Pelton, David

From: Lefrancois, Mark
Sent: Monday, May 10, 2004 1:35 PM
To: Pelton, David, RI
Cc: Annett, Michael; Rusin, Richard; Wierzbowski, George; Dreyfuss, John
Subject: Root Cause Analysis Report for MSIV Stem Galling

Please find attached the subject report. At your convenience, we are available to discuss any aspect of the MSIV stem galling issue. Note that the file is 1Mb in size, so it should probably be saved outside of the email system.

MSIVRootCause.pdf (1 MB)

Mark LeFrancois,
System Engineering Supervisor, Entergy Northeast Vermont Yankee
Tel 802-451-3058

ROOT CAUSE ANALYSIS REPORT

CR Number: CR-VTY-2004-00955 **Category:** ☐ A ☒ B

Assigned Department: System Engineering

Investigation Team:

Name	Department	Function
Rich Rusin	Components	Sponsor
Michael Annett	System Engineering	Team Leader
Larry Prill	ENNE-JAF- Valve Engineer	Valve Expert
George Short	Training	Team member with MSIV Maintenance Experience and Root Cause expertise
Larry Lukens	Programs	Team Member
Jim Taylor	Technical Support	Mentor

Date Report Completed:
4/8/2004-4/16/2004

☒ **The CR was caused by or identified an equipment/component failure.**
(If YES, complete VYAPF 0009.06 (Equipment Failure Evaluation Checklist) in accordance with Appendix M.)

☒ **The CR involved one or more HU inappropriate acts.**
(If YES, complete VYAPF 0009.05 (ENVY Human Performance Evaluation Form) in accordance with Appendix H.)

Problem Statement:

Investigation following a failed As-found leak rate test during RFO24 found MSIV V2-80B to have a galled stem.

Executive Summary:

During investigation following a failed as-found LRT for MSIV V2-80B, the valve stem was found galled and bound into packing follower. Stem material was raised up due to scoring at the packing spacer and took up clearances between the stem and the packing follower, resulting in binding. There had been metal-to-metal contact between the packing spacer and the valve stem at the "12:00 position" or "top" of stem. The as-found diametrical clearances of V2-80B packing spacer/stuffing box allowed for metal-to-metal

contact at the top of stem. The stuffing box ID is oversized by (0.009 to 0.015) [2.299 as-found; 2.284-2.290 design]. This oversized condition resulted from a maintenance activity performed prior to 1999 when the stuffing box bore was "cleaned up", "honed", or "machined" without adequate control of the work activity. Prior to 1999, the significance of stuffing box clearances was not explicitly documented and may not have been recognized. The failure to recognize the significance of the clearance tolerances within the stuffing box resulted in the valve being reassembled with inadequate clearances. With the excessive clearance between the packing spacer and the stuffing box ID, the clearance between the stem and packing spacer ID is compromised, allowing metal-to-metal contact.

Immediate corrective actions in RFO24 included modification of the stuffing box configuration to utilize a custom fit carbon packing spacer in lieu of the cadmium plated carbon steel standard packing spacer and increased clearances in the backseat and packing follower areas.

Long term corrective actions include development of a MSIV Maintenance Procedure to improve control of the maintenance activity on the MSIVs and ensure configuration control.

Report Narrative:

Description of the Condition.

During investigation following a failed as-found LRT for MSIV V2-80B, the valve stem was found galled and bound into packing follower. Stem material was raised up due to scoring at the packing spacer and took up clearances between the stem and the packing follower, resulting in binding. There had been metal-to-metal contact between the packing spacer and the valve stem at the "12:00 position" or "top" of stem. The as-found diametrical clearances of V2-80B packing spacer/stuffing box allowed for metal-to-metal contact at the top of stem. The stuffing box ID is oversized by (0.009 to 0.015) [2.299 as-found; 2.284-2.290 design]. This oversized condition resulted from a maintenance activity performed prior to 1999 when the stuffing box bore was "cleaned up", "honed", or "machined" without adequate control of the work activity. Prior to 1999, the significance of stuffing box clearances was not explicitly documented and may not have been recognized. The failure to recognize the significance of the clearance tolerances within the stuffing box resulted in the valve being reassembled with inadequate clearances. With the excessive clearance between the packing spacer and the stuffing box ID, the clearance between the stem and packing spacer ID is compromised, allowing metal-to-metal contact.

Barrier Analysis:

A barrier analysis (see Attachment A) was performed. The following barriers which should have prevented this condition failed:

Existing proceduralized Packing Guideline (OP 5281) is too generic to address specific requirements for the MSIVs. For example, stuffing box dimensional checks are measured in inches as opposed to the nearest 0.001" and necessary stem centering/alignment techniques during valve packing are not addressed.

The work control process failed to control the work activity that resulted in the oversized stuffing box bore. This oversized condition resulted from maintenance activity performed prior to and during RFO19 (1998). Stuffing box wear and dimensional information was not obtained from the Vendor until the 1999 RFO when the 80A,D and 86 A,D valves were refurbished.

The corrective action program failed as the galling which occurred in 1998 was identified as due to excessive clearance between the stuffing box bore and the packing junk ring (at that time, it was because the junk ring was under sized). The corrective actions in 1998 did not address the stem galling, but were instead simply focused on restoring the valve to pass the LLRT. The stem was replaced, but no actions were developed to prevent recurrence.

The design change process utilized in 1989 when the packing configuration was changed failed to incorporate guidance from the vendor that the stuffing box dimensional clearances should be verified.

A timeline of the events is provided as Attachment B.

Interviews:

Interviews were conducted with the RFO24 Day and Night leads and the mechanic responsible for disassembly of the MSIVs. These individuals have been involved with maintenance of the MSIVs for the full span of the timeline since before 1998 to the present and have significant expertise on the subject valves. The interviewees were forthcoming and showed a very positive effort to determine the cause of the condition.

The most significant result of the interviews was a confidence that the as-found condition of the valve was not the result of actuator/valve misalignment. The descriptions of the methods to disassemble, the results of feeler gauge inspections of actuator feet, and the lack of any cold spring in the stems upon decoupling provided this confidence. The interviews also provided insights into methods and processes utilized to ensure alignment which are not necessarily documented in procedure, but have evolved over time.

Important data from the Related Condition/OE Search

In summary, the OE suggests that other plants also have MSIVs with tight tolerances and our peers highlighted the fact that valve/actuator alignment is critical to ensuring score-free operation. Alignment means actuator/valve stem alignment, bonnet centering, valve stem/disc/body bore alignment, verifying body bore concentricity, verifying stem clearances in the stuffing box, backseat, and packing follower. Most plants using the Rockwell Edwards Y-pattern globe valve still use the cadmium plated carbon steel packing spacer.

Equipment Failure Evaluation

The key insights from the Equipment Failure Evaluation are detailed below.

1. A deficiency in past maintenance was identified where the stuffing box bore was machined without adequate control of the activity. The resulting oversized bore in the valve bonnet allowed for metal-to-metal contact of the packing spacer to the valve stem.

2. Previous corrective actions associated with a stem galling event (CR-VTY-1998-00476) did not adequately address actions to prevent recurrence. The CR resolution focused on resolution of the leak rate failure problem.

3. Current work practices are not proceduralized and rely heavily on the experience and skill of the craft and may allow for excessive discretion of the craftsman and/or supervisor and may require personal familiarity with the specific attributes of particular valves to ensure adequate alignment and assembly (i.e. bonnet centering, stem centering, and valve packing techniques.)

4. There are design deficiencies which contribute to the failure including certain valves have conditions which are outside design tolerances. These conditions are not reflected on controlled drawings. The valve vendor has reviewed conditions outside of tolerance (not the stuffing box bore, however) and has accepted it, but the deviations are not reflected on controlled documents. Maintenance has developed work-arounds to cope with certain conditions (Bonnet centering using dial indicators where the bonnet rabbet fit is outside of design tolerances.)

Root Cause of the Condition:

RC-1 – [J.1.e.1] Risks and consequences associated with change not adequately reviewed or assessed.
(Corrective Maintenance)
Prior to 1999, when the V2-80B stuffing box was "cleaned up" or "honed", the stuffing box dimensions were not verified to check the packing/stuffing box clearance against design allowables. The significance of the tolerance in this

area was not recognized. The oversized condition allowed the packing spacer to contact the stem leading to stem galling and ultimately to binding. There was an opportunity to verify that the stuffing box dimensions were correct in 1989 (VYV-89-201), when the packing configuration was changed. At that time, the vendor had advised that the stuffing box dimensions should be verified.

Contributing Cause(s)

CC-1 [N.2.v.2] Not per design fabrication.
(Manufacturing)
The bonnet rabbet clearances are not within vendor specifications for all of the valves. This condition creates the need for special alignment techniques using dial indicators to ensure that the bonnet is centered. These techniques are not proceduralized, but are performed in the field. This condition can lead to scoring on the top of the valve stem at the bonnet bore/backseat location similar to that found on V2-80A and V2-86D. Additionally, the V2-80B valve stem (design 1.498-1.500 inch dia.) was 0.001 inch oversized. By design, there is only 0.001 inch of radial clearance between the packing spacer and the stem if the stem is 1.500 inches and the spacer is located at an extreme end of the stuffing box. This made the available radial clearance even if the stuffing box bore was correct only 0.0005 inches.

CC-2 [L.2.a.2] Causes of a known problem were not determined.
(Corrective Action)
No CR was generated in 1998 to specifically address the galling problem with the V2-80B valve.

The CR generated in 1998 (CR-VTY-1998-00476) to address the failure of V2-80B to pass it's As-Found leak rate test briefly discussed the stem galling problem with the valve but focused primarily on the failed leak rate corrective actions.

Response to Specific CRG Instructions/Additional Considerations:

N/A

Extent of Condition:

Effects on Equipment:
The condition associated with the over-bored stuffing box may impact any of the eight MSIVs at ENVY. Including V2-80B, five of the valve stuffing boxes have been inspected during RFO24. No others had the overbore to the extent of V2-80B. V2-86C was 0.002 oversized at the top, but this condition should not adversely affect the stem as the bottom of the box is within specification. No scoring was evident on the V2-86C stem. All five valves have been equipped with custom fit packing spacers during RFO24. The other three will be equipped similarly when they are scheduled for repack.

There is no immediate nuclear safety or risk to generation concern associated with this condition for the valves which have not been worked in RFO24, V2-86B, V2-80C, and V2-80D. This modified packing is considered to be an enhancement. Based on document review, none of these three valves is known to have an oversized stuffing box and there is no evident or reported stem scoring on any of these valves.

There are no other large Air-Operated Rockwell-Edwards Y-Pattern Globe valves at ENVY. There are two large Motor-Operated Rockwell-Edwards Y-Pattern Globe valves which may be affected by similar conditions; these are the RHR Outboard Injection Valves V10-27A and V10-27B. A corrective action has been initiated to review the maintenance history of V10-27A, B to ascertain whether there has been stem galling or binding and whether the stuffing box configuration is vulnerable and to review the maintenance processes which would be used to control work activities on these valves to ensure tight tolerances are maintained.

The JAF MSIVs are a similar valve and would be vulnerable to similar conditions. Presently, one JAF MSIV has stem scoring.

Effects upon Processes/programs:

The effected processes include the work control process, the configuration control process, and the corrective action program process. No other processes are impacted. Barriers from each of these three processes should have prevented the stem galling problem described herein. Corrective Actions will address necessary changes to the work control and configuration control processes associated with these valves. The changes to those processes will effectively ensure that the Corrective Action process is invoked when necessary.

Effects upon Human Performance:

The lack of process controls (specific procedures) allowed for errors to be made and go undetected. There was a component of the "Pollyanna" effect where maintenance was conducted without awareness that critical design clearances could be affected. There was lack of a "Questioning Attitude" with respect to work performance which was not controlled in procedure or even in work order step text. Another human factor observation is that when working MSIVs after a failed LLRT, the focus of the team is to correct the leaking valve. Side issues, such as scored stems, have a secondary level of concern. Therefore, the scored stem would tend to be "corrected" by replacement or buffing/polishing and valve reassembly and alignment. The cause of the stem score would tend to go uninvestigated.

Related Operating Experience:

Previous Related Conditions (ENVY):

Identify results of Related Conditions/OE Search (see Appendix O).

CR-VTY-1998-00476 describes a similar galling event associated with V2-80B. In that event, the packing junk ring was found to have been undersized. The same clearance discrepancy which caused this event had cause that event, ie ID of stuffing box to OD of junk ring or packing spacer, resulted in stem galling. A root caused evaluation was performed in 1998 to address the multiple failed leak rate tests, but there were insufficient corrective actions to prevent the stem galling from recurring.

CR-VTY-2004-00918 was initiated during RFO24 to address an adverse trend in ENVY MSIV as-found leak rate test results.

Related Industry OE:

Important data from the Related Condition/OE Search

In summary, the OE suggests that other plants also have MSIVs with tight tolerances and our peers highlighted the fact that valve/actuator alignment is critical to ensuring score-free operation. See Attachment G.

Corrective Actions:

Immediate/Interim Actions Completed	
Item #	Action Taken
N/A	Initiated the planned contingency diagnostic inspection/repair/refurbish plan for valves failing LLRT. WO 04-001270-000 for V2-80B
CC-1	Install custom packing spacers (Carbon) in accordance with WOSE 2004-030 which include specific clearance tolerance for as-built/as-found stem and stuffing box dimensions on valves which are worked during RFO24.
NN	Nuclear Network entry # OE18258 was submitted. (CR-VTY-2004-00955 CA CA00002)

Proposed/Assigned Corrective Actions					
Item #	Action	CA Type	Assigned Department	Due Date	CA #
RC-1 CC-1 CC-2	Develop a controlled MSIV maintenance procedure that adequately describes the required as-found dimensions, the acceptance criteria for the dimensions, the action required for out-of-tolerance dimensions, the disassembly process, the refurbishment process, the reassembly process, and the post-maintenance test requirements and acceptance criteria. This procedure will address both packing and valve internals maintenance. It is intended that this procedure will be a stand-alone reference for all MSIV maintenance work.	LT-CAPR	Maintenance Support	3/31/2005	CR-VTY-2004-00955 CA00004
RC-1 CC-1	Update MSIV drawings, as necessary, to specifically identify critical design dimensions. For example, the bonnet rabbet clearances, the stuffing box clearances, allowed stem diameter, and valve internal dimensions.	LT-CA	Design Engineering	May 30, 2005	CR-VTY-2004-00955 CA00005
CC-1	Initiate WOR to install custom packing spacers (Carbon) in	EN	System Engineering	6/30/2004	CR-VTY-2004-00955 CA00006

Proposed/Assigned Corrective Actions					
Item #	Action	CA Type	Assigned Department	Due Date	CA #
	accordance with WOSE 2004-030 (or equivalent ER) which includes specific clearance tolerance for as-built stem and stuffing box dimensions on three valves which are not worked during RFO24 (V2-80C, V2-80D, and V2-86B). These upgrades to be installed at the next occasion to repack the valves.				
CC-1	Provide a recommendation to Outage Management specifying recommended scope of work for RFO25 on the three MSIVs not worked during RFO24. This recommendation should be in the form of a memo.	EN	System Engineering	6/30/2004	CR-VTY-2004-00955 CA00007
RC-1 CC-1	Review/document all known deviating conditions for all MSIVs and develop a restoration plan.	EN	System Engineering	12/30/2004	CR-VTY-2004-00955 CA00008
Common	Review the maintenance history of V10-27A, B to ascertain whether there has been stem galling or binding and whether the stuffing box configuration is vulnerable and to review the maintenance processes which would be used to control work activities on these valves to ensure tight tolerances are maintained. Identiy/eview/document all known deviating conditions for these valves, if any, and develop a restoration plan.	EN	System Engineering	12/30/2004	CR-VTY-2004-00955 CA00009
CC-2	Initiate TCR to provide training to Mechanical Maintenance personnel with respect to potential significance of dimensional tolerances which can be impacted by maintenance activity.	EN	System Engineering	6/30/2004	CR-VTY-2004-00955 CA00010
CC2	Initiate TCR to provide training to Engineering population	EN	System Engineering	6/30/2004	CR-VTY-2004-00955 CA00011

Proposed/Assigned Corrective Actions					
Item #	Action	CA Type	Assigned Department	Due Date	CA #
	during ESP cycle training with respect to potential significance of dimensional tolerances which can be impacted by maintenance activity.				

Personnel Interviewed:

Larry Doucette
Rich Booth
John Apostoles
Ron Scherman
Joe Boivin
SL Adams – Flowserve Corporation (Formerly Rockwell Edwards)

Keywords:

Stem Scoring
Stem Galling
MSIV
LLRT

Attachments:

A. Barrier Analysis Worksheet
B. Timeline of Events
C. VYAPF 0009.06 Equipment Failure Evaluation Checklist
D. VYAPF 0009.05 ENVY Human Performance Evaluation Form
E. Sketch of Stuffing Box Configuration which allowed galling
F. Sketch of As-found stem condition
G. Summary of Industry Operating Experience telephone conversations
H. Mechanistic Root Cause Evaluation
I. Independent Peer Review by White Plains Metallurgist
J. Historical MSIV Leak Rate Test Results

Attachment A
BARRIER ANALYSIS WORKSHEET

CONSEQUENCE(S)	BARRIER(S) THAT SHOULD HAVE PRECLUDED	BARRIER ASSESSMENT [WHY THE BARRIER(S) FAILED]
MSIV V-80B stuffing box inside diameter measurement out of tolerance. Reading 2.299 Specification 2.284-2.290	OP-5281 Valve Packing Guidelines	Procedure provides only generic guidelines for measuring and recording stuffing box and packing components. MSIV 80B requires precision measurements to ensure proper fit and clearances. Refer to VYAPF 5281.01
V2-80B packing stuffing box enlarged to larger than design specifications	Work Control Process AP-0168	Specific guidance for packing stuffing box dimensions not included in the work order nor are they recorded in the work order notes. No statement of caution in WO to address the critical nature of packing components dimensions and required clearances.
Corrective action process failed to address and correct V2-80B stem galling.	Corrective action process AP-0009	No corrective action to incorporate 1998 analysis of packing component dimensions, as written in WO notes 98-002519-000, into plant procedures and processes. Corrective actions focused on LLRT failure not stem galling issue. 1998 failure similar in nature to current 2004 failure.
Failure to recognize the significance of tight stuffing box and packing spacer clearances	Plant Drawing 5920-2038 Work order process AP-0168, Plant procedure OP-5281	Best estimate of time stuffing box for V2-80B was oversized is prior to 1999. Method used to clean out stuffing box not identified in a work order, and not included in the work order notes. Hand written drawing used to identify components and clearances instead of using

CONSEQUENCE(S)	BARRIER(S) THAT SHOULD HAVE PRECLUDED	BARRIER ASSESSMENT [WHY THE BARRIER(S) FAILED]
		proper drawings. Packing done in accordance with OP-5281 which is generic in nature.
Risks and consequences associated with change not adequately reviewed or assessed	Corrective action program AP-0009	Out of specification (Bore diameter 2.299 instead of 2.284-2.290 not entered into the corrective action program i.e. corrective action not utilized eliminating best chance of evaluating risks earlier.
Risks and consequences associated with change not adequately reviewed or assessed	OP-5281/Work order process	Procedural guidance in OP 5281 does not specifically address MSIV packing component dimensions and allowable clearances. Additionally it does not discuss the potential consequences of improper clearances. Also Work Orders regarding MSIV repacking do not identify dimensions or consequences associated with out of specification measurements. Work orders step text refers back to OP-5281 and VYEM-0079
Risks and consequences associated with change not adequately reviewed or assessed	Communications; Verbal and written	Direction to clean stuffing box by mechanical means done verbally by project lead to mechanic. Communication based on no formal written communication e.g. procedure, work order. Discussion of change in stuffing box inside diameter and associated consequences of that change not discussed. Additionally no formal written communication

CONSEQUENCE(S)	BARRIER(S) THAT SHOULD HAVE PRECLUDED	BARRIER ASSESSMENT [WHY THE BARRIER(S) FAILED]
		exists to identify processed used and before and after dimensions. Investigation of event revealed hand written notes done by project supervisor and interview with individual. Action considered skill of the craft without consideration of clearance dimensions.
Failure to recognize the significance of tight stuffing box and packing spacer clearances	1989 Design Change process when packing configuration was changed.	Vendor recommended verifying stuffing box dimensions, suggesting that cleaning out box tends to open up tolerances over time. There is no evidence that this recommendation was heeded.
(List one at a time; Need not be in sequential order.)	(Identify all applicable Physical and Administrative barriers for each consequence.)	(Identify if barrier was missing, weak, or ineffective and why.)

Attachment B

Event Time Line

At time of modifying the valve packing configuration, vendor provides advice that verifying the dimensions of the stuffing box bore is important as the bore can become oversized over time as box is cleaned out.	10/25/1989
V2-80B Fails As-Found Local Leak Rate test (CR-VTY-1998-00476)	3/22/1998
V2-80B has stem galling attributed to junk ring out of tolerance allowing junk ring contact with stem. (OD of junk Ring small) (98-002519-000)	3/23/1998
Stuffing Box machined such that ID is over-sized	~3/23/1998
V2-80B Fails As-Found Local Leak Rate test (CR-VTY-2002-02211)	10/07/2002
Valve repaired under WO 01-004406-000, stem reported in good condition, no scoring, installed new packing spacer	10/8/2002-10/13/2002
V2-80B Fails As-Left Local Leak Rate test CR-VTY-2002-02503)	~10/14/2002
Valve repaired under WO 01-004406-004, including replacing stem	10/16/02 – 10/20/2002
Valve identified to have scoring evident (CR-VTY-2003-02165)	10/1/2003
Failed As-Found Leak Rate Test (CR-VTY-2004-00841)	4/5/2004
Stem Bound in Packing Follower (CR-VTY-2004-00955)	Reported 4/8/2004

Attachment C
ENVY EQUIPMENT FAILURE EVALUATION CHECKLIST

CR No: CR-VTY-2004-00955	Dispositioning Dept: System Engineering

Equipment/Component Being Evaluated: Main Steam Isolation Valve V2-80B

Item #	Question for Review	Response			Info Included in Disposition Report (initial)
		YES	NO	N/A	
1	Was the equipment failure expected?		X		
2	Had any associated PMs been missed or otherwise delayed?		X		
3	Is there any aspect of the PM Program that appears to be inadequate?		X		
4	Are there deficiencies in the performance of past maintenance?	X			MGA
5	Are there system or component Performance Monitoring deficiencies?		X		
6	Does any OE exist that is applicable to this component?	X			MGA
7	Does any associated component OE relate to this type of component failure?	X			MGA
8	Are there any previous corrective actions that appear to have been inadequate?	X			MGA
9	Are there deficiencies in current operating procedures or practices?		X		
10	Are there deficiencies in current maintenance practices/behaviors or in associated training?	X			MGA
11	Does there appear to be any deficiency in design?	X			MGA
12	Is there any concern with quality of parts, shipping, or handling?		X		
13	Does this appear to be a Maintenance Rule Functional Failure?	X			MGA

Evaluation Completed By: Michael Annett	Date: 4/16/2004

ENVY HUMAN PERFORMANCE EVALUATION FORM

CR No: CR-VTY-2004-00955	Dispositioning Dept: System Engineering
	Cause Department: Maintenance

Applicable HU TRAPs:

- ☐ Time Pressure
- ☐ Distraction/Interruption
- ☐ Multiple Tasks
- ☐ Overconfidence
- ☒ Vague Guidance
- ☐ First Shift/Late Shift
- ☐ Peer Pressure
- ☐ Change/Off-Normal
- ☐ Physical Environment
- ☐ Mental Stress

Description of Inappropriate Act(s):	Assoc Process/Prog/Org Issue(s): __N/A
The stuffing box bore for V2-80B was honed (or otherwise machined) such that the inside diameter was not in conformance with the vendor specified tolerances.	The work activity was not controlled by work order step text or procedure and the significance of the stuffing box clearance tolerances was not recognized. A change was made without recognizing that there was a change or without understanding the significance of the change.

Worker Behaviors:

- ☒ Procedure Use/Adherence
- ☐ Placekeeping
- ☒ Spoken Communication
- ☒ Written Communication
- ☐ Self-Checking
- ☐ Peer Checking
- ☐ Knowledge
- ☐ Skill
- ☐ Fitness for Duty
- ☐ Turnover/Handoff
- ☒ Problem Solving Method

Supervisor Behaviors:

- ☒ Spoken Communication
- ☒ Written Communication
- ☐ Task Allocation
- ☐ Clear Expectations
- ☐ Pre-Job Brief

Management Behaviors:

- ☐ Communications
- ☒ Resource Allocation
- ☒ Change Management
- ☐ Conservative Decision Mkg
- ☐ Scheduling/Sequencing
- ☐ Clear Expectations

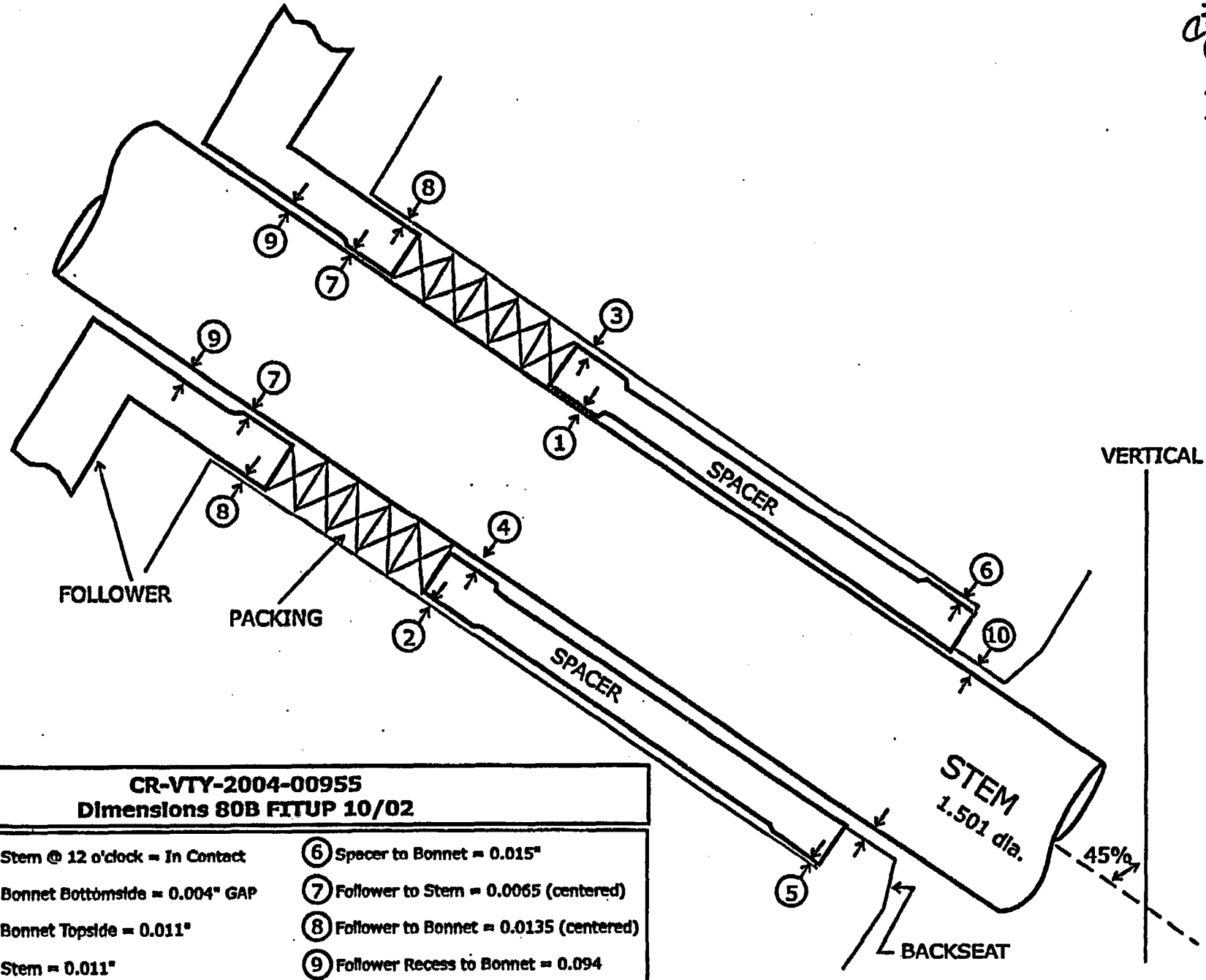
Process/Programmatic/Organizational Issues:

- ☐ Ergonomic/Human Factors
- ☐ Environmental Conditions
- ☐ Housekeeping
- ☐ Equipment Labeling
- ☒ Procedure/Wk Pkg Quality
- ☐ Training

Dispositioner: Michael Annett	Date Completed: 4/17/2004

Attachment E
Sketch of Stuffing Box Configuration which allowed galling

SEE PAGE 17A



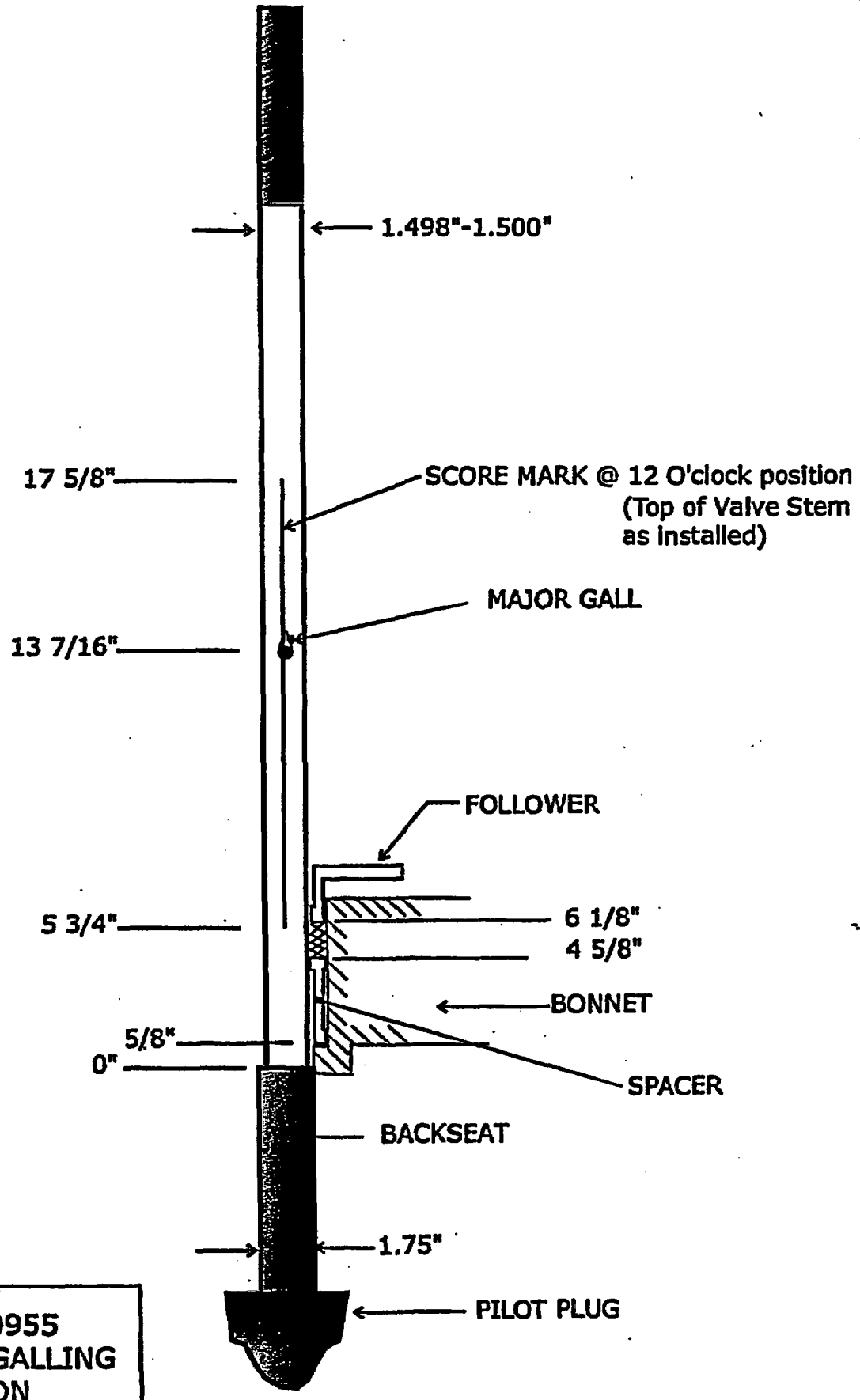
CR-VTY-2004-00955
Dimensions 80B FITUP 10/02

(1) Spacer to Stem @ 12 o'clock = In Contact	(6) Spacer to Bonnet = 0.015"
(2) Spacer to Bonnet Bottomside = 0.004" GAP	(7) Follower to Stem = 0.0065 (centered)
(3) Spacer to Bonnet Topside = 0.011"	(8) Follower to Bonnet = 0.0135 (centered)
(4) Spacer to Stem = 0.011"	(9) Follower Recess to Bonnet = 0.094
(5) Spacer to Bonnet = In Contact	(10) Bonnet to Stem = 0.045

Attachment F
Sketch of As-found stem condition

SEE PAGE 18A

PAGE 18A



CR-VTY-2004-0955
V2-80B STEM GALLING
CONFIGURATION

Attachment G
Summary of Operating Experience Telephone Conversations:

Operating Experience concerning MSIV packing and stem galling.

04/13/04
Susquehanna 1 / 2 - Steve Kartchner (Main Steam System Engineer) ph 570-542-3196
These plants use Atwood-Morrill MSIVs. They have 2 inch stems. The packing configuration is a 3 inch stellite bushing having 0.018 inch diametrical clearance to the stem, 2.5 inch carbon bushing, 5 ring square ring graphite stack (Argo packing), 1 inch carbon bushing and then the follower. The bushings have standard Argo clearances which are:

1) for <2 inch stems 0.010+/- .003 both inside (stem) and outside (stuffing box)
2) for >= 2 inch stems 0.010+/- .003 for stem and 0.015+/-.003 for the stuffing box

They had a recent problem with stem galling caused by gross actuator misalignment- the stems were side loaded enough to contact the stellite bushing and became galled. The actuators were not properly aligned upon assembly. The carbon bushings were pressed to the side of the stuffing box and had to be chipped out. They are generally pleased with the performance of this packing arrangement and intend to continue with it. Steve believed that the close tolerance stellite bushing was required by design (GE Design Spec) and the basis for it was stem buckling when the stem was loaded forcing the plug into the seat.

Brian Willy- AOV Engineer and packing expert- Susquehanna (ph x3809). The best ARGO product to address unevenness in the bottom of the stuffing box is a 1/16 thick graphite gasket-washer. It is soft enough to accommodate stress risers and small enough so that if it gets wasted away the live-load is not totally lost. He validated the ARGO carbon bushing sizing.

04/13/04
Duane Arnold, Eric Sorenson, ph 319-851-7469 Project Engineer MSIVs. They have the same Rockwell-Edwards y-globe valves as VY. Their stems are 1.5 inch. The dimensional info is the same as VY.
Stems are 17-4 PH and design size is 1.492 to 1.500 OD, stuffing box is 2.285-2.290 ID, junk ring spacer is 2.282-2.284 OD and 1.510-1.512 ID. Backseat bore is 1.590-1.595 ID (was opened up), packing follower is 1.510-1.512 ID.
They installed new bonnets in 1990 and the stuffing box depth was shallower due to having to accommodate only one set of packing. Their junk ring is only 0.4 inch in height. They pack the valves with Garlock G700 square graphite rings. If the bonnet rabbit fitup becomes loose beyond design tolerance they weld buildup the bonnet to restore tolerances.

04/13/04
Brunswick, Boyd Stanley, Main Steam System Engineer, ph 910-457-2386.
Brunswick has Rockwell-Edwards y globe MSIVs with 2 inch stems. The packing is 3.04 OD and 2.00 ID, they use a 5 ring square shaped graphite dieformed stack precompressed to 170ft-lb and then left at 40ft-lb final torque. Stem design is 1.999-2.000 OD, stuffing box is 3.040- 3.035 ID. The carbon steel junk ring is 3.032-3.034 OD and 2.20-2.10 ID. The metal junk ring section is the same I shape as the VY design (having the inside lower leg missing). They have experienced stem galling which was caused by a metal washer located in the bottom of the stuffing box below the junk ring. The gland follower ID is 2.012-2.020.

04/14/04
Nine Mile Point, Steve Heimewitz, Valve Engineering (ph 315-349-4702)
Nine Mile Point Unit 2 utilizes Rockwell-Edwards Y-globe valves for their MSIVs. They utilize the Edwards provided cadmium plated Carbon Steel packing spacer and have had no stem scoring issues. Steve did not have the specific stuffing box clearance information, but believed that the clearances for ENVY were quite tight compared to NMP. NMP uses ARGO packing in their MSIVs.

Attachment H
Mechanistic Root Cause Evaluation

A dimensional analysis was performed on the V2-80B valve packing subcomponents including the design specifications for the subcomponents. Field dimensional data for valves V2-86C and V2-86D was included in the analysis for comparison value.

Valve packing subcomponents as-found dimensional data is summarized below.

	Packing Spacer ID	Packing Spacer OD	Stuffing Box ID	Backseat Bore ID	Packing Gland ID	Stem OD (proc. says 1.492-1.500)
Design Dimension	1.510-1.512	2.282- 2.284	2.285- 2.290	1.590	1.510-1.512	1.498-1.500
V2-80B	1.514	2.285 top 2.283 bottom	2.299	1.590 AL 1.533 AF	1.517	1.501
V2-86C	1.515	2.284 top 2.286 bottom	2.292 top 2.290 bottom	1.590	1.516	1.497-1.499
V2-86D	1.516	2.278 top 2.284 bottom	2.290 top 2.289 bottom	1.548 AF 1.5905 AL	1.5125	1.497
V2-80A	Not Taken	2.282 top 2.284 bottom	2.290 top 2.287 bottom	1.525 AF 1.592 AL	1.516	1.4995
V2-86A	Not Taken	Not Taken	2.289 top 2.288 bottom	1.592 AL	1.527 AL	1.500

Performing a dimensional evaluation of the V2-80B packing subcomponents in the as-left condition from the October 2002 repacking, the following is evident- see attached drawing of MSIV stuffing box-Attachment E.

The 80B stem material is 17-4 PH stainless steel whose hardness value is approximately Rockwell C 34-36. The packing spacer is carbon steel A105-cadmium plated. The hardness of the packing spacer (A 105) is approximately HB 187 corresponding to a Rockwell B of 91 which is softer than the stem. The silver cadmium plating is relatively soft compared to the stem. The packing follower is made of ASTM A331 GR4140HT which is as hard or harder than the stem depending on the specific heat treatment.

During the first 6-8 strokes of the valve following the repack, the stem was rubbing off the cadmium coating and the carbon steel spacer and thus, when observed by the VY Valve Engineer at 20% power during plant startup, no galling was indicated. The 80B valve was stroked for Tech Spec Surveillances each quarter and stem scoring noted during a Oct 2003 shutdown. The rubbing and friction between the carbon steel spacer and the stainless stem resulted in an accumulation of material on the stem. This material builtup in size and by sticking to the stem was transported to the follower and when it exceeded the radial clearance (.005inch) was stopped by the follower. The hardness of the carbon steel was increased by work hardening until it resulted in the observed score

marks on the stem. The scoring accumulated additional material from the stem into the ball of material being held by the follower on the upward stroke and tearing through the spacer on the down stroke. The material from the gall finally wedged between the follower and stem causing the follower to cock grabbing the opposite side of the stem and stopping stem movement. Evaluation of the stem marking/galling of the 80B MSIV stem (see attached drawing- Attachment F) reveals that the gall runs for the approximate distance of the valve stroke (12 inches). From interviews it was established that the score mark was at the 12 o'clock position – top of the stem as installed in the valve.

This evaluation concludes that the 80B stem galling was initiated by the interaction of the packing spacer contacting the valve stem during stroking of the valve due to the ID dimension of the stuffing box being oversize out of specification.