

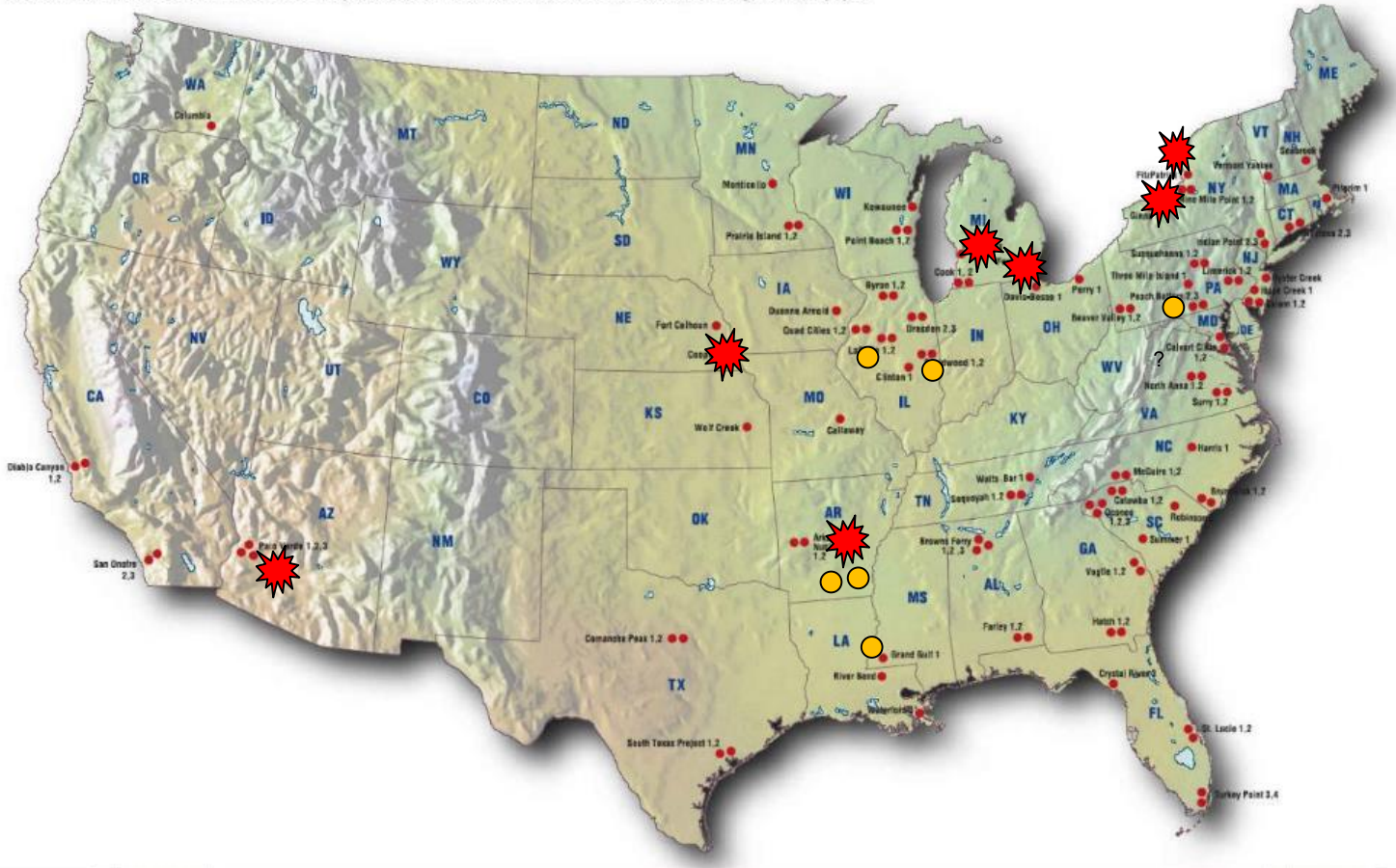
2017 and 2018 (so far) OE Review

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FLMUG
January 2019



Leaks Causing Shutdowns 2018 (reported as of 10/18)

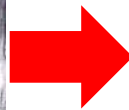
US NUCLEAR PLANTS 31 OCTOBER 2003 http://nei/documents/U.S._Nuclear_Plants_Country-Wide_Map.pdf



- Weld or base metal leaks
- ★ Replaceable Seal Leaks

Repeat Failure of O-ring in MSIV Hydraulic Actuator Block Causes Shutdown

- The root cause of this event (RC-1) was the unresolved insufficient support of the O-ring provided by original design and manufacture
- This was a repeat failure which had an unknown root cause when it occurred the first time



96 Page Root Cause Report

Steam Line Compression Fitting Leak and Subsequent Tightening Activities Results in a Reactor Scram

- **Direct Cause:** Incorrect installation of the tee compression fitting ...resulted in separation of the fitting SCRAM.
- **Causal Factor #1:** Maintenance lacks a standard process on how to properly verify compression tubing and fitting engagement...
- **Causal Factor #2:** ...The worker and the QC inspector were not clear on the intent of the hold point.
- **Causal Factor #3:** Construction testing for tubing runs during post modification testing did not ensure that a hydrostatic or pressure test was completed
- **Causal Factor #4:** Project engineers and technicians **did not communicate with the MCR about the leak prior to touching the leaking fitting.**
- **Causal Factor #6:** Project engineers did not understand the impact of the tubing separating at its fitting and the impact of closing the root valves on the control logic; and the need to electronically remove the affected points from the logic.

5.3.3.1 Depth Marking Tool

The Swagelok depth marking tool (DMT) is designed to provide safe installation of tubing into Swagelok tube fittings. Following are suggestions on how the DMT (shown in Figure 5-10) will ensure proper bottoming of the tubing on the shoulder inside the Swagelok tube-fitting body.

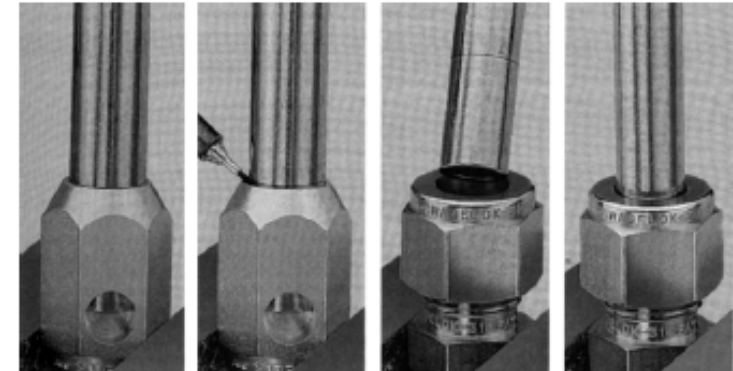


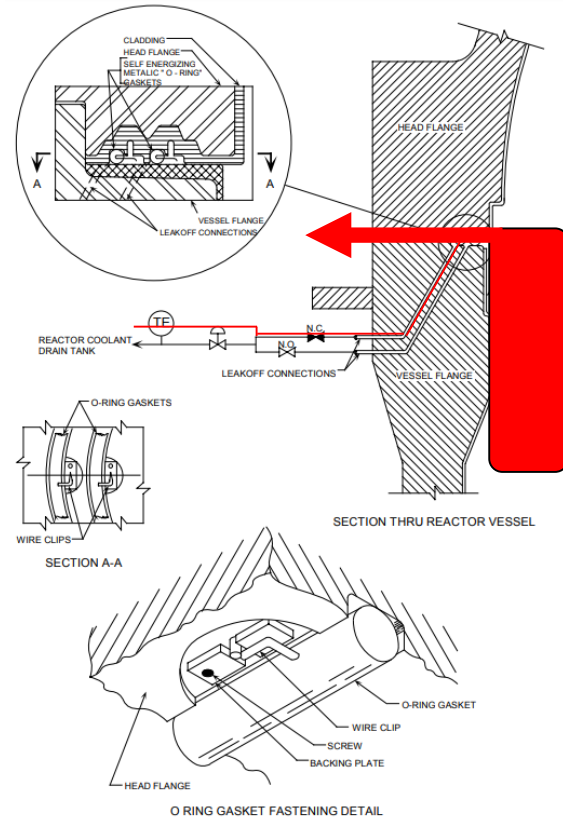
Figure 5-10
Swagelok DMT

From EPRI
1016994

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Cause Report

Reactor Vessel O-ring Leak Caused Shutdown (Repeat Event)

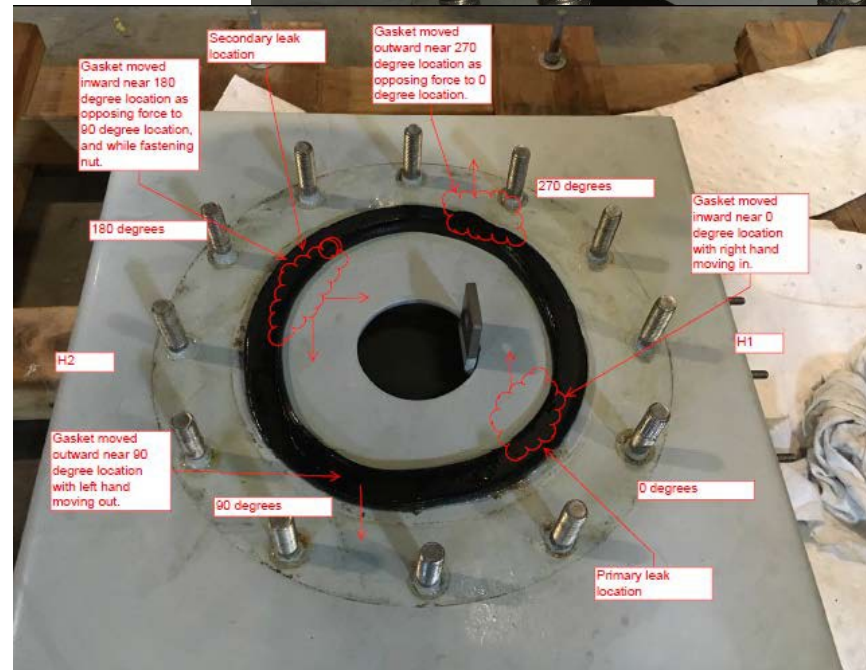
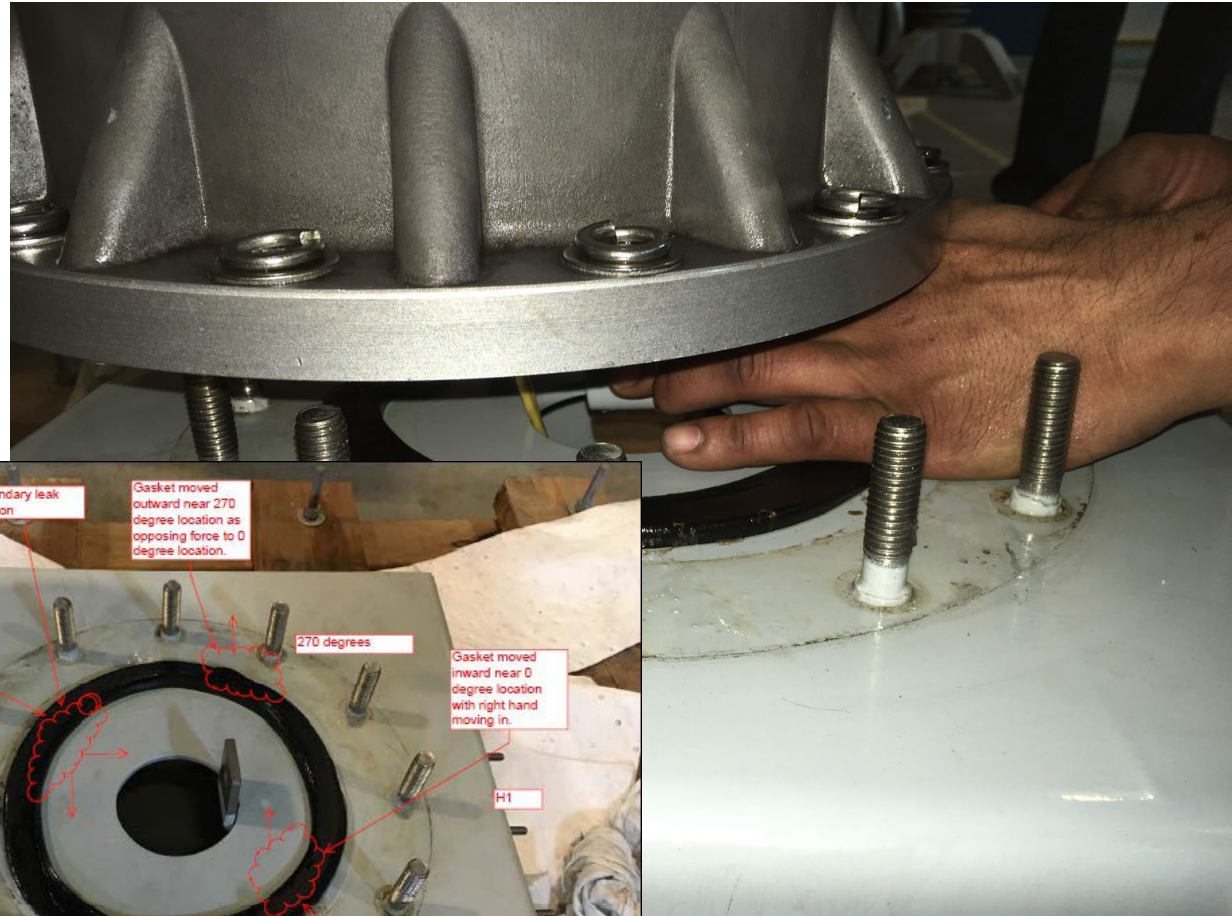
- Inner and outer Rx head O-Ring seals were compromised with a black oxide (FME) layer that caused a leak path around both O-rings caused by recent variations in the RHR flow while starting, stopping and swapping pumps during the period after the Reactor Head is landed but before it has been tensioned which has caused borated water (RCS) to be pushed up through the Upper Internals and then contact the flange surface and O-Rings.
- This causes the O-Rings sealing surfaces to become contaminated with debris and compromises the O-Ring seal.
- Previous cause evaluations have not captured all of the O-ring failure causes, resulting in actions not being put into place to completely prevent recurrence.
- Potential causes of the current inner O-ring leak are thought to be flange defects and/or the decontamination processes, as discussed in the FMA.



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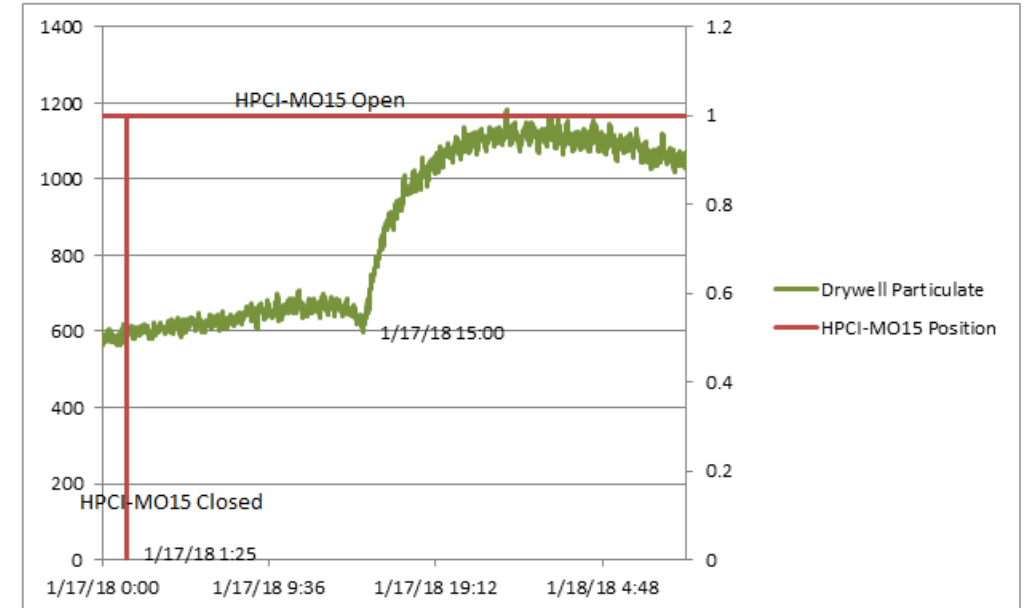
Gasket Leak on Revenue Measuring Current Transformer Flange Causes Shutdown

- Reaching in to connect a wire moved the gasket.
- The torque sequence was also questionable



56+27 (83)
Page Root
Cause Report

High Pressure Coolant Injection Valve Packing Leak Causes Unplanned LCO Entry and Shutdown



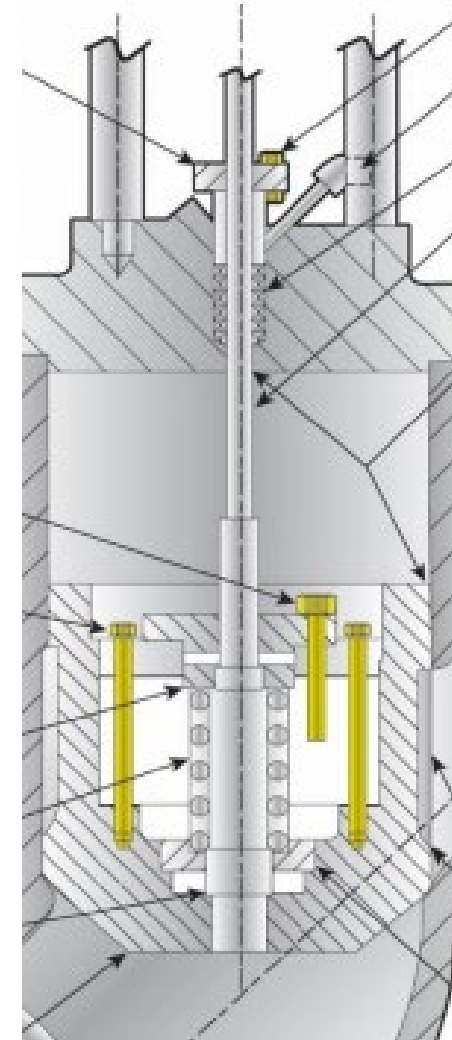
Root Cause: Packing consolidation and torquing methods were altered which impacted packing sealing performance to maximize the margin for the MOV along with following an over thrust event in 2006 and extensive valve work performed in 2008, declining valve performance was noted due to packing performance not monitored

Other Contributing Causes: stuffing box tolerances out of spec and packing was not resized, packing below minimum recommended loading after retightening was performed. Additional actions were not taken to address the low load.

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MSIV Packing Leak Causes Shutdown

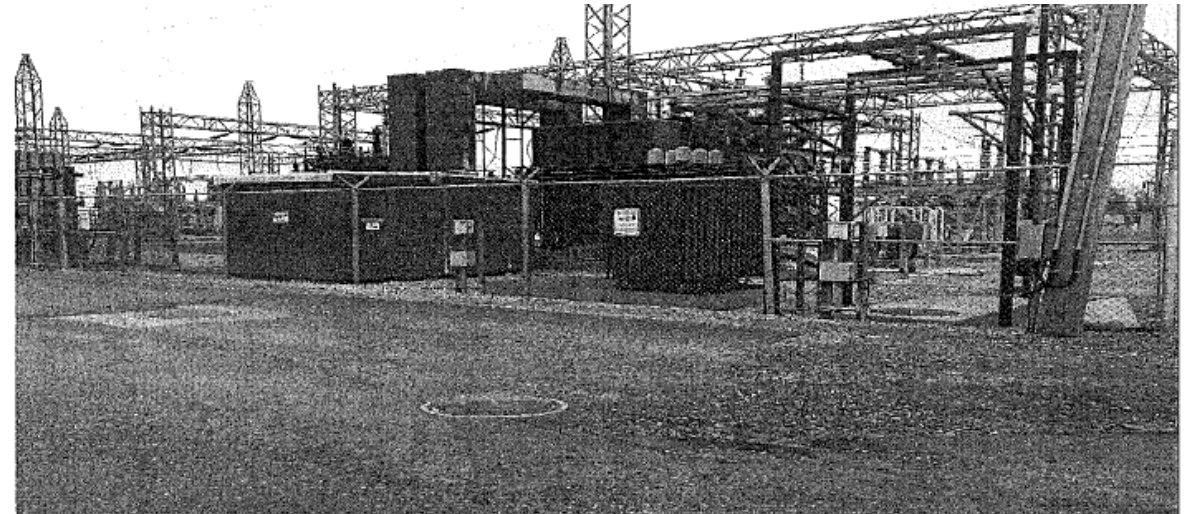
- Packing load loss listed as cause
- Visual inspection of packing sealing areas found slight scuffing on the stem and minor pitting in packing chamber which could have contributed to the leakage



Root Cause
Report Not
Available

Degradation of Switchgear Enclosure Causes Shutdown

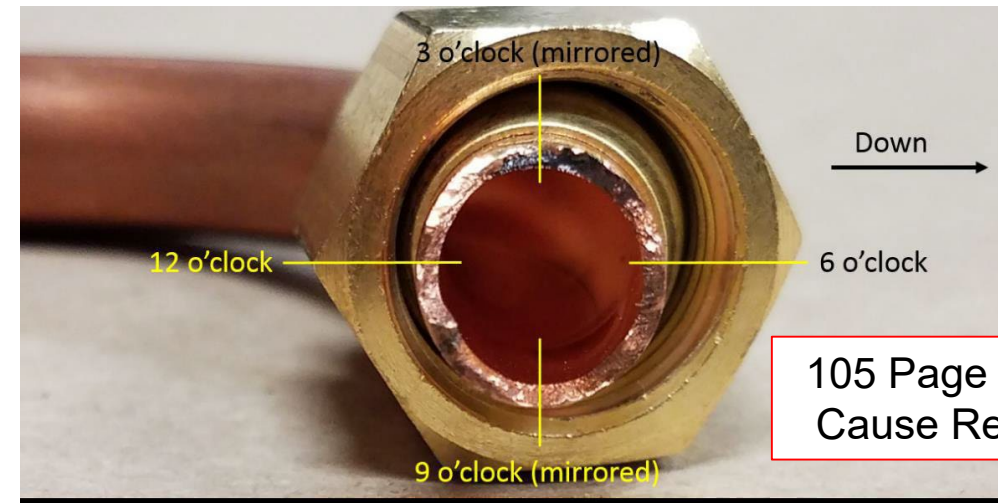
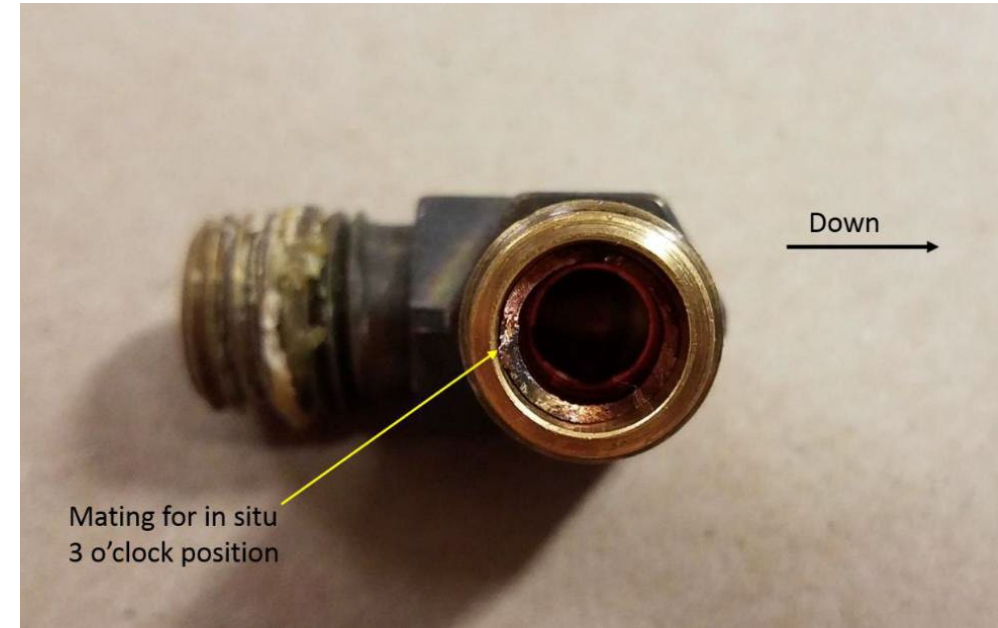
- Sometimes we have to keep water OUT
- Plant organizations tolerated low standards for material condition of outdoor metalclad switchgear



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Cause Report

Instrument Air Line Failure Causes Plant Shutdown

- Instrument copper tubing failed at the compression fitting.
- The material and configuration of the instrument air tubing revealed the potential of a fatigue failure, workmanship error, physical impact, manufacturing defect, erosion or corrosion, etc.
- It was determined the failure mode of the copper tubing was vibration induced high cycle fatigue.
- Commonality in the current instrument air tubing fatigue failure and previous failures due to subtle workmanship errors is the use of copper tubing with brass fittings in the high vibration application during low power plant startup operations. Specifically, copper tubing with brass fittings is not robust enough to tolerate high vibration applications
- Many Stations have addressed this by replacing with flexible hose



Wrong Response to a Leak Causes Shutdown

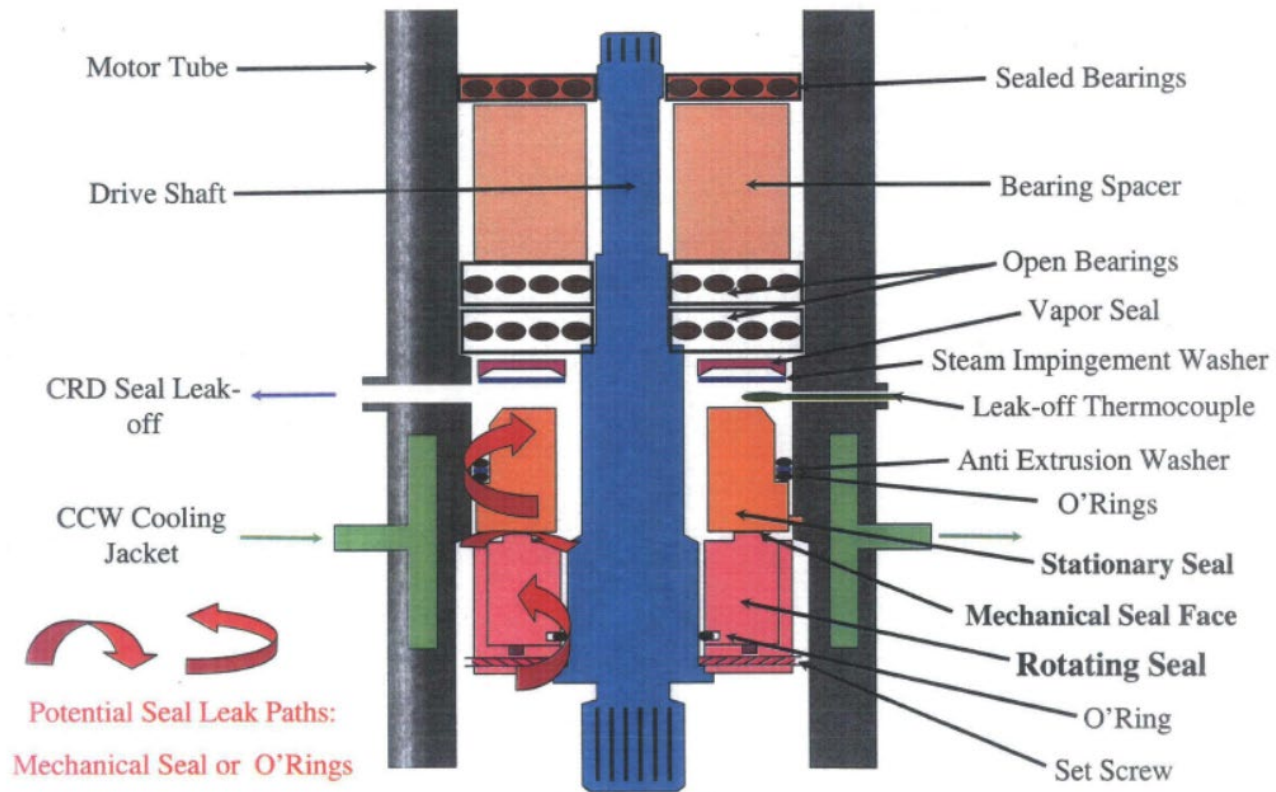
- The root cause of the automatic reactor trip was determined to be, contrary to station requirements an auxiliary operator took action to block air venting from the [very important] valve causing the valve to move in the closed direction.



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Cause Report

Control Rod Drive Seals are Causing Multiple Shutdowns

Control Rod Drive Seal Sketch



Cause Summary:

- There may not be just one common cause but several different causes such as:
 - Manufacturing issues
 - Assembly issues
 - Overall design issues
- Appears to be difficult mechanical seal application
- **Application is currently in only one US plant**

Some Interesting Generation Impacts

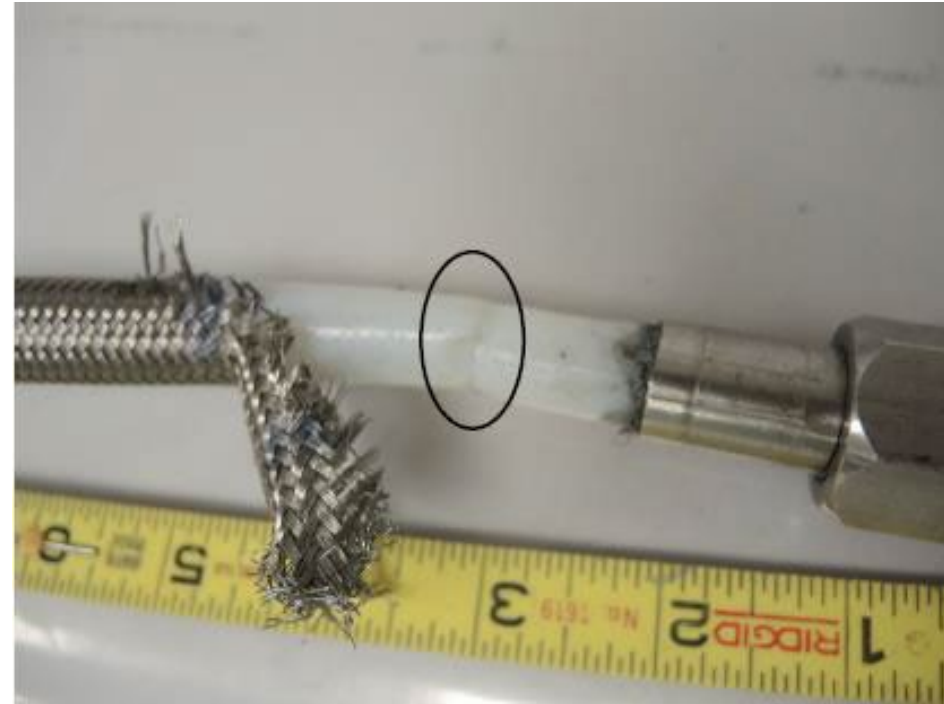
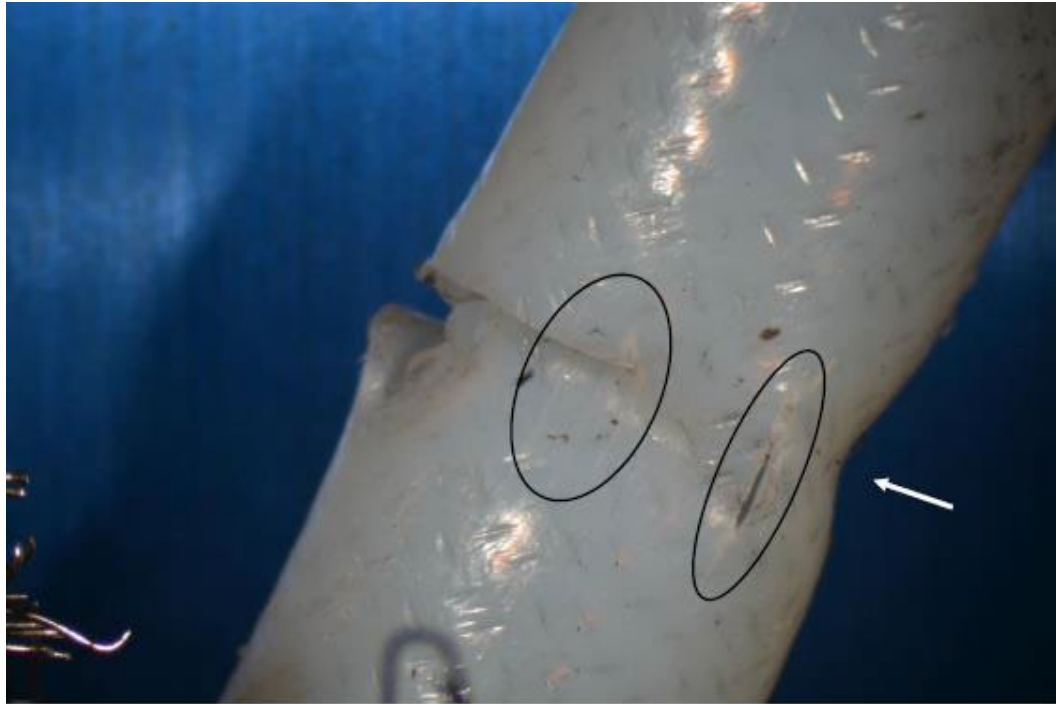
Power Reduction to 53% Due to Worn Out Fittings on a Condensate Pump

- The maintenance installation procedure for the motor does not require inspection or replacement of fittings during a motor replacement. **(CONTRIBUTING CAUSE)**



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Low Recirc Pump Oil Level Resulted in a Downpower to 30% and Drywell Entry Caused by a Leaking Braided Hose



Installation/handling of the lower reservoir flexible hose that placed the hose in a kinked state which later propagated a circumferential tear

33 Page Root Cause Report

Leak on Adjustable Speed Drive Cooling Lines Causes Recirc Pump Trip and Power Reduction to 30%

- Manufacturing defect on bronze fitting caused leak resulting in electrical issues

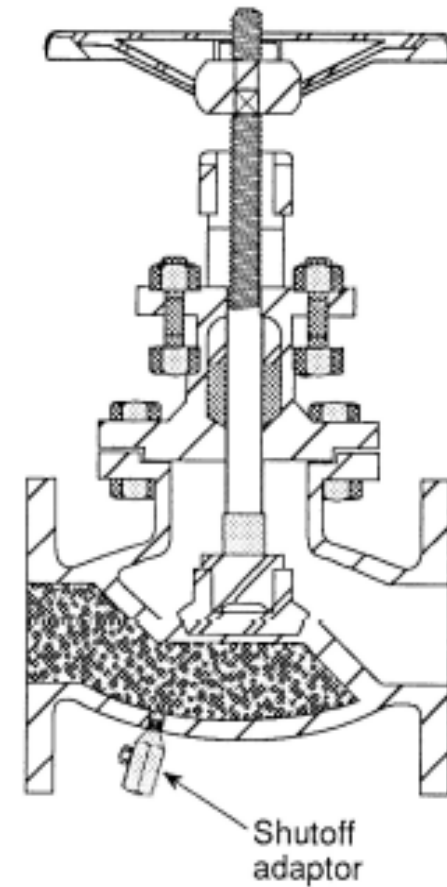


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Rx Down Power to 13% Due to Elevated Drywell Identified Leakage Due to Double Isolation Drain Valves Leaking Through

- 41 year old valves leaked through
- Cut and cap action is being processed for approximately 30 lines with additional lines under review

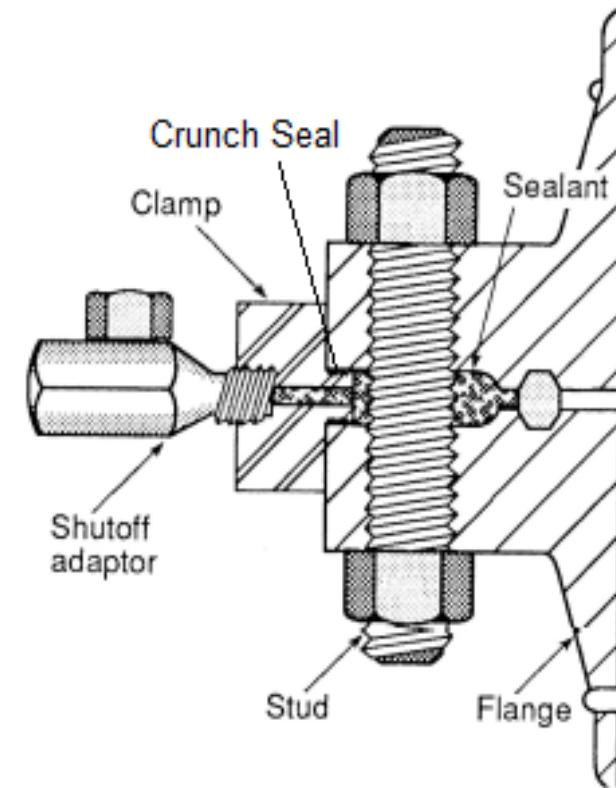
8 Page Root
Cause Report



Unplanned downpower to 79% Reactor Power for Temporary Repair Due to Leak on Valve Bonnet

- The valve was known to have a bonnet leak following the previous refueling outage. The valve was scheduled to be replaced during the outage modification.
- However, due to supplier delays in receiving the valve, the modification was removed from the outage without addressing a temporary repair from the previous cycle in place. Therefore, this was a business decision not to extend the outage to wait on the valve.

Root Cause
Report Not
Available

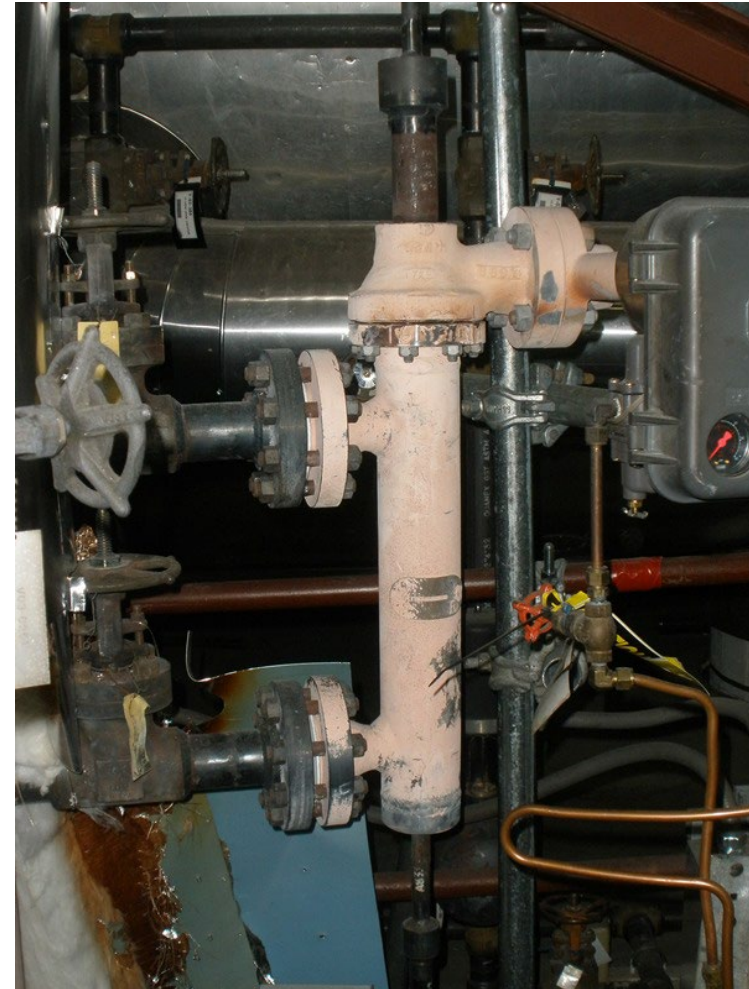


Typical Bonnet Leak Temporary Repair

Level Transmitter Steam Leak Flanged Joint Resulted in a Downpower to 71% Power for approximately 12 hrs

- Less than adequate torque applied during work in 2009.
- Isolation of transmitter and created a single point vulnerability

9 Page Root
Cause Report



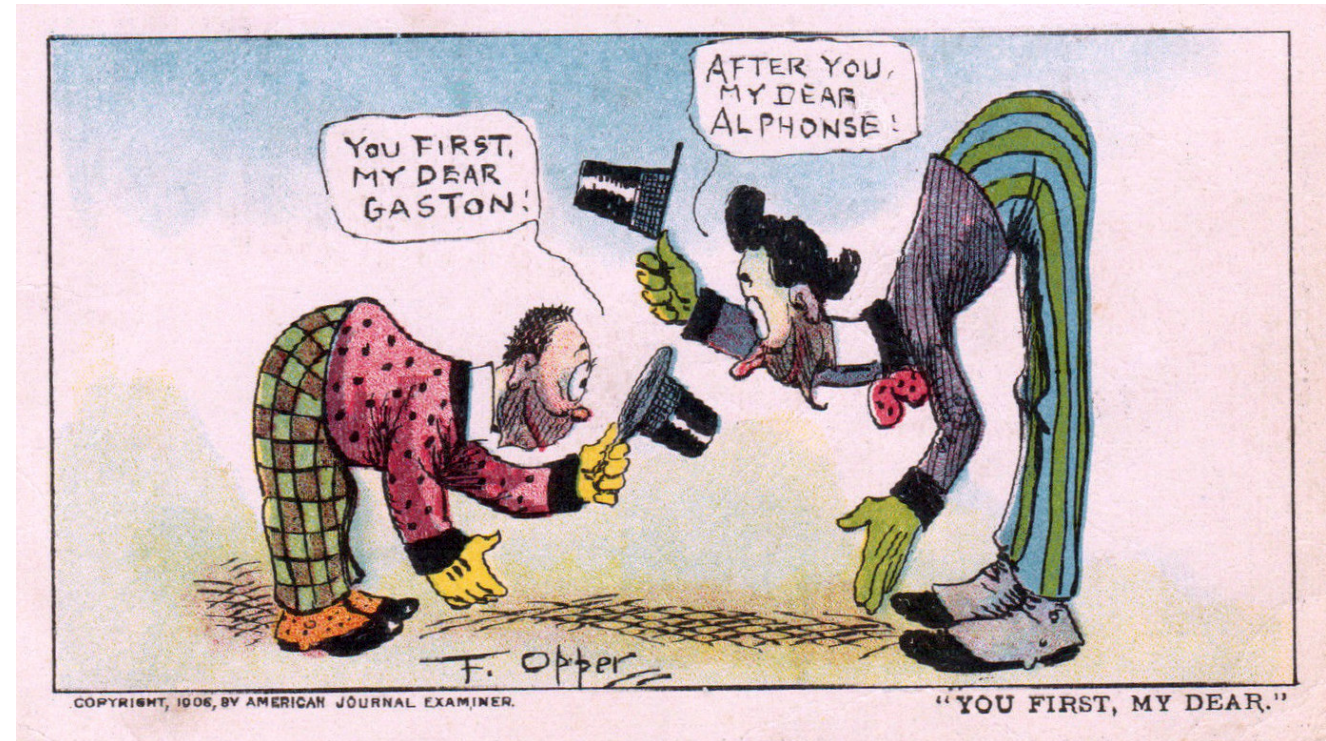
Manway Cover Installed Incorrectly Leads to Multiple Issues and Power Reduction to 78% Power

- Incorrect torque of manway cover bolts
- Torque used was for a 1.25" bolt BUT the bolt was 1.5" resulting in only a fraction of the required torque
- When the feedwater heater was removed from service for repair, it was removed incorrectly (wrong system line up) resulting in lifting of a relief valve and subsequent exposure to flow accelerated corrosion (FAC) conditions and through wall leaks resulting in degraded vacuum



MSIV Packing Leak at BWR Results in Reduction to 75% to Tighten Packing

- Packing installers did not perform final torque/consolidation because they think the test team will do it
- The test team did not perform final torque/consolidation because the procedure is incomplete and they do not realize they need to consolidate packing
- Final packing configuration is not controlled



17 page
apparent cause
report

Unplanned Downpower to 5% Power Due to Oil Loss in the Reactor Recirculation Pump Motor Lower Bearing Oil Reservoir

Damage to threaded elbow caused by a side-load being exerted on the fitting nut caused by the tubing not entering the fitting straight which is a critical requirement for the Swagelok fitting assembly

There must be a sufficient straight length of tubing to allow the tube to be bottomed in the fitting (see Table 5-2 and Figure 5-9). A minimum length of straight tube from a compression fitting is recommended to ensure that a proper connection is made. In all cases, the fitting nut must travel back on a straight length far enough to enable inspection of both ferrules.

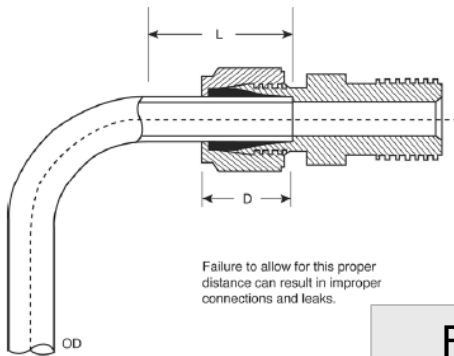


Figure 5-9
Tubing allowance for bends



From EPRI
1016994

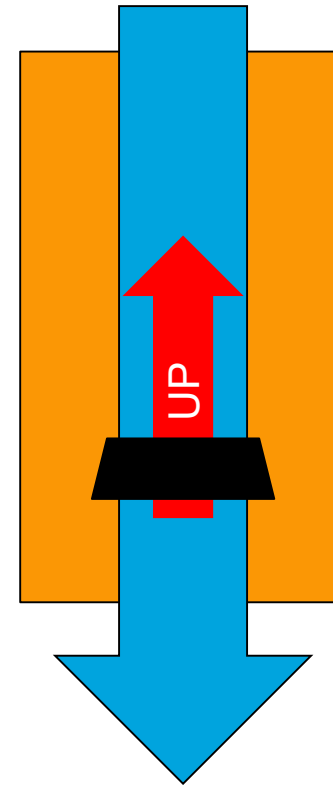
89 Page Root
Cause Report

Oil Leak Due to Incorrectly Assembled Valve Actuator Causes Downpower to 50%

- Rod seal assembly was installed backwards during previous maintenance

Which end is up?

8 Page Root Cause Report





Insights from Reports

Insights from Reading Causal Analysis Reports- Valve Packing

- Stations who have not maintained industry standard packing programs are likely to have leaks
 - What are the valves that are most likely to cause a shutdown?
 - Valves in containment that can cause a high unidentified or identified leakage rate
 - Valves with low thrust margin where packing load and consolidation may be less than desired to prevent leakage
 - MSIV's and HPCI steam valves have a high impact on generation

Valve Packing Maintenance and Program Practices—Update to 3002005353

3002008059

Final Report, November 2016

Compression Fittings

- Compression fittings and tubing must be installed properly to be effective
 - Poor work practices (maybe we think they are too easy?)
 - “YYY tube fittings are designed to provide three easy components for the installer”. Words such as “excellent vibration and temperature compensation and the integrity of two seal points”
 - “XXX tube fittings deliver a leak-tight, gas-tight seal in an easy-to-install, disassemble and reassemble form”. Words such as robust, vibration resistant, fatigue resistant, withstands high pressures and temperature extremes
- Vibration of these lines can cause failures
 - Routing and support matters
 - Copper is particularly susceptible to fatigue
- Careful observance of lines that are vibrating may be helpful to identify susceptible line, particularly if going to important (e.g. “critical” instrumentation)

Nuclear Maintenance Applications Center: Compression Fitting Application Manual

1016994

Final Report, December 2008



O-rings Can Be Tricky

- Fits and tolerances are important
- Often the final configuration is hidden such that extrusion may be hard to see

Static Seals Maintenance Guide

TR-104749

Research Project 3814-06

Final Report
December 1994



Gaskets seem to Suffer Mostly from Poor Work Practices

- Insufficient gasket loading (e.g. from low bolt torque)
- Gaskets not in place properly

Assembling Gasketed, Flanged Bolted Joints

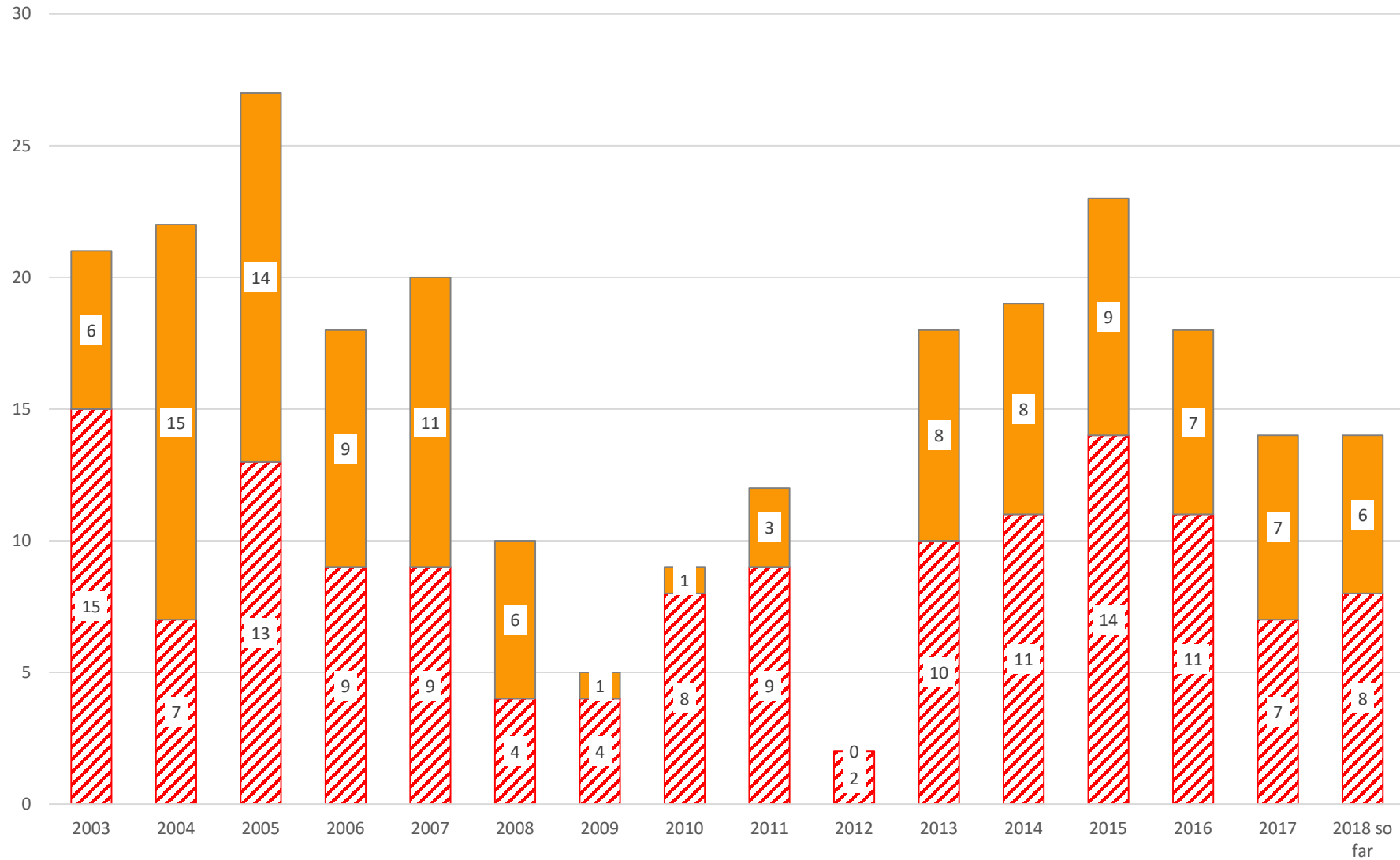
Update of Report 1015337

3002008061

Final Report, August 2016



External Leaks Causing Shutdowns in US Nuclear Plants in ICES Database as of 12/3/18



Replaceable Seals and Joints
 Welds, Base Metal, etc.

**“How many things have to happen to you
before something occurs to you?”**

— Robert Frost

Together...Shaping the Future of Electricity