Start-up Experiences with Operation & Maintenance of Motor Operated Valves in a Delayed Coker

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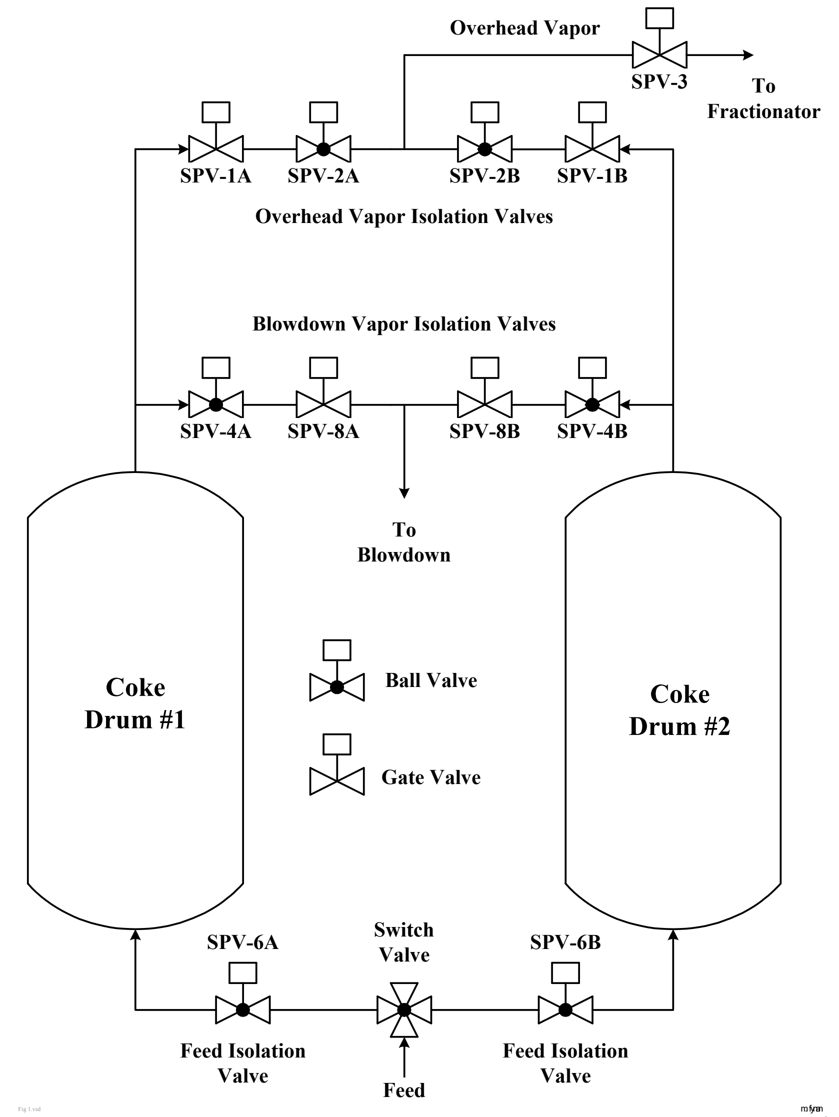
Outline

- Introduction
- Ball Valve Actuator Fires
- Overhead Vapor Valve
- Switch Valve
- Gate Valve
- Summary
- Conclusion
- Acknowledgements

Figure #1: Delayed Coker Overview



Ball Valve Actuator Fires

Figure #2: Typical Ball Valve Cross-Section

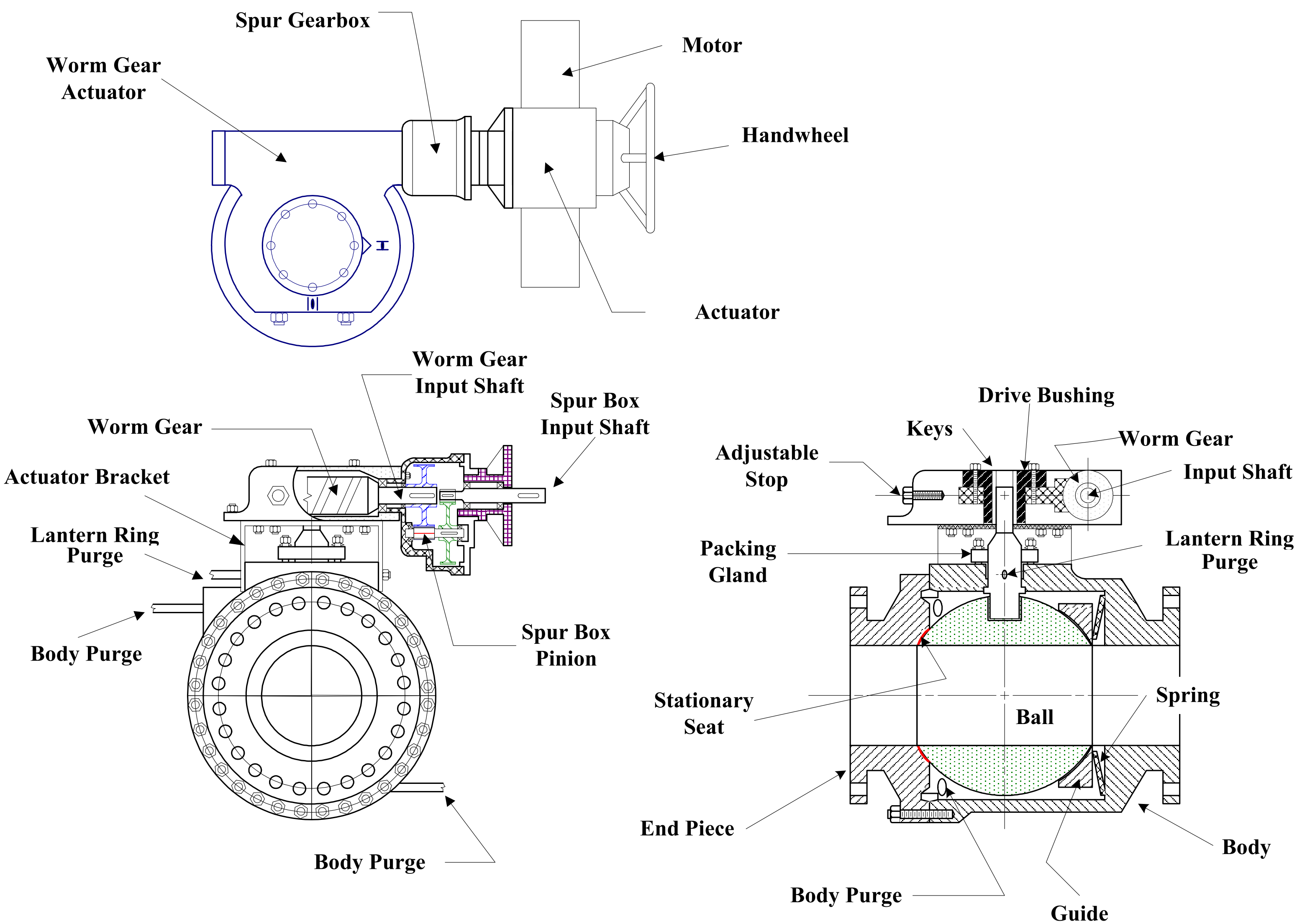


Fig 2.vsd

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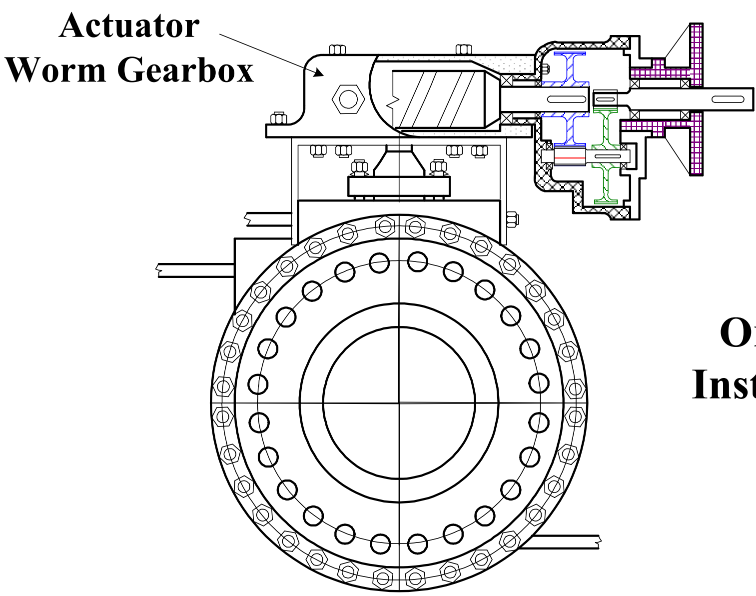
Figure #3A: Original Actuator Mounting



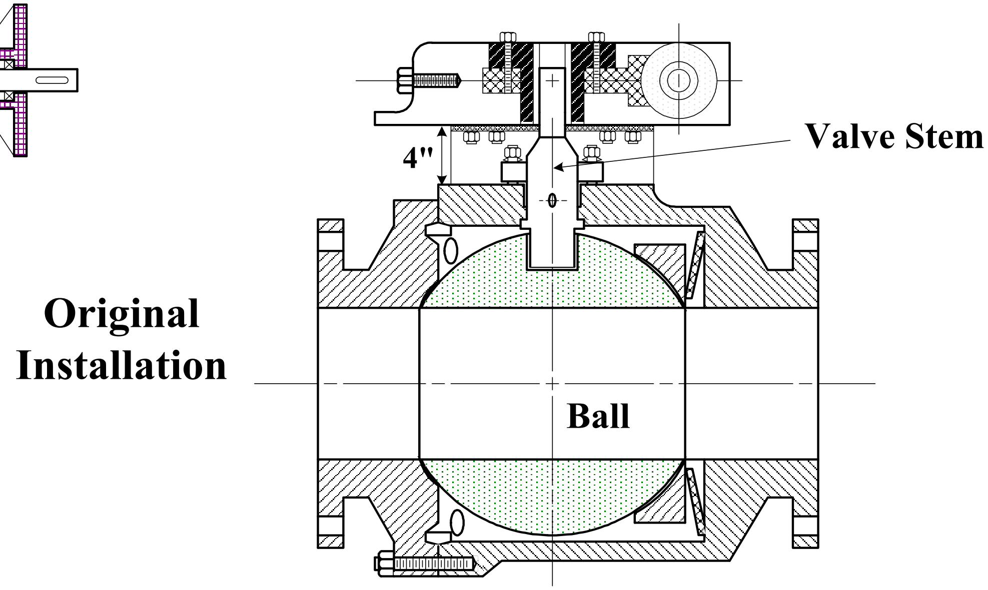


Figure #3B: Revised Actuator Mounting

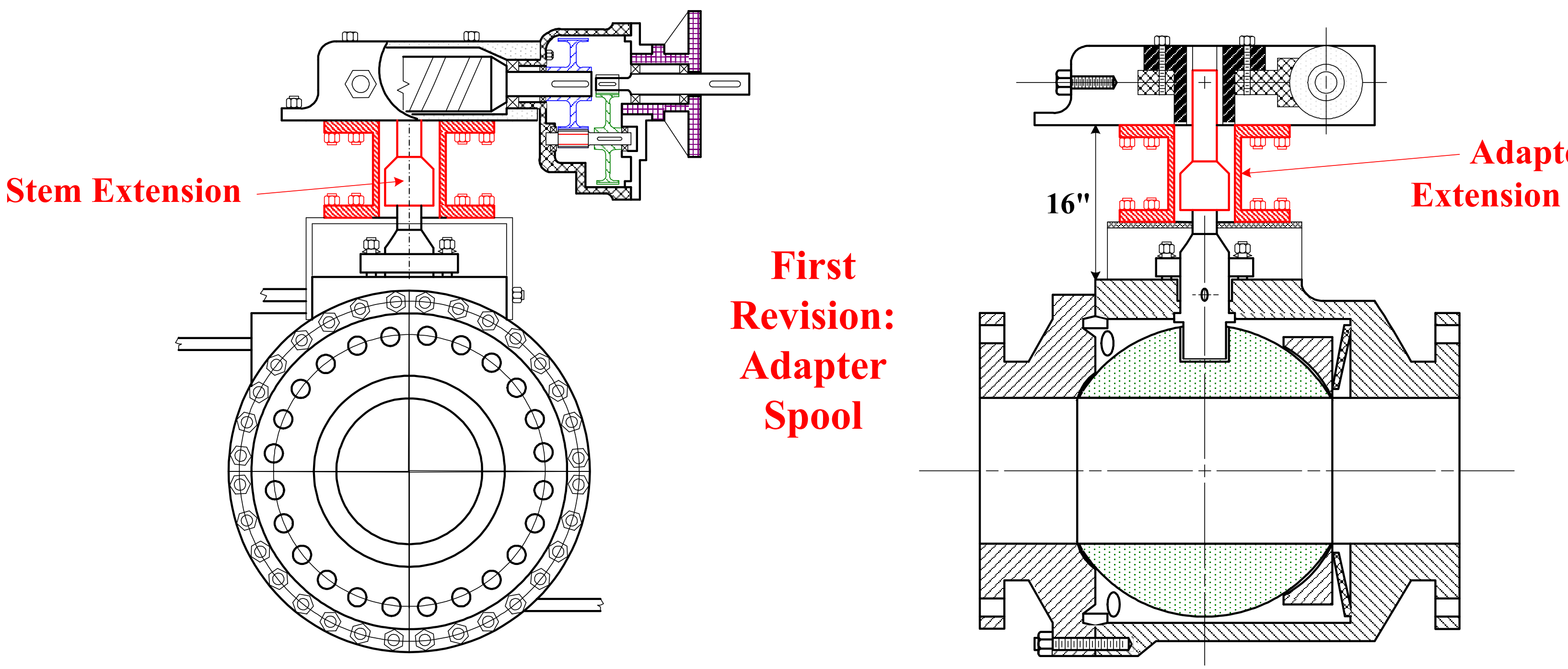
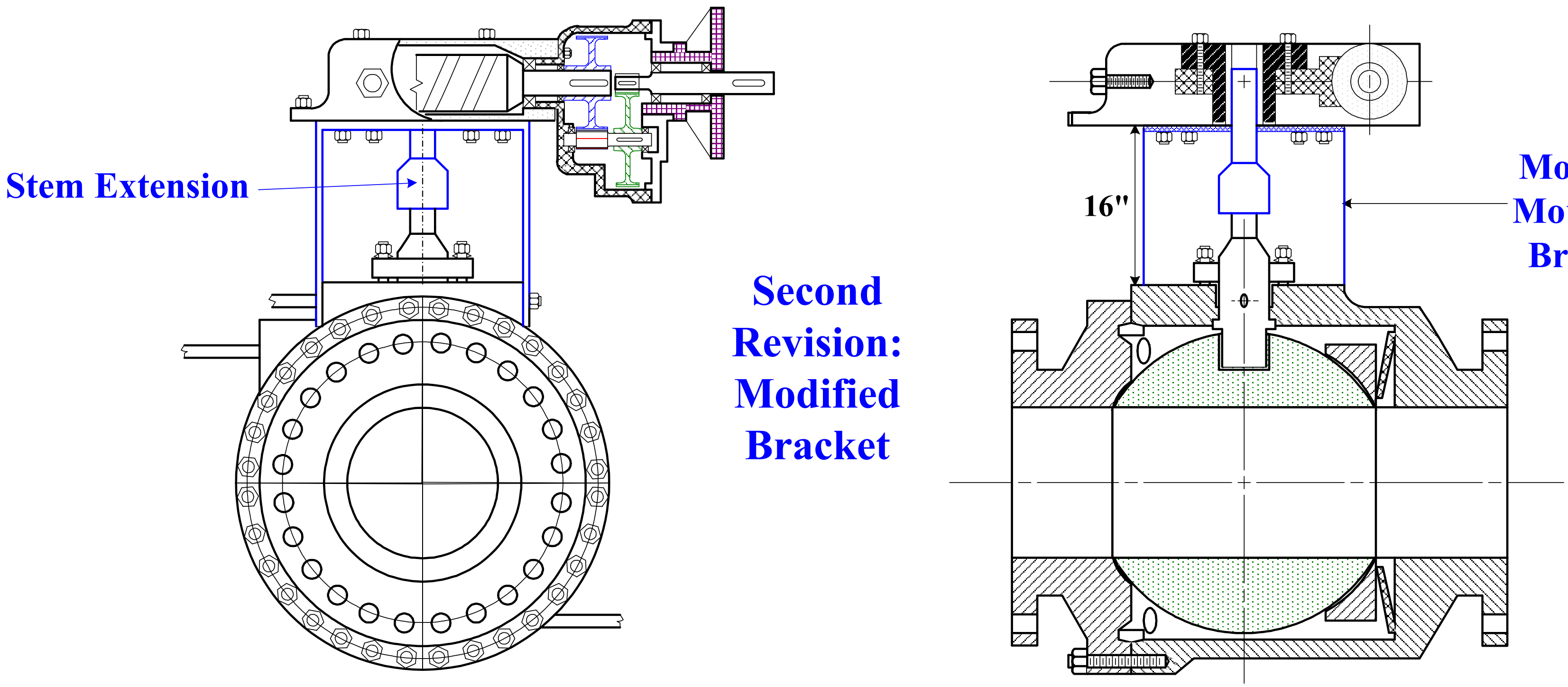


Figure #3C: Final Actuator Mounting



Second Revision: Modified Bracket

Overhead Vapor Valves

Initial Ball Valve Sticking

- **In February 1998 the overhead vapor isolation valve, SPV-2A, stuck for the first time. The valve was in the 100% open position (fully open) and the coking operator was attempting to close the valve. After approximately 10% of travel in the closed direction (90% open) the ball stuck. Though the ball could be opened, it could not be further closed with the actuator.**

- **After repeated attempts to close the valve, the actuator spur gears stripped. Excessive force applied to the actuator handwheel exceeded the maximum torque rating of the spur gears resulting in stripping the gear teeth from the gears.**

- **With a full coke drum and a stuck valve extraordinary measures were necessary to prevent a coker shutdown. A piping stress heating contractor was summoned and insulated heating coils installed on the valve.**

Initial Ball Valve Sticking- Continued

- **The outside of the valve body was heated to between 900°F to 1,000°F and held at temperature for one hour.**
- **As the inside cavity surrounding the ball is steam purged, it was thought that the rapid heating of the body would provide sufficient differential expansion to relax the force pushing the ball against the seat & guide applied by the Belleville spring.**
- **The stripped spur gears were removed and a large impact gun directly applied to the worm gear input shaft.**
- **These actions was successful as the valve was turned to the closed position and normal operating procedures could be resumed.**
- **This same scenario was repeated several times from 1998 until 2003 when the valve was removed for shop overhaul.**

Figure #4: Ball Valve Torque Before Overhaul

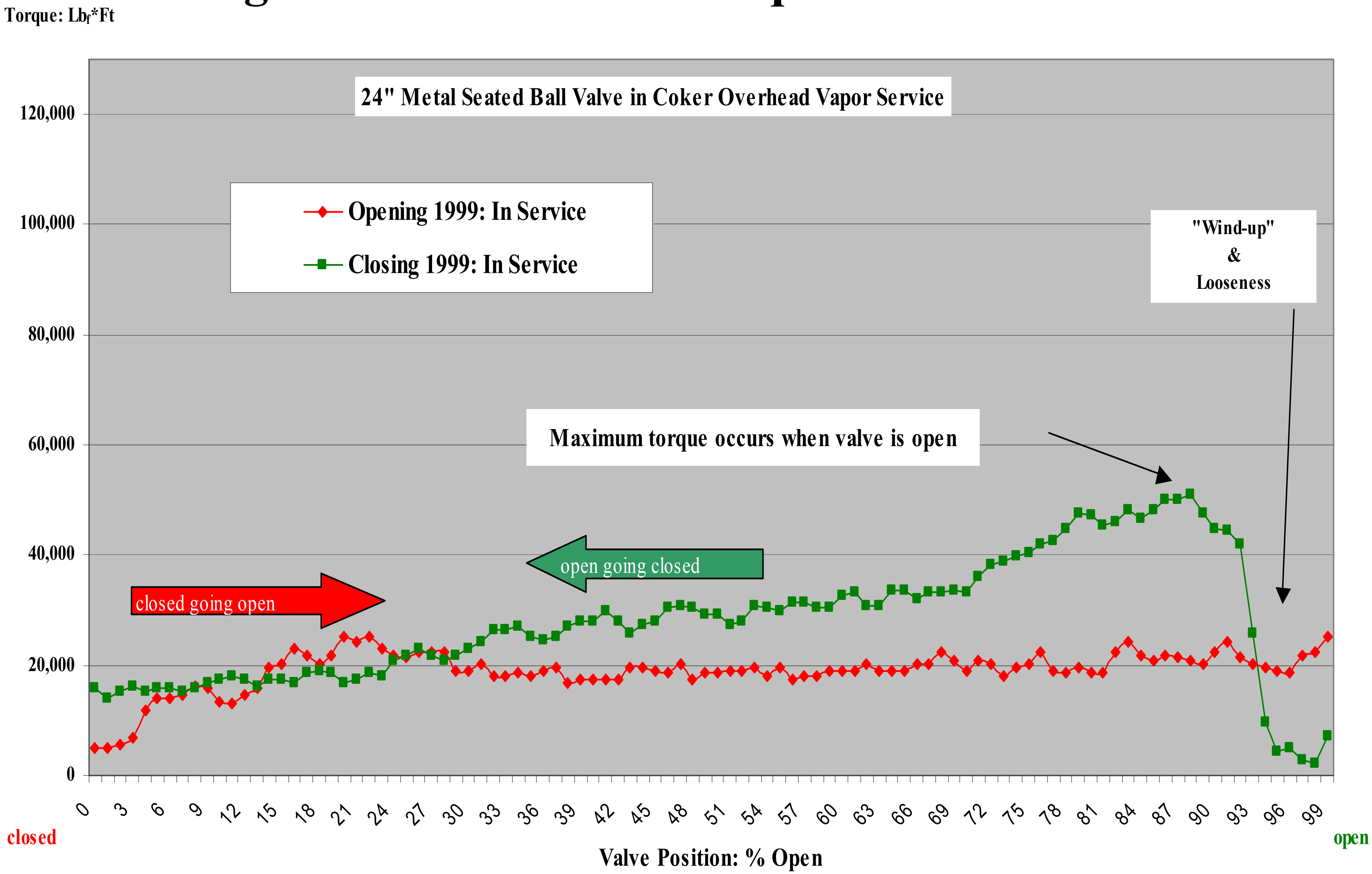
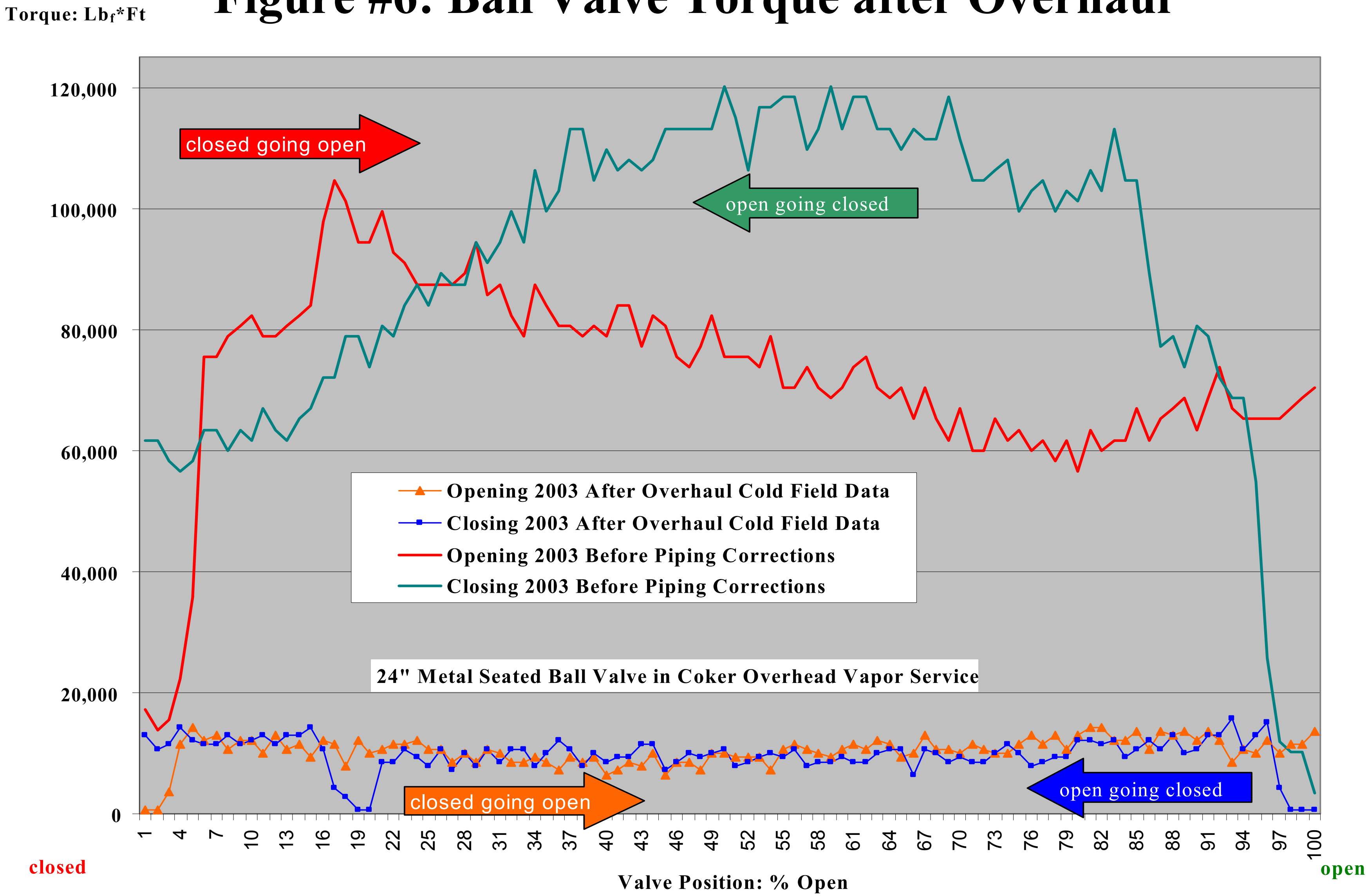


Figure #5: Assembled Ball Valve in Shop

Figure #6: Ball Valve Torque after Overhaul



Ball Valve Pipe Strain

- **After several months of fighting recurring valve sticking problems two major changes were made:**
  - **The spur gear and worm gear actuators were replaced with larger & stronger gearing.**
  - **A piping stress analysis and associated piping support changes were made.**

- **The piping stress analysis consisted of a computer model that included changes in piping stresses & strains due to process pressure and temperature changes. The results of this analysis suggested that several pipe supports were improperly located. This resulted in large forces and moments applied to the valve flanges.**

- **Our belief was that the large loads applied to the valve flanges resulted in internal misalignment of the ball and resulting high torque requirements.**

Figure #7: Ball Valve Torque after Piping Corrections

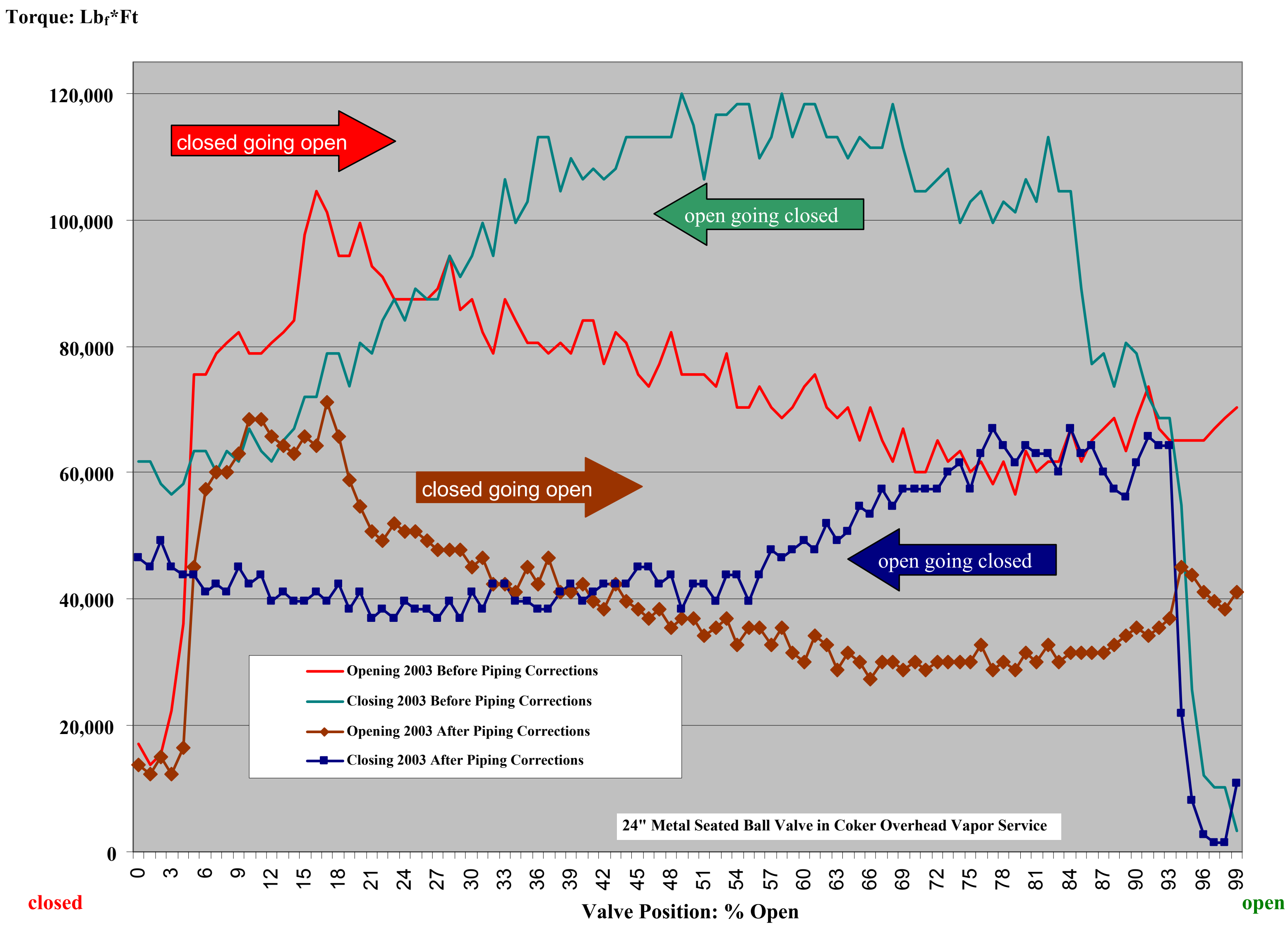
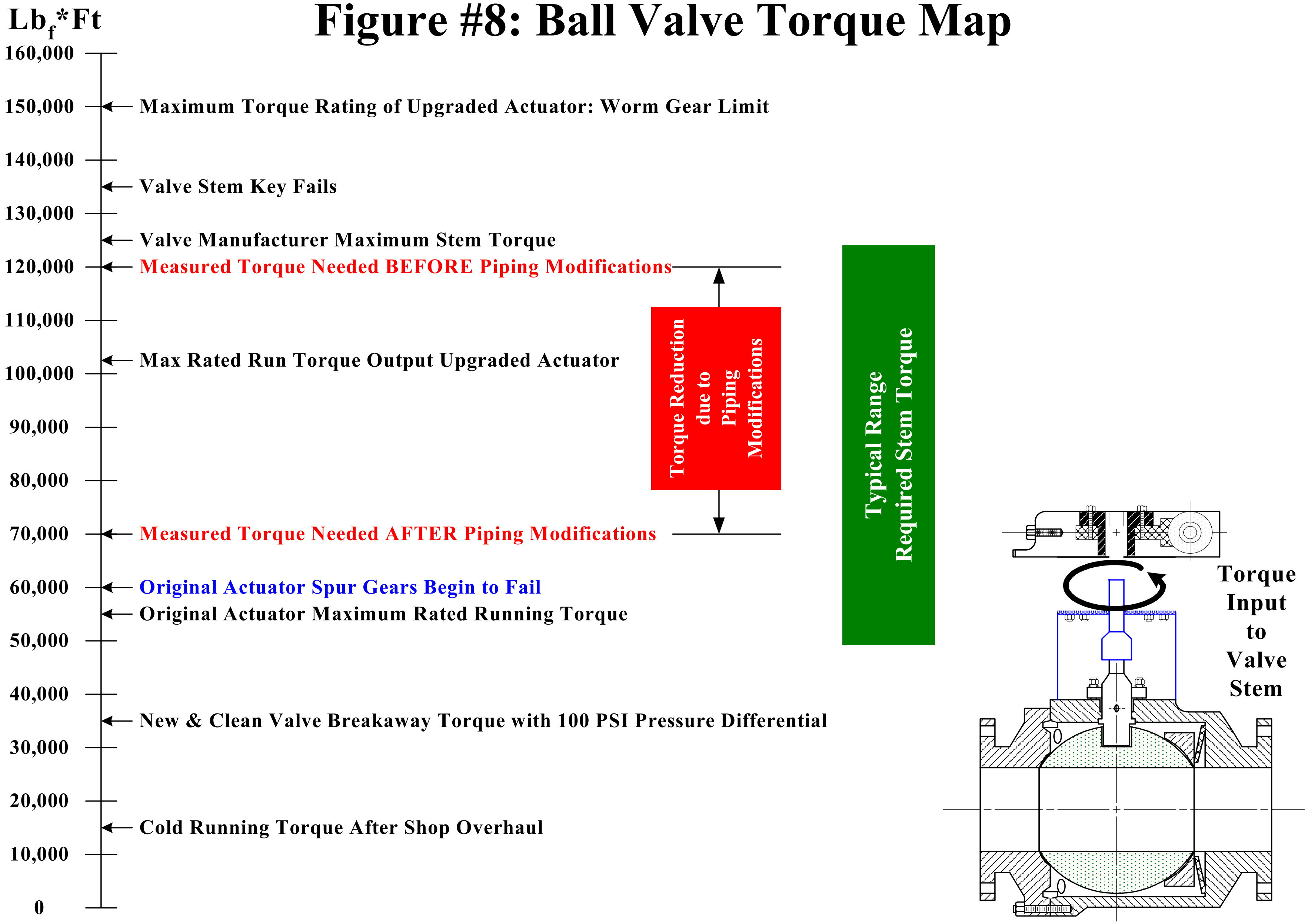


Figure #8: Ball Valve Torque Map



Switch Valve

Figure #9: Switch Valve Cross-Section

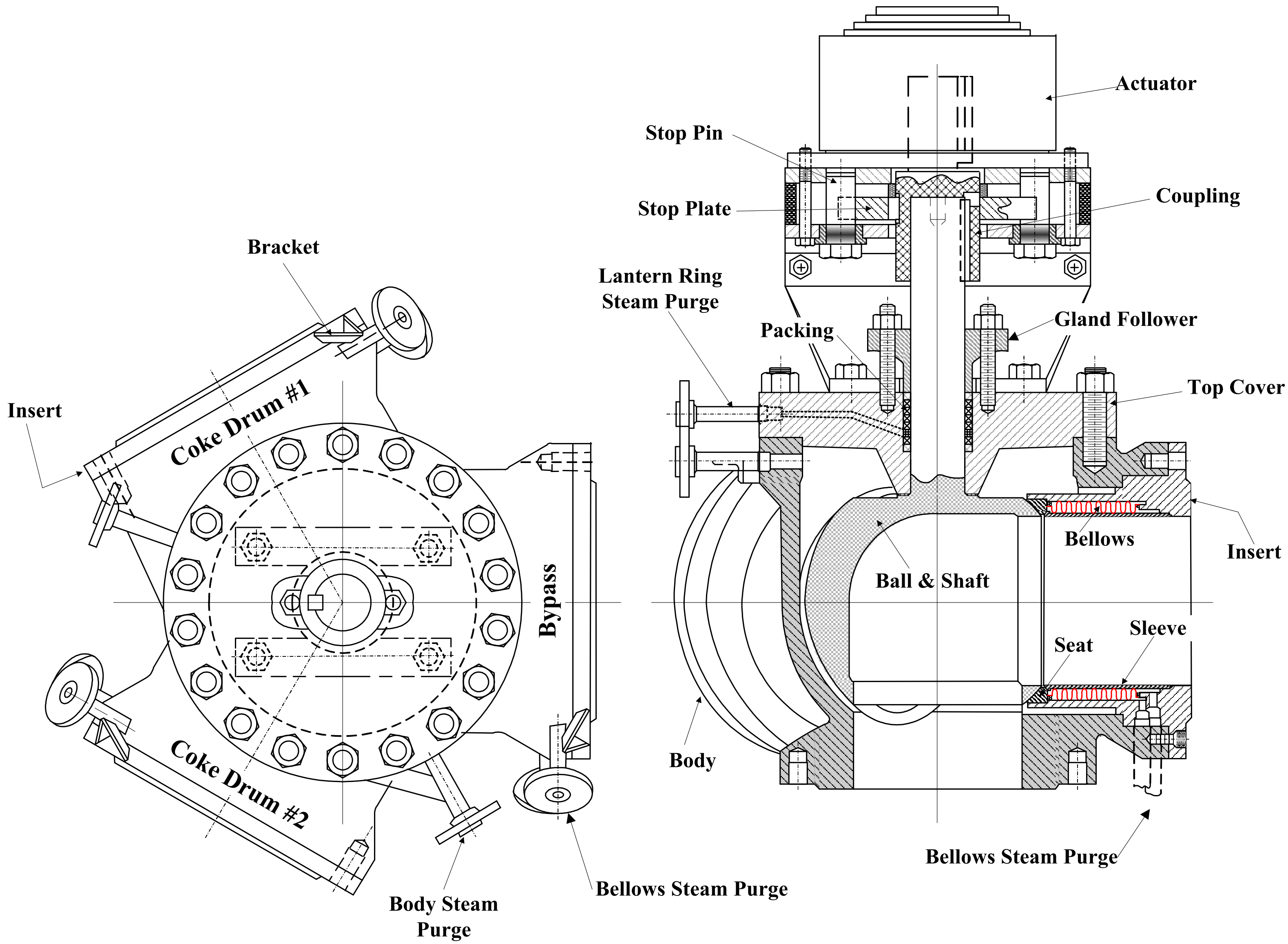


Fig 3.vsd

Figure #10: Switch Valve Overview

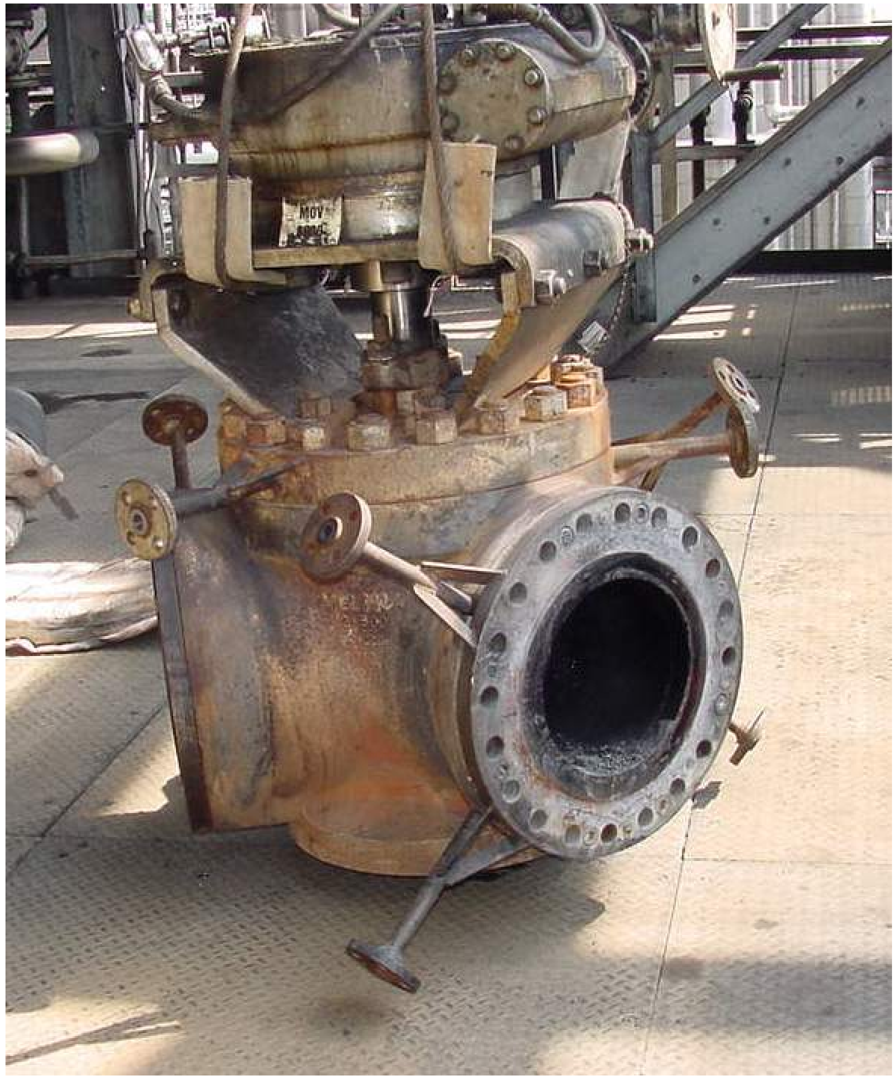


Figure #11: Steam Purge Line Plugging

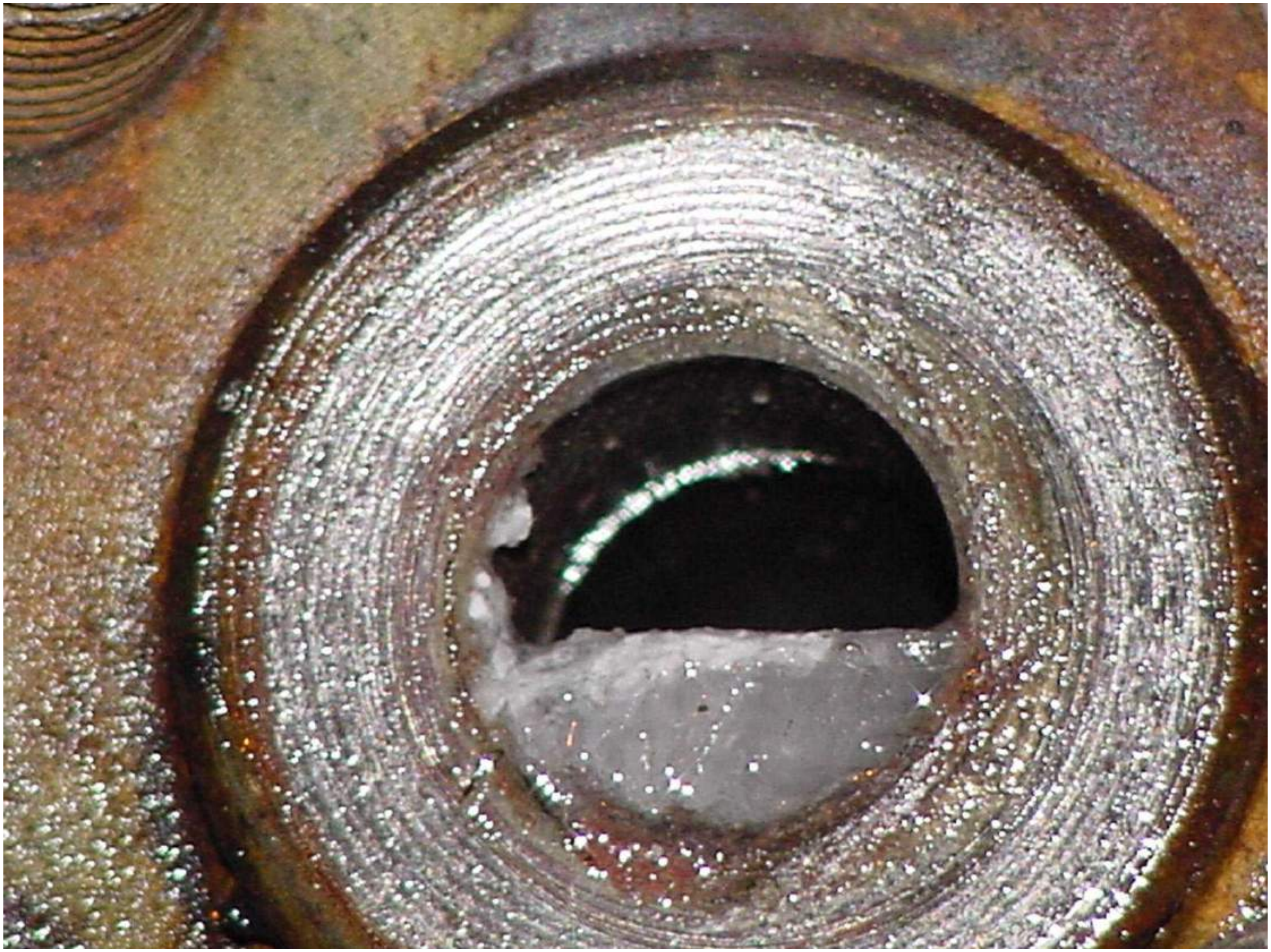


Figure #12: Switch Valve Bellows

Switch Valve - Continued

- **After upgrading the actuator and valve stem couplings to deliver more torque, the sticking switch valve was removed and the spare valve installed in early March of 2001.**

- **This spare valve was brand-new from the factory and had never been in service.**

- **During the coker start-up in late March, the switch valve seized when attempting the initial switch from Drum#1 to Drum #2. Despite all our attempts, the valve would lock-up when going from Drum #1 to Drum #2 but would turn easily when going in the reverse direction.**

- **After the new switch valve was disassembled in the shop, the immediate cause for lock-up was readily apparent.**

Figure #13: Switch Valve Ball Damage

Figure #14: Switch Valve Pipe Strain

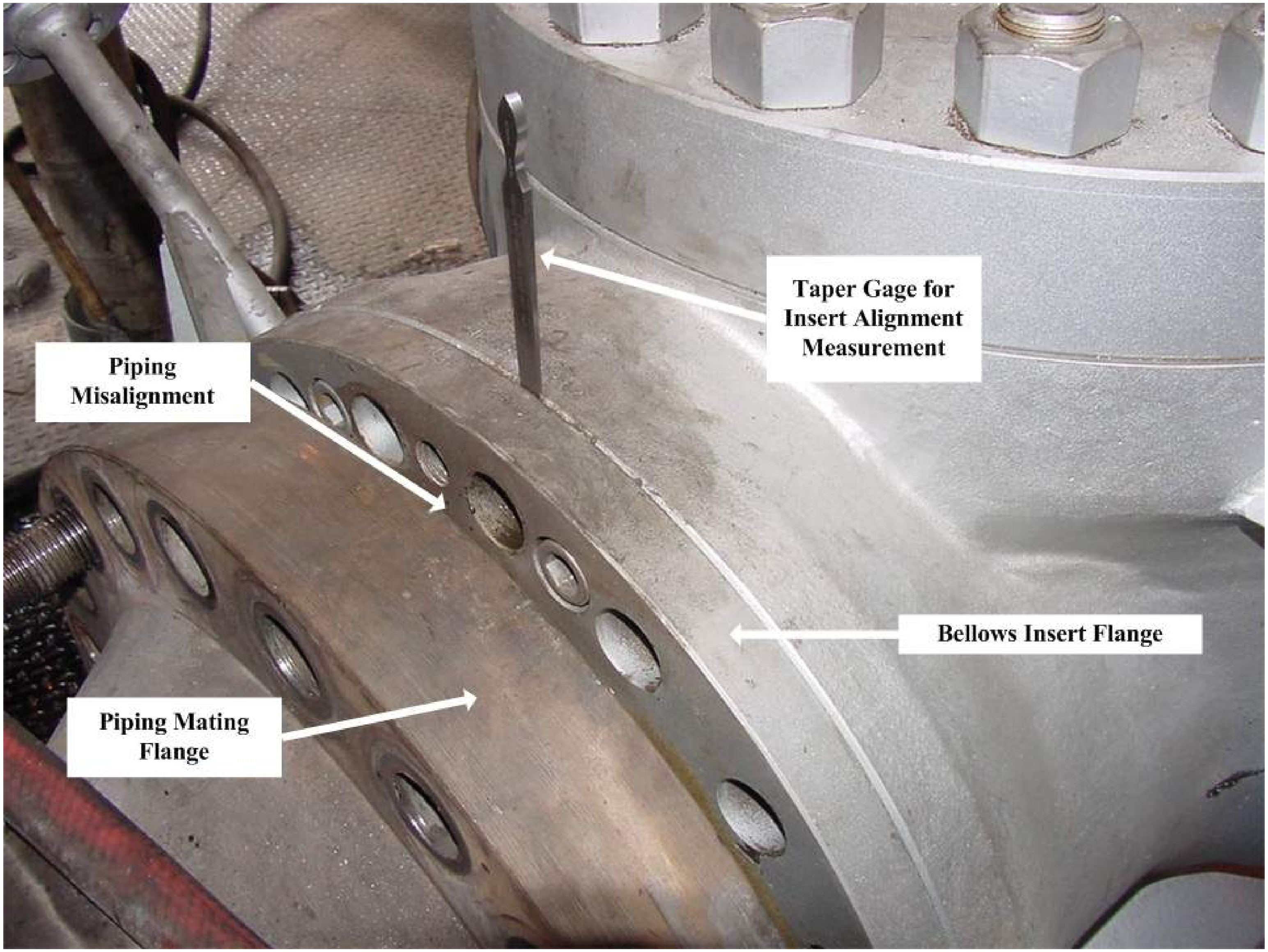
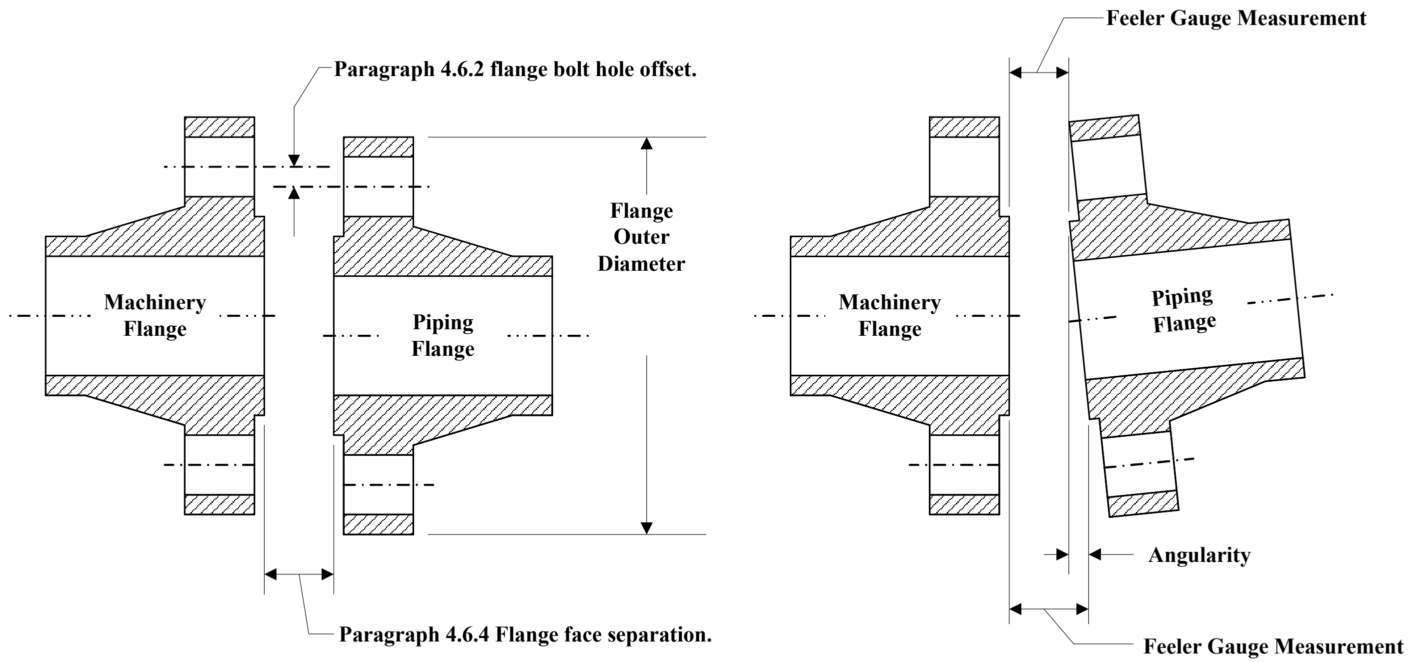


Figure #15: API Standard RP-686 Pipe Strain



Chapter 6: Piping

4.6.2 Pipe flange bolt holes shall be lined up with machinery nozzle bolt holes within 1.5 millimeters (1/16 inch) maximum offset from the center of the bolt hole to permit insertion of bolts without applying any external force to the piping.

4.6.4 Flange face separation shall be within the gasket spacing plus or minus 1.5 millimeters (1/16 inch). Only one gasket per flanged connection shall be used.

4.6.3 The machine and piping flange faces shall be parallel to less than 10 micrometers per centimeter (0.001 inch per inch) of pipe flange outer diameter up to a maximum of 750 micrometers (0.030 inch).

For piping flange outer diameters smaller than 25 centimeters (10 inches), the flanges shall be parallel to 250 micrometers (0.010 inch) or less.

.....For raised face flanges, feeler gauge readings shall be taken at the raised face. For flat faced flanges, feeler gauge readings shall be taken at the flange outside diameter.

Fig 17.vsd

Gate Valves

Figure #16: Gate Valve Cross-Section

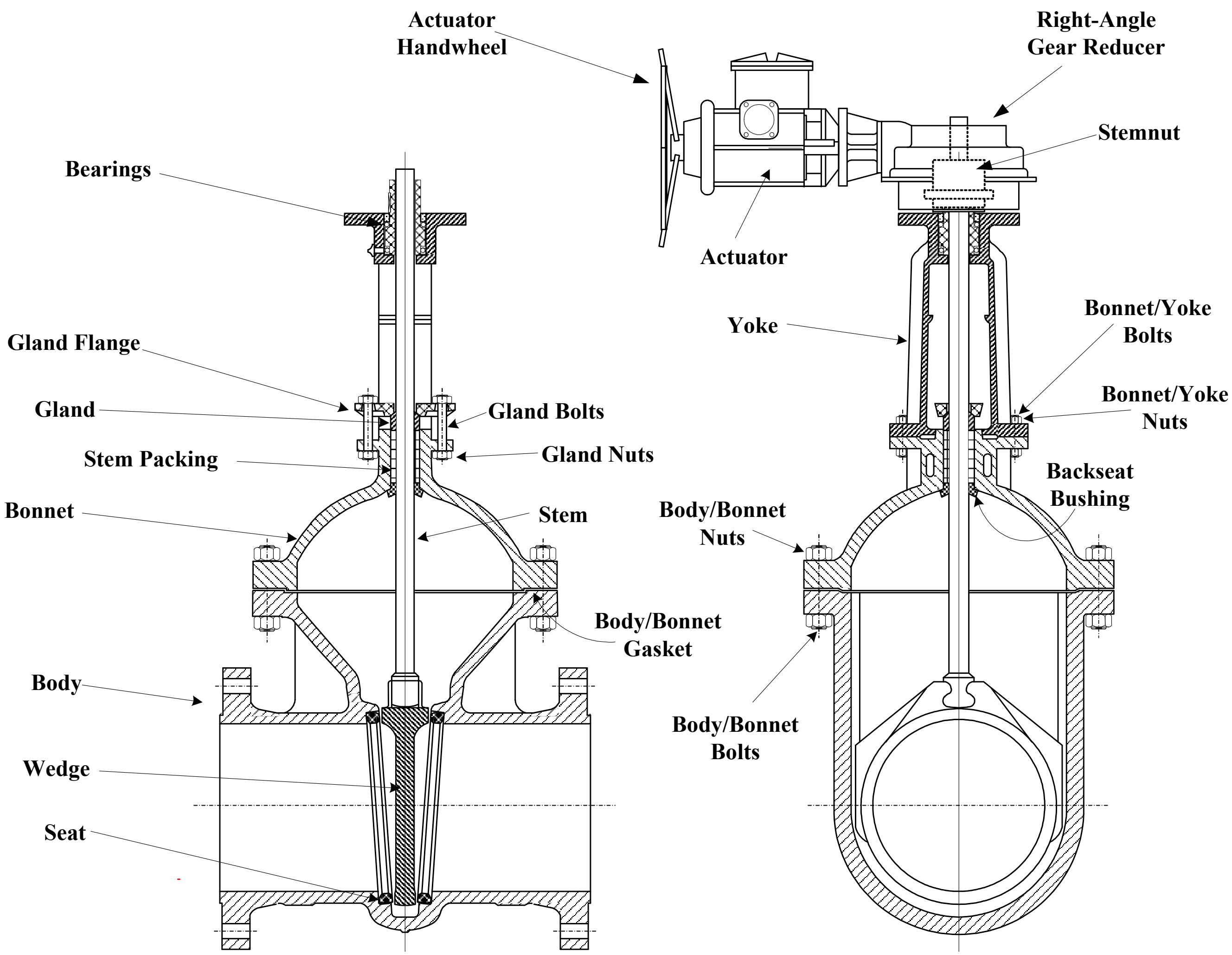
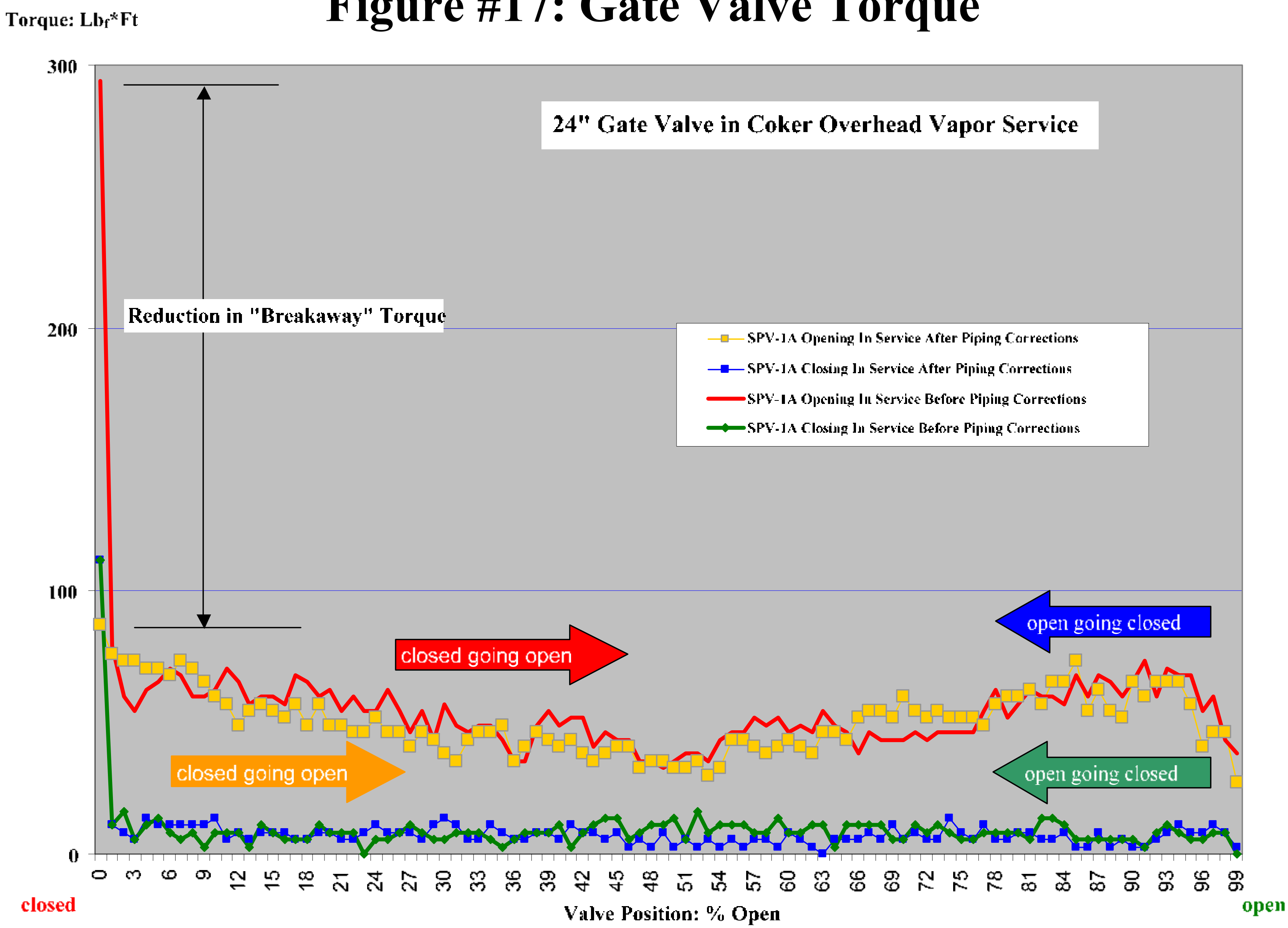


Figure #17: Gate Valve Torque



Actuator Sizing

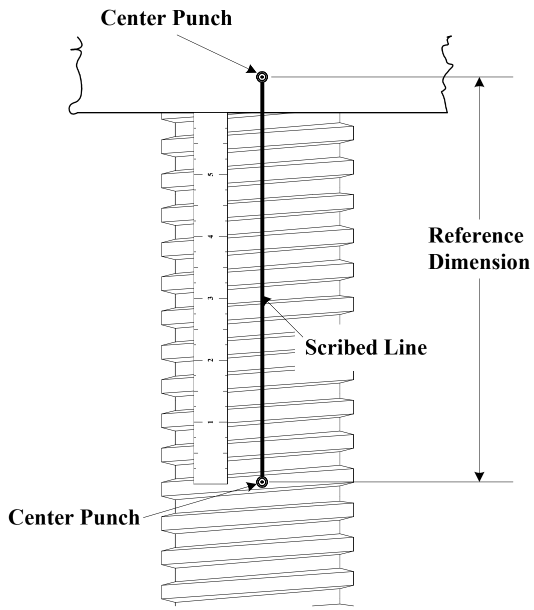
- **While we were dealing with the above ball valve and gate valve problems, we also discovered a fundamental problem with the basic actuator sizing procedure for valves.**

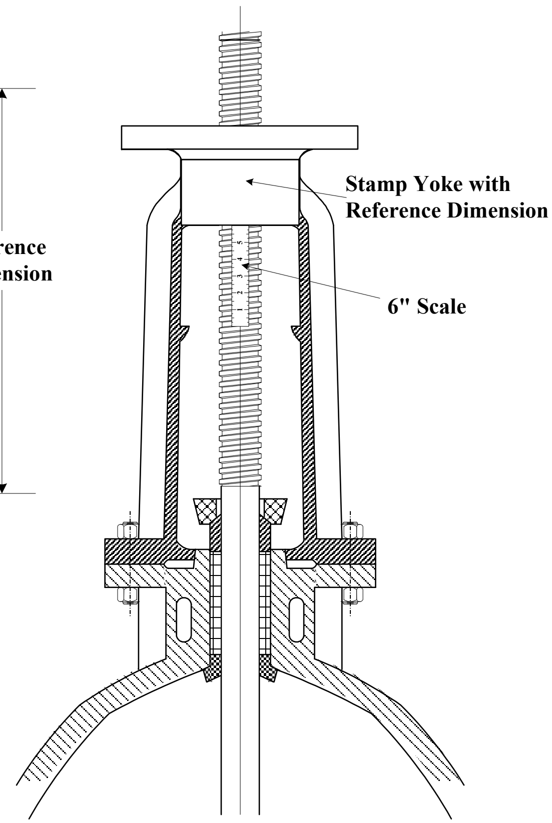
- **Many valve actuator manufacturer's utilize a sizing formula of the following general form:**

$$\text{Stem Thrust} = (\Delta P)\,(\text{Area})\,(\text{Geometry Factor}) + \text{Gland Friction} + \text{Piston Effect}$$

$$\text{Torque} = (\text{Stem Thrust})\,(\text{Stem Factor})$$

Figure #18: Valve Stem Marking





Instructions

1. **Verify wedge is in the full closed position.**
2. **Place 6" scale on valve stem as shown.**
3. **Scribe straight line on valve stem & yoke.**
4. **Center punch reference dimple on thread and yoke.**
5. **Using dividers and scale, measure & record the reference distance between the two punch marks.**
6. **Stanp the yoke with this reference dimension.**

Summary

- **Pipe strain as well as transient piping stresses are frequently neglected in the design and installation of large motor operated valves. Though these valves appear massive, they may be subject to internal distortion despite meeting the requirements of ASME. These piping induced strains can result in excessive distortion of the valves resulting in internal binding or ultimately seizure of the valve moving elements.**

- **We have found that two different metal seated ball valve designs as well as gate valves are all susceptible to binding from piping distortion.**

Summary - Continued

- **Adoption of piping misalignment limitations such as those described in RP-686 can help prevent valve seizures.**

- **Torque requirements for valves in coker services are much greater than that typically predicted by theory.**

- **Our experience suggests that metal seated ball valves are subject to the greatest torque when going closed from a full open position. This is contrary to common belief. Break torque to unseat gate valves is also far greater than expected.**

- **The basic formula used to size valve actuators are driven by valve differential pressure: i.e. the larger the differential pressure the greater the torque to open the valve. For large diameter valves in coker overhead vapor service this results in a grossly undersized actuator.**

Conclusion

- **To prevent valve binding the pipe strain requirements of API Recommended Practice 686 "Machinery Installation and Installation Design" should be applied to coker valves unless more stringent requirements are specified by the valve manufacturer.**

- **Valves in delayed coker services are subject to large thermal transients due to the cyclical nature of coker operations. All of the major valves in coker overhead, blowdown and feed services should be subjected to a static piping analysis. The objective of this analysis should be a piping design that minimizes flange loadings on the coker valves.**

- **This static piping analysis includes an analysis of the piping system connected to the valves to determine forces and moments on the valve flanges caused by various loading conditions such as pipe weight, liquid loads, and thermal expansion or contraction. This analysis also includes the specification of pipe anchors, guides, supports, spring supports and expansion joints to minimize valve loadings.**

Conclusion - Continued

- **Delayed Coker operating personnel must understand the basis for valve actuator sizing.**
- **The valve manufacturer should always state the maximum permissible torque that the valve will accept without damage.**
- **The valve manufacturer should also indicate the component limiting the maximum torque and the estimated torque to fail this component.**

Acknowledgements

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