Pump and Valve Requirements and Guidance for New Reactors

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Overview

- Lessons learned from motor-operated valve (MOV) issues are applicable to functional design, qualification, and Inservice Testing (IST) programs for all power-operated valves (POVs).
- ASME Standard QME-1 provides improved qualification of pumps, valves, and dynamic restraints (snubbers) as accepted in NRC Regulatory Guide (RG) 1.100, Rev. 3
- ASME Operation and Maintenance (OM) Code provides updated IST provisions for pumps, valves, and snubbers.
- NRC has improved requirements and guidance for functional design, qualification, and IST programs for pumps and valves.

Discussion Topics

I. New Reactor Regulations and Guidance
II. MOV Lessons Learned
III. ASME Standard QME-1
IV. ASME OM Code
V. 10 CFR 50.55a
VI. Vogtle COL Pump and Valve IST Program
VII. New Reactor Inspection Guidance
VIII. Conclusions

I. New Reactor Regulations and Guidance

Regulations for New Reactors

- 10 CFR Part 52 - Design Certification (DC) and Combined License (COL) requirements
- 10 CFR Part 50, App. A and B – General Design Criteria (GDC) and Quality Assurance (QA) criteria
- 10 CFR 50.49 – Electrical Equipment Environmental Qualification
- 10 CFR 50.55a - ASME OM Code IST requirements and regulatory conditions
- 10 CFR 50.69 - Risk-informed treatment approach
- 10 CFR Part 50, Appendix S - Seismic Qualification

10 CFR Part 52

- Design Certification
  - 10 CFR 52.47 requires that information normally contained in procurement specifications be available for NRC audit.
  - 10 CFR 52.47(a)(9) requires DC applications to evaluate design against NRC Standard Review Plan (SRP) in effect 6 months before docket date.
  - 10 CFR 52.47(a)(22) requires DC applications to address operating experience.

- COL application
  - 52.79(a)(11) requires applicant to provide description of programs and implementation necessary to ensure that systems and components meet ASME Boiler & Pressure Vessel (BPV) Code and OM Code per 50.55a
  - 52.79(a)(37) requires application to include information necessary to demonstrate how operating experience has been incorporated into plant design.
  - 52.63(c) requires applicant to have available for audit information contained in procurement specifications.
  - 50.55a(f)(4)(i) requires initial IST program to meet ASME Code incorporated in 50.55a 12 months before fuel loading.

SECY-05-0197

- COL applicants should fully describe Operational Programs to avoid need for Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC).
- Operational Programs should be clearly and sufficiently described in terms of scope and level of detail to allow reasonable assurance finding of acceptability.
- Operational Programs should be described at functional level and increasing level of detail where implementation choices could materially and negatively affect program effectiveness and acceptability.

Operational Programs

- DC Design Control Document (DCD) may provide general information to allow flexibility by COL applicant in developing plant-specific operational programs.
- For DCD, NRC review of preservice testing (PST), IST and MOV Testing programs focuses on design aspects and PST/IST accessibility, and whether program description is acceptable for reference in COL application.
- COL Final Safety Analysis Report (FSAR) needs to support NRC Final Safety Evaluation Report (FSER) conclusion that operational program descriptions provide reasonable assurance of safe plant operation.
- SECY-04-0032 Staff Requirements Memorandum (SRM) on 5/14/2004 directed NRC staff to evaluate completed operational programs as part of inspection activities.

Regulatory Treatment of Non-Safety Systems (RTNSS)

- Nuclear reactors with passive emergency cooling systems (such as AP1000) rely on active nonsafety-related systems for first line of defense.
- SECY-95-132 specifies Commission policy regarding functional design, qualification, and IST of RTNSS pumps and valves.
- NRC staff consolidated RTNSS policy in memorandum dated July 24, 1995.
- NRC staff working with ASME to develop guidance for treatment of RTNSS pumps and valves.

Regulatory Guide 1.206

- RG 1.206 provides guidance for COL applications.
- Section 3.9.6 addresses COL applications referencing standard design for functional design, qualification, and IST programs for pumps, valves, and dynamic restraints.
- RG 1.206 helps to streamline review process for COL applications.
- NRC staff preparing revision to RG 1.206 to incorporate lessons learned from COL application reviews.

NRO Review of Operational Programs

- Evaluate operational programs to extent described in DC applications to ensure consistent with NRC regulations and guidance, and acceptable for incorporation by reference in COL application.
- Determine whether operational programs are fully described in COL applications using applicable SRP sections.
- Provide assistance to Region for NRC inspection of operational programs during plant construction and startup of new nuclear power plants (NPPs).

Standard Review Plan Section 3.9.6 Functional Design, Qualification, and Inservice Testing of Pumps, Valves, and Dynamic Restraints

- Areas of Review:
  - Functional Design and Qualification of Pumps, Valves, and Dynamic Restraints
  - IST for Pumps, Valves, and Dynamic Restraints
  - Relief Requests and Alternatives to ASME OM Code
  - ITAAC
  - COL Action Items and Certification Requirements and Restrictions
  - Operational Program Description and Implementation
- Incorporates lessons learned from operating experience into acceptance criteria for staff review of DC and COL applications.

Regulatory Issue Summary (RIS) 2012-08 (Rev. 1) Developing Inservice Testing and Inservice Inspection Programs Under 10 CFR Part 52

- Describes NRC staff position on IST and inservice inspection (ISI) programs developed for nuclear power plants licensed under 10 CFR Part 52.
- COL holder may request use of ASME OM Code edition referenced in FSAR description of IST program for initial 10-year IST program as 50.55a alternative.
- NRC will evaluate differences between OM Code edition specified in FSAR and most recent edition in 50.55a.
- COL holder or applicant may propose risk-informed IST program, but NRC staff recognizes challenges with no plant-specific component performance history.

NUREG-1482

Guidelines for Inservice Testing at Nuclear Power Plants (Revision 2)

- Describes regulatory basis for IST programs.
- Provides guidance for development of IST programs:
  - Scope
  - IST program documentation
  - Preconditioning
  - Specific valve guidance
  - Specific pump guidance
  - New reactor IST programs
- Future update being considered based on revised ASME OM Code and recent 10 CFR 50.55a rulemaking.

II. MOV Lessons Learned

MOV Operating Experience

- In 1980s, operating experience revealed weaknesses in design, qualification, maintenance, personnel training, and IST for MOVs:
  - Davis Besse Feedwater Failure (IN 85-50)
  - Catawba Auxiliary Feedwater Failure (IN 89-61)
  - Palisades PORV Block Valve Failure (AIT Nov. 1989)
- Research programs by industry and NRC confirmed MOV performance weaknesses.
- NRC initiated regulatory action to address these weaknesses.

Past MOV Issues

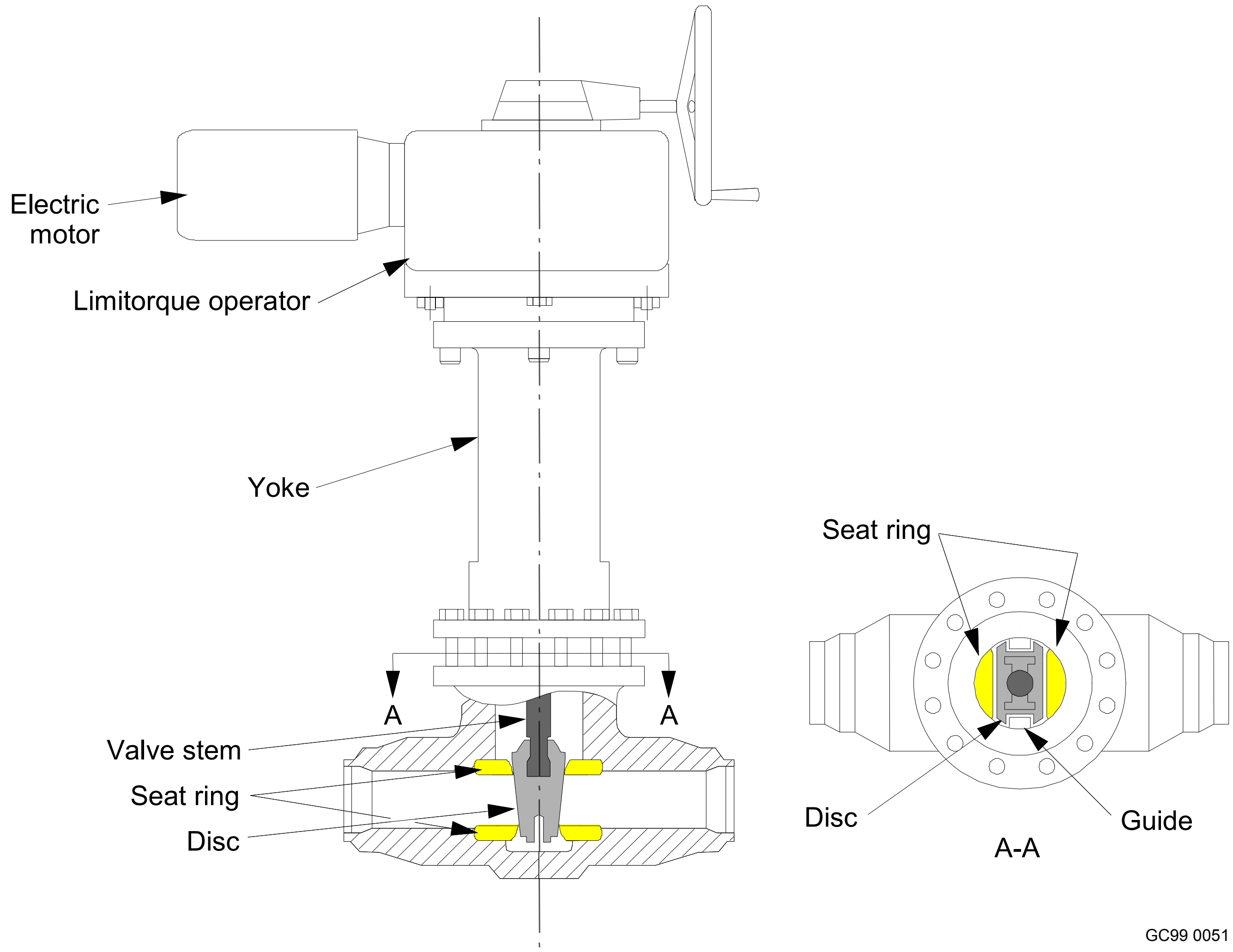
- Underestimation of required valve thrust or torque from assumptions for differential pressure (DP), valve factors, butterfly valve torque coefficients, and unwedging.
- Overestimation of motor actuator thrust or torque output from assumptions for actuator efficiency, degraded voltage effects, ambient temperature effects, stem friction, and load sensitive behavior.
- Potential unpredictability of valve performance under high flow conditions.
- Significant variation in MOV performance.

Past MOV Issues

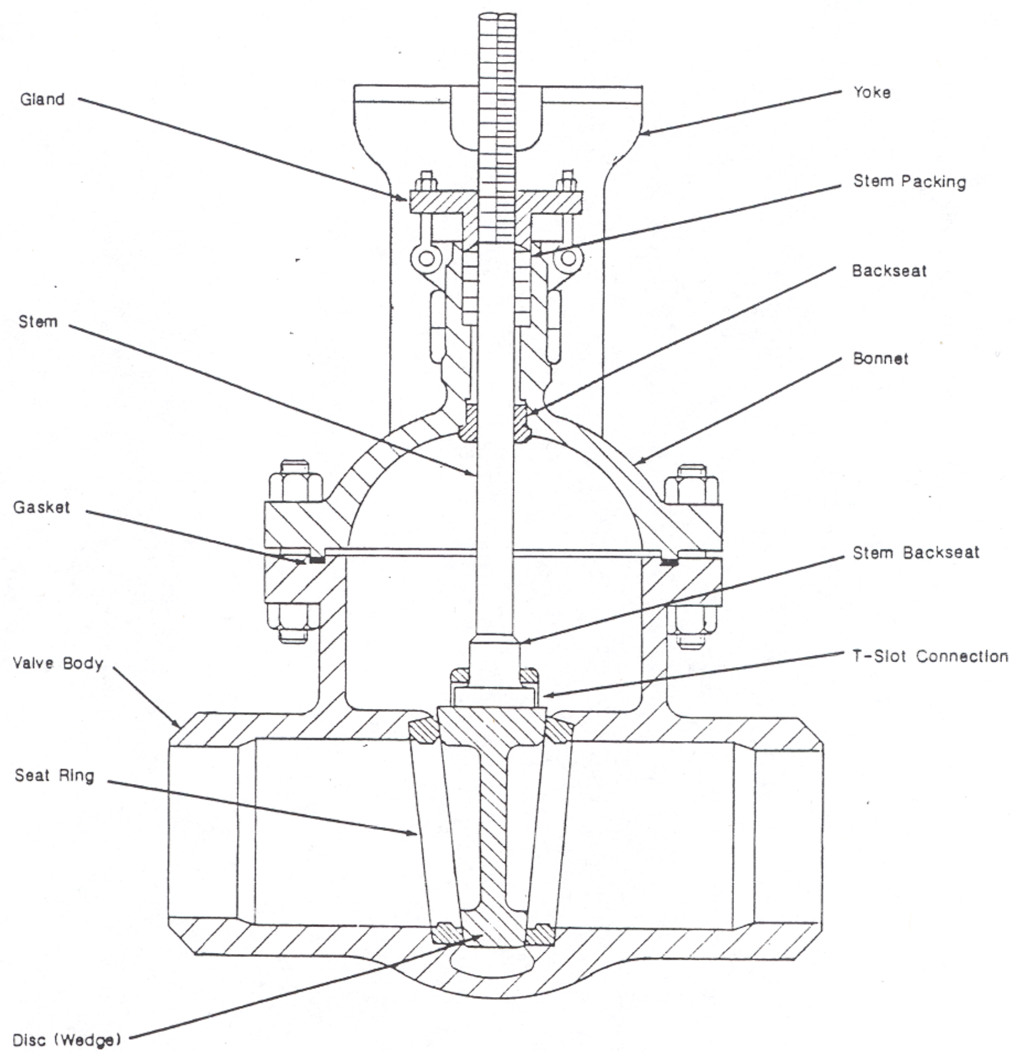
(continued)

- Deficiencies in MOV parts (e.g., torque and limit switches, motor shafts, pinion keys, valve yokes).
- Improper low voltage operation of motor brakes.
- Inadequacies in some MOV diagnostic equipment in accurately measuring thrust and torque.
- Gearbox and spring pack grease hardening.
- Maintenance and training weaknesses.
- Inadequate corrective action.
- MOV magnesium rotor degradation.
- Motor thermal overload.

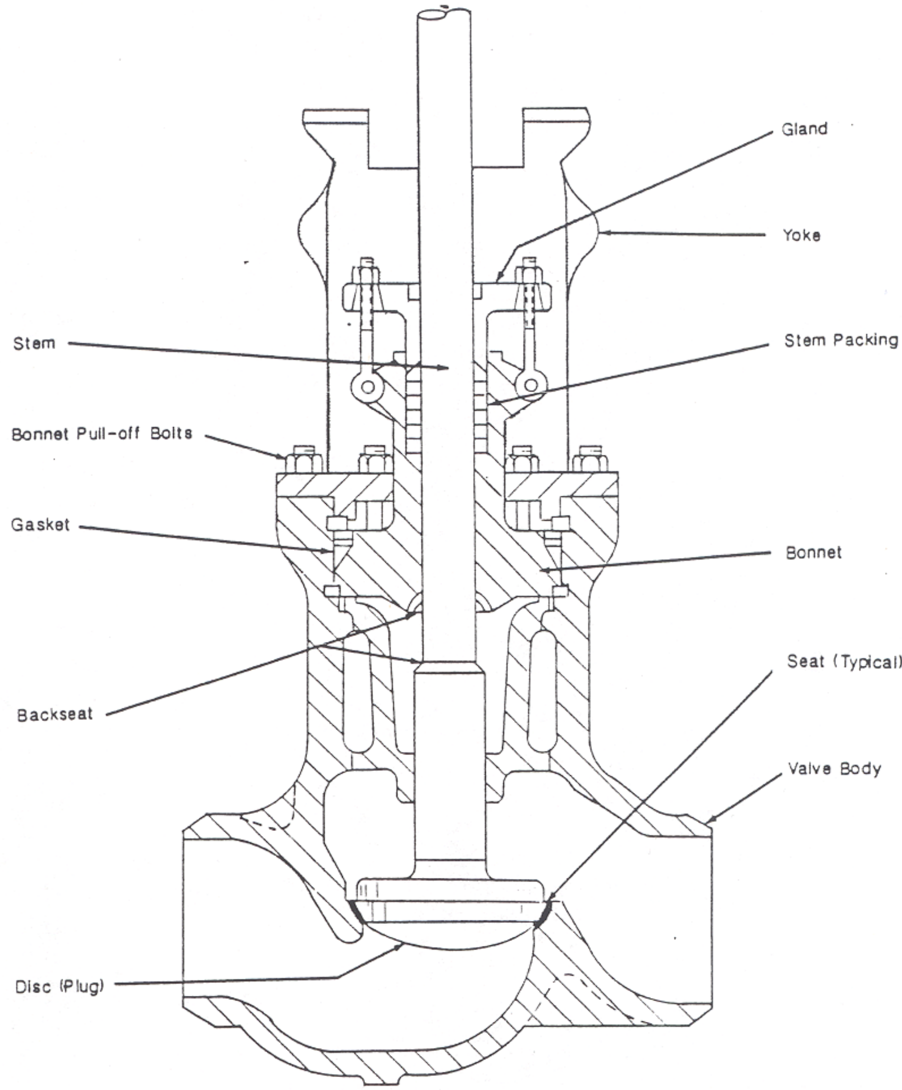
MOV Gate Valve



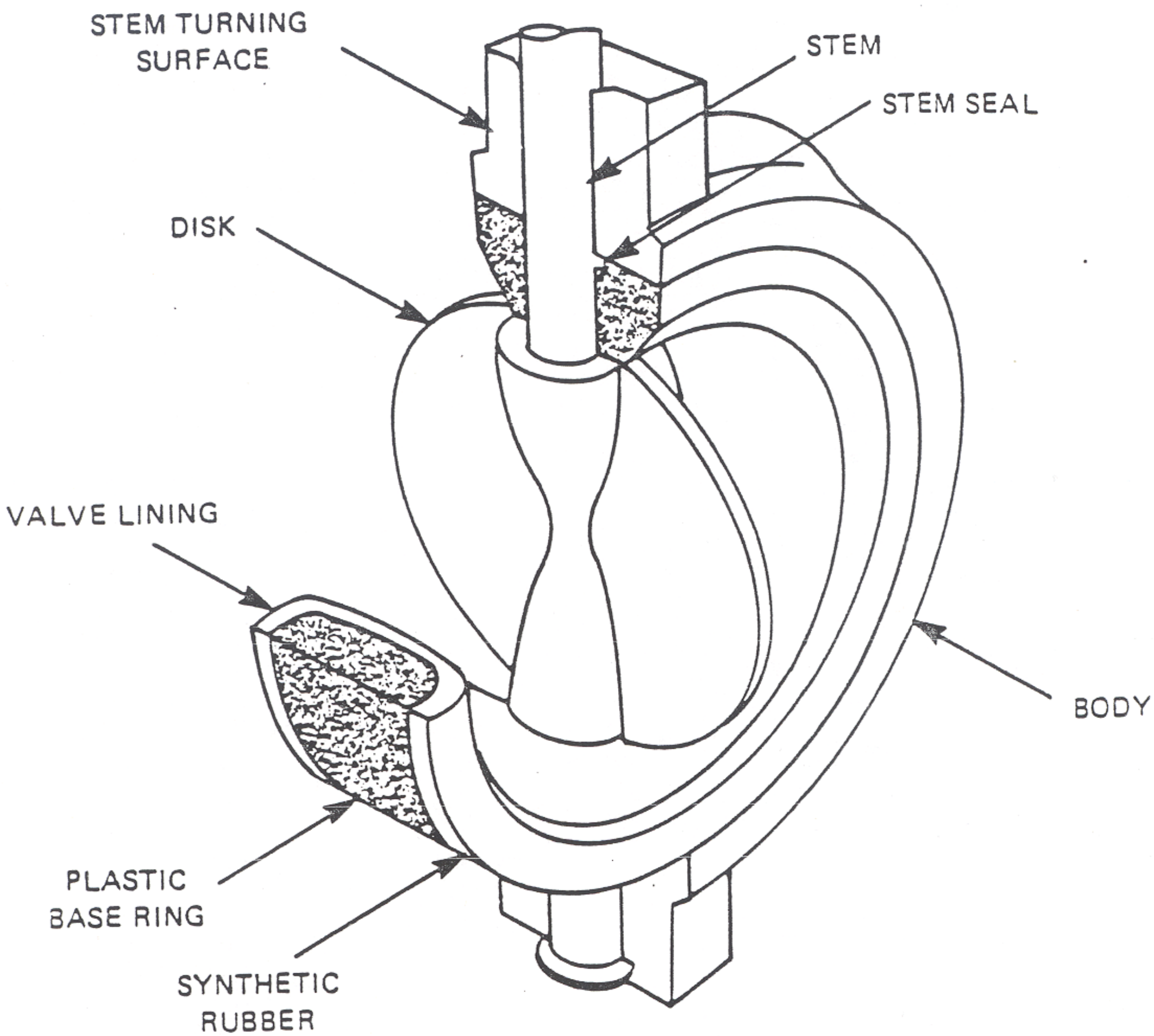
Gate Valve Internals



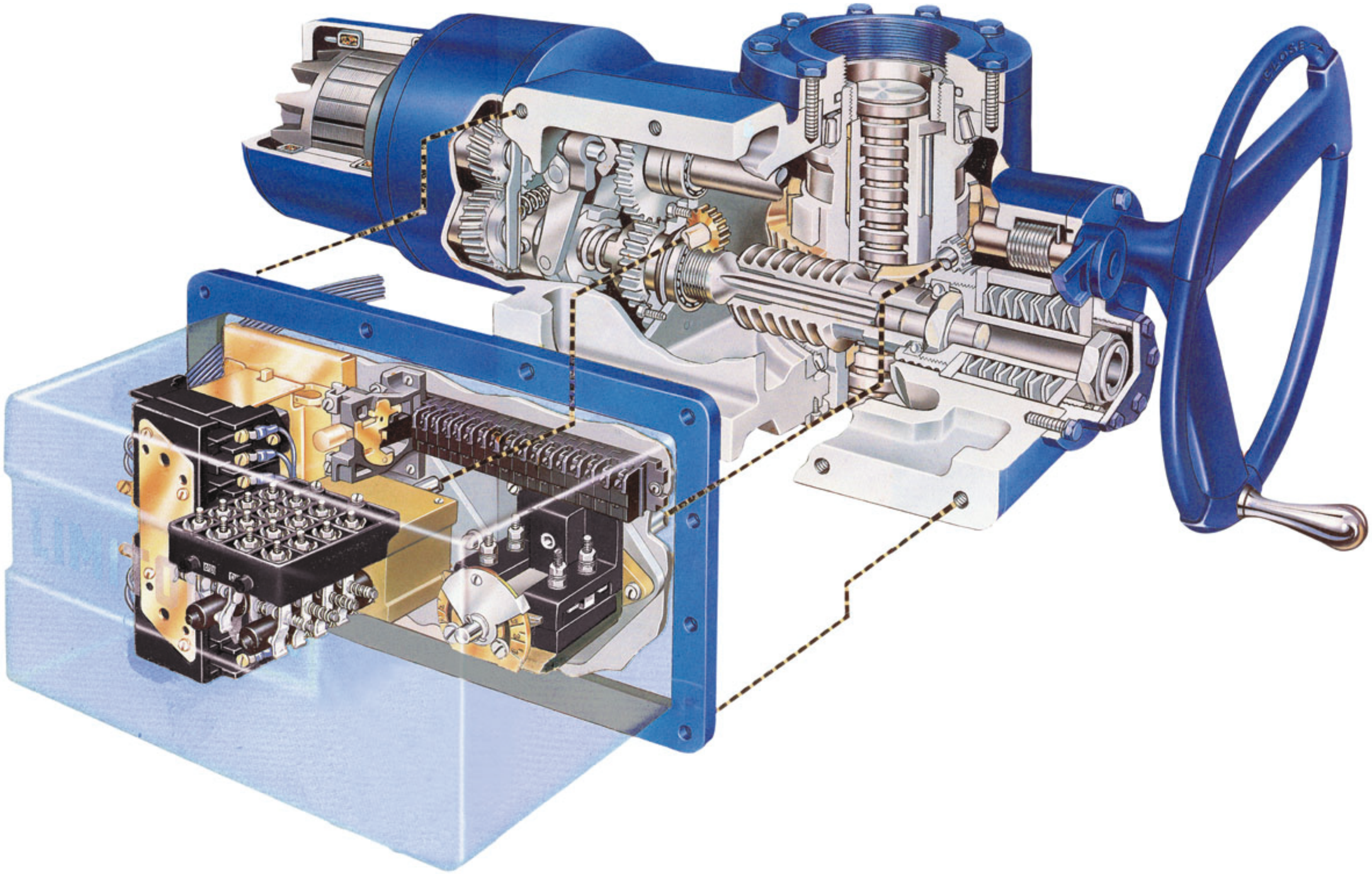
Globe Valve Internals



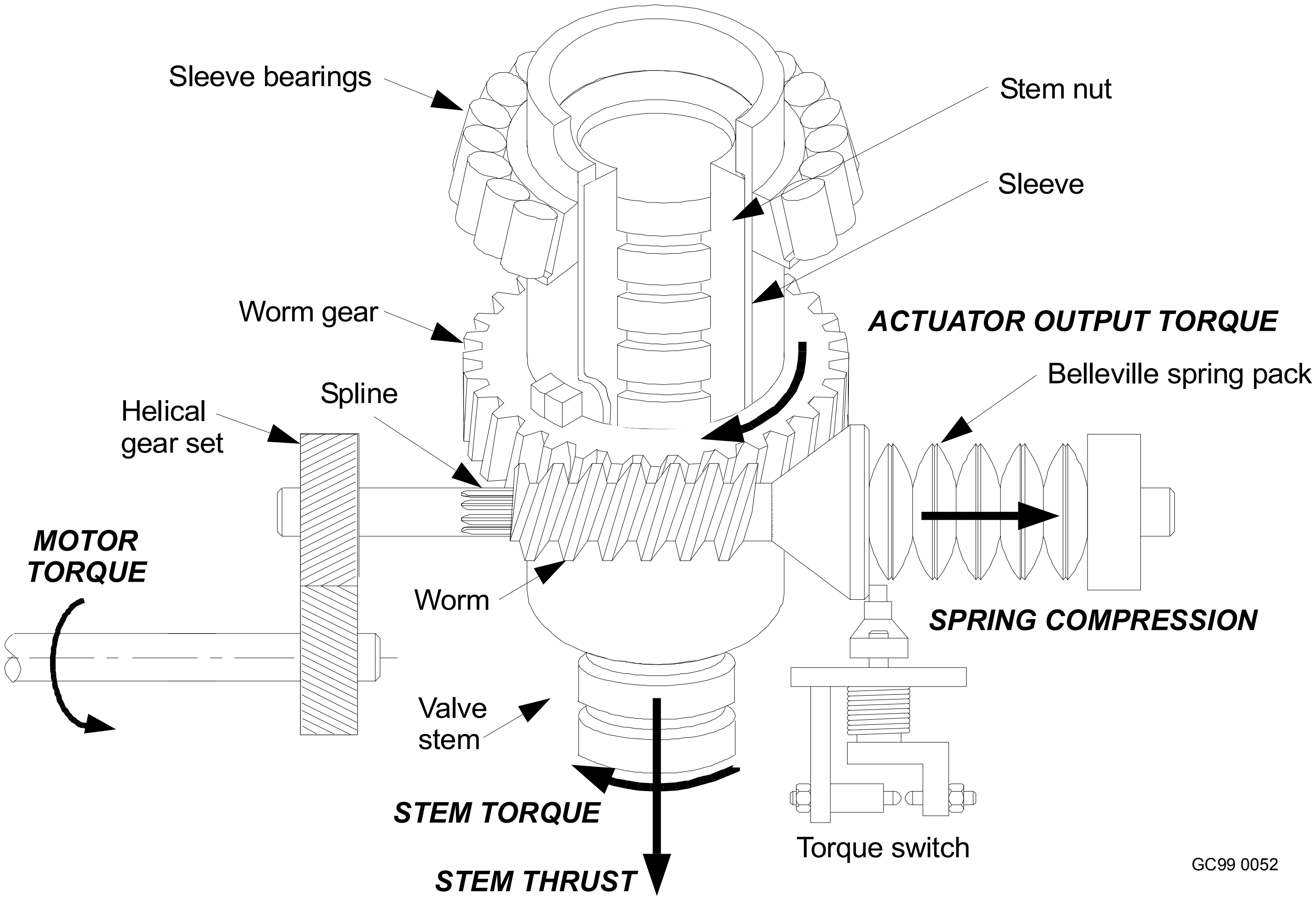
Symmetric Disc Butterfly Valve



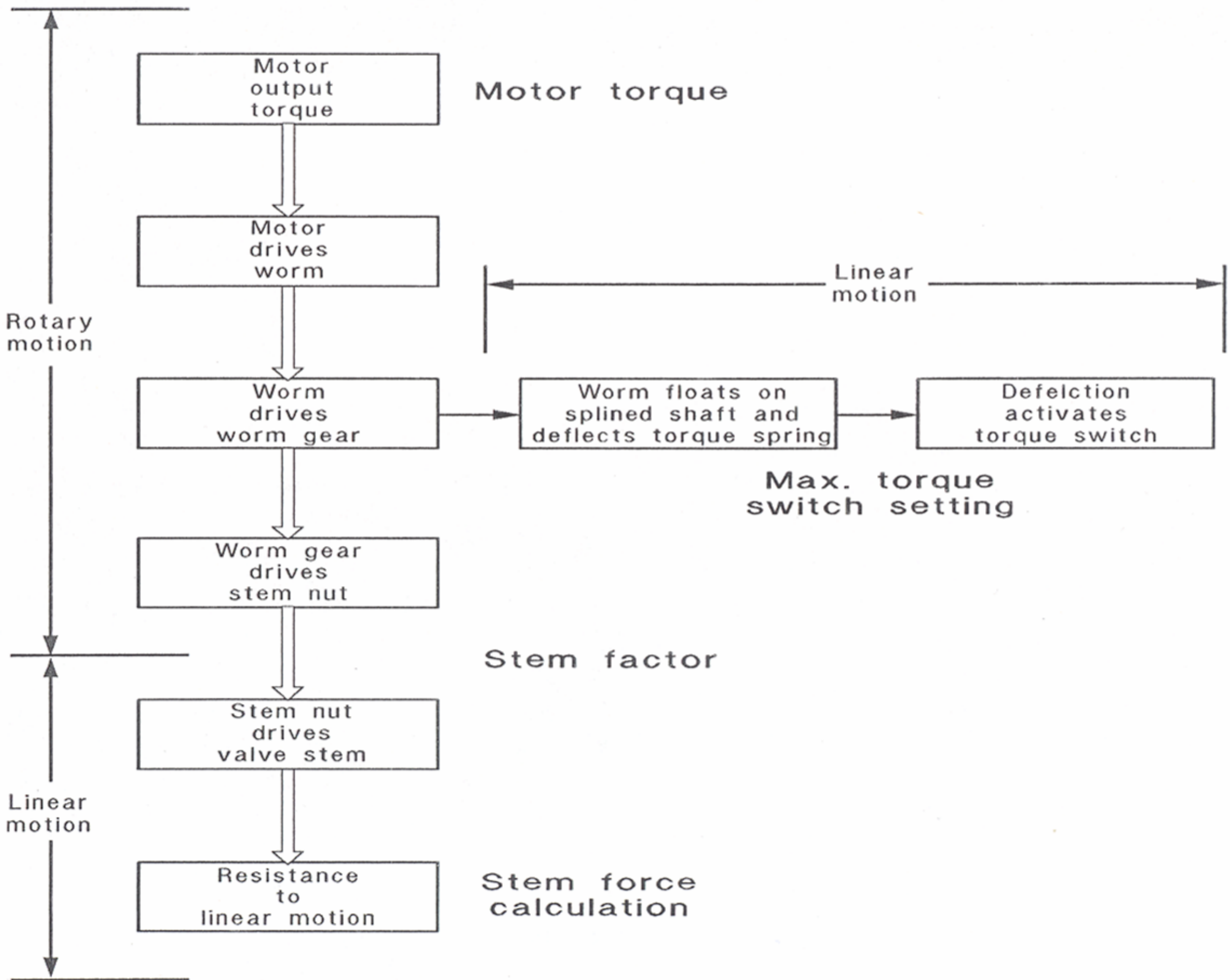
Limitorque SMB-0



Limitorque Motor Operation



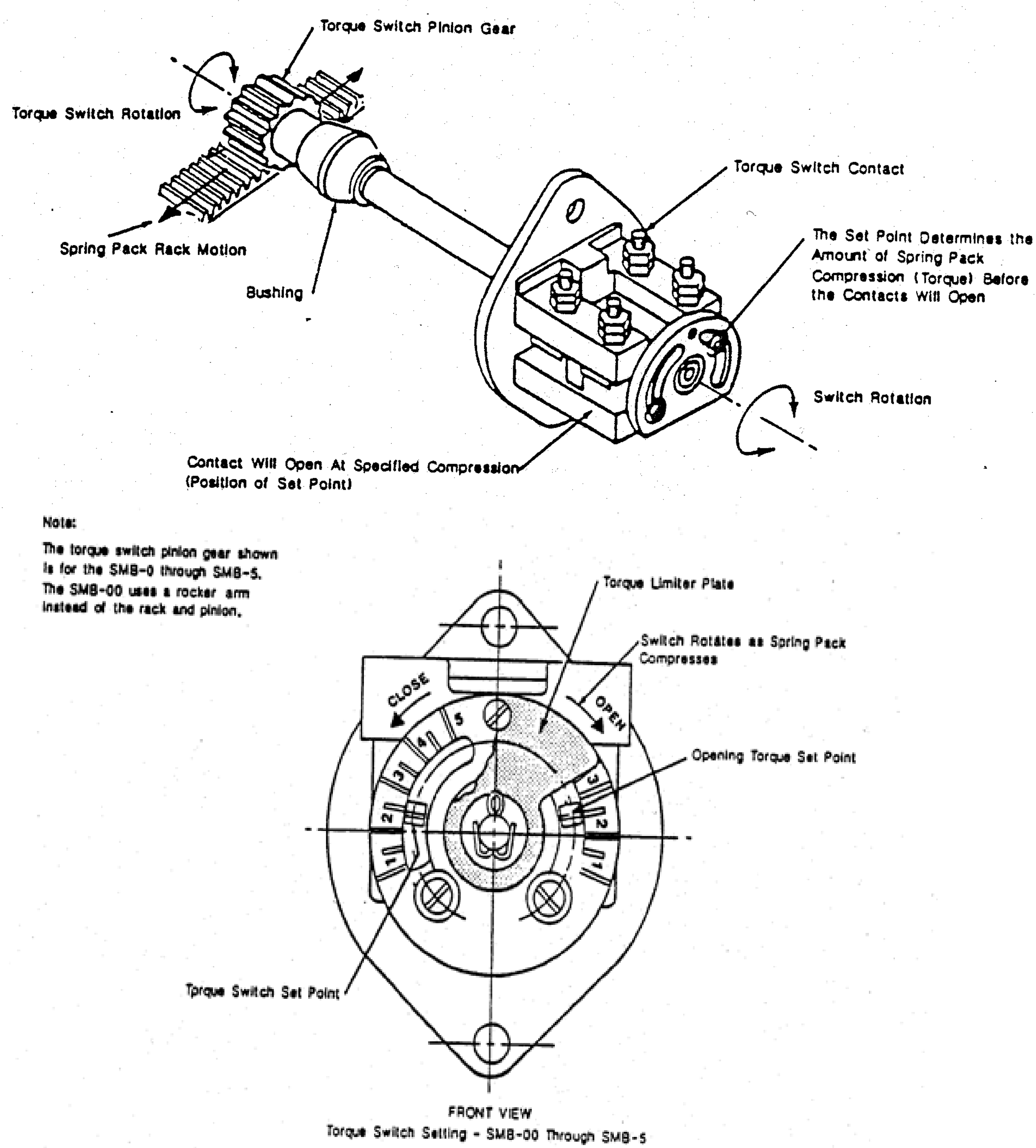
Motor Operator Process Diagram



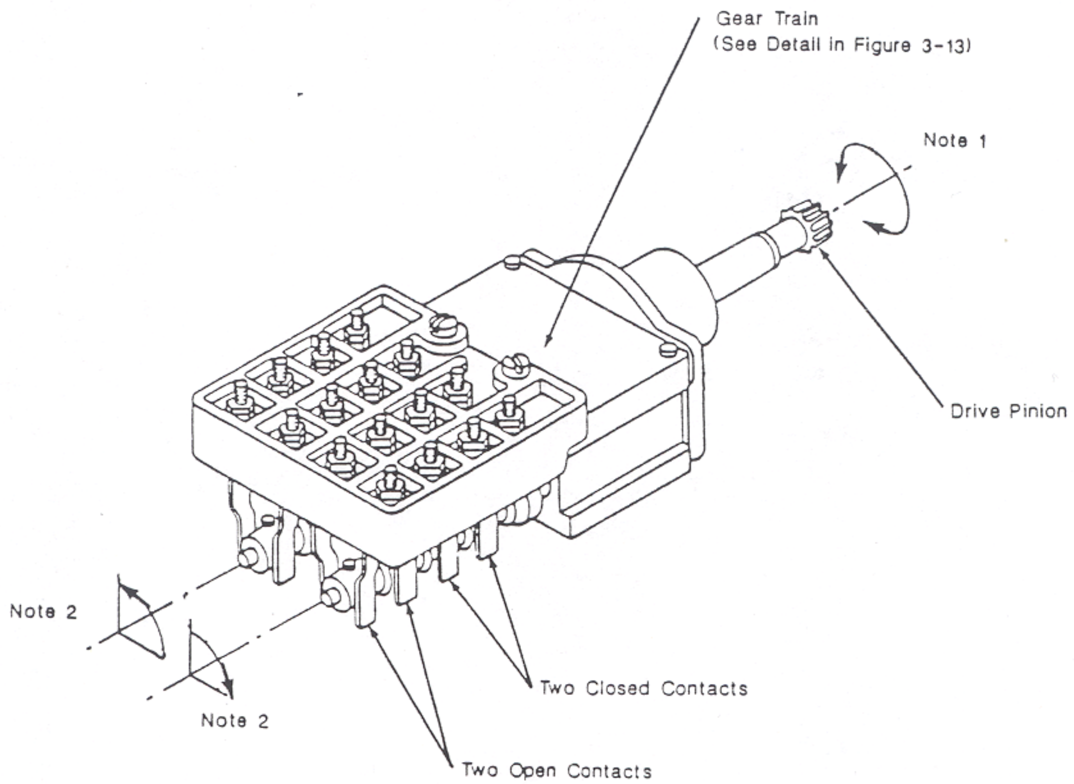
Limitorque

Torque

Switch



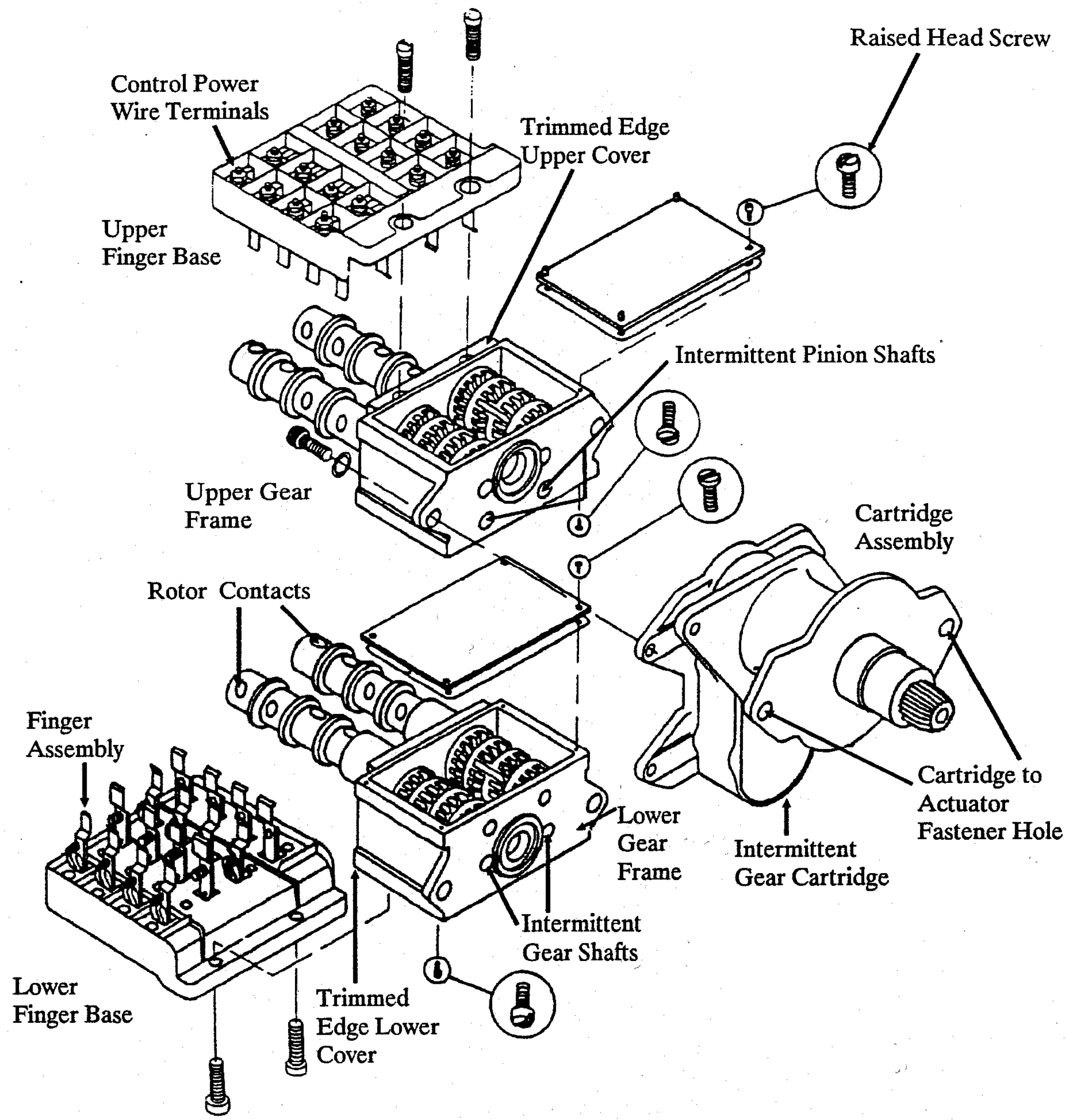
Limitorque 2-Train Limit Switch



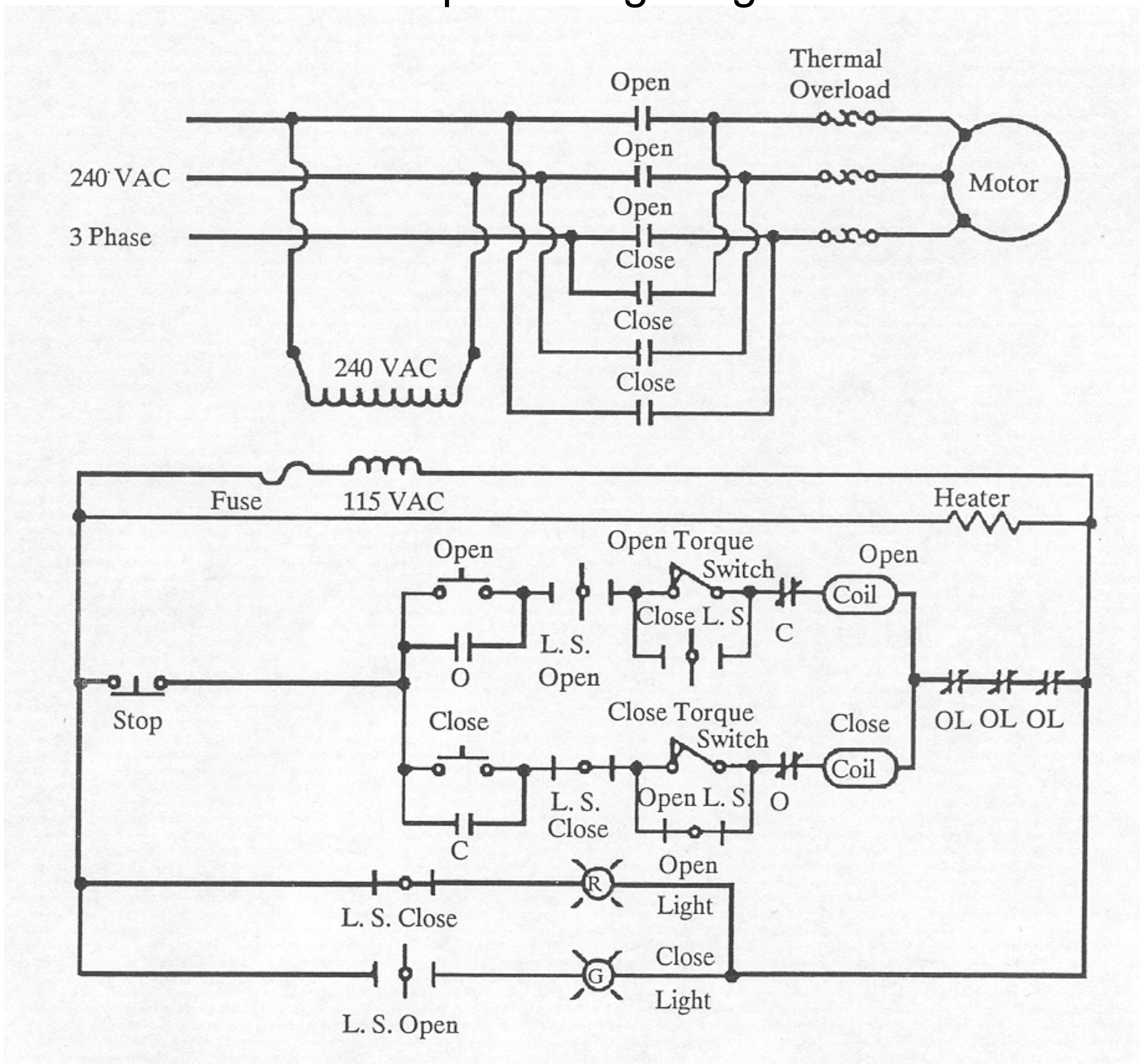
Notes:

1. Input shaft driven by operator at high speed.
2. Rotor turns at 90° at one unique valve stem position.

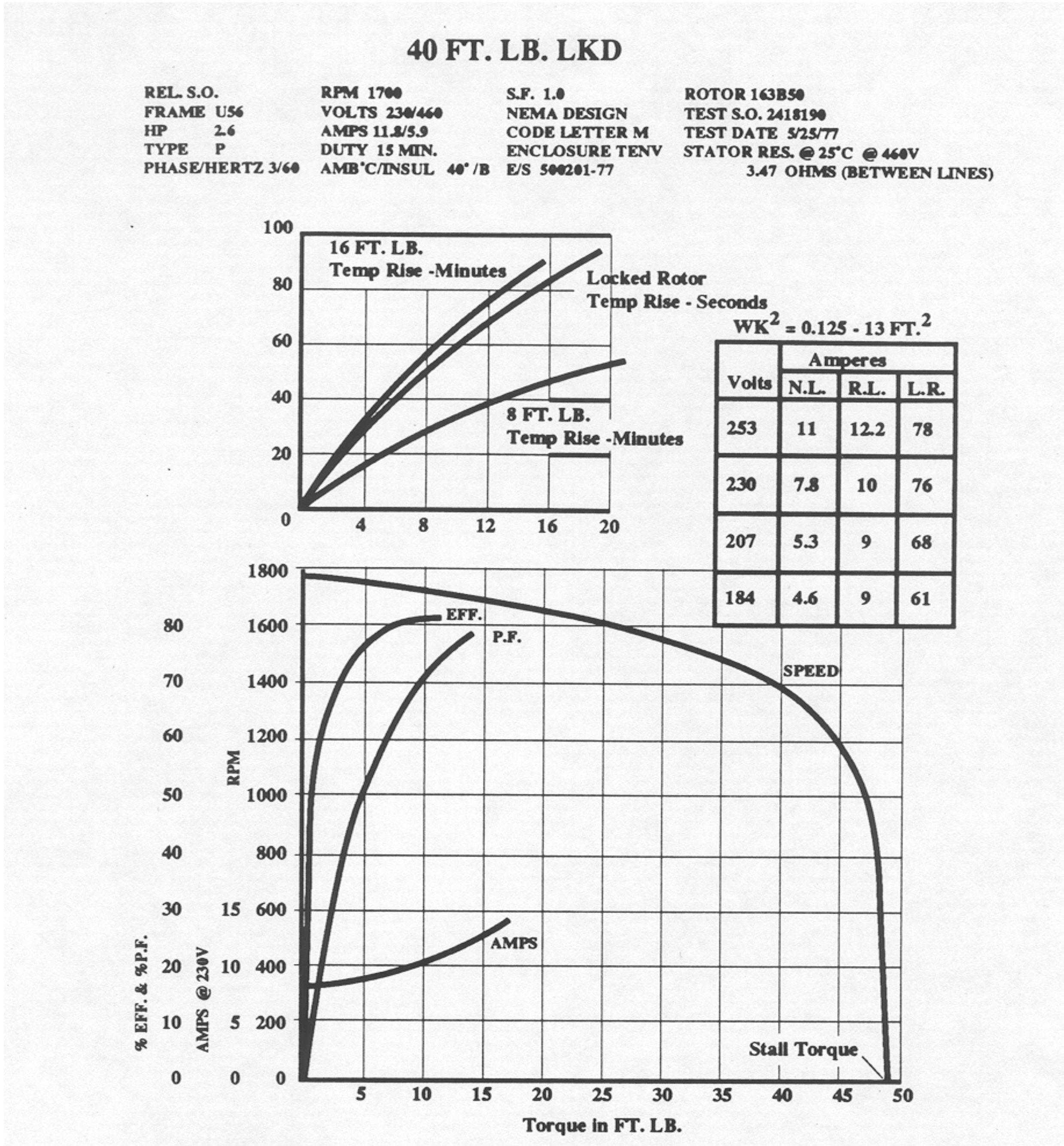
Limitorque 4-Train Limit Switch



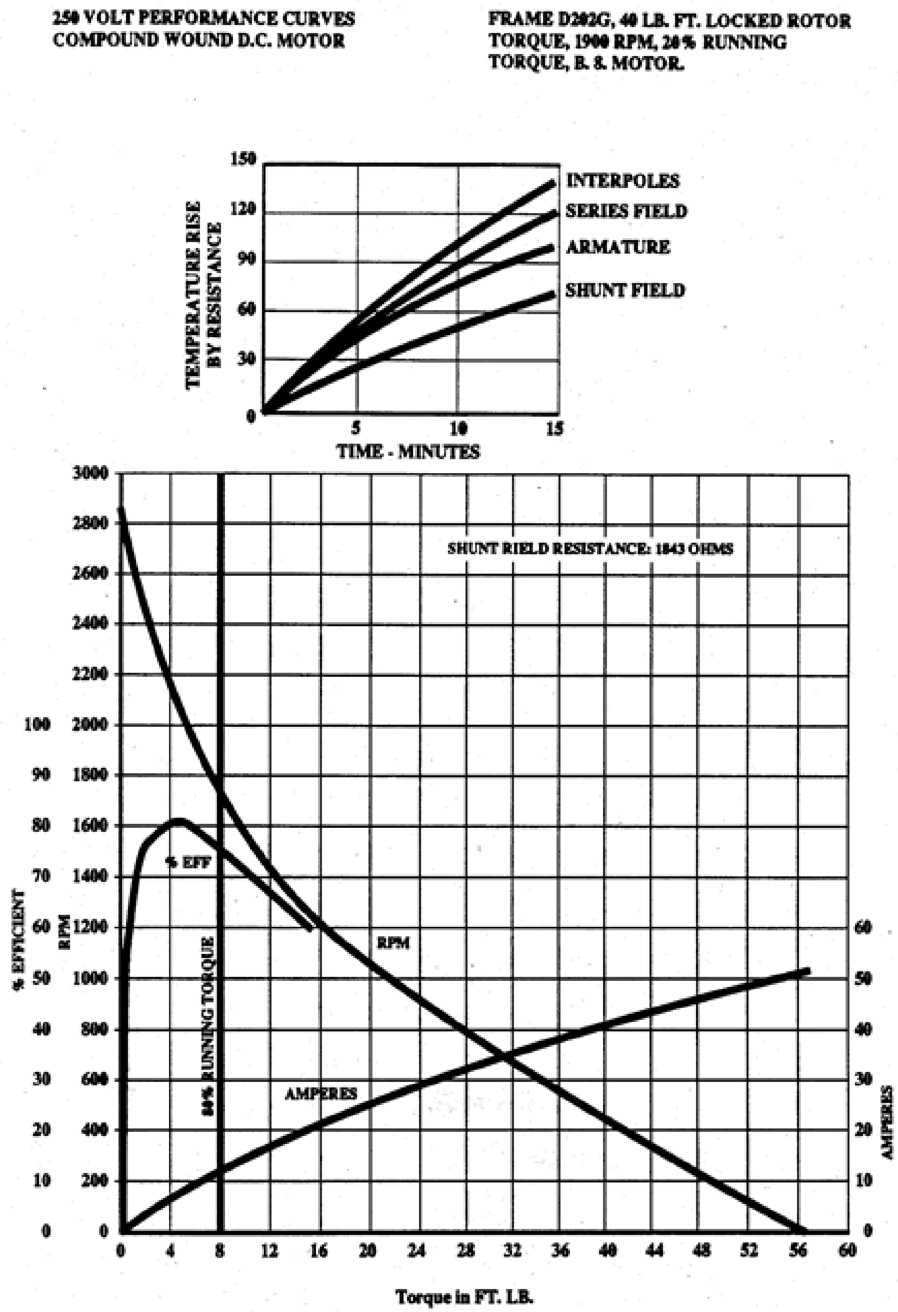
Limitorque Wiring Diagram



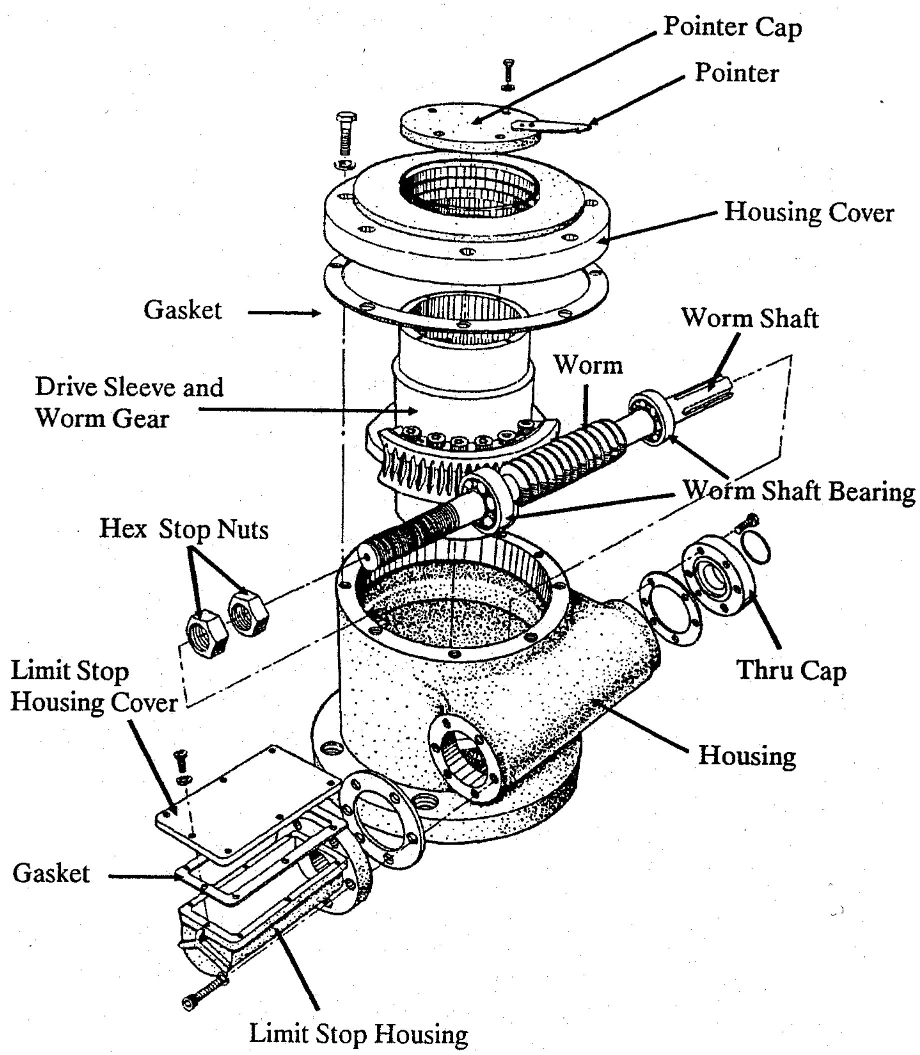
AC Motor Curve



DC Motor Curve



HBC-0 to 3 Operator



Rotork

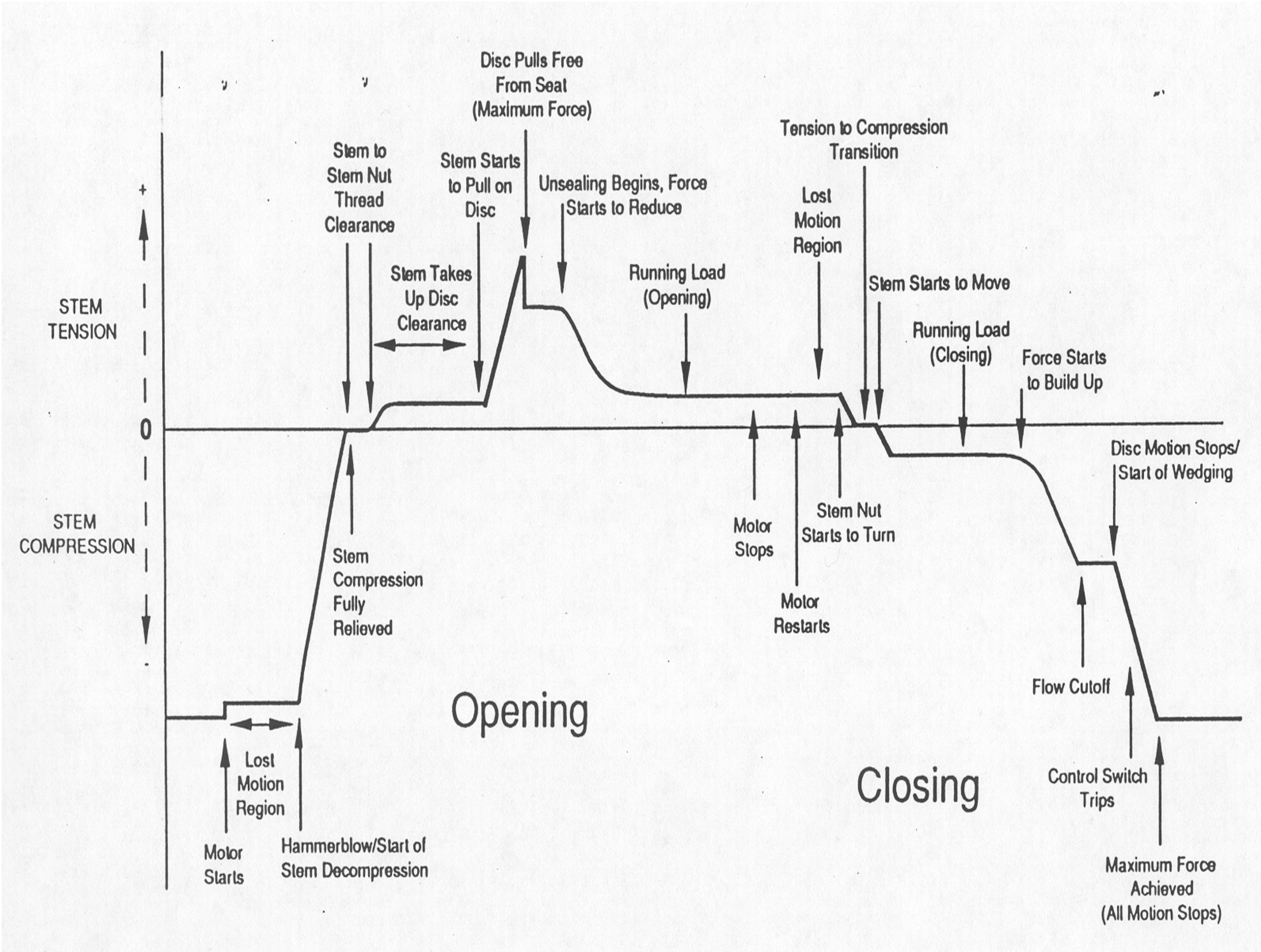
- Electric motor driven gear box similar to Limitorque
- Oil gear lubrication
- Open and close spring packs
- Motor shaft also acts as worm shaft

MOV Diagnostics

- Force
  - Stem strain (Strain gauge or Smartstem)
  - Yoke strain (VOTES)
  - Valve yoke/operator bolt or load washers
  - Calibrated C clamp
- Torque
  - Stem Strain (Strain gauge or Smartstem)
  - Spring Pack Displacement (MOVATS)
- Motor
  - Current
  - Power/power factor
- Control Switches
- Stem Position

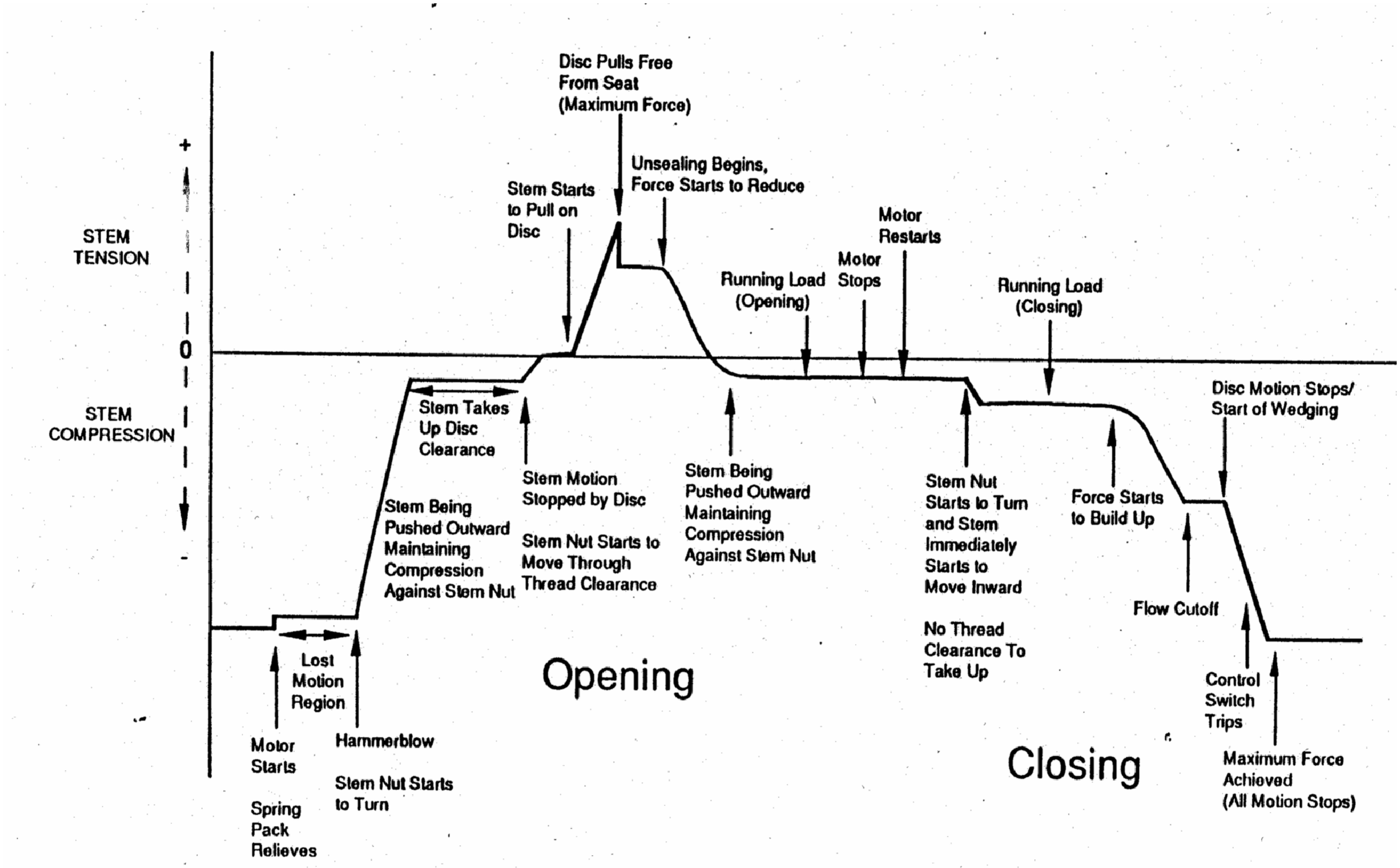
Gate Valve Opening to Closing DP Stroke

(stem rejection does not exceed packing force)



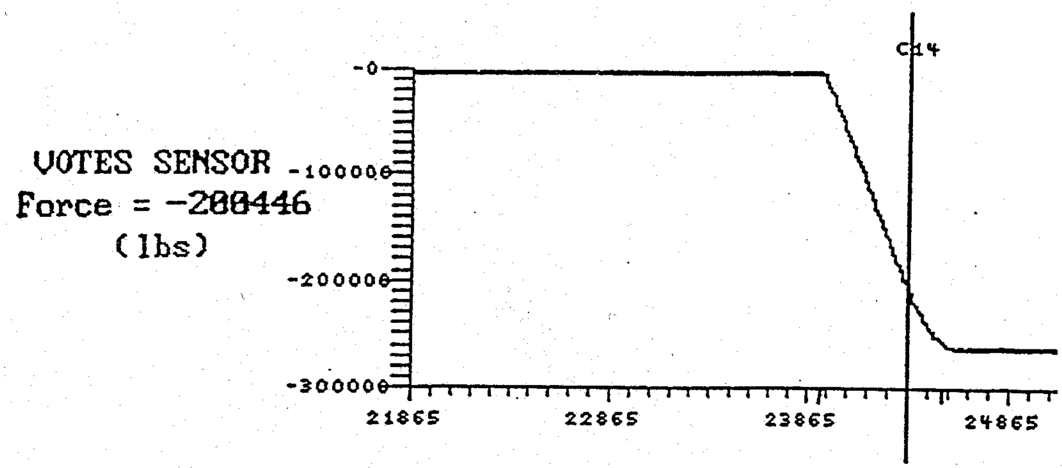
Gate Valve Opening to Closing DP Stroke

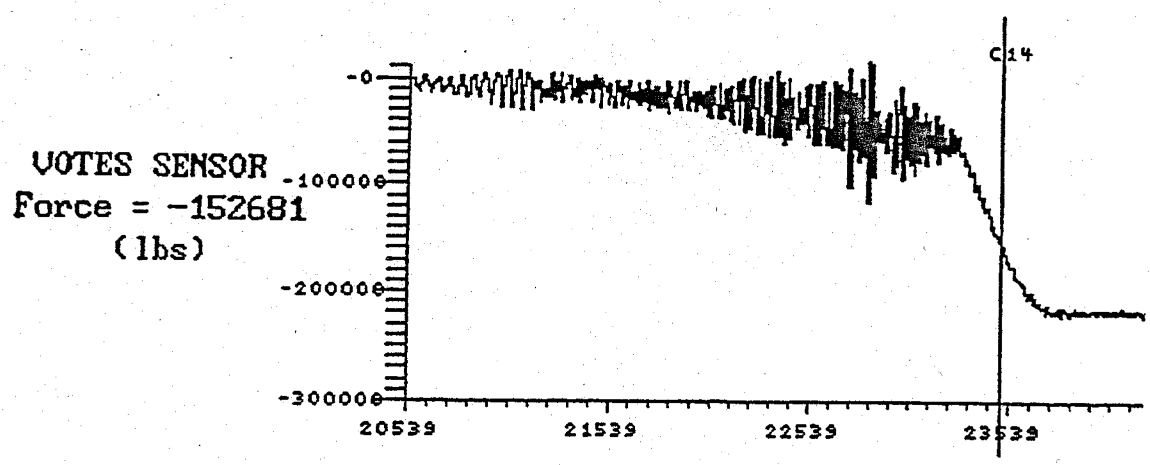
(stem rejection exceeds packing force)



Rate of Loading Effects

(Load Sensitive Behavior)





$$ROL = \frac{TST_{Static} - TST_{Dyn}}{TST_{Static}} * 100\%$$

$$ROL = \frac{200446 - 152681}{200446} * 100\%$$

ROL = 24%

Regulatory Action

- NRC Office of Nuclear Regulatory Research sponsored extensive program by Idaho National Engineering Laboratory (INL) to evaluate valve performance.
- 10 CFR 50.55a revised to supplement ASME OM Code stroke-time IST provisions with MOV periodic design-basis capability requirement.
- Bulletin 85-03 and Generic Letters (GLs) 89-10, 95-07, and 96-05
- RIS 2000-03 and RIS 2001-15
- MOV Information Notices (INs)
- Updated RGs 1.73, 1.100, and 1.106
- Reviews and inspections of MOV programs at current nuclear power plants.
- SRP and inspection procedures updated.

NRC-Sponsored INL Research

- Valve flow performance
- AC-powered MOV output
- DC-powered MOV output
- Stem friction coefficient
- Temperature effects
- Actuator efficiency
- Valve aging

INL Test Stand

INL MOV Research Reports

NUREG/CR-5406 (10/1989) - Gate Valve Flow Tests

NUREG/CR-5558 (1/1991) – Gate Valve Flow Tests

NUREG/CR-5720 (6/1992) – MOV Research Update

NUREG/CR-6100 (9/1995) – Gate Valve & Operator

NUREG/CR-6478 (7/1997) – Actuator Motor and Gearbox

NREG/CR-6611 (5/1998) – Pressure Locking

NUREG/CR-6620 (5/1999) – DC-Powered MOVs

NUREG/CR-6750 (10/2001) – Stem Lubricant Performance

NUREG/CR-6806 (9/2002) – Stem Lubricant Aging

NUREG/CR-6807 (3/2003) – Stellite Aging

Bulletin 85-03

Motor-Operated Valve Common Mode Failures During Plant Transients due to Improper Switch Settings

- Requested licensees to test high-pressure safety-related MOVs under design-basis DP and flow conditions.
- Supplement 1 clarified scope to all MOVs in specified systems and to address potential mispositioning.
- Static testing primarily conducted.
- Implementation results indicated about 8% of MOVs might not have operated under design-basis conditions.
- Results supported development of GL 89-10 to expand scope to all safety-related MOVs.

Generic Letter 89-10

Safety-Related Motor-Operated Valve Testing and Surveillance

- Requested licensees to verify design-basis capability of safety-related MOVs:
  - Reviewing MOV design bases
  - Establishing MOV switch settings
  - Dynamically testing MOVs where practicable
  - Verifying settings every 5 years and following maintenance
  - Improving corrective action and trending MOV problems.
- Licensees requested to complete GL 89-10 in 5 years or three refueling outages (RFOs).
- Justified as compliance backfit under 10 CFR 50.109

GL 89-10 Activities

- NRC staff conducted inspections using Temporary Instruction (TI) 2515/109 to evaluate GL 89-10 program development, implementation, and completion.
- NRC closed out GL 89-10 typically through inspections.
- GL 89-10 implementation involved several million dollars at each NPP.
- Following implementation, Boiling Water Reactor Owners Group (BWROG) reported at a public meeting an acceptable cost/benefit analysis based on numerous MOV deficiencies resolved as a result of GL 89-10 activities.

GL 89-10 Supplements

Supplement 1 (June 13, 1990): Provided results of GL 89-10 workshops in fall 1989.

Supplement 2 (Aug. 3, 1990): Allowed additional time for incorporation of Supplement 1 into GL 89-10 programs.

Supplement 3 (Oct. 25, 1990): Accelerated review of isolation valves in high pressure coolant injection (HPCI), reactor core isolation cooling (RCIC) system, and reactor water cleanup (RWCU) system in response to MOV tests.

GL 89-10 Supplements
(continued)

Supplement 4 (Feb. 12, 1992): Deleted mispositioning from GL 89-10 scope for BWR plants.

Supplement 5 (June 28, 1993): Addressed MOV diagnostic equipment accuracy.

Supplement 6 (Mar. 8, 1994): Provided results of several GL 89-10 workshops including guidance on grouping and pressure locking.

Supplement 7 (Jan. 24, 1996): Deleted mispositioning from GL 89-10 scope for PWR plants.

Generic Letter 95-07

Pressure Locking and Thermal Binding of Safety-Related Power-Operated Gate Valves

- Pressure locking (PL) of flexwedge gate valve or parallel disc gate valve occurs when pressurized fluid in bonnet prevents valve opening.
- Thermal binding (TB) of flexwedge or solid wedge gate valve caused by mechanical interference between valve disc and seat.
- Requested licensees to address potential PL/TB of power-operated gate valves.
- Justified as compliance backfit.
- NRC reviewed licensee submittals and prepared safety evaluation (SE) for each operating nuclear power plant.

Generic Letter 96-05

Periodic Verification of Design-Basis Capability of Safety-Related Motor-Operated Valves

- Requested licensees to develop programs to periodically verify MOV design-basis capability.
- Justified as compliance backfit.
- 98 reactor units committed to implement Joint Owners Group (JOG) Program on MOV Periodic Verification.
- Callaway, Fort Calhoun, Palisades, and San Onofre 2/3 reviewed separately.
- SE prepared based on submittals and commitments.
- Sample GL 96-05 inspections conducted at Callaway, Palisades, Peach Bottom, San Onofre, Seabrook, Saint Lucie, Summer, Turkey Point, and Vermont Yankee.

RIS 2000-03

Resolution of Generic Safety Issue 158: Performance of Safety-Related Power-Operated Valves Under Design Basis Conditions

- Current regulations provided adequate requirements to ensure verification of POV design-basis capability with no new regulatory requirements needed at that time.
- Air-Operated Valve (AOV) JOG program acceptable with NRC comments.
- NRC will monitor licensee activities to ensure that POVs capable of performing safety-related functions under design-basis conditions.
- Attachment provides successful POV program attributes.

Attributes of Successful POV Program

- Maintenance rule scope for POV program.
- Verify POVs in non-safety position can return if operable.
- Verify use of GL 88-14 on AOV instrument air supply.
- Evaluate MOV risk ranking methodologies for applicability.
- Focus initial efforts on safety-related active high-risk POVs.
- Verify methods for predicting POV operating requirements using MOV lessons learned or specific POV dynamic diagnostic testing.
- Justify method for predicting POV actuator output capability by test-based program.
- Address applicable weak links of actuator, valve, and stem.
- Ensure QA program coverage.

Attributes of Successful POV Program
(continued)

- Provide sufficient diagnostics.
- Specify if dynamic or static diagnostic testing needed.
- Ensure post-maintenance testing verifies capability.
- Ensure POV maintenance procedures incorporate valve lessons learned.
- Upgrade training to incorporate lessons learned.
- Apply feedback from plant-specific and industry information.
- Establish quantitative (test data) and qualitative (maintenance and condition reports) trending of POV performance with detailed review following each RFO.

RIS 2001-15

Performance of DC-Powered Motor-Operated Valve Actuators

- Alerted licensees to updated methodology developed by BWROG to evaluate capability of DC-powered MOVs to perform their safety functions.
- Based on INL sample testing, NRC staff considered BWROG methodology to represent a reasonable approach in improving past industry guidance for predicting DC-powered MOV output.
- Noted BWROG recommended schedule for BWR plants to implement methodology.
- Indicated that methodology also applicable to DC-powered MOVs in PWR plants.

MOV Information Notices

- IN 1981-31, Failure of Safety Injection Valves to Operate Against DP
- IN 1986-02, Failure of Valve Operator Motor During Environmental Qualification Testing
- IN 1989-61, Failure of Borg-Warner Gate Valves to Close Against Differential Pressure
- IN 1990-21, Potential Failure of Motor-Operated Butterfly Valves
- IN 1990-40, Results of NRC-Sponsored MOV Testing
- IN 1990-72, Testing of Parallel Disc Gate Valves in Europe
- IN 1992-17, NRC Inspections of MOV Programs
- IN 1992-23, Results of Validation Testing of MOV Diagnostic Equipment
- IN 1992-26, Pressure Locking of Motor-Operated Flexible Wedge Gate Valves
- IN 1992-27, Thermally Induced Accelerated Aging and Failure of ITE/Gould AC Relays
- IN 1992-83, Thrust Limits for Limitorque Actuators

- IN 1993-74, High Temperatures Reduce AC Motor Output
- IN 1993-98, Motor Brakes on Actuator Motors
- IN 1994-41, Problems with GE Type CR124 Overload Relay
- IN 1994-50, Failure of GE Contactors to Pull In at Required Voltage
- IN 1994-69, Potential Inadequacies in Torque Requirements and Output for Motor-Operated Butterfly Valves
- IN 1995-14, Susceptibility of Containment Sump Valves to Pressure Locking
- IN 1995-18, Potential Pressure Locking of Gate Valves
- IN 1995-30, Low Pressure Coolant Injection and Core Spray Valve Pressure Locking
- IN 1996-08, Thermally Induced Pressure Locking of HPCI Valve
- IN 1996-30, Inaccuracy of Diagnostic Equipment for Motor-Operated Butterfly Valves
- IN 1996-48 and Supplement 1, MOV Performance Issues
- IN 1997-07, GL 89-10 Close-out Inspection Issues
- IN 1997-16, Preconditioning of Plant SSCs before ASME Code Inservice Testing or TS Surveillance Testing

- IN 2002-26 S2, Additional Flow-Induced Vibration Failures after a Recent Power Uprate
- IN 2003-15, Importance of Maintenance Follow-up Issues
- IN 2005-23, Vibration-Induced Degradation of Butterfly Valves
- IN 2006-03, Motor Starter Failures due to Mechanical-Interlock Binding
- IN 2006-15, Vibration-Induced Degradation and Failure of Safety-Related Valves
- IN 2006-26, Failure of Magnesium Rotors in Motor-Operated Valve Actuators
- IN 2006-29, Potential Common Cause Failure of Motor-Operated Valves as a result of Stem Nut Wear
- IN 2008-20, Failures of Motor-Operated Valve Actuator Motors with Magnesium Alloy Rotors
- IN 2010-03, Failures of Motor-Operated Valves due to Degraded Stem Lubricant
- IN 2012-14, Motor-Operated Valve Inoperable due to Stem-Disc Separation
- IN 2013-14, Potential Design Deficiency in Motor-Operated Valve Control Circuitry

RG 1.73

Qualification Tests for Safety-Related Actuators in NPPs (Revision 1, October 2013)

- Updated to endorse IEEE 382-2006
- References RG 1.89 for environmental qualification.
- Applicant or licensee responsible for qualifying actuator for its qualified life including design cycles.
- Environmental qualification should also address flow-induced vibration caused by acoustic resonance and hydraulic loading in reactor, steam, and feedwater systems.
- IEEE 382-2006 acceptable for environmental qualification of power-operated valves per RG 1.100 with conditions.
- Equipment needs to be qualified for operational performance duration for each design-basis event.

RG 1.106

Thermal Overload Protection for Electric Motors on Motor-Operated Valves (Revision 2, February 2012)

- IEEE 603-2009 for thermal overload (TOL) circuitry.
- For valves required to function immediately during accident, TOL devices should bypassed, but in service for testing.
- For valves that operate under normal conditions and automatically actuate, TOL devices should be in service normally, but bypassed under accident conditions.
- For valves that do not have an immediate function, TOL devices should be in service.
- All uncertainties should be in favor of completing action.
- Trip setting should conform to IEEE 741-2007.

Industry Action

- Current nuclear power plants implemented resource-intensive programs in response to GLs 89-10, 95-07, and 96-05.
- Electric Power Research Institute (EPRI) developed test-based valve performance methodology.
- JOG developed MOV dynamic testing program in response to GL 96-05.
- DC and COL applicants recognize need to address MOV lessons learned in applications.

EPRI MOV Performance Prediction Program

- Test-based methodology for predicting operating requirements for gate, globe, and butterfly valves described in EPRI TR-103237 (Rev. 2, 1997).
- NRC accepted EPRI MOV PPM with conditions in SE (3/15/96) with supplements:
  - Supplement 1 (2/20/97) accepted EPRI PPM hand-calculation methods for two additional valve designs
  - Supplement 2 (4/20/01) accepted modeling improvements in PPM Addendum 1
  - Supplement 3 (9/30/02) accepted thrust uncertainty method in PPM Addendum 2
  - Supplement 4 (2/24/09) accepted various PPM improvements in PPM Addenda 3 to 7.
- EPRI provides updated MOV guidance in Application Guide TR-106563 (Vol. 1 and 2), and Technical Repair Guidelines NP-6229 (SMB-000) and NP-6631 (SMB-00).

JOG Program on MOV Periodic Verification

- Risk-informed program to share test information on valve operating requirements for responding to GL 96-05.
- 5-year dynamic testing of sample MOVs at each participating plant.
- Static and dynamic testing based on program results and margin.
- Test frequency based on risk and margin.
- NRC accepted in SE dated September 2006.
- RIS 2011-13 indicates licensees may implement ASME OM Code Appendix III or Code Case OMN-1 for JOG Class D valves outside scope of JOG program.

ComEd MOV Output Methodology

- In 1990s, ComEd tested motors to evaluate output capability and degraded voltage factors.
- ComEd evaluated test data from other sources for actuator performance.
- ComEd White Paper 125 (Rev. 3, 2/8/99) provides methodology for sizing motor actuators.
- NRC staff accepted use of ComEd White Paper 125 during GL 89-10 inspections.

BWROG DC MOV Methodology

- Based on research identifying effects on DC MOV output from temperature, voltage, and loading, BWROG developed updated methodology for DC MOV output and stroke time.
- BWROG used vendor motor curves and test data from INL and industry sources in developing its methodology.
- BWROG indicated that methodology would be made available to PWR licensees.
- NRC discussed BWROG methodology in RIS 2001-15.

ASME Activities

- ASME Standard QME-1-2007 incorporates MOV lessons learned with recent 2012 Edition and upcoming 2017 Edition.
- OM Code Cases OMN-1 and 11 for MOVs, and OMN-12 for AOVs and hydraulic-operated valves (HOVs) provide alternatives to stroke-time IST.
- Appendix III in OM Code (2009 Edition) replaced MOV quarterly stroke-time IST with periodic exercising and diagnostic testing.
- Appendix IV in OM Code (upcoming 2017 Edition) supplemented AOV quarterly stroke-time IST with periodic performance assessment testing.

Additional Related Topics

- Generic Communications
- Preconditioning
- MOV maintenance care
- 10 CFR 50.69
- Magnesium rotor degradation
- Flow-induced vibration

Information Notices

- IN 2008-02, Findings Identified During Component Design Bases Inspections
- IN 2008-04, Counterfeit Parts Supplied to NPPs
- IN 2011-01, Commercial-Grade Dedication Issues Identified during NRC Inspections
- IN 2012-06, Ineffective Use of Vendor Technical Recommendations
- IN 2014-11, Recent Issues of Qualification and Commercial Grade Dedication of Safety-Related Components
- IN 2015-13, Main Steam Isolation Valve Failure Events
- IN 2016-09, Recent Issues when using Reverse Engineering Techniques in Procurement

Regulatory Issue Summaries

- RIS 2015-08, Oversight of Counterfeit, Fraudulent, and Suspect Items in Nuclear Industry
- RIS 2016-01, Nuclear Energy Institute Guidance for Use of Accreditation in lieu of Commercial Grade Surveys for Procurement of Laboratory Calibration and Test Services
- RIS 2016-05, Embedded Digital Devices in Safety-Related Systems

Preconditioning

- Preconditioning can be acceptable or unacceptable depending on several factors.
- Inspection Manual Chapter 0326 (12/3/15), Operability, states repetitive testing might constitute preconditioning.
- Tech. Guidance on Maintenance – Preconditioning (9/28/98) provides acceptability questions.
- IP 61726 (6/24/98), Surveillance Observations, and IP 71111.22 (7/1/15), Surveillance Testing, provide guidance to evaluate preconditioning.
- IN 1997-16 describes preconditioning examples.
- NUREG-1482 (Rev. 2) provides updated information on preconditioning.

MOV Maintenance Care

- MOV maintenance activities can be hazardous if not conducted according to procedure.
- In January 2004, catastrophic MOV failure occurred at Crystal River Coal Plant with a fatal injury.
- Plant workers had overstressed MOV during closing and actuator “exploded” upon attempted opening.
- Limitorque issued Safety Bulletin 6-04 emphasizing proper use of maintenance procedures and prohibition of use of cheater bars.

10 CFR 50.69

- 50.69 allows license amendment for safety-related SSCs categorized as low risk significant (RISC-3) to be exempt from most special treatment requirements.
- 50.69 eliminates most ASME OM and BPV Code IST and ISI, and repair and replacement, provisions for RISC-3 pumps and valves.
- SECY-04-0109 forwarded 50.69 to Commission.
- SRM dated October 7, 2004, approved issuance of 50.69 with revision of RISC-3 treatment.
- Vogtle Units 1 and 2 implementing 50.69 on trial basis.

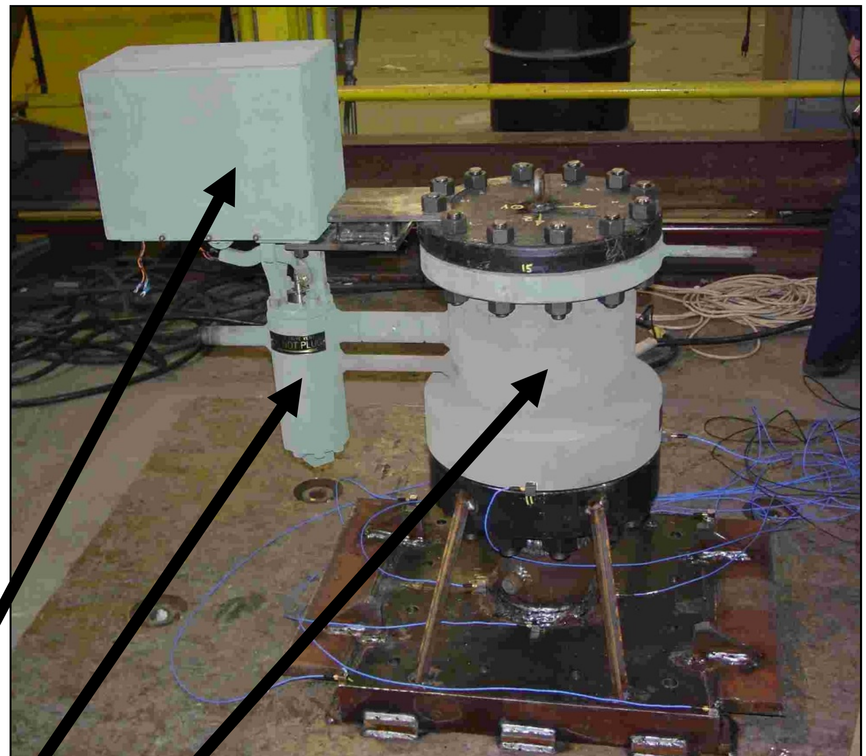
Magnesium Rotor Degradation

- Several MOVs with actuator motors manufactured with magnesium alloy rotors have failed.
- Failures attributed to corrosion of magnesium alloy rotors.
- GE SIL 425 (1985) and Limitorque Technical Update 06-01 (2006) provided industry guidance.
- Information Notices 1986-02, 2006-26, and 2008-20.
- NRC staff continuing to monitor magnesium rotor issue with MOV motors.

Flow-Induced Vibration

- Acoustic resonance can cause vibration that degrades reactor, feedwater, and steam components.
- IN 2002-26 and supplements discussed flow-induced component degradation during BWR uprate operation.
- In late 2005, main steam relief valves at Quad Cities 1/2 found degraded by flow-induced vibration. Resolved by installation of Acoustic Side Branches in standpipes for Quad Cities valves in 2006 to avoid resonance.
- Beginning in 1999, Palo Verde Unit 1 experienced flow-induced vibration of shutdown cooling valve. Resolved by relocation of valve in 2006 to avoid resonance.
- SRP Sections 3.9.2 and 3.9.5, and RG 1.20 updated to include guidance on potential flow-induced vibration.

Electromatic Relief Valve

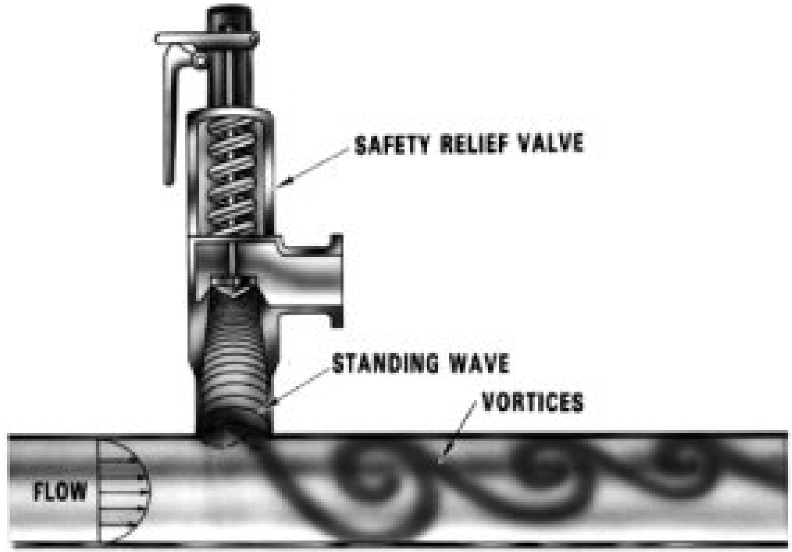


Actuator

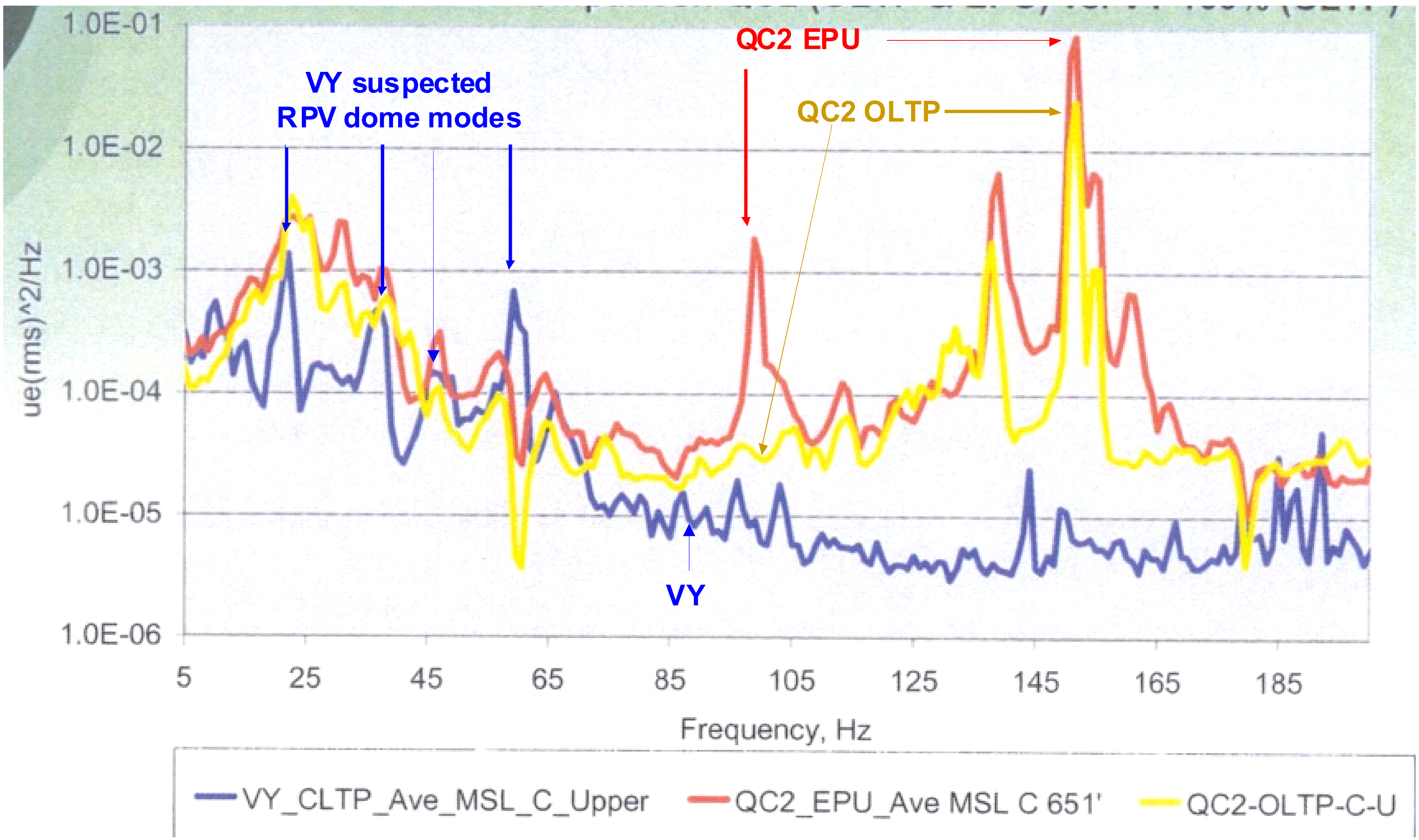
Pilot Valve

ERV

Singing Relief Valve



Main Steam Line Strain Gage Readings for Quad Cities and Vermont Yankee



III. ASME Standard QME-1, Qualification of Active Mechanical Equipment Used in Nuclear Power Plants

ASME QME-1 Standard

- QME-1 specifies provisions and guidelines for qualifying active mechanical equipment.
- QME-1 describes principles, procedures, and methods of qualification.
- QME-1 refers to IEEE standards for qualification of electric components.
- Qualification aspects for mechanical/electrical component interface addressed.
- Qualification confirms equipment adequacy over expected range of service conditions, including design-basis events, and ISI and IST conditions.

QME-1 Contents

Section QR	General Requirements
Section QDR	Qualification of Dynamic Restraints
Section QP	Qualification of Active Pump Assemblies
Section QV	Functional Qualification Requirements for Active Valve Assemblies for Nuclear Power Plants

QME-1 Section QR General Requirements

- Demonstrate equipment can perform specified function when operational and environmental conditions are imposed per equipment qualification specification.
- Qualification Program Requirements
- Qualification Specification
- Documentation
- Nonmandatory Appendices
  - QR-A: Dynamic Qualification of Mechanical Equipment
  - QR-B: Guide for Qualification of Nonmetallic Parts

QME-1 Section QDR
Qualification of Dynamic Restraints

- Qualification requirements and guidelines for ASME BPV Code dynamic restraints.
- Scope includes hydraulic snubbers, mechanical snubbers, and gap restraints.
- Nonmandatory Appendices
  - QDR-A: Functional Specification for Dynamic Restraints
  - QDR-B: Restraint Similarity
  - QDR-C: Typical Values of Restraint Functional Parameters

QME-1 Section QP

Qualification of Active Pump Assemblies

- Qualification requirements and guidelines for active pump assemblies.
- Applicable to all pump types per ASME BPV Code.
- Nonmandatory Appendices
  - QP-A: Pump Specification Checklist
  - QP-B: Pump Shaft-Seal System Specification Checklist
  - QP-C: Pump Turbine Driver Specification Checklist
  - QP-D: Pump Similarity Checklist
  - QP-E: Guidelines for Shaft-Seal System Material and Design Consideration

QME-1 Section QV
Functional Qualification Requirements for Active Valve Assemblies for Nuclear Power Plants

- Qualification requirements and guidelines for active valve assemblies that perform nuclear safety function.
- Power-operated, self actuated, and relief valves.
- Environmental and aging, sealing capability, end loading, seismic qualification, and functional qualification.
- Mandatory Appendix QV-1, Qualification Specification
- Nonmandatory Appendix QV-A, Functional Specification
- Guide to Section QV: Section QV-G, Determination of Valve Assembly Performance Characteristics

Subsection QV-7460
POV Functional Qualification

- Establish Qualified Valve Assembly (Qualified Valve, Actuator, and Interface)
- Develop methodology to extrapolate qualification of valve assembly (Extrapolated Valve, Actuator, and Interface)
- Assure Production Valve Assembly performs as predicted by Qualified Valve Assembly (Production Valve, Actuator, and Interface)
- Post-installation Verification and IST Baseline

ASME QME-1-2017

- ASME is finalizing QME-1-2017 to provide significant improvements in the qualification provisions for pumps and valves.
- Subsection QV expanded to provide specific provisions for squib valves and manual valves.
- Subsection QP revised to provide improved qualification provisions for pumps with an updated format.
- Pump and valve specification appendices improved with more detail.

Regulatory Guide 1.100 (Rev. 3)

Seismic Qualification of Electrical and Active Mechanical Equipment and Functional Qualification of Active Mechanical Equipment for Nuclear Power Plants

- NRC accepted ASME QME-1-2007 in Rev. 3 to RG 1.100 with regulatory positions:
  - Pump, valve, and dynamic restraint provisions provide reasonable approach for functional qualification
  - Nonmandatory appendices specified in procurement specifications become mandatory
  - Seismic qualification conditions
- NRC preparing proposed Revision 4 to RG 1.100 for acceptance of QME-1-2012 and/or QME-1-2017.

IV. ASME OM Code, Operation and Maintenance of Nuclear Power Plants

ASME OM Code

- Subsection ISTA: General Requirements
- Subsection ISTB: Pumps in Pre-2000 Plants
- Subsection ISTC: Valves
- Subsection ISTD: Dynamic Restraints
- Subsection ISTE: Risk-Informed IST Program (2009)
- Subsection ISTF: Pumps in Post-2000 Plants (2011)
- Appendix I: Safety and Relief Valves
- Appendix II: Check Valve Condition Monitoring
- Appendix III: MOV IST (2009)
- Appendix IV: AOV IST (2017)
- Appendix V: Pump Periodic Verification (2012)

Subsection ISTA: General Requirements

- ISTA-1100 specifies scope of OM Code as
  a) pumps and valves required to perform specific function in shutting down reactor to safe shutdown condition, in maintaining safe shutdown condition, or in mitigating consequences of accident;
  b) pressure relief devices that protect systems or portions of systems in (a); and
  c) dynamic restraints used in systems in (a) or to ensure integrity of reactor coolant pressure boundary.
- Specifies Owner's Responsibilities, accessibility, definitions, test and examination plan requirements, and administrative requirements.

Subsection ISTB: Inservice Testing of Pumps in Pre-2000 Plants

- Pre-2000 Plant issued construction permit prior to January 1, 2000
- Group A pump: operated routinely
- Group B pump: not operated routinely
- PST requirements
- Quarterly IST with parameters based on Group A or Group B pump
- Comprehensive pump testing every 2 years
- Pump Periodic Verification Test in accordance with Appendix V every 2 years

Subsection ISTC: Inservice Testing of Valves

- Valve Categories:
  - Category A: seat leakage limited
  - Category B: seat leakage is inconsequential
  - Category C: self-actuating (pressure relief and check valves)
  - Category D: energy source with one operation (squib valves)
- PST requirements
- Safety and relief valves tested per Appendix I
- Check valves quarterly exercise with condition monitoring allowed by Appendix II
- POV quarterly stroke-time IST requirements except
  - MOVs tested per Appendix III (2009 Edition)
  - AOVs tested per Appendix IV (2017 Edition)

- ISTC-5260 Explosively Actuated Valves
  - (a) Record of service life of each charge shall be maintained and not exceed 10 years
  - (b) Concurrent with first test and at least once every 2 years, service life records shall be reviewed.
  - (c) At least once every 2 years, 20% of charges shall be fired and replaced. If charge fails to fire, all charges with same batch number shall be removed, discarded, and replaced with charges from different batch.
  - (d) Replacement charges shall be from batches with sample charge tested with service life that meets (b).
- 2012 Edition includes ISTC-3100(d) and ISTC-5260(e) for squib valve PST and IST in post-2000 plants consistent with Vogtle COL license condition.

Subsection ISTD: Preserve and Inservice Examination and Testing of Dynamic Restraints (Snubbers)

- Snubber IST requirements moved from ASME BPV Code, Section XI, beginning with 2006 Addenda to BPV Code.
- Preservice examination requirements
- Inservice sampling provisions
- NUREG-1482 (Revision 2) includes Appendix A with snubber IST guidance.

Subsection ISTE: Risk-Informed IST of Components

- Establishes safety categorization methodology for pumps and valves into high safety significant component (HSSC) and low safety significant component (LSSC) groups.
- Based on Code Case OMN-3 approach.
- Specifies testing requirements for pumps, check valves, MOVs, and AOVs.
- Specifies performance monitoring, feedback, and corrective action.
- Recent 10 CFR 50.55a Rulemaking (July 2017) requires approval of alternative request per 50.55a(z) necessary to implement ISTE.

Subsection ISTF:
Inservice Testing of Pumps in Post-2000 Plants

- Post-2000 Plants issued CP or COL on or after January 1, 2000
- PST requirements
- Quarterly IST requirements with conditions consistent with comprehensive pump testing in ISTB.
- Recent 10 CFR 50.55a Rulemaking (July 2017) requires implementation of Appendix V for pump periodic verification with ISTF.
- ISTF updated in 2017 Edition to include Appendix V provisions.

ASME OM Code Appendices

- Appendix I: Safety and Relief Valves
- Appendix II: Check Valve Condition Monitoring
- Appendix III (2009 Edition): MOV exercising at least every 24 months and diagnostic testing up to 10 years per margin.
- Appendix IV (2017 Edition): AOV quarterly stroke-time testing with preservice performance assessment testing (PAT) for all AOVs and periodic PAT for HSSC AOVs up to 10 years per margin.
- Appendix V (2012 Edition): Pump periodic verification flow test every 2 years.

Example OM Code Cases

- OMN-1 allows alternative to MOV quarterly stroke-time testing using exercising and periodic diagnostic testing.
- OMN-3 provides guidance for risk ranking components.
- OMN-11 provides risk-informed guidance for OMN-1.
- OMN-12 allows alternative to quarterly stroke-time testing for AOVs and HOVs using risk insights.
- OMN-20 allows grace period for extending IST intervals.

ASME OM Code Improvements under development

- Subsection ISTG for valves in new reactors.
- Standard to provide guidance for surveillance of pumps and valves within RTNSS scope for new nuclear power plants with passive emergency cooling systems.

V. 10 CFR 50.55a, Codes and standards

Current 10 CFR 50.55a
(as of July 1, 2017)

- ASME OM Code, 1995 Edition through 2006 Addenda, incorporated by reference with conditions.
- 50.55a(b)(3) includes conditions:
  - i. ASME Standard NQA-1 acceptable where supplemented by Appendix B of 10 CFR Part 50 as necessary
  - ii. Periodic verification of MOV design-basis capability
  - iii. Reserved
  - iv. Appendix II check valve condition monitoring
  - v. Subsection ISTD for snubbers
  - vi. Manual valve 2-year exercise interval
- 50.55a(f) requires latest OM Code incorporated by reference 12 months before fuel load for initial 10-year IST interval and 12 months before successive IST intervals.

10 CFR 50.55a Rulemaking

(final rule issued on July 18, 2017)

- ASME OM Code through 2012 Edition with conditions.
- Appendix III MOV testing condition.
- New reactor condition requiring:
  - Periodic verification of POV design-basis capability
  - Check valve bi-directional testing
  - Flow-induced vibration monitoring
  - RTNSS treatment
- Appendix II check valve sampling condition.
- Use of Subsection ISTE requires 50.55a alternative.
- Valve position indication condition.
- Code Case OMN-20 accepted for IST grace periods.
- Augmented IST for safety-related pumps and valves not ASME BPV Code Class 1, 2 or 3.

Future 10 CFR 50.55a Rulemaking

- NRC staff is reviewing ASME OM Code 2015 and 2017 Editions for possible incorporation by reference in 10 CFR 50.55a.
- NRC staff may consider relaxation of requirement to satisfy latest Code edition incorporated by reference in 50.55a 12 months before fuel load for initial 10-year IST/ISI program and 12 months before successive 10-year IST/ISI program.
- NRC staff may consider transfer of IST Program Plan submittal requirement from ASME OM Code to 10 CFR 50.55a

Regulatory Guide 1.192

Operation and Maintenance Code Case Acceptability, ASME OM Code

- RG 1.192 (Rev. 1) incorporated by reference in 50.55a
- Accepts OMN-2, 5, 6, 7, 8, 13, 14, and 16 without conditions.
- Accepts OMN-1, 3, 4, 9, and 12 with conditions
- Code Cases in RG 1.192 incorporated into 50.55a may be applied without requesting relief or alternatives.
- Current Code Case Rulemaking proposes to incorporate by reference RG 1.192 (Rev. 2), which proposes to accept OMN-15 (R2) and 17 without conditions and OMN-16 (R1), 18, 19 and 20 with conditions.

VI. Vogtle COL Pump and Valve IST Program

AP1000 DCD (Revision 19)

- Tier 2, Section 3.9.3.2.2 specifies functional capability of active valve assemblies will meet ASME QME-1-2007.
- Tier 2, Section 3.9.6 specifies:
  - General PST and IST program description
  - IST program will meet ASME OM Code 1995 Edition through 1996 Addenda
  - No safety-related pumps in AP1000 design.
  - POV program applies guidance from GLs 89-10 and 96-05, and JOG MOV Periodic Verification Program
  - Table 3.9-16 specifies IST method and frequency for each valve in IST program

AP1000 Design Certification FSER

NUREG-1793 Supplement 2

- AP1000 DCD supports design aspects.
- NRC conducted audit of design specifications for pumps, valves, and dynamic restraints.
- ASME QME-1-2007 required by design specifications.
- IST program description acceptable for incorporation into COL application.
- NRC staff will review operational program aspects regarding functional design, qualification, and IST programs for safety-related valves and dynamic restraints in COL application.

Vogtle COL FSAR

- Section 3.9 incorporates by reference AP1000 DCD.
- Section 3.9.6 provides full description of PST/IST operational program such as:
  - IST program based on OM Code 2001 Edition through 2003 Addenda
  - MOV IST testing implements OM Code Case OMN-1 (Rev. 1) as 50.55a alternative request
  - MOV design-basis testing based on GL 96-05 and JOG MOV Program
  - AOV design-basis testing based on JOG AOV program and RIS 2000-03
  - AOV program attributes applied to other POVs.

Vogtle COL FSER

NUREG-2124

- ASME QME-1-2007 acceptable per RG 1.100 (Rev. 3).
- IST program description based on OM Code 2001 Edition to 2003 Addenda acceptable with 50.55a(f) requirement to update 12 months before fuel load.
- OM Code Case OMN-1 (Rev. 1) acceptable as 50.55a alternative for MOV testing.
- AOV design-basis testing acceptable using RIS 2000-03 and JOG AOV program with attributes to other POVs.
- Flow-induced vibration addressed in initial test program.
- Squib valve surveillance based on design and qualification lessons learned.

Vogtle COL Conditions

(10) Operational Program Implementation

(c) PST program before initial fuel load

(l) MOV Testing program before initial fuel load

(11) Operational Program Implementation Schedule

– 12 months after COL issuance submit operational program schedule

– Update every 6 months until 12 months before fuel load and then every month until fully implemented

(12) Site- and Unit-specific Conditions

(f)(10) Surveillance Program for Squib Valves in addition to OM Code provisions

Squib Valve License Condition

- Preservice Testing
  - Verify operational readiness of actuation logic and circuits for each valve with pyrotechnic charge removed
  - Sample 20% of charges (including one valve from each redundant train) for capability of necessary motive force
  - Take corrective action to resolve any deficiencies in actuation logic or circuits, or charges
  - If charge fails to fire or capability not confirmed, all charges in same batch shall be removed, discarded, and replaced with charges from different batch with successful 20% sampling.

- Operational Surveillance
  - At least every 2 years, each squib valve undergoes visual external examination and remote internal examination to verify operational readiness and internal actuator position.
  - At least every 10 years, each squib valve shall be disassembled to verify operational readiness with both designs examined every 2 years.
  - For squib valves sampled every 2 years per OM Code, verify operational readiness of actuation logic and circuits after removal of charge.
  - For squib valves sampled every 2 years per OM Code, sampling must select one valve from each redundant safety train to confirm capability.

VII. New Reactor Inspection Guidance

Inspection Procedure 73758

Part 52, Functional Design and Qualification, and Preservice and Inservice Testing Programs for Pumps, Valves, and Dynamic Restraints (4/19/2013)

- Objectives are to evaluate:
  - establishment, implementation and results of functional design and qualification of pumps, valves, and dynamic restraints (snubbers)
  - establishment, implementation, and results of PST and IST for pumps, valves, and dynamic restraints during construction of Part 52 plants.

IP 73758 Overview

- IP 73758 based on inspection approach used for MOV inspections in response to GL 89-10.
- Appendices describe each programmatic inspection phase.
- Attachments describe specific MOV, AOV, and squib valve inspection activity.
- Inspection resources estimated as 160-500 hours for programmatic inspections described in each appendix.

IP 73758 Inspection Phases

- Initial program inspection (Appendix A)
- Implementation inspection of functional design and qualification program (Appendix B)
- Implementation inspection of PST/IST program (Appendix C)
- Close-out inspection of functional design, qualification, and PST/IST programs in preparation for plant startup (Appendix D)

Appendix A, Review of Functional Design, Qualification, and PST/IST Programs for Pumps, Valves, and Dynamic Restraints

- Evaluate development of functional design, qualification, and PST/IST programs for pumps, valves, and snubbers.
- Confirm functional design and qualification process specified in plant program and procedures consistent with FSAR and DCD as accepted in applicable FSERs.
- Determine whether PST/IST programs satisfy program description specified in FSAR and DCD as accepted in FSERs and comply with regulations.
- Perform early during construction process prior to component installation to confirm establishment of programs.

Appendix B, Implementation of Functional Design and Qualification Program for Pumps, Valves, and Dynamic Restraints

- Review documentation supporting functional design and qualification of sampled components.
- Review implementation of methodology with ASME QME-1-2007 as accepted in RG 1.100 (Rev. 3).
- For new component designs, review QME-1 provisions such as squib valves and nozzle check valves.
- Review qualification plan, testing, evaluation of test data, extrapolation of test data, post-qualification and post-installation requirements, and documentation.
- Evaluate RTNSS functional design and qualification.
- Perform prior to or during initial installation to confirm functional design and qualification process.

Appendix C, Implementation of PST/IST Program for Pumps, Valves, and Dynamic Restraints

- Review ongoing PST/IST activities.
- Evaluate PST/IST results for sample of components.
- In sample, emphasize plant risk, maintenance, programmatic weaknesses, and PST/IST schedule.
- Use IP 73758 attachments for PST/IST inspection of MOVs, AOVs, and squib valves.
- Verify licensee incorporating surveillance of RTNSS pumps and valves.
- Perform after installation to confirm implementation of PST/IST programs.

Appendix D, Close-Out Inspection for Functional Design, Qualification, and PST/IST Programs for Pumps, Valves, and Dynamic Restraints in Preparation of Plant Startup

- Review documentation supporting completion of functional design and qualification in comparison to design-basis requirements.
- Determine whether PST/IST activities satisfy OM Code as incorporated in 50.55a, and accepted relief or alternatives.
- Verify licensee completed functional design and qualification, and implemented surveillance for RTNSS pumps and valves.
- Perform 6 months before planned fuel loading to close-out construction inspection activities.

IP 73758, Attachment 1
Motor-Operated Valves

- MOV Selection
- MOV Program Scope
- Design Calculations
- Design-Basis Verification, PST and IST Testing
- MOV Trending
- Preventive Maintenance
- Corrective Actions
- Post-Maintenance Testing
- Operating Experience
- Periodic Verification
- Program Changes

MOV Selection

- MOV risk insights and performance
- BWROG (NEDC-32264) and WOG (V-EC-1658, Rev. 1) MOV risk ranking methodologies accepted with conditions in SE on 2/27/96 and 4/14/98, respectively.
- Focus on high risk and low margin MOVs
- Consider various sizes, types, and manufacturers
- Verify PL/TB addressed.

MOV Program Scope

- Safety-related MOVs
- If valve position has no effect on train operation, then MOV can be removed from scope; but containment isolation valves always have at least close function.
- MOVs in position that prevents safety-related train operation must be capable of returning to safety position.
- Licensees may rely on FSAR for design-basis events where consistent with facility licensing basis.
- Safe shutdown licensing basis defined in licensing documents.

MOV Design Calculations

- Review determination of design-basis functional requirements.
- Part 52 licensees have specified use of ASME QME-1-2007 as accepted in RG 1.100 (Rev. 3).
- Review other methodologies used for thrust/torque calculations:
  - Industry valve factor method
  - EPRI Application Guide TR-106563 on MOVs
  - EPRI MOV PPM for valve thrust/torque requirements
  - Limitorque Technical Update 98-01 (S1) for AC MOV output
  - ComEd White Paper 125 for MOV output
  - BWROG DC MOV methodology for stroke time and output
  - EPRI MOV Thrust Uncertainty Method for torque switch setting

- Review bases for MOV performance assumptions
  - Valve factor (VF)
  - Stem friction coefficient (SFC)
  - Load sensitive behavior or rate of loading (LSB or ROL)
  - Margins for stem lubrication degradation and springpack relaxation
  - Motor performance
    - rating
    - efficiencies (pullout, run, and stall)
    - application factor
    - degraded voltage factor
    - ambient temperature
  - Actuator efficiency
  - Degraded voltage

- Review bases for MOV performance assumptions (continued)
  - Differential pressure load extrapolation
  - Torque switch repeatability
  - Thrust/torque limit extrapolation
  - Equipment error
  - Degradation
  - Grouping (GL 89-10 Supplement 6)

- Evaluate design-basis capability of sampled MOVs
  - Request table of safety-related MOVs indicating ID number; description; open/close safety function; calculation method; MOV type and size (AC/DC motor, actuator, and valve); risk significance; DP; VF; SFC; ROL; design thrust/torque; control switch trip thrust/torque; and margin (as applicable)
  - Select 3 to 5 MOVs based on risk and margin, plus other items of interest (such as questions on identified parameters)
  - Review design calculations for sampled MOVs in detail
    - MOVs should have 5% margin after all uncertainties addressed to avoid operability calls for minor items
  - Review stall thrust and torque evaluations
  - Expand sample as necessary

- MOV Operating Requirements
  - ASME QME-1-2007 qualification program (RG 1.100)
  - EPRI PPM calculation
  - Plant-specific test data
  - Vendor or industry test data where justified

- AC motor actuator capability (gate and globe)

  (NRC Information Notice 96-48, S1; and Limitorque TU 98-01, S1)

$$ACT_{TOR} = M_T * Eff * AF * OAR * Temp * \left(\frac{V_{MIN}}{V_{RAT}}\right)^2$$

$$ACT_{THR} = \frac{ACT_{TOR}}{SF}$$

where

ACT_{TOR} = motor actuator output torque capability

ACT_{THR} = motor actuator output thrust capability

M_T = motor rated torque

V_{MIN} = minimum voltage at motor

V_{RAT} = rated motor voltage

Eff = pullout efficiency

AF = application factor

OAR = overall actuator ratio

Temp = temperature degradation factor (Limitorque TU 93-03)

- DC motor actuator capability (gate and globe)
  - BWROG methodology discussed in RIS 2001-15
  - BWROG methodology iterates over entire stroke length to determine changes in output capability and actuator speed
  - BWROG calculates final stroke time and capability margin

- Butterfly valve motor actuator capability

  Output Torque =

  SMB output * HBC Gear Ratio * HBC Gear Efficiency

  where HBC Gear Ratio and Efficiency obtained from Limitorque SEL documents

- Available MOV output least of:
  - motor actuator output capability (adjusted for degradation)
  - torque switch available output
  - operator torque/thrust rating (or justified extension)
  - maximum spring pack setting
  - valve torque/thrust weak link

- MOV output uncertainty examples
  – Test Equipment Inaccuracy
  – Torque Switch Repeatability
  – Rate of Loading
  – Spring Pack Relaxation
  – Stem Lubricant Degradation
  – Butterfly Valve Seat Degradation (e.g., seat hardening)

Limit or torque switch control, and use of diagnostics, will determine applicability of uncertainties

- MOV Margin for Gate and Globe Valves

Static Test

Close Margin = $\text{Thrust}_{\text{TST MEAS}}$ – Uncertainties – Required Thrust

Open Margin = Actuator Available Thrust – Required Thrust

Dynamic Test

Close Margin =

$\text{Thrust}_{\text{TST MEAS}}$ – Uncertainties – Extrapolated Required Thrust with uncertainties

Open Margin =

Act. Avail Thrust – Extrapolated Required Thrust with uncertainties

- MOV Margin for Butterfly Valve (Limit Control)

<u>Static Test</u>

Margin =

Actuator Available Torque – Required Torque

<u>Dynamic Test</u>

Margin =

Actuator Available Torque – Extrapolated Required Torque with uncertainties

Design-Basis Verification, PST and IST Testing

- Review licensee actions to:
  - Use best available data
  - Consider industry data
  - Justify each assumption
  - Assume reasonable value where no plant-specific data
  - Where realistic values assumed, take action if calculation predicts capability problem
  - Promptly evaluate test results
  - Justify accuracy of diagnostic equipment
  - Monitor test data to affirm assumptions
  - Justify application of data to valve group
  - Verify ITAAC met.

- When observing testing:
  - verify equipment setup and calibration in accordance with vendor specifications
  - verify procedures followed
  - verify test personnel qualification
  - verify Quality Control (QC) personnel participation
  - determine equipment inaccuracies
  - verify test results adequately reviewed before declaring MOV operable
- Determine that licensee has justified accuracy of MOV diagnostic equipment.
- Verify licensee training program for personnel testing MOVs and using diagnostic equipment.
- Determine that licensee activities prior to testing do not result in unacceptable preconditioning.

MOV Trending

- Licensee periodically reviews MOV deficiencies and corrective action for trends.
- Licensee addresses plant-specific and industry feedback.
- MOV parameters for trending include:
  – valve factor
  – stem factor (as found and as left)
  – load sensitive behavior (rate of loading)
  – actuator torque output
  – quarter-turn valve bearing coefficients
  – running loads
  – motor current and voltage
  – torque switch settings
  – capability margin
  – thrust and torque at control switch trip

MOV Preventive Maintenance

- Verify periodic MOV preventive maintenance (PM) based on MOV operation, environment, and experience.
- Walkdown of PM activities include checking:
  - MOV housing for cracking and grease or oil leakage
  - mounting flange and yoke for damage
  - missing fasteners and tightness
  - stem, gear cases, and limit switches for adequate lubrication
  - stem and stem nut for damage, and metal shavings below stem nut
  - T-drains and grease relief valve (paint or dirt)
  - grease in spring pack for hardening
  - limit switch compartment for grease, dirt, and wiring integrity.
- Determine adequate MOV personnel maintenance training.
- Evaluate implementation of MOV vendor recommendations.

MOV Corrective Actions

- Verify administrative procedures require MOV failures/malfunctions/deficiencies are promptly identified and corrected.
- On sample basis, verify adequacy of analysis of MOV deficiencies, justification of corrective actions, and trending.
- Review recent MOV deficiencies and corrective actions for adequate resolution.
- Verify appropriate level of cause analysis based on safety significance.

MOV Post-Maintenance Testing

- Verify post-maintenance testing (PMT) procedures require MOVs be properly tested before return to service.
- Review selected maintenance packages and verify PMTs demonstrate MOV capable of performing its function.
- If no PMT performed, licensee should justify that test not necessary to demonstrate MOV capability
  - If PMT not performed following packing adjustment, licensee needs adequate basis to demonstrate packing torque does not adversely affect capability.
- Verify licensee adequately addressing potential preconditioning.

MOV Operating Experience

- Review licensee’s procedures for addressing lessons learned from operating experience from plant, industry, and vendor notifications.
- Select sample of recent MOV issues to determine acceptable licensee action.

MOV Periodic Verification

- Review implementation of licensee's program for MOV periodic verification for compliance with 10 CFR 50.55a and ASME OM Code.
- Consider MOV operating requirements and output capability.
- Review licensee consideration of safety-related MOVs outside JOG program scope, if applicable.
- Review results of sample MOV diagnostic tests for feedback into program assumptions for valve factor, stem friction coefficient, and load sensitive behavior.

MOV Program Changes

- Review changes in MOV program since previous reviews and inspections.
- Determine significance of changes and consistency with licensee commitments and lessons learned from operating experience.

IP 73758, Attachment 2
Air-Operated Valves

- AOV Selection
- AOV Program Scope
- Design Calculations
- Design-Basis Verification, PST and IST Testing
- AOV Trending
- Preventive Maintenance
- Corrective Actions
- Post-Maintenance Testing
- Operating Experience
- Periodic AOV Program Verification
- Program Changes

AOV Selection

- AOV risk insights and performance.
- Focus on high risk and low margin AOVs.
- Consider various sizes, types, and manufacturers.
- Consider operating experience issues for specific AOV types.

AOV Program Scope

- Safety-related AOVs
- If valve position has no effect on train operation, then AOV can be removed from scope; but containment isolation valves always have at least close function.
- AOVs in position that prevents safety-related train operation must be capable of returning to safety position.
- Licensees may rely on FSAR for design-basis events where consistent with facility licensing basis.
- Safe shutdown licensing basis defined in licensing documents.

AOV Design Calculations

- Review determination of design-basis functional requirements.
- Review implementation of ASME QME-1-2007 as accepted in RG 1.100 (Rev. 3) as specified in FSAR and DCD.
- Licensee may apply EPRI MOV PPM for valve operating requirements for AOV thrust/torque.
- Determine licensee actions to address pressure locking and thermal binding.

Design-Basis Verification, PST and IST Testing

- Review licensee actions to determine whether licensee has demonstrated functional design-basis AOV capability such as by implementing ASME QME-1-2007 as accepted in RG 1.100 (Rev. 3).
- Determine that applicable ITAAC have been satisfied.
- Determine that ASME OM Code as incorporated by reference in 10 CFR 50.55a has been met.
- Review application of RIS 2000-03 as specified in FSAR and DCD.
- Review AOV table for sizing and setting assumptions.

- When observing testing:
  - verify equipment setup and calibration in accordance with vendor specifications
  - verify procedures followed
  - verify test personnel qualification
  - verify QC personnel participation
  - determine equipment inaccuracies
  - verify test results adequately reviewed before declaring AOV operable
- Determine that licensee has justified accuracy of AOV diagnostic equipment.
- Verify licensee training program for personnel testing AOVs and using diagnostic equipment.
- Determine that licensee activities prior to testing do not result in unacceptable preconditioning.

AOV Trending

- Licensee periodically reviews AOV deficiencies and corrective action for trends.
- Licensee addresses plant-specific and industry feedback.
- Determine that licensee is evaluating trends of qualitative information on AOV performance.

AOV Preventive Maintenance

- Verify periodic AOV preventive maintenance based on AOV operation, environment, and experience.
- Evaluate preventive maintenance activities during a walkdown of installed AOVs.
- Determine that licensee has adequate training program for personnel performing AOV maintenance.
- Evaluate licensee implementation of vendor recommendations for AOV preventive maintenance.

AOV Corrective Actions

- Verify administrative procedures require AOV failures/malfunctions/deficiencies are promptly identified and corrected.
- On sample basis, verify adequacy of analysis of AOV deficiencies, justification of corrective actions, and trending.
- Review recent AOV deficiencies and corrective actions for adequate resolution.
- Verify appropriate level of cause analysis based on safety significance.

AOV Post-Maintenance Testing

- Verify that PMT procedures require AOVs be properly tested before return to service.
- Review selected maintenance packages and verify PMTs demonstrate AOV capable of performing its function.
- If no PMT performed, licensee should justify that test not necessary to demonstrate AOV capability
  - If PMT not performed following packing adjustment, licensee needs adequate basis to demonstrate packing torque does not adversely affect capability.
- Verify licensee adequately addressing potential preconditioning.

AOV Operating Experience

- Review licensee’s procedures for addressing lessons learned from operating experience from plant, industry, and vendor notifications.
- Select sample of recent AOV issues to determine acceptable licensee action.

AOV Periodic Verification

- Review implementation of licensee’s program for AOV periodic verification consistent with FSAR and DCD, and applicable 50.55a regulations.
- Licensees have specified in FSAR or DCD that RIS 2000-03 attributes will be implemented.
- Review documentation to determine that commitments have been implemented.

AOV Program Changes

- Review changes in AOV program since previous reviews and inspections.
- Determine significance of changes and consistency with licensee commitments and lessons learned from operating experience.

IP 73758, Attachment 3
Pyrotechnic-Actuated Valves

- Squib Valve Selection
- Squib Valve Program Scope
- Design Calculations
- Design-Basis Verification, PST and IST Testing and Surveillance
- Squib Valve Trending
- Preventive Maintenance
- Corrective Actions
- Post-Maintenance Testing and Surveillance
- Operating Experience
- Periodic Testing and Surveillance Results
- Program Changes

Squib Valve Selection

- With small population of squib valves, select all squib valves with safety functions for initial inspection.
- Subsequent inspections may sample squib valve population.

Squib Valve Program Scope

- Determine that licensee has included squib valves with safety functions in scope of Appendix B to 10 CFR Part 50.

Squib Valve Design Calculations

- Review determination of design-basis functional requirements.
- Review implementation of ASME QME-1-2007 as accepted in RG 1.100 (Rev. 3) as specified in FSAR and DCD.
- Review design-basis capability calculations for squib valves.

Design-Basis Verification, PST and IST Testing and Surveillance

- Review licensee actions to determine whether licensee has demonstrated functional design-basis capability such as by implementing ASME QME-1-2007 as accepted in RG 1.100 (Rev. 3).
- Determine that applicable ITAAC have been satisfied.
- Determine that ASME OM Code as incorporated by reference in 10 CFR 50.55a has been met.
- Review implementation of COL license conditions for PST and IST surveillance of squib valves.

- When observing squib valve surveillance:
  - verify equipment setup and calibration in accordance with vendor specifications
  - verify procedures followed
  - verify test personnel qualification
  - verify QC personnel participation
  - determine equipment inaccuracies
  - verify surveillance results adequately reviewed before declaring squib valves operable
- Determine that licensee has justified accuracy of diagnostic equipment.
- Verify licensee training program for personnel testing squib valves and using diagnostic equipment.
- Determine that licensee activities prior to testing do not result in unacceptable preconditioning.

Squib Valve Trending

- Licensee periodically reviews squib valve information and corrective action for trends.
- Licensee addresses plant-specific and industry feedback.
- Determine that licensee is evaluating trends of qualitative information on squib valve performance.

Preventive Maintenance

- Verify periodic squib valve preventive maintenance.
- Evaluate PM activities during walkdown of installed squib valves.
- Determine that licensee has adequate training program for personnel performing squib valve maintenance.
- Evaluate licensee implementation of vendor recommendations for squib valve preventive maintenance.

Corrective Actions

- Verify administrative procedures require squib valve failures/malfunctions/deficiencies are promptly identified and corrected.
- Verify adequacy of analysis of squib valve deficiencies, justification of corrective actions, and trending.
- Review recent squib valve deficiencies and corrective actions for adequate resolution.
- Verify appropriate level of cause analysis based on safety significance.

Post-Maintenance Testing and Surveillance

- Verify that PMT procedures require squib valves receive proper testing and surveillance before return to service.
- Review selected maintenance packages and verify PMTs demonstrate squib valve capable of performing its function.
- Where squib valve stroking is not practicable, the licensee may use other PMT methods.
- Review licensee’s justification for PMT of squib valves.

Operating Experience

- Review licensee’s procedures for addressing lessons learned from operating experience from plant, industry, and vendor notifications.
- Select sample of recent issues to determine acceptable licensee action.

Periodic Testing and Surveillance Results

- Review implementation of licensee's program for squib valve periodic testing and surveillance consistent with FSAR and DCD, applicable 50.55a regulations, and COL license conditions.
- Review documentation to determine that requirements have been implemented.

Program Changes

- Review changes in squib valve program since previous reviews and inspections.
- Determine significance of changes and consistency with licensee commitments and lessons learned from operating experience.

IP 62708
Motor-Operated Valve Capability

- Objective is to assess extent of performance issues and adequacy of licensee's evaluation of MOVs when directed by IP 95002.
- Addresses MOV selection, scope, design calculations, testing, trending, PM, corrective action, PMT, operating experience, periodic verification, and program changes.
- Appendix A provides guidance on MOV program scope.
- 2013 update discusses:
  - 4 acceptable methods to demonstrate MOV design basis capability
  - Extending MOV exercising from quarterly to RFOs
  - JOG MOV periodic verification program
  - MOV background issues and bases in new Appendix B.

IP 62710
Power-Operated Gate Valve
Pressure Locking and Thermal Binding

- Objective is to provide guidance to inspectors to independently assess extent of condition related to power-operated gate valve PL/TB as part of IP 95002.
- Addresses power-operated gate valve program scope, design bases conditions, PL/TB calculations, testing, corrective actions, and trending.
- Provides guidance on PL methodologies and modifications.
- Provides guidance on TB analyses.
- Updated in 2010 to address design improvements to avoid pressure locking.

IP 65001.07
Inspection of ITAAC-Related Installation of Valves

- Inspection Objectives
  - Verify design bases and vendor design information correctly translated to valve installation
  - Installation in accordance with DCD and regulatory requirements
  - FSAR requirements correctly translated to construction specifications
  - Valve installation welding conducted according to requirements
  - Confirm POV switch setup
  - Determine records reflect work accomplished in accordance with requirements
  - Evaluate QA program implementation

- Inspection requirements address installation, welding, post-installation activities, testing and verification and problem resolution.
- Testing and verification ensures that POVs capable of performing safety functions under design-basis conditions through functional design and qualification program, and flow tests following POV installation.
- IP 73758 provides inspection guidance for evaluating functional design, qualification, and IST programs.
- Verify that test reports exist that conclude that each valve changes position under design conditions.
- 1040 hours of direct inspection effort over the course of plant inspection.

IP 65001.14
Inspection of ITAAC-Related Installation of Complex Systems with Multiple Components

- Objectives include determination that ITAAC-related tests and verification activities being conducted in accordance with design specifications, approved procedures, and design criteria.
- Provides general inspection guidance for installation walkdown, design modification review, testing and verification inspection, evaluation of seismic and environmental qualification criteria, and problem resolution.
- Updated in 2015.

IP 65001.D
Inspection of ITAAC-Related Operational Testing Program

- Objectives are to provide guidance for inspection of all types of operational testing to accomplish ITAAC; and to ensure that testing is adequate, consistent with regulatory requirements, and licensee commitments.
- Provides guidance for procedure review, test witnessing, test results review, and problem resolution.
- Periodic update in 2014.

VIII. Conclusions

- COL applications specify functional qualification using ASME QME-1-2007 and fully describe IST and MOV Testing operational programs by incorporating by reference DCD provisions with FSAR supplemental provisions.
- MOV lessons learned applied to improve NRC regulations, guidance, and inspection procedures; ASME Standard QME-1; and ASME OM Code.
- In Vogtle COL FSER, NRC evaluated and accepted FSAR provisions for functional qualification, and IST and MOV Testing program description.
- Inspection procedures provide guidance for evaluation of functional design, qualification, and IST programs for pumps and valves at new reactors.