The CARMAGEN ENGINEERING INC. Report©

Partnering in Engineering Excellence™

OCTOBER 2004

1 How Much Cash is Going Up in Smoke?

2 Common Causes of Flange Leakage

3 Common Causes of Piping Vibration

In the Next Issue:

- ***Hot Bolting***
- ***Screening Piping Vibration Problems***

The Carmagen Engineering Report© is published periodically by our staff and presents information and viewpoints on engineering topics relevant to the hydrocarbon processing industry. While the contents of The Carmagen Engineering Report© have been carefully reviewed, Carmagen Engineering, Inc. does not warrant it to be free of errors or omissions. Some back issues are available and may be requested while supplies last.

***Editor** ……………………..Lori Carucci*
***Writers** …….Carmagen Engineering Staff*

We welcome your comments and suggestions for future editions. Please send them to bmesa@carmagen.com.

How Much Cash Is Going Up in Smoke?

By Arthur R. Tenner

Many refineries boast about their energy conservation or efficiency improvement programs they have had in place for decades. With recent increases in energy costs, however, most have further room for improvement. Opportunities are likely to be abundant, particularly in areas often neglected.

STEAM SYSTEM OPERATION

One refinery designed for energy efficiency in the 1970s uses high pressure steam to power turbines that exhaust to a medium pressure header for process heating. The cold eyes perspective of an energy specialist showed refinery management how changes in run plans and operating conditions had resulted in steam system imbalances. Some medium pressure steam was being produced from a high pressure header let down station. Further, the low pressure header was balanced by a partially open let down station from the medium pressure header. Most alarming, low pressure steam was venting to the atmosphere. Not only was the refinery essentially venting high pressure steam, it was also losing highly valued polished water. Once identified, the problem was easily solved within hours and at no cost.

This refiner also misstated the marginal economics among his three steam systems. Although projects and operating plans were based on precise four-digit costs for each utility system, use of accounting data masked true economics. With a let down station open between high and medium pressure headers, what is the difference in marginal value for a pound of steam from each header? The answer is zero, and favoring the use of medium pressure steam has no incremental value over high pressure steam as long as the valve remains open.

STEAM TRAP MAINTENANCE

Poorly maintained steam traps represent another common area of opportunity. When asked about his program, one refiner reported that he had successfully engaged a trap vendor in a survey three years ago. A brief inspection of current operations, however, revealed incentives worth more than \$1M/year to reinstate an ongoing maintenance program.

Continued on Page 4

Corporate Office: 4 West Main Street, Rockaway, NJ 07866 • Telephone: (973) 627-4455 • Fax: (973) 627-3133
Gulf Coast Division: PO Box 77910, Baton Rouge, LA 70879 • Telephone: (225) 752-0909 • Fax: (225) 752-0906
E-mail: carmagen@carmagen.com • Web Site: http://www.carmagen.com

Common Causes of Flange Leakage

By Vincent A. Carucci

A previous article highlighted the primary causes of flange leakage. This article provides more information about these.

- Uneven Bolt Stress. An incorrect boltup procedure or cramped working conditions near the flange can leave some bolts loose while others are overtightened and crush the gasket. This can cause in-service leaks, especially in high temperature services when the heavily loaded bolts relax.

- Improper Flange Alignment. Improper flange alignment, especially flange face parallelism, causes uneven gasket compression, local crushing, and can cause subsequent leakage. Improper flange centerline alignment can also cause uneven gasket compression and flange leaks.

- Improper Gasket Centering. If a gasket is installed off center compared to the flange faces, the gasket will be unevenly compressed and make the joint prone to leakage. Spiral wound and double jacketed gaskets usually have a centering ring that extends to the inner edge of the bolts. A sheet gasket can be cut so that its outside diameter matches the inner edge of the bolts.

- Dirty or Damaged Flange Faces. Dirt, scale, scratches, protrusions, weld spatter on gasket seating surfaces, and warped seating surfaces provide leakage paths or can cause uneven gasket compression that can result in flange leakage.

- Excessive Piping System Loads at Flange Locations. Excessive forces and bending moments can loosen the bolting or distort the flanges and lead to leaks. Common causes are inadequate piping flexibility, using cold spring to align flanges, and improper location of supports or restraints.

- Thermal Shock. Rapid temperature fluctuations can cause flanges to deform temporarily. This is typically a greater potential problem in high temperature applications. Process variations cannot always be avoided. A related problem is temperature variation around the flange circumference (e.g., cooling on top due to rain, or cool liquid at the bottom and hot gas at the top). Where this is a problem, sheet metal shields can be installed to protect against rain or snow impingement that could cause thermal gradients across the flange and cause leakage. Such shields also serve to keep the flanges and bolts at a more uniform temperature.

- Improper Gasket Size or Material. Sometimes, the wrong gasket size or material is installed. The wrong size should be fairly obvious during installation, and something that a trained boltup crew will immediately identify. The wrong material may not be apparent until corrosion or blowout damages the gasket.

- Improper Flange Facing. Deeper serrations than specified will prevent the seating of double jacketed or spiral wound gaskets and provide a leakage path. Normal raised face flange finishes have grooves that are 0.002 to 0.005 in. (0.05 to 0.13 mm) deep.

- High Vibration Levels. Excessive vibration can loosen flange bolts and ultimately cause flange leakage.

Common Causes of Piping Vibration

By Vincent A. Carucci

This article briefly discusses the most common causes of Piping System Vibration.

ACOUSTICALLY INDUCED VIBRATION

Acoustically induced vibration is a potential problem in high capacity, gas flow, pressure reducing systems. The pressure reduction can occur at control valves, at restriction orifices, safety valves, or when sonic flow occurs at a branch connection to a header. Failures can occur in only a few hours since the higher structural and acoustical natural frequencies are excited, and the material endurance limit can be reached in a short time. Failures have occurred in steam desuperheater systems, compressor recycle letdown systems, and safety letdown systems. Severe vibration has also occurred in pipeline pressure letdown systems.

The approach to designing such a system consists of:

- Screening a system to determine if it is prone to acoustically induced vibration.
- Calculating sound power levels throughout the piping system downstream of the pressure reducer.
- Comparing the calculated sound power level to a design limit that is typically based on pipe diameter and thickness.
- Treating (i.e., modifying) the system if the sound power levels are excessive. Treatment alternatives include reducing the sound power level at the source (e.g., using a low noise control valve), improving the structural integrity of the system, or some combination of methods.

SURGE INDUCED VIBRATION

When the steady-state velocity of a fluid is suddenly altered, a pressure change occurs in the piping. The transient pressure variation is called hydraulic surge or water hammer. The pressure surge moves through the pipe at the speed of sound. Potential consequences are excessive internal pressure, pipe collapse, flange leaks, and large pipe movements.

Common causes of surge include:

- Rapid valve closure, especially in firewater systems and loading lines. Pressure is positive upstream and negative downstream of the valve. This is classic water hammer.
- Vapor pocket collapse. A collapsing vapor pocket causes two columns of liquid to collide with each other. A positive pressure rise occurs in both directions. Steam hammer is an example.
- Safety valve blowdown into a line full of liquid. The pressure rises as the released fluid collides with the fluid already in the line.
- Pump startup and shutdown. A pressure surge develops when the discharge valve downstream of the pump is left partially or fully open. For pump startup, surge is positive downstream and negative upstream. For pump shutdown, surge is negative downstream and positive upstream.

Continued on Page 4

Continued from Page 1: How Much Cash Is Going Up in Smoke?

STEAM TRAP MAINTENANCE (continued)

Speaking of maintenance, how effective is your program to clean fouling heat exchangers? One refinery was knowingly wasting energy by extending cleaning intervals to control its more highly visible maintenance budget. Plant management grew comfortable with this imbalance when energy costs were based on crude oil at less than $20/bbl. Incentives are now at least 50% greater to define and implement an effective exchanger cleaning program.

IMPROVE YOUR BOTTOM LINE

Energy is likely the single largest operating cost for a refinery. These are just a few typical examples of how CEI can help to improve energy efficiency in a plant. Through the application of our ***Energy Management Program*** or ***Fast-Scope***©, we can help achieve world-class performance by focusing attention on the vital few major opportunity areas based on experience.

Continued from Page 3: Common Causes of Piping Vibration

SLUG FLOW

Slug flow can cause flow-induced vibration in two-phase fluid systems. In a horizontal line, the vapor above the liquid can travel much faster than the liquid. This creates waves at the liquid surface and entrains some of the liquid into the vapor stream. At high vapor rates, slugs of liquid form across the pipe cross-section and travel at speeds that approach the vapor velocity. When this occurs, a wide range of reaction forces can occur at pipe bends, depending on the size of the slugs that are formed. Reaction forces developed at pipe bends due to slug flow can cause excessive piping vibration and movement unless the piping system is adequately restrained.

WIND INDUCED VIBRATION

Wind can cause piping vibration by vortex shedding from the pipe surface. If wind strikes at a right angle to the axis of a cylinder, aerodynamic forces due to vortex shedding occur at the following frequency that is a function of wind velocity, cylinder diameter, and Strouhal number (0.18 for cylinders in air).

These forces act on the pipe at right angles to the wind direction. Although the forces are small, the amplitude of vibration may be large if the shedding frequency is close to the natural frequency of the piping.

If a problem exists, the stiffness and the natural frequency of the piping should be increased by adding bracing, consistent with still meeting piping flexibility and associated equipment requirements. Mechanical snubbers and shock absorbers may also be used to change the stiffness and add damping to the piping system while still permitting its thermal movement.

EARTHQUAKES

Earthquakes can cause piping vibration either directly due to resonance or by the motion of pipe supports or equipment connections. Piping in areas known to experience earthquakes should be checked for forces due to earthquakes.

Highlights

- Conducted engineering training courses at various worldwide locations. Course topics have included Crane Safety, Equipment Fitness-for-Service Evaluations, Pump Technology, Applying Reliability Engineering Principles to Process Equipment Maintenance, Machinery Failure Analysis and Prevention, Pressure Vessel Design and Maintenance.
- Provided process/mechanical assistance to a client developing a novel process in Europe.
- Generated an assessment of benefits for a novel process technology being developed.
- Assisted a European client in troubleshooting a Hydrocracking unit.
- Developed a VPS internals revamp specification for a European client.
- Led or participated in multiple refining facilities HAZOP reviews in the U.S. and Australia.
- Provided amine treating troubleshooting and operational support to a U.S.-based client.
- Performed a third party technology assessment for a U.S.-based client.
- Provided process expert testimony in support of a European client engaged in a formal arbitration.
- Provided long-term process design and safety support at a U.S. Refinery.
- Assisted a U.S.-based client in technology selection evaluation for a planned Asian refinery.
- Assisted a client in conditioning a commercial LNG process technology for a Middle Eastern project.
- Continuing to provide fluid-bed technology support to a U.S.-based novel process developer.
- Supported an FCC catalyst vendor in troubleshooting a Latin American unit.
- Provided five months of on-site contract engineering consulting support to a North American client.
- Completed heavy lift reviews and conducted project management services for the repair of coke drum support foundations for several clients in the Gulf Coast Region.
- Initiated a Reliability & Maintenance Survey for a major refiner in Europe.
- Provided refractory engineering consulting support and developed an engineering standard covering refractory design and installation for refining clients in North America.
- Provided cost estimating consulting services on a new process for a Chemicals client.
- Carried out several heavy lift “cold-eyes” reviews and developed and presented training material on proper crane lift procedures for a number of clients in North America and the Far East.
- Carried out several furnace/heater reviews and developed design specifications for furnaces for several clients in Europe and the U.S.
- Carried out a structural review of the support structure and hold-down system for several LPG spheres.
- Carried out a review of the structural integrity of several storage tanks for a domestic refiner.
- Continued to support a client’s request to witness shop tests on a number of rotating equipment components for several domestic refineries.
- Conducted a review of a pipeline surge analysis for an upstream client.
- Provided consulting assistance on a power plant boiler system to reduce NO_x emissions.
- Carried out reviews of welding designs/procedures for several domestic clients.