ASME Valve & Pump Symposium 2025
Mandatory Appendix IV Implementation

Chuck Linden – AOV Program Engineer
Palo Verde Generating Station

PaloVerde™ GENERATING STATION

AGENDA

- Background
- Mandatory Appendix IV OM-2022
- Implementation of Appendix IV at PVNGS
- Path Forward

Background

AOV Programs in the industry previously implemented by the nuclear industry under **INPO Document NX-1018, Revision 1** titled **Joint Owners Group (JOG)** Air Operated Valve Program. This document predates the 2017 version of the initial OM Code which requires for Air Operated Valves discussed in Mandatory Appendix IV Preservice and Inservice Testing of Active Pneumatically Operated Valve Assemblies in Nuclear Reactor Power Plants.

EPRI Technical Report 30030112918, ASME Operation and Mandatory Code: Mandatory Appendix IV Implementation Guide was issued in 2019 states that plants, which was voluntarily implemented under INPO Document NX-1018 have already completed much of the effort required to meet Appendix IV. AOV Programs previously established under INPO Document NX-1018 should only require some administrative changes to procedures and enhancements for analysis and evaluation processes to meet the code requirements which is in progress at Palo Verde Generating Station.

Mandatory Appendix IV is required by 10 CFR 50.55a Codes and Standards invoking Mandatory Appendix IV. Implementation of Mandatory Appendix IV will be required during the ASME 10-year OM Code update for Palo Verde Generating Station in 2028.

Mandatory Appendix IV

IV-3820 Risk-Informed Methodology

- AOVs shall be evaluated and categorized using a documented Risk Ranking Methodology.
- Subsection ISTE provides an acceptable methodology for Risk Ranking.
- Utilities should have developed Risk Ranking for their AOV Programs as defined by the INPO Document NX-1018 titled AOV Joint Owners Group Document.

Note:

Risk Ranking is the ***Foundation*** for meeting the requirements for Mandatory Appendix IV to have a successful AOV Program.

Mandatory Appendix IV

IV-3821 High Safety Significant Components (HSSC)

- AOVs classified as HSSCs require **Performance Assessment Testing** to assess functional margin
- The AOV JOG Document defines HSSCs as Category 1 AOVs which meets the requirements for Risk-Ranking methodology.
- IV-3410 states PAT shall be performed within three refueling cycles or 5 years, which ever is longer following implementation of Appendix IV for pre-2000 plants.
- IV-3410 states PAT shall be performed for post-2000 plants prior to plant startup or during plant startup activates.

Mandatory Appendix IV

Requires establishing Performance Assessment Testing (PAT) for Air Operated Valves necessary to evaluate Functional Margin

Functional Margin as defined in IV-2000 Supplemental Definitions

- An increment or percentage by which the AOV is available as tested capability meets or exceeds the thrust/torque load required to operate under worst case conditions.
- Test parameters which may be determined from data obtained during testing and are important to monitor (e.g. tracking and trending) to ensure functional capability.
- Parameters should include but not limited to are bench set, spring preload, spring rate, full stroke time, valve travel, measured torque or thrust and seat loading.

Mandatory Appendix IV

IV-3410 Performance Assessment Testing (PAT)

- For pre-2000 plants, an initial PAT shall be performed within 3 Refueling Cycles or 5 years which every is longer following implementation of this Appendix to assess Functional Margin. Post 2000 plants shall perform this testing prior to plant startup or during plant startup activities.
- Testing activities that were performed as part of the plant's Legacy AOV Program can be used to satisfy PAT requirements of IV-1400(a).
- PAT is required prior to Maintenance activities concurrently scheduled to support Tracking and Trending.
- The interval for each AOV shall not exceed 10 years.

Mandatory Appendix IV

IV-3000 General Testing Requirements

- Performance Assessment Test
- Stroke Time Test
- Fail Safe Test, if applicable.
- Leak Testing in accordance with ISTC-3600 and ISTC-5000, as applicable
- Position Verification Testing

Note:

PAT will be performed under the Air Operated Valve Program at Palo Verde Generating Station, while the remaining tests are already performed under the current Surveillance Testing Program.

Program Development Plan

- AOV Categorization - Completed
- KVAP 4.3 Software and calculations completed for Category 1 AOVs
- Contracted Kalsi Engineering to revise procedures for data acquisition using Teledyne FS3 diagnostics and performance assessment of test evaluation as discussed in IV-6000.
  - Guidance will be developed to analyze and evaluate the functional margin in accordance with IV-6400
  - The evaluation process will provide reasonable assurance of actuator margin meeting the acceptance criteria at present and during the PAT interval as required by IV-3410. This includes ensuring positive functional margin will be maintained over the next scheduled test interval.
- Installation of KVAP 4.4 is projected by the end of 2025 or early 2026
- Procedures are projected for completion by spring of 2026 to allow for testing administrative processes.
- The process is expected to be operational by the end of 2026 in preparation for implementation of Mandatory Appendix IV.

Questions ????

Pre-Test Information

PRE-TEST INFORMATION

Test type(s)	As Found
System condition during test	Static
Test location	At Valve
Is test for post maintenance only?	N/A
Is test used for Appendix III/Periodic verification? **(Appendix III-3300)**	N/A
Are test conditions sufficient to determine functional margin? **(Appendix III-5200, if Inservice Test)**	N/A
Are test prerequisites and test performance in accordance with plant procedures? **(Appendix III-5100/5400)**	N/A
Are limits and precautions of testing identified? **(Appendix III-5300, if Inservice Test)**	N/A
Is As-Found local leak rate testing (LLRT) required?	N/A
Is As-Left local leak rate testing (LLRT) required?	N/A
Is remote position verification required? **(Appendix III-3300)**	N/A
Is supplemental obturator verification required? **(ISTC-3700)**	N/A
Are additional tests required?	N/A
Is additional test required?	N/A
Stem nut wear evaluation required?	N/A
Other work (Specify in notes below)	N/A
Magnesium rotor inspection required?	N/A

© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

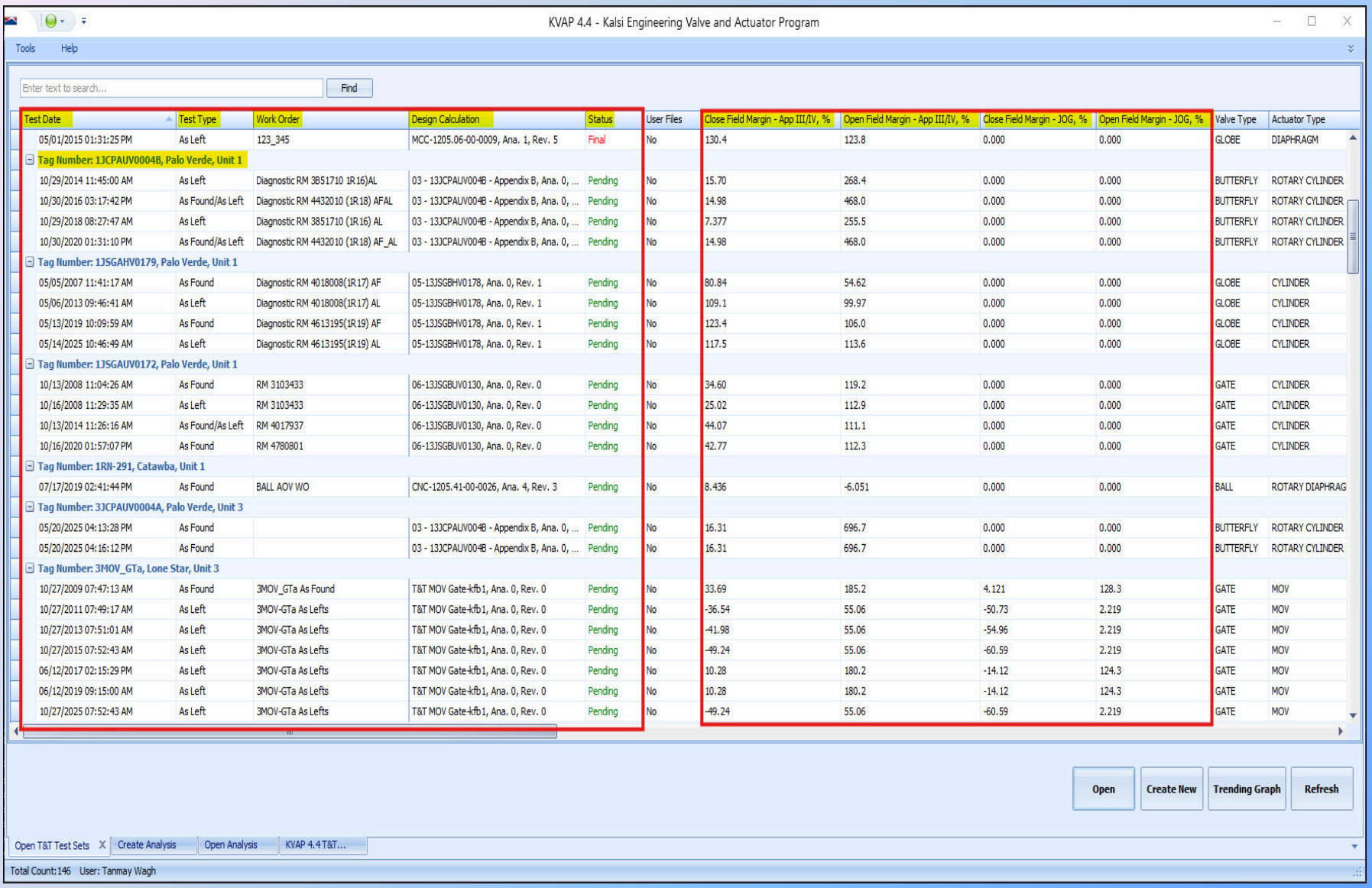
Pre-Test Setup Sheet

AS-FOUND TEST CRITERIA

Parameter	Minimum Required	Measured Data	Maximum Allowed	SAT / UNSAT
Adjusted thrust at CST (close)	3673 lb		NA	SAT UNSAT
Adjusted torque at CST (close)	NA		69.83 ft-lb	SAT UNSAT
Adjusted SP displacement at CST (close)	NA		-3.112E-2 in	SAT UNSAT
Adjusted thrust structural (close)	NA		10331 lb	SAT UNSAT
Adjusted torque structural (close)	NA		271.1 ft-lb	SAT UNSAT
Adjusted SP displacement at structural (close)	NA		9.066E-2 in	SAT UNSAT
Adjusted thrust at unseating (wedge GTs only)	NA		2546 lb	SAT UNSAT
Adjusted torque at unseating	NA		NA	SAT UNSAT
Adjusted SP displacement at unseating	NA		NA	SAT UNSAT
Adjusted running thrust (close)	NA		772.6 lb	SAT UNSAT
Adjusted running thrust (open)	NA		772.6 lb	SAT UNSAT
Adjusted running torque (close)	NA		NA	SAT UNSAT
Adjusted running torque (open)	NA		NA	SAT UNSAT
Stroke time (close)	NA		48.97 secs	SAT UNSAT
Stroke time (open)	NA		48.97 secs	SAT UNSAT
Stem nut clearance time, ZTT (close)	NA		0.3854 secs	SAT UNSAT
Stem nut clearance time, ZTT (open)	NA		0.3854 secs	SAT UNSAT
Stem factor at CST (close)	7.110E-3 ft		1.162E-2 ft	SAT UNSAT
Stem factor (open)	7.110E-3 ft		1.162E-2 ft	SAT UNSAT
Stem COF at CST (close)	0.1000		0.2000	SAT UNSAT
Stem COF (open)	0.1000		0.2000	SAT UNSAT

© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

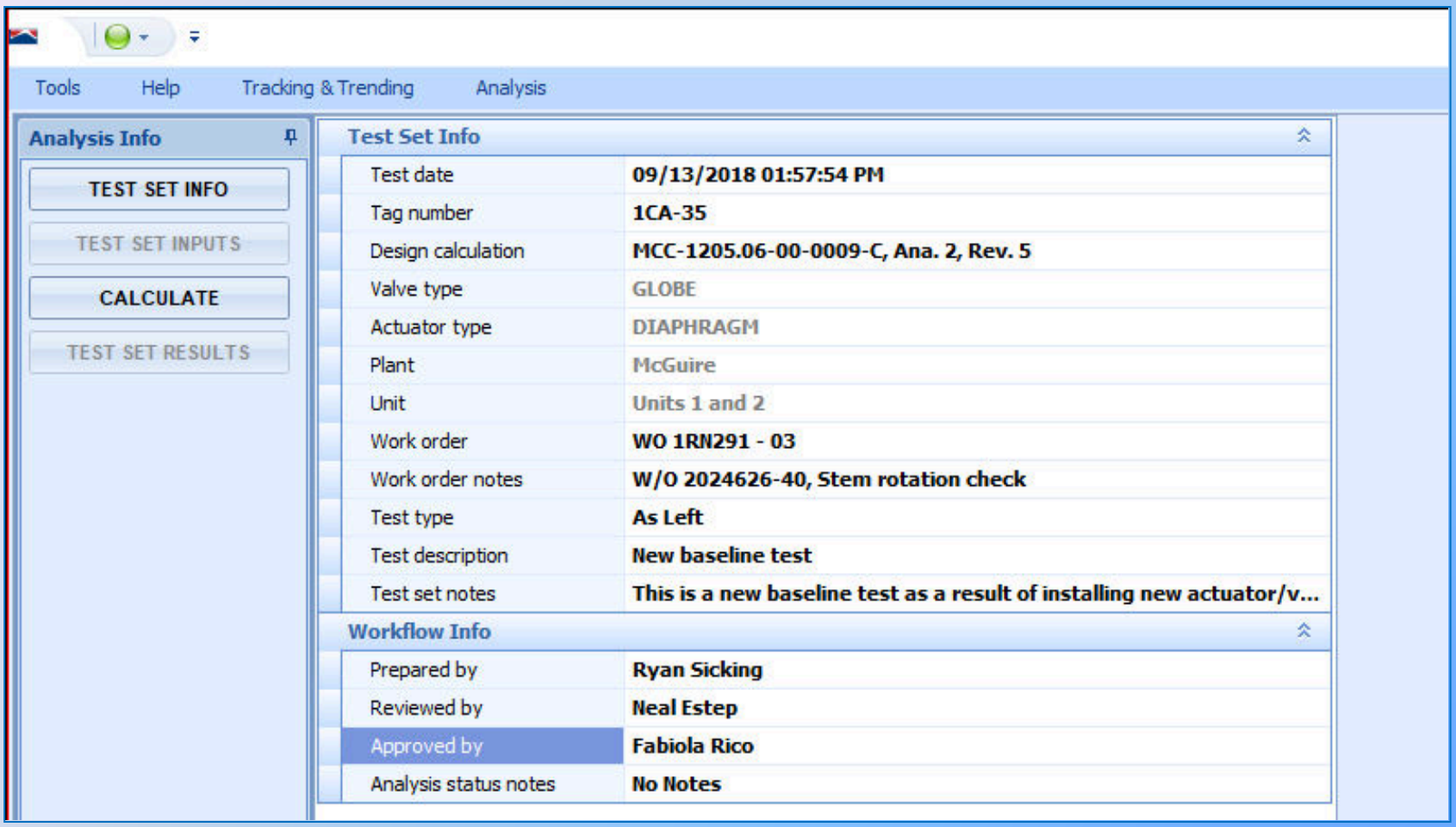
Tracking & Trending New Interface



Test Date	Test Type	Work Order	Design Calculation	Status	User Files	Close Field Margin - App III/IV, %	Open Field Margin - App III/IV, %	Close Field Margin - JOG, %	Open Field Margin - JOG, %	Valve Type	Actuator Type
05/01/2015 01:31:25 PM	As Left	123_345	MCC-1205.06-00-0009, Ana. 1, Rev. 5	Final	No	130.4	123.8	0.000	0.000	GLOBE	DIAPHRAGM
Tag Number: 1JCPAUV0004B, Palo Verde, Unit 1											
10/29/2014 11:45:00 AM	As Left	Diagnostic RM 3B51710 1R16)AL	03 - 13JCPAUV004B - Appendix B, Ana. 0, ...	Pending	No	15.70	268.4	0.000	0.000	BUTTERFLY	ROTARY CYLINDER
10/30/2016 03:17:42 PM	As Found/As Left	Diagnostic RM 4432010 (1R18) AFAL	03 - 13JCPAUV004B - Appendix B, Ana. 0, ...	Pending	No	14.98	468.0	0.000	0.000	BUTTERFLY	ROTARY CYLINDER
10/29/2018 08:27:47 AM	As Left	Diagnostic RM 3851710 (1R16) AL	03 - 13JCPAUV004B - Appendix B, Ana. 0, ...	Pending	No	7.377	255.5	0.000	0.000	BUTTERFLY	ROTARY CYLINDER
10/30/2020 01:31:10 PM	As Found/As Left	Diagnostic RM 4432010 (1R18) AF_AL	03 - 13JCPAUV004B - Appendix B, Ana. 0, ...	Pending	No	14.98	468.0	0.000	0.000	BUTTERFLY	ROTARY CYLINDER
Tag Number: 1JSGAHV0179, Palo Verde, Unit 1											
05/05/2007 11:41:17 AM	As Found	Diagnostic RM 4018008(1R17) AF	05-13JSGBHV0178, Ana. 0, Rev. 1	Pending	No	80.84	54.62	0.000	0.000	GLOBE	CYLINDER
05/06/2013 09:46:41 AM	As Left	Diagnostic RM 4018008(1R17) AL	05-13JSGBHV0178, Ana. 0, Rev. 1	Pending	No	109.1	99.97	0.000	0.000	GLOBE	CYLINDER
05/13/2019 10:09:59 AM	As Found	Diagnostic RM 4613195(1R19) AF	05-13JSGBHV0178, Ana. 0, Rev. 1	Pending	No	123.4	106.0	0.000	0.000	GLOBE	CYLINDER
05/14/2025 10:46:49 AM	As Left	Diagnostic RM 4613195(1R19) AL	05-13JSGBHV0178, Ana. 0, Rev. 1	Pending	No	117.5	113.6	0.000	0.000	GLOBE	CYLINDER
Tag Number: 1JSGAUV0172, Palo Verde, Unit 1											
10/13/2008 11:04:26 AM	As Found	RM 3103433	06-13JSGBUV0130, Ana. 0, Rev. 0	Pending	No	34.60	119.2	0.000	0.000	GATE	CYLINDER
10/16/2008 11:29:35 AM	As Left	RM 3103433	06-13JSGBUV0130, Ana. 0, Rev. 0	Pending	No	25.02	112.9	0.000	0.000	GATE	CYLINDER
10/13/2014 11:26:16 AM	As Found/As Left	RM 4017937	06-13JSGBUV0130, Ana. 0, Rev. 0	Pending	No	44.07	111.1	0.000	0.000	GATE	CYLINDER
10/16/2020 01:57:07 PM	As Found	RM 4780801	06-13JSGBUV0130, Ana. 0, Rev. 0	Pending	No	42.77	112.3	0.000	0.000	GATE	CYLINDER
Tag Number: 1RN-291, Catawba, Unit 1											
07/17/2019 02:41:44 PM	As Found	BALL AOV WO	CNC-1205.41-00-0026, Ana. 4, Rev. 3	Pending	No	8.436	-6.051	0.000	0.000	BALL	ROTARY DIAPHRAG
Tag Number: 3JCPAUV0004A, Palo Verde, Unit 3											
05/20/2025 04:13:28 PM	As Found		03 - 13JCPAUV004B - Appendix B, Ana. 0, ...	Pending	No	16.31	696.7	0.000	0.000	BUTTERFLY	ROTARY CYLINDER
05/20/2025 04:16:12 PM	As Found		03 - 13JCPAUV004B - Appendix B, Ana. 0, ...	Pending	No	16.31	696.7	0.000	0.000	BUTTERFLY	ROTARY CYLINDER
Tag Number: 3MOV_GTa, Lone Star, Unit 3											
10/27/2009 07:47:13 AM	As Found	3MOV_GTa As Found	T&T MOV Gate-kfb1, Ana. 0, Rev. 0	Pending	No	33.69	185.2	4.121	128.3	GATE	MOV
10/27/2011 07:49:17 AM	As Left	3MOV-GTa As Lefts	T&T MOV Gate-kfb1, Ana. 0, Rev. 0	Pending	No	-36.54	55.06	-50.73	2.219	GATE	MOV
10/27/2013 07:51:01 AM	As Left	3MOV-GTa As Lefts	T&T MOV Gate-kfb1, Ana. 0, Rev. 0	Pending	No	-41.98	55.06	-54.96	2.219	GATE	MOV
10/27/2015 07:52:43 AM	As Left	3MOV-GTa As Lefts	T&T MOV Gate-kfb1, Ana. 0, Rev. 0	Pending	No	-49.24	55.06	-60.59	2.219	GATE	MOV
06/12/2017 02:15:29 PM	As Left	3MOV-GTa As Lefts	T&T MOV Gate-kfb1, Ana. 0, Rev. 0	Pending	No	10.28	180.2	-14.12	124.3	GATE	MOV
06/12/2019 09:15:00 AM	As Left	3MOV-GTa As Lefts	T&T MOV Gate-kfb1, Ana. 0, Rev. 0	Pending	No	10.28	180.2	-14.12	124.3	GATE	MOV
10/27/2025 07:52:43 AM	As Left	3MOV-GTa As Lefts	T&T MOV Gate-kfb1, Ana. 0, Rev. 0	Pending	No	-49.24	55.06	-60.59	2.219	GATE	MOV

© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

Tracking & Trending New Interface



© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

Acceptance Criteria & Functional Margin

MOV

TEST SET ACCEPTANCE CRITERIA					
Parameter Name	Design/ Target Value	Minimum	Maximum	Measured Value	Meets Criteria
Stroke time (open), s	37.00	30.00	40.00	0.000	No
Stroke time (close), s	37.00	30.00	40.00	35.00	Yes
Adjusted thrust at unseating (wedge GTs only), lb	-	6000	6773	9500	No
Adjusted torque at unseating, ft-lb	-	40.00	50.89	0.000	No
Adjusted thrust at CST (close), lb	**-**	***10656***	***9566***	***9500***	No
Adjusted torque at CST (close), ft-lb	**-**	***78.74***	***91.33***	***80.00***	***Yes***

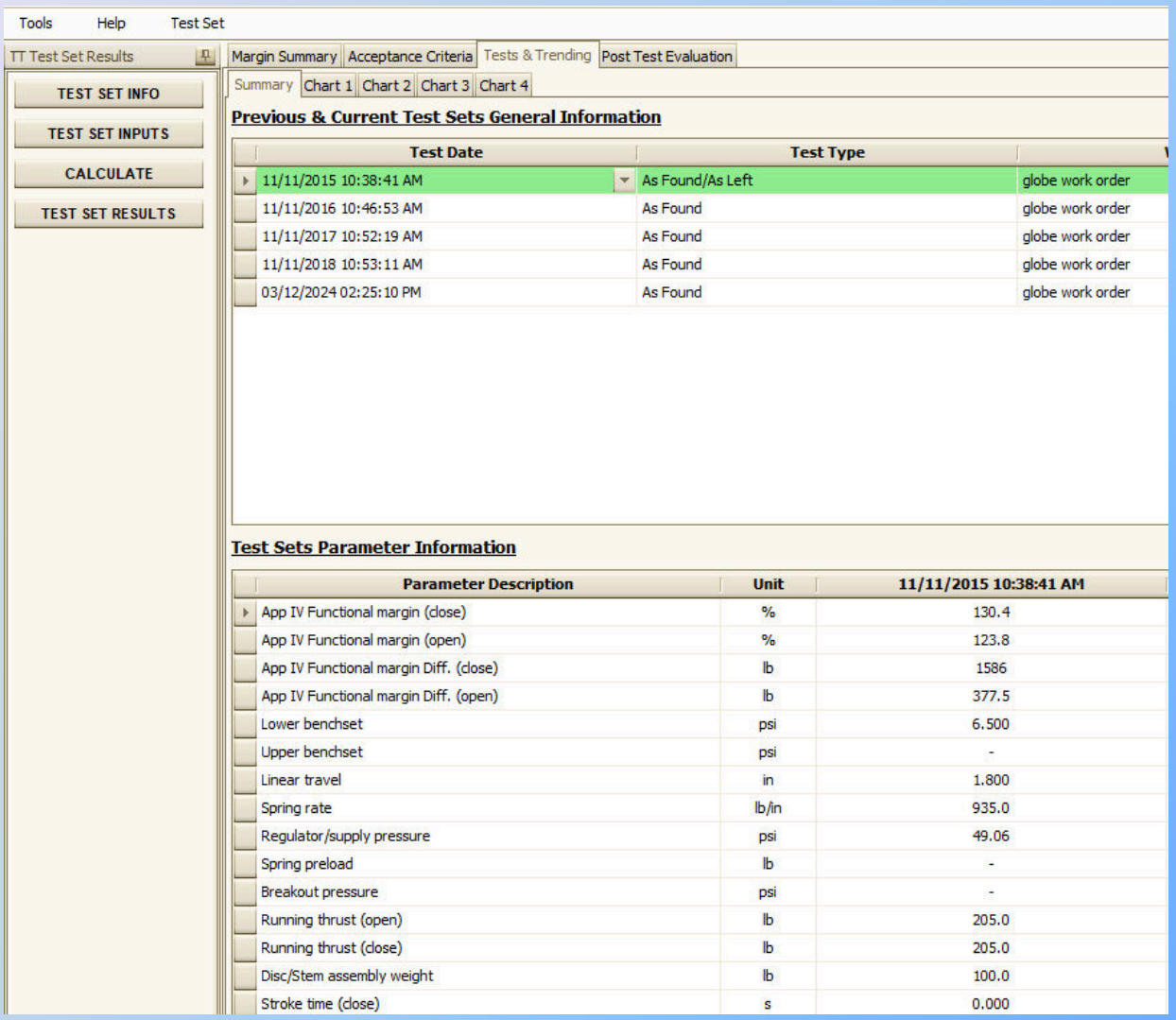
AOV

TEST SET ACCEPTANCE CRITERIA						
Parameter Name	Design/ Target Value	Range-Minimum	Range-Maximum	Measured Value	Uncertainty	Meets Criteria
Lower benchset, psi	***6.500***	***6.500***	***6.500***	***5.000***	***0.000***	No
Linear travel, in	***1.800***	***1.800***	***1.800***	***2.000***	***0.000***	No
Spring rate, lb/in	-	-	-	930.0	0.000	N/A
Regulator/supply pressure, psi	***49.06***	***49.06***	***49.06***	***44.00***	***0.000***	No
Running thrust (open), lb	**-**	***0.000***	***205.0***	***250.0***	***0.000***	No
Running thrust (close), lb	**-**	***0.000***	***205.0***	***200.0***	***0.000***	***Yes***
Disc/Stem assembly weight, lb	***100.0***	**-**	**-**	***80.00***	***0.000***	***N/A***
Stroke time (close), s	-	-	-	0.000	0.000	N/A
*Parameters used in functional margin calculation shown in Bold Italic						

CURRENT TEST FUNCTIONAL MARGIN SUMMARY		
Parameter Name	**Value**	**Notes**
App III Functional margin (close), %	113.9	N/A
App III Functional margin (open), %	578.5	N/A
App III Functional margin Diff. (close), ft-lb	213.0	N/A
App III Functional margin Diff. (open), ft-lb	379.4	N/A

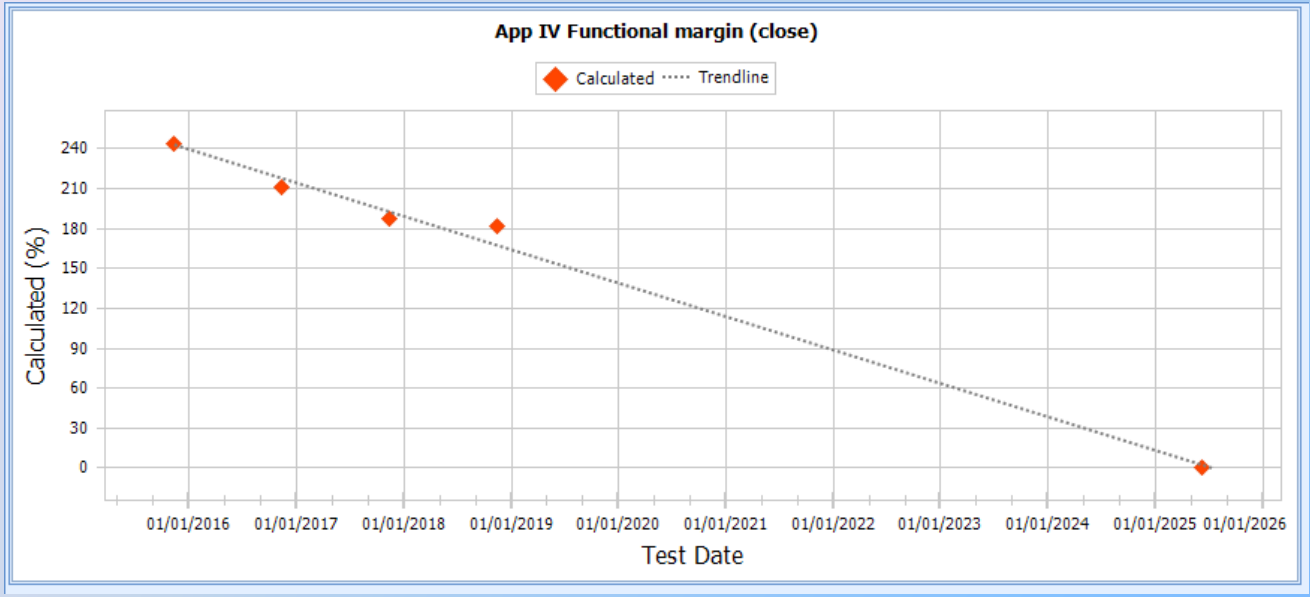
© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

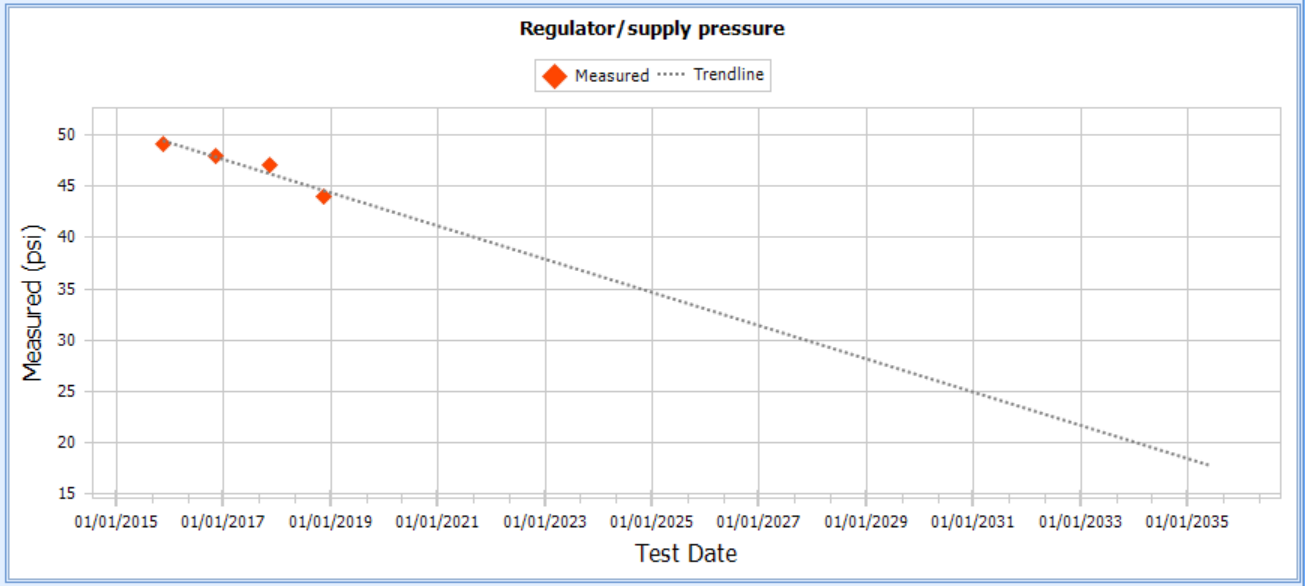
Tracking and Trending



© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

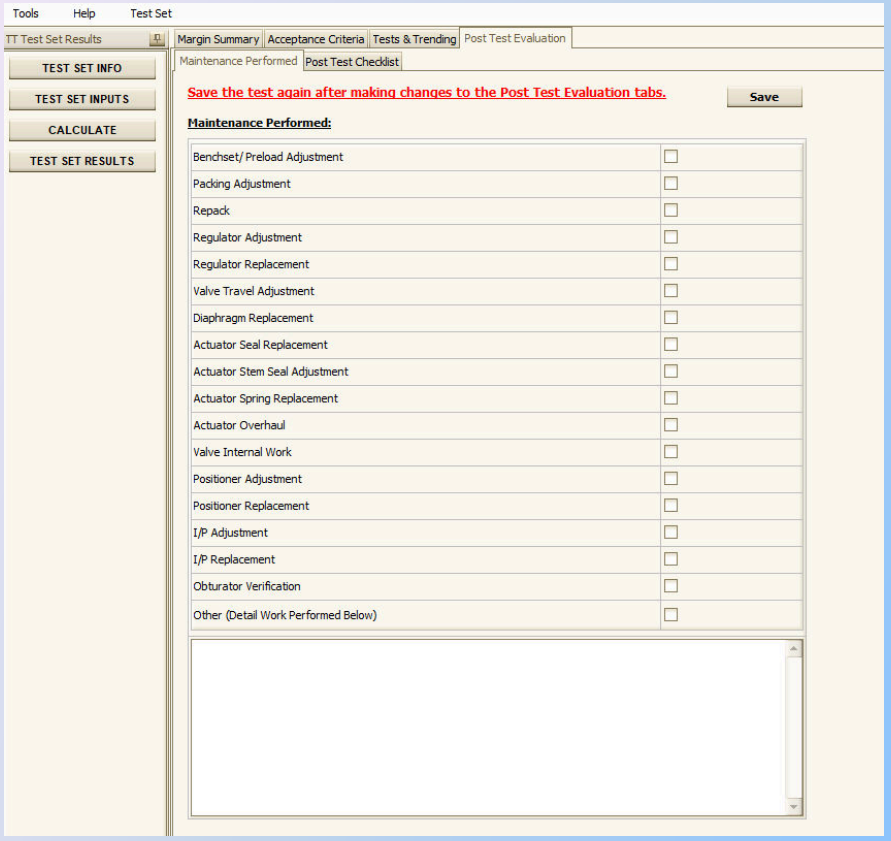
Tracking and Trending

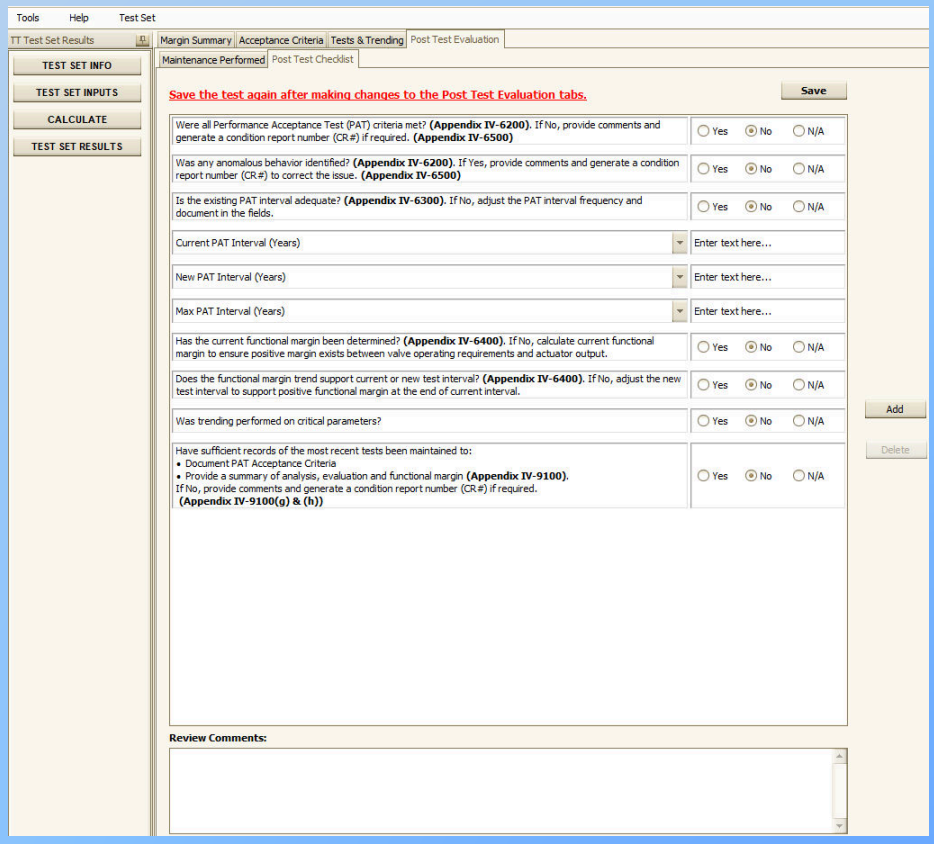




© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

Post Test Evaluation





© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

App. III Post Test Evaluation

Maintenance Performed:
Stem Lube
Packing Adjustment
Repack
Spring Pack Replacement
Close Torque Switch Adjustment
Open Torque Switch Adjustment
Close Limit Switch Adjustment
Open Limit Switch Adjustment
Torque Switch Bypass Adjustment
Remote Position Verification
Stem Thread Cut
Stem Nut Replacement
Actuator Replacement
Actuator Regear
Motor Replacement
Magnesium Rotor Inspection
Other (Detail Work Performed Below)

POST TEST CHECKLIST	
Was all acceptance criteria met? **(Appendix III-6200)**. If No, provide comments and generate a condition report number (CR#) if required. **(Appendix III-6500)**	Yes
Is the existing test interval adequate? **(Appendix III-6300)**. If No, adjust the test interval frequency and document in the fields below.	Yes
Current PAT Interval (Enter in Year or RFO)	2
New PAT Interval (Enter in Year or RFO)	2
Max PAT Interval (Enter in Year or RFO)	2
Has the current functional margin been determined? **(Appendix III-6430)**. If No, calculate current functional margin to ensure positive margin exists between valve operating requirements and actuator output.	Yes
Does the functional margin trend support current or new test interval? **(Appendix III-6440)**. If No, adjust the new test interval to support positive functional margin at the end of current interval.	Yes
Was trending performed of critical parameters?	Yes
Was any anomalous behavior identified? **(Appendix III-6500/9100)**. If Yes, provide comments and generate a condition report number (CR#) to correct issue.	Yes
Have sufficient records of the most recent tests been maintained to satisfy information requirements of **Appendix III-9100 (a) through (j)**? If No, document information requirements as defined in **Appendix III-9100**.	Yes
Test Data/Analysis has been evaluated by qualified individual and independently verified? **(Appendix III-9200)**. If No, test data must be verified by independent reviewer.	Yes

© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information

App. IV Post Test Evaluation

Maintenance Performed:
Benchset/ Preload Adjustment
Packing Adjustment
Repack
Regulator Adjustment
Regulator Replacement
Valve Travel Adjustment
Diaphragm Replacement
Actuator Seal Replacement
Actuator Stem Seal Adjustment
Actuator Spring Replacement
Actuator Overhaul
Valve Internal Work
Positioner Adjustment
Positioner Replacement
I/P Adjustment
I/P Replacement
Obturator Verification
Other (Detail Work Performed Below)

POST TEST CHECKLIST	
Were all Performance Acceptance Test (PAT) criteria met? **(Appendix IV-6200)**. If No, provide comments and generate a condition report number (CR#) if required. **(Appendix IV-6500)**	Yes
Was any anomalous behavior identified? **(Appendix IV-6200)**. If Yes, provide comments and generate a condition report number (CR#) to correct the issue. **(Appendix IV-6500)**	Yes
Is the existing PAT interval adequate? **(Appendix IV-6300)**. If No, adjust the PAT interval frequency and document in the fields below.	Yes
Current PAT Interval (Enter in Year or RFO)	2
New PAT Interval (Enter in Year or RFO)	2
Max PAT Interval (Enter in Year or RFO)	2
Has the current functional margin been determined? **(Appendix IV-6400)**. If No, calculate current functional margin to ensure positive margin exists between valve operating requirements and actuator output.	Yes
Does the functional margin trend support current or new test interval? **(Appendix IV-6400)**. If No, adjust the new test interval to support positive functional margin at the end of current interval.	Yes
Was trending performed on critical parameters?	Yes
Have sufficient records of the most recent tests been maintained to: • Document PAT Acceptance Criteria • Provide a summary of analysis, evaluation and functional margin **(Appendix IV-9100)**. If No, provide comments and generate a condition report number (CR#) if required. **(Appendix IV-9100(g) & (h))**	Yes

© Copyright Kalsi Engineering, Inc. 2025
Proprietary & Confidential Information