

Anchor Darling Double Disc Gate Valve Wedge Pin Failure 10CFR21 and LaSalle HPCS MOV Stem Disc Separation Industry Response

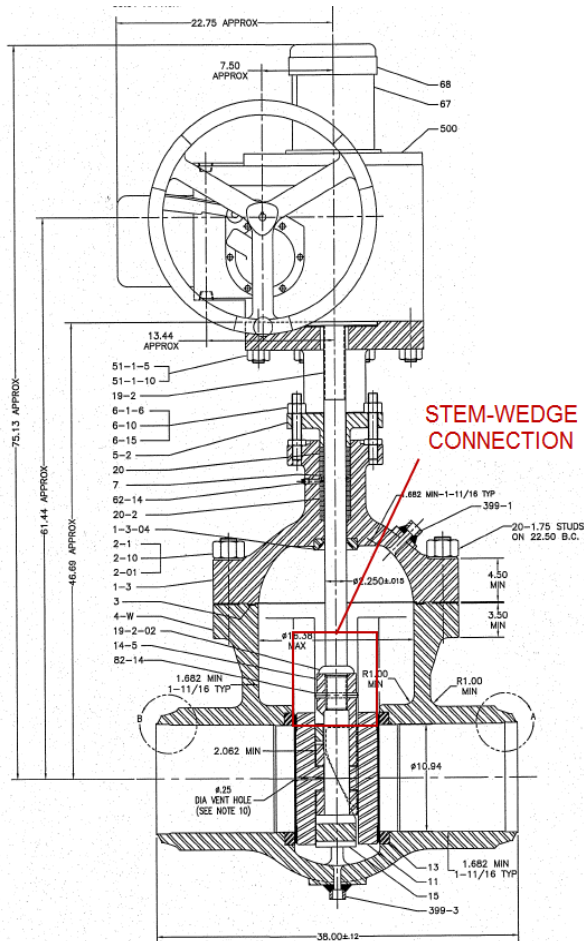
Teledyne Quiklook User Group Meeting – August 17 2017

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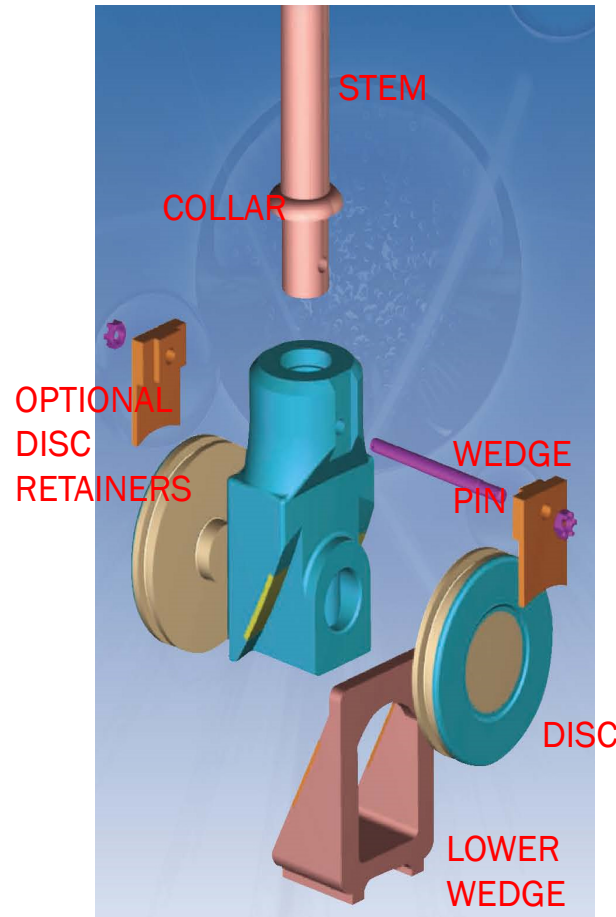


Exelon Generation®

Typical ADDDGV Construction / Components



STEM-WEDGE CONNECTION



Motor Actuator operational stem torque and thrust is transmitted to the valve internals.

- Stem
- Upper Wedge
- Wedge Pin
- Disc Pack
- Body Seats

Stem / Upper Wedge Interface

- Threaded and Pinned
- Stem Collar - Pressed-on or Integral

SCOPE OF POTENTIAL STEM CONNECTION ISSUE

Flowserve – 10CFR Part 21 – Feb 2013
Anchor/Darling Double Disc Gate Valve with Wedge Pins
Subjected to Potentially Damaging Forces

- Threaded Stem-Wedge Connections Subjected to Stem Torque
- Safety-Related, Motor Operated Valves
- Valve Sizes: 2 and Larger
- Pressure Classes 150 through 2500

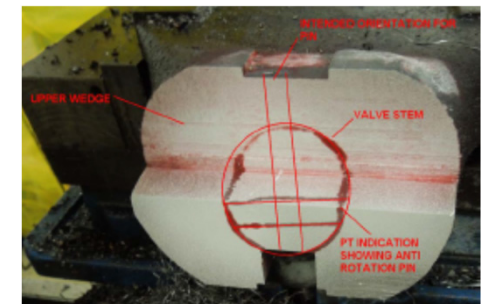
Background - Browns Ferry Operating Experience (302059)

On October 20, 2012, the as-found local leak rate test (LLRT) for the Browns Ferry Unit 1 HPCI Inboard Steam Isolation Valve significantly exceeded administrative limits. The valve was subsequently disassembled to investigate the cause for the failure. This investigation revealed that the wedge pin had broken in several locations and the disc retainer had fallen from the wedge assembly and was found located between the valve discs.



Direct Cause: *The direct cause for the wedge pin shearing is rotation of the valve stem at its threaded connection to the upper wedge connection.*

Root Cause: *Station personnel failed to validate that vendor had torqued the stem to upper wedge connection per vendor's procedures which were modified in response to earlier failures of the same valve design.*



Background – BWROG Industry Response and Guidance

Initial Response - Within one week of the Flowserve Part21, the BWROG VTRG chairman advocated for the BWROG VTRG to prepare recommended guidance to address the issue which included alternatives to the re-torque/repair only option. The VTRG committee developed and issued this guidance in less than two months.

BWR Owners Group issued Topical Report BWROG-TP-13-06 (April 2013)

- Wedge pin structural analyses recommended for to assess susceptibility of the Flowserve Part 21
- Augmented Diagnostic testing and stem rotation checks every RFO (new) endorsed as an alternative to in-body inspections and/or repair/replacement

December 2016, the BWROG issued Revision 1 to the topical report based on industry OPEX

- As-found inspections performed at Nuclear Utilities between 2013 and 2016 identified 24 of 26 valves inspected had loose stem – wedge connections; no examples of stem-disc separation
- Long-term remediation paths recommendations:
 - Verify the stem / disc connection is adequate structurally, or
 - Repair / replace the stem disc connection

LaSalle Unit 2 OE - HPCS Injection Valve Failure

- February 2017, LaSalle U2 High Pressure Core Spray Injection valve (2E22-F004) failed to open
- Failure of the wedge pin and wedge threads – stem/disc separation
- Prior to the failure, BWROG and Fleet governance were followed, including inspection schedules, diagnostic testing, and stem rotation checks
- A difference from previous traces in a prior diagnostic test was reasonably attributed to other conditions in the valve.
- Stem Rotation checks were reported to be at end of acceptable range. ~ 10 degrees vs ≤ 5 degrees for other Exelon Valves

LaSalle 2E22-F004 - Stem with external threads with severe wear degradation



LaSalle 2E22-F004 – Upper wedge with internal threads with severe wear degradation, wedge pin was found sheared.



Exelon LaSalle / Fleet Actions – LaSalle Post Failure

- Reviewed LaSalle Unit 2 existing MOV diagnostic data for potential scope additions to L2R16 based on anomalies identified on 2E22-F004 prior to the Feb 2017 failure. (Corporate/Fleet)
- Reviewed Exelon Fleet MOV diagnostic data for similar anomalies. (Corporate/Fleet – Feb 2017)
- Corporate developed Internal Yellow Nuclear Event Report to drive accelerated fleet actions to accelerate repair of susceptible MOVs (Issued March 16 2017) .
- LaSalle initiates Root Cause Investigation for the event (March 2017)
- Failed 2E22-F004 Parts were sent to PowerLabs for mechanical failure analysis
- Detailed Engineering Failure Analysis performed by MPR Associates

LaSalle Unit 2 HPCS Injection Valve – Exelon Fleet Actions

- Issue Exelon Nuclear Event Report (NC-17-008-Y) (complete)
- Revise BWROG guidance (complete BWROG TP-16-1-112, R2 & R3)
- Revise fleet MOV Program Governance to address revised BWROG guidance and accelerated actions required by NER NC-17-008-Y (complete)
- Re-evaluate initial fleet Part 21 responses and assess EOC (complete)
- Schedule repair of susceptible critical and program MOVs (in progress)
 - Repair high/med active safety related susceptible valves by end of 2019
 - Repair remaining active safety related susceptible valves by end of 2021
 - Exceptions require detailed risk assessment subject to fleet challenge
- Perform diagnostic testing and stem rotation checks until repairs are made (in progress)
- Expedite delivery of stem/disc replacement parts (in progress)
- Develop plans for non-critical, non run to maintenance MOV's (in progress)

Exelon Fleet Extent of Condition (NER NC-17-008-Y Actions)

- Fourteen (14) Exelon Stations Evaluated (23 Units)
- Data for Active Safety Related GL 96-05 MOVs
 - # of ADDDGV with threaded stem/wedge assembly subject to Part 21: 72
 - Nine (9) Exelon Stations subject to Part 21
 - # of valves excluded by wedge-pin analysis: 43
 - # of valves repaired: (2) LAS HPCS Injection MOVs
 - # of valves subject to NER Repair & Monitoring Actions: **27**
 - Four (4) Applicable Exelon Stations subject to NER Repair & Monitoring Actions
- Data for Operationally Critical Non-Program MOVs
 - # of ADDDGV with threaded stem/wedge assembly: 14
 - Four (4) Exelon Station Applicable
 - # of valves excluded by wedge-pin analysis: 4
 - # of valves repaired: (2) CPS Recirc Discharge MOVs
 - # of valves subject to NER Repair & Monitoring Actions: **8**
 - Three (3) Applicable Stations to NER Repair & Monitoring Actions

LaSalle Unit 2 HPCS Injection Valve – Failure Analysis

- Insufficient load (thrust) carrying capacity of the shrink fit stem
- Multiple closing high load cycles (axial thrust and torque)
- Eventual wedge pin shear failure
- Wedge and stem thread wear
 - Adhesive wear (i.e., galling)
 - Aggressive abrasive wear
- Axial shear failure of degraded wedge threads
- Contributing was the lack of pre-load with insufficient capacity of the stem collar and pin assembly

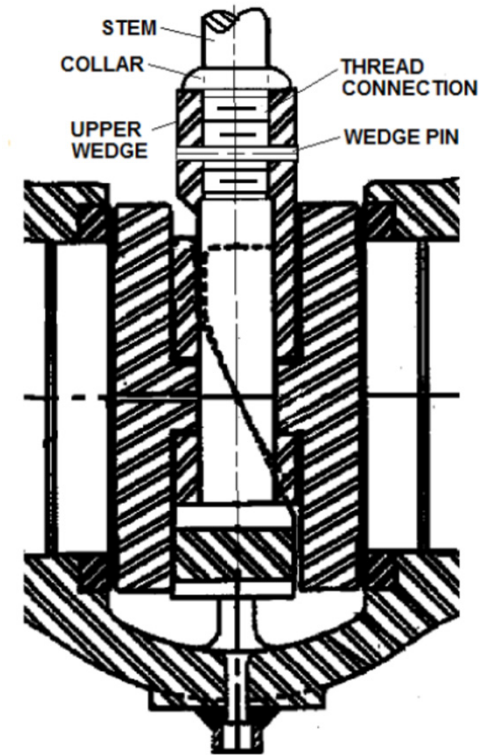


Figure 3: Stem-To-Wedge Connection

References:

1. MPR Report 2101-0022-RPT-001, Rev. 0
2. Exelon PowerLabs Report LAS-28310, Rev. 1, dated May 30, 2017

LaSalle Unit 2 HPCS Injection Valve – Insights and Actions

Insights:

- Vulnerability and risk/consequences of failure should be factored into monitoring and repair plans
- Stem rotation checks should be performed using instruments with sufficient accuracy to support trending
- Trace differences should be thoroughly analyzed based on recent industry experience
- Structural assessment of wedge-pin connection should assume highest applied torque during time in service, which may differ from current set-up
- Weak-Link analyses of Anchor Darling Double Disc Gate Valves should fully assess the stem-wedge assembly including the thrust collar
- Replacement stems should be of the integral one-piece design

Next Actions:

- Provide input to Flowserve to update Part 21 Notification to include vulnerabilities with press-fit stem collars
- Work with BWROG to revise topical report to incorporate
 - LAS Unit 1 HPCS inspection and LAS Unit 2 HPCS insights
 - Flowserve Part 21 update
- Coordinate industry communications through NEI
- Finalize repair plans to address Exelon fleet extent of condition

NEI Survey – Industry Impact Summary

15% of the US Nuclear fleet do not have any AD valves in safety related applications.

A total of 694 AD valves were reported, and of those, 571 were considered in the affected population (82%).

Of the 571 affected population, 564 are safety-related, and of those, 110 had an unacceptable wedge pin analysis or has not performed the wedge pin analysis (19.5%).

Of the 110 from above, 50 of the valves have been repaired or replaced (45%) and 60 are being monitored (55% and affecting 10 sites).

Of the 60 valves being monitored, 18 have an Open or Open & Close active safety function (30%) – affects 3 stations (all are PWRs) and compromises 3% of the affected population (18/571)

Industry Engagement & Recent Events

- Apr – May 2017 - 6 Week NRC Inspection at LaSalle Station
- Jun 28 2017 – NRC Holds Public / Web Meeting at Rockville Headquarters
- July 8 2017 – Flowserve Issues 10CFR Part 21 Update
- NEI with Exelon Executive Sponsorship has lead for coordinating US Nuclear Industry Response
- BWROG has lead for developing detailed risk based recommendations and schedule to resolve perceived safety issue. Rev.4 to be issued by August 31 2017.
- NEI is working with affected utility execs to commit to BWROG Recommended Repairs and schedule for High Risk Susceptible MOVs by Aug 31 2017.

BWROG Topical Report TP-16-1-112 Rev.4 (Aug 31 2017)

Revision 4 Update

In July 2017, Flowserve issued a letter to the NRC which provided an update to the original February 2013 10CFR21 notification based on the additional insights and information gained from the engineering failure analysis of the LaSalle HPCS MOV (Feb 2017). This analysis showed that limitations of the pressed-on stem collar design played a contributing causal factor leading up to the LaSalle MOV stem-disc separation. The update provides additional scoping criteria and recommendations to address this discovery. The update provides additional guidance regarding stem rotation check methods to ensure they are sufficient accurate, representative and trendable. Flowserve provided a review and endorsement of this update.

New actions from revision 4.

1. Evaluate impact of pressed-on stem collar on possible susceptible MOV scope additions.
2. Schedule applicable safety related MOVs for periodic stem rotation checks in conjunction with periodic verification (diagnostic) testing.
3. Evaluate existing Stem Rotation Check techniques against recommended guidance provided in Attachment 7 (new).
4. Review recommended actions and schedule in Attachment 10 (new) and take appropriate actions.
5. Review changes to configuration control recommendations to prevent reoccurrence.

Timeline – Key Industry and Exelon Events

- Oct 2012 Browns Ferry U1 HPCI Inboard Steam Isolation Valve Leakage (LLRT) Failure
- Feb 2013 Flowserve 10CFR Part 21 notification for Anchor-Darling Double Disc Gate Valves
- Mar 2013 Exelon OPEX Response (Issue Report #1484815) – Fleet Actions
- Apr 2013 BWR Owners Group Topical Report BWROG-TP-13-06 Revision 0
- Dec 2016 BWROG-TP-16-1-112 Revision 1 (incorporated OE into previously BWROG-TP-13-06)
- Feb 2017 LaSalle U2 High Pressure Core Spray Injection valve (2E22-F004) stem-disc separation
- Mar 2017 Exelon Nuclear Event Report (NER) NC-17-008-Y Revision 0
- May 2017 BWROG-TP-16-1-112 Revision 2 (incorporated LaSalle OE)
- Jun 2017 BWROG-TP-16-1-112 Revision 3 (incorporated Flowserve input)
- Jun 2017 Information Notice 2017-03, ADDDGV Wedge Pin and Stem-Disc Separation Failures
- Jun 2017 LaSalle Root-Cause evaluation U2 HPCS Injection valve failure
- Jun 2017 LaSalle Unit 1 HPCS Injection valve (1E22-F004) Inspection and Repair
- Jun 28 '17 NRC Public Meeting on understanding planned industry response
- Jul 8 '17 Flowserve 10CFR Part 21 notification update
- Jul 14 '17 NEI LTR to NRC – NEI plan to coordinate US Industry Response
- Jul 31' 17 NRC LTR to NEI – NRC Expectations for US Response
- Aug 4 '17 NEI LTR to US Nuclear Utilities (2 Tier Response)
- Aug 31 '17 BWROG-TP-16-1-112 Revision 4
- Aug 31 '17 Expected US Utility Commitment Letters to NRC for High Risk Susceptible MOVs

Questions?

