  2. Plant Operation; Reduced Maintenance & Operating Cost
  3. Process & Plant Safety Issues
  4. Corrosion & Environmental Issues
  5. CAESAR Analysis Comparison
Founded in Richland, Washington

2006

Granted US Patent

2011

Quoting & Manufacturing Disc Spring

2014

Applied for US Patent

2007

Entered License Agreement with Piping Technology & Products

2014

PT&P / DST

pipingtech.com / springsupportsolutions.com

The purpose of today’s Webinar is to introduce the compact spring support and present solutions to the following common process issues:

- Preventive Equipment Failures
- Assurance of safer Plant Operations
- Reduction in Operational Cost

Effective preventive maintenance and elimination of unscheduled System Shut-downs are the key to essential plant safety and reduction in catastrophic accidents.

Sources: www.pinnacleequipments.com/oil-gas-refineries.html
Key Objectives of DST Support System

- Promotion of safety and reliability
- Prevention of unscheduled plant shutdowns
- Loss of production
- Minimizing facility and equipment damages
- Eliminate regulatory fines and damaging public reputation
- Most significantly, loss of human life
Conventional Helical Coil Support

DST – Disc Spring Support

Equal Loads While Consuming

50% Less Space
Kirk V. Leonardi
Disc Spring Technology, LLC
Director of Design & Research

HOME TOWN:
New Orleans, La. USA
Currently living in Houston, Tx – Since 2012

PROFESSION:
Pipe Stress Engineer

EDUCATION
Bachelor of Science Degree in Industrial Technology
South Eastern Louisiana University, Hammond, Louisiana (Dec.1972)

CAREER
Piping Stress Analyst Ford Bacon and Davis (5/96-4/01) Baton Rouge, La.

PIPE STRESS PROGRAMS
Simplex, Triflex, Pengan, Caesar II
3501 Exxon Pipe Stress Analysis Program
ME101 Bechtel Pipe Stress Analysis Program
“Necessity is the Mother of Invention”

Necessity was the Reduction in Equipment Nozzle Loads

Background
• As pipe stress analyst, vessel experts and designers, we realize the importance of meeting code standards on process equipment nozzles.

Current Practices
• Meeting code allowable stresses and nozzle loading can eat into an engineering budget very quickly.
• Redesigning piping with loops or shifting the pipe mass away from process equipment nozzles is a costly and time consuming.
Misalignment
- Thermal Expansion
- Pipe Lift-off
- Poor Engineering Practices and Design Errors

The end result is strain on the equipment.

Figure Shows Sources of Pipe Strain

• 70 percent of all pump failures are attributed to some form of misalignment.

• The cause of more than 80 percent of chronic failures involved pipe strain.

Sources: (left) www.drakemech.com and (right) solumeca.jimdo.com/p5
• “Misalignment problems caused by expansion (or contraction) in a poorly designed system can result in major equipment failure.”

• “Seal failure is the most common reason for shutting down a pump.”

• “90% of mechanical seals are failing prematurely.”

• “Pipe strain can cause "failure" of the packing or mechanical seal.”

• Piping must be designed and installed such that there is essentially zero forces and moments applied to the machinery nozzles when the system is not operating.

• Springs are needed in these cases in order for the supports to be effective when the system is operating.

According to L.C. Peng, a leading authority in piping engineering:

“The load and stress imposed from a connecting piping system can greatly affect the reliability of equipment. These loads, either from expansion of a pipe or from other sources, can cause shaft misalignment, as well as shell deformation, interfering with the internal moving parts. Therefore, it is important to design the piping system to impose as little stress as possible on the equipment. Ideally, it is preferred to have no piping stress imposed on equipment.”

• The sustained weight stress from piping lifts off should be calculated considering the support as inactive.

• “The piping is still not in compliance with the piping code, which requires that the sustained stress be within the allowable all the time, not just some of the time.”

• “It is found that the majority of the accidents were caused by technical and engineering failures.”

• “Based on the accident reports, the basis of the equipment failure and the root cause of the accidents are related to design error, which only appeared after an accident.”

• “Almost half of accidents occur during normal operations and are directly related to the design error.”

Depending upon the severity of misalignment, increases in power costs between 2% and 9% may be seen.

“A 9% impact is worth $692 per year. These costs affect the bottom line and can be quite significant in a typical process plant with hundreds, if not thousands, of pumps.”

Sources: (left) www.pipedesign.com and (middle) www.totalpumps.co.nz and (right) www.worldpumps.com
Average cost of a pump repair = $15,000
A typical refinery has 2,000 operating pumps
Pump replacements = twice a year
Refineries spend avg. of $15 million a year on pump repair.

PROFESSIONAL AFFILIATIONS:
P. E. (California/Oregon/Washington); Served on ASME B31.3 committee - Oregon

EDUCATION / COMPUTER PROGRAMS
California State Polytechnic University, B. S. M. E., 1972
COMPRESS, CODECALC, APV, NozzlePro, CAESAR II, TRIFLEX, and SIMFLEX

EXPERIENCE
Highly experienced in the areas of process piping, pressure vessels, heat exchangers and API process tank design used for Interstate Gas Pipelines, Refineries, Chemical & Power Plants, Pulp and Paper Mills Semiconductor and Nuclear Industry in accordance with the ASME, ANSI, API, TEMA, AISC, UBC, DOT, OSHA and CFR codes and standards.

Areas of experience in diverse process industry include: Vessels, Heat Exchangers, and API Tank design and analysis; Codes Calculation, Fabrication, Welding, Inspection, Testing and Repairing background; Stress analysis of process piping and pipe support design; Local Stress analysis of Nozzles per WRC 107, 297 and Nozzle Pro; Preparation of technical specifications and detail drawings for bid inquiry; Seismic analysis, Anchor bolt, Anchor chair and Base plate design; Tank assessment, re-building & mechanical integrity certification per PSM, EPA & local codes; Design and fabrication of FRP and dual laminates tanks.
ASME Sec. VIII, Division 1 requirements for nozzle loads from piping:

- Paragraph UG-22(c) & UG-45
- Problem areas that may cause overstressed conditions - code violations
- Nozzle loads (no reinf. or hi loads)
- Geometry / flexibility / rigid piping
- Modular design or off-the-shelf vessels
- Exceeds flange rating (ASME B 16.5)
- Not properly designed or installed
- Support(s) not active - all cases (lift off)
- Not enough space for supports
- Vendor’s allowable too low
- Coordination with other group / vendors
- Poor maintenance
- PSM / OSHA Inspection – Integrity Check
ASME B31.1 Code Requires Piping Layout, Piping Design and selection of Supports Prevent the Following:

1. Piping stresses in excess of those permitted in the code.
2. Leakage at the flange joints.
3. Excessive thrust and moments on connected equipment (such as pumps / turbine).
4. Excessive stresses in the supporting (or restraining) elements.
5. Resonance with imposed fluid induced vibrations.
6. Excessive interference with thermal expansion and contraction in a piping system, which is otherwise adequately flexible.
7. Unintentional disengagement of piping from its supports.
8. Excessive piping sag in systems requiring drainage slope.
9. Excessive heat flow, exposing supporting elements to temperature extremes outside their design limits.
<table>
<thead>
<tr>
<th>Codes</th>
<th>Code Name</th>
<th>Used for Designing:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASME B 31.1</td>
<td>Power Piping</td>
<td>Piping Sys. in Power Gen. Station</td>
</tr>
<tr>
<td>ASME B 31.3</td>
<td>Process Piping</td>
<td>Piping Sys. in Refineries, Chemicals, Textiles &amp; Paper Mills</td>
</tr>
<tr>
<td>ASME B 31.8</td>
<td>Gas Transportation &amp; Distribution</td>
<td>Piping Sys. for Gas Transportation &amp; Distribution</td>
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<tr>
<td>ASME Boiler &amp; PV Code Sec. VIII, Division 1</td>
<td>Rules for Construction of P.V.</td>
<td>Unfired Pressure Vessel Design</td>
</tr>
<tr>
<td>ASME Boiler &amp; PV Code Sec. VIII, Division 2</td>
<td>Alternative Rules for Construct. of P.V.</td>
<td>Unfired Pressure Vessel Design</td>
</tr>
<tr>
<td>ASME Sec. I</td>
<td>Rules for Construction of P.B.</td>
<td>Power Boiler Design</td>
</tr>
<tr>
<td>Equipment</td>
<td>Industry Standard</td>
<td>Parameters Used for Acceptable Loads</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Centrifugal Pumps</td>
<td>API 610</td>
<td>Nozzle Size</td>
</tr>
<tr>
<td>Centrifugal Compressor</td>
<td>API 617, 1.85 Times NEMA SM-23 Allowable</td>
<td>Nozzle Size Material</td>
</tr>
<tr>
<td>Air-Cooled Ht. Exch.</td>
<td>API 661</td>
<td>Nozzle Size</td>
</tr>
<tr>
<td>Tank Nozzles</td>
<td>API 650</td>
<td>Nozzle Size, Thk. Re-pad, Vessel/Ht Exch. Diameter, Nozzle Elevation</td>
</tr>
<tr>
<td>Steam Turbines</td>
<td>NEMA SM-23</td>
<td>Nozzle Size</td>
</tr>
</tbody>
</table>
Fixed Saddles
Restrain the Nozzle Growth

Close Coupled Nozzles Want to Expand

Note: TEMA does not provide any guidance on how to relieve the Thermal Growth in Nozzles
Stacked Example: Negative Affects of Thermal Expansion in Close Coupled Nozzles
HOME TOWN:
Silver Spring, MD USA – July 1968 – July 2002
Currently, I live in Pasco, WA – Since 2002

PROFESSION:
Mechanical Designer/Support Engineer/Pipe Designer

EDUCATION
Bachelor of Science Degree in Mechanical Engineering Technology
Old Dominion University, Norfolk, Virginia (May 1997)
(Design Elements for Manufacturing)

CAREER
Mechanical Design Engineer - Howmet (Casting) Corporation,
Hampton, Virginia - Responsible for design of large scale part fixtures
for casting and machining.
Mechanical Designer/Support Engineer/Design Engineer - Bechtel
Power Corporation, Frederick, Maryland – Pipe Systems Designer
Bechtel National, Incorporated, Richland, Washington – Responsible
for nuclear piping systems, support qualification and engineering of
large scale support structures.
Often, catastrophic accidents are caused by overloaded or overstressed conditions imposed on critical process equipment and poor maintenance practices.
Catastrophic Failure of Critical Process Equipment include:

- Pumps
- Heat Exchangers
- Steam Lines / Pressure Vessels / Boilers
- Compressors
- Turbines
- Engineers are required to meet vendor requirements and regulatory codes such as API, ASME, UBC, etc.
- Operating companies are forced to meet government agency compliance such as OSHA, EPA, WISHA, etc.

Source: www.sublimedescaler.com
• DST Compact Spring Supports are specifically designed to minimize excessive loads on process equipment.

• Its compact design allows the spring to be installed under equipment nozzles or directly under the equipment.
• DST Spring Supports are designed to consuming 50% less space but support the same loads as helical coil spring.

• These attributes make them ideal for locating the spring support under equipment flanges.

• This helps meet code and equipment allowable limits and saves stress analysis time.
• Support is maintained throughout the pipe’s thermal range.

• Its compact design allows for retrofit into confine spaces.

• Lift-off loads are not transmitted to the equipment.
Advantages: Load Sensitive Equipment

- Flange loads are reduced substantially during startup and cyclic operation.
- Thermal growth is controlled reducing stress, fatigue & maintenance on the pump nozzle.
- Misalignment is minimized.
- Lift-off loads are not transmitted to the equipment.
- A proper seal at the flange can be maintained.
Advantages: Plate & Frame Heat Exchangers

- Reduced nozzle load reactions helping to meet ASME code nozzle allowable loads.
- Fatigue & maintenance are minimized.
- Added flexibility to the piping system reducing the overall load at the exchanger’s nozzles.
- Thermal growth is controlled maintaining a proper seal at the flange.
• Substantially reduces thermal loads on the close coupled inter-connecting nozzles.

• Assures the correct flange bolt torque is maintained throughout the exchanger’s thermal cycle.

• Proper flange seal is maintained mitigating maintenance and lengthening the life of the unit.
DST SPRINGS BETWEEN THE SADDLES ALLOWS MOVEMENTS which reduce nozzle loads and local stress plus helps maintain the flange seal.

TREMENDOUS STRESSES RELIEVED

EXCHANGER SADDLES
Vessel Nozzle Advantages

- No added space is needed to support pipes above the vessel.
- The adjoining pipes move upward with the vessel’s thermal growth.
- Lift-off loads are not transmitted to the vessel nozzles.
- A proper seal at the vessel flange can be maintained.
Corrosion due to salt air, chemical spills or VOC’s affect conventional carbon steel spring support’s function rendering them ineffective and deteriorating them from the inside out.
• DST offers springs in carbon and stainless steel alloys.
• The entire spring support (spring and housing) can be made from stainless steel or other suitable alloys.
• They are ideal to combat aggressive corrosive environments like saltwater, marine air or corrosive chemicals.
• If needed, DST Spring Supports can also be offered with an amorphous glass coating making the springs virtually impervious to corrosion.
Spring Corrosion: DST Support Replacement

Helical Spring Support with Aggressive Chemical Aging

Stainless Steel - DST Spring Support with Amorphous Glass Coating
TEST RESULTS FOR STAINLESS STEEL DISC SPRINGS:

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Description</th>
<th>Load vs. Displacement</th>
<th>Max Load</th>
<th>Max Displacement</th>
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</thead>
<tbody>
<tr>
<td>SS SPRINGS</td>
<td>Disc Spring XY Test 5K.1</td>
<td>Load vs. Displacement</td>
<td>173 Lb</td>
<td>0.501 in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS SPRINGS</td>
<td>Disc Spring XY Test 5K.2</td>
<td>Load vs. Displacement</td>
<td>171 Lb</td>
<td>0.504 in.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS SPRINGS</td>
<td>Disc Spring XY Test 5K.3</td>
<td>Load vs. Displacement</td>
<td>175 Lb</td>
<td>0.508 in.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS SPRINGS</td>
<td>Disc Spring XY Test 5K.4</td>
<td>Load vs. Displacement</td>
<td>172 Lb</td>
<td>0.503 in.</td>
</tr>
</tbody>
</table>

Disc Spring Servo Hydraulic Test Setup
The DST Selection Program is based on the DST Selection Table (found in DST Catalog).

Enter the following data:
• Deflection (either + or -),
• Operating load
• Spring support type

The program returns the following data:
• Shortest spring support size
• Figure number
• Variability
• Spring rate
• Installed load
• Overall installed height
- DST website
- DST Catalog (Over 1100 Types & Sizes)
- Carbon & Stainless Steel Selection Charts and Disc Spring Information

<table>
<thead>
<tr>
<th>Item</th>
<th>O.D.</th>
<th>C</th>
<th>B</th>
<th>D</th>
<th>E</th>
<th>Load (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
<td>0.75</td>
<td>1</td>
<td>5</td>
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<tr>
<td>200</td>
<td>1.5</td>
<td>2.5</td>
<td>0.75</td>
<td>1.125</td>
<td>2.5</td>
<td>10</td>
</tr>
<tr>
<td>300</td>
<td>2</td>
<td>3</td>
<td>0.75</td>
<td>1.25</td>
<td>3</td>
<td>15</td>
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</table>

*Figure 125 C5 Type F*
Piping Stress Analysis

Example Application
This Compressor Analysis can be Directly Compared to Pumps

@ Pump Flange

Fy = 933 Lbs.
Fy = 408 Lbs.
Mx = 2531 Ft. Lbs.
Mx = 2297 Ft. Lbs.
Compressor Station Analysis with 1 Spring at the Adjacent Elbow
As seen below, the Allowable Load is relatively low and difficult to meet. The Resultant force is the total force as seen by the compressor nozzle. Comparing the Resultant Force against the Compressor Nozzle Allowable Load, the ratio <= 1.0 indicates a load greater than the governing code allowable.

<table>
<thead>
<tr>
<th>Nozzle</th>
<th>D (in)</th>
<th>ineq</th>
<th>Area (in²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet</td>
<td>28.00</td>
<td>15.33</td>
<td>615.75</td>
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<tr>
<td>Exhaust</td>
<td>20.00</td>
<td>12.67</td>
<td>314.16</td>
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</tbody>
</table>

### COMPRESSORS WITHOUT EXTRA SPRING

<table>
<thead>
<tr>
<th>Node</th>
<th>D (in)</th>
<th>Fx</th>
<th>Fy</th>
<th>Fz</th>
<th>Mx</th>
<th>My</th>
<th>Mz</th>
<th>F (lbs)</th>
<th>M (ft-lbs)</th>
<th>F+1.09Mc</th>
<th>RESULTANT FORCE</th>
<th>ALLOWABLE LOAD</th>
<th>FORCE/ALLOWABLE RATIO w/ SPRING @ ELBOW</th>
<th>RATIO &gt; 1.0, NOT GOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet Case 4 OPE</td>
<td>10</td>
<td>12.67</td>
<td>81</td>
<td>-861</td>
<td>9</td>
<td>60.7</td>
<td>34.7</td>
<td>373</td>
<td>865</td>
<td>379</td>
<td>1,278</td>
<td>684</td>
<td>1.87</td>
<td>N.G.</td>
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<tr>
<td>Outlet Case 11 OCC</td>
<td>10</td>
<td>12.67</td>
<td>44</td>
<td>-861</td>
<td>11</td>
<td>68.9</td>
<td>39.8</td>
<td>404</td>
<td>865</td>
<td>411</td>
<td>1,311</td>
<td>684</td>
<td>1.92</td>
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<tr>
<td>Outlet Case 12 OCC</td>
<td>10</td>
<td>12.67</td>
<td>82</td>
<td>-865</td>
<td>39</td>
<td>56.3</td>
<td>98.6</td>
<td>400</td>
<td>870</td>
<td>416</td>
<td>1,323</td>
<td>684</td>
<td>1.93</td>
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<tr>
<td>Outlet Case 5 OPE</td>
<td>560</td>
<td>12.67</td>
<td>107</td>
<td>-855</td>
<td>13</td>
<td>83.7</td>
<td>46.4</td>
<td>41.5</td>
<td>862</td>
<td>104</td>
<td>975</td>
<td>684</td>
<td>1.43</td>
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<tr>
<td>Outlet Case 18 OCC</td>
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<td>-855</td>
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<td>75</td>
<td>41.1</td>
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<td>867</td>
<td>87</td>
<td>962</td>
<td>684</td>
<td>1.41</td>
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<tr>
<td>Outlet Case 19 OCC</td>
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<td>71</td>
<td>-856</td>
<td>14</td>
<td>92.3</td>
<td>51.5</td>
<td>79.4</td>
<td>859</td>
<td>132</td>
<td>1,003</td>
<td>684</td>
<td>1.47</td>
<td>N.G.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Node</th>
<th>D (in)</th>
<th>Fx</th>
<th>Fy</th>
<th>Fz</th>
<th>Mx</th>
<th>My</th>
<th>Mz</th>
<th>F (lbs)</th>
<th>M (ft-lbs)</th>
<th>F+1.09Mc</th>
<th>RESULTANT FORCE</th>
<th>ALLOWABLE LOAD</th>
<th>FORCE/ALLOWABLE RATIO w/ SPRING @ ELBOW</th>
<th>RATIO &gt; 1.0, NOT GOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet Case 11 OCC</td>
<td>1110</td>
<td>12.67</td>
<td>75</td>
<td>-859</td>
<td>16</td>
<td>100</td>
<td>56.5</td>
<td>89.1</td>
<td>862</td>
<td>145</td>
<td>1,021</td>
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<td>Outlet Case 12 OCC</td>
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<td>12.67</td>
<td>110</td>
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<td>43</td>
<td>81.5</td>
<td>111</td>
<td>96.6</td>
<td>872</td>
<td>168</td>
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<td>979</td>
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</table>
Compressor Station with Added Spring at the Compressor Elbow

<table>
<thead>
<tr>
<th>NO</th>
<th>FIG</th>
<th>VERTICAL MOVEMENT</th>
<th>HOT INSTALLED LOAD</th>
<th>SPRING RATE</th>
<th>HORIZONTAL LOAD</th>
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<tr>
<td>85</td>
<td>PTP-1</td>
<td>90</td>
<td>0.052</td>
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<td>635</td>
<td>PTP-1</td>
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<td>0.066</td>
<td>1168</td>
<td>1210</td>
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<td>0.206</td>
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</table>
Comparing the Resultant Force/Allowable load ratios before and after adding the spring support at the compressor nozzle, the ratio with the spring support added at the nozzle is less than 1 (meeting the code allowable).

The drop in load case ratios are as great as 84% - a substantial drop in load!

Once the load is below the code or manufacturer’s allowable load, nozzle stresses remain low and flange seals maintain their shape.

<table>
<thead>
<tr>
<th>NOZZLE</th>
<th>D (in)</th>
<th>D equiv (in)</th>
<th>Area (in²)</th>
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</thead>
<tbody>
<tr>
<td>Inlet</td>
<td>28.00</td>
<td>15.33</td>
<td>615.75</td>
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<tr>
<td>Exhaust</td>
<td>20.00</td>
<td>12.67</td>
<td>314.16</td>
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</table>

<table>
<thead>
<tr>
<th>COMPRESSORS WITH EXTRA SPRING</th>
<th>RESULTANT FORCE</th>
<th>ALLOWABLE LOAD</th>
<th>FORCE/ALLOWABLE RATIO@SPRING @ ELBOW</th>
<th>FORCE/ALLOWABLE RATIO@SPRING @ ELBOW &amp; NOZZLE</th>
<th>RATIO &lt;= 1.0, OK</th>
<th>% DROP IN RATIO</th>
</tr>
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<tbody>
<tr>
<td>Outlet Case 4 OPE</td>
<td>10</td>
<td>12.67</td>
<td>81</td>
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<td>246</td>
<td>684</td>
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<td>12.67</td>
<td>44</td>
<td>101</td>
<td>241</td>
<td>684</td>
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<td>97</td>
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<td>108</td>
<td>103</td>
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<td>12.67</td>
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<td>684</td>
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</table>
Stacked Heat Exchanger without Spring at Saddles
Stacked Heat Exchanger without Spring at Saddles
• The operating load case tells the story. In both the vertical loading and moments, the thermal loading has decreased substantially.

• The reduced loading on the interconnecting nozzles allows the nozzle gaskets to keep their shape and the potential for leaks is avoided.

### Heat Exchanger Comparison with / without Spring Support

#### EXCHANGER WITHOUT SPRINGS

<table>
<thead>
<tr>
<th>NODE</th>
<th>LOAD CASE</th>
<th>Fx (lb.)</th>
<th>Fy (lb.)</th>
<th>Fz (lb.)</th>
<th>Mx (ft-lb.)</th>
<th>My (ft-lb.)</th>
<th>My (ft-lb.)</th>
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#### EXCHANGER WITH SPRINGS SUPPORTS ADDED @ SADDLES

<table>
<thead>
<tr>
<th>NODE</th>
<th>LOAD CASE</th>
<th>Fx (lb.)</th>
<th>Fy (lb.)</th>
<th>Fz (lb.)</th>
<th>Mx (ft-lb.)</th>
<th>My (ft-lb.)</th>
<th>My (ft-lb.)</th>
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<td>20.5</td>
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</table>
Heat Exchanger

SPRING SUPPORT (4 LOCATIONS)
Compact Spring Support

- Reduces excessive loads at process equipment nozzles
- Corrosion Resistant
- Over 1100 standard models
- Even more compact models engineered on request
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PT&P Contacts:
info.pipingtech.com/contact-piping-technology/

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