



EPRI Circuit Breaker Maintenance Research



Jim Sharkey
Senior Principal Technical Leader
jsharkey@epri.com

National Shipbuilding Research Program
Joint Welding Technology and Electrical Technology Panel
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Presentation Outline

- Circuit breaker user's group (CBUG) mission / objectives
- Critical Circuit breaker industry documents
- Circuit breaker nuclear plant populations
- Supplemental information
 - EPRI Circuit Breaker/Switchgear Products Available
- Training
- Example research project – Bus monitoring and arc fault mitigation

Mission of the Circuit Breaker Users Group

- Provide circuit breaker and switchgear information, guidance, and tools to help increase reliability, reduce costs, and improve safety
 - **Resolve**
 - Resolve industry issues (via working with the manufacturers, service providers, CBUG working groups, EPRI initiatives, and industry guidance)
 - **Inform**
 - Develop/Maintain preventive maintenance basis
 - Information repository (Website; Collaboration tools)
 - Contact network (CBUG Inquiries; Benchmarking, Surveys)
 - **Educate**
 - Workshops / Tutorials
 - **Facilitate**
 - Facilitate interaction with utility peers, vendors/suppliers (Vendor Expos)

CBUG Objectives

▪ **Interact**

- Interaction with peers and vendors
- Benchmark programs and practices

▪ **Industry Trends**

- Discuss operating experience
- Program issues (Maintenance intervals, etc.)
- Regulatory issues
- Equipment issues
- EPRI research projects
- New technologies, techniques, products, test equipment, monitoring systems

▪ **Professional Development**

- Informative workshops and tutorials

Goals

- Build relationships; Get to know your peers and vendors
- Operating experience
- Equipment issues
- New technologies and equipment
- Industry initiatives



Critical Industry/CBUG Documents

Critical Documents - US NRC Information Notice 99-13

- [US NRC 99-13 - Insights from NRC Inspections of Low- and Medium-voltage Circuit Breaker Maintenance Programs](#)
- Summarizes observations and insights gained during inspections of licensee circuit breaker maintenance programs using Temporary Instruction (TI) 2515/137, Rev 1
- Includes
 - Program issues
 - preventive maintenance
 - Licensee / Vendor interface
 - Control voltage calculations,
 - Operating experience

The screenshot shows the US NRC website header with the logo and navigation links. The main content area displays the title 'Information Notice No. 99-13: Insights from NRC Inspections of Low- and Medium-voltage Circuit Breaker Maintenance Programs' and a table of contents.

U.S. NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

FAQ | AGREEMENT STATES | FACILITY LOCATOR | WHAT'S NEW | SITE HELP | INDEX A-Z | CONTACT US | EMAIL UPDATES

REPORT A SAFETY CONCERN [SEARCH]

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NUCLEAR REACTORS NUCLEAR MATERIALS RADIOACTIVE WASTE NUCLEAR SECURITY PUBLIC MEETINGS & INVOLVEMENT NRC LIBRARY ABOUT NRC

Home ▶ NRC Library ▶ Document Collections ▶ Generic Communications ▶ Information Notices ▶ 1999

Information Notice No. 99-13: Insights from NRC Inspections of Low- and Medium-voltage Circuit Breaker Maintenance Programs

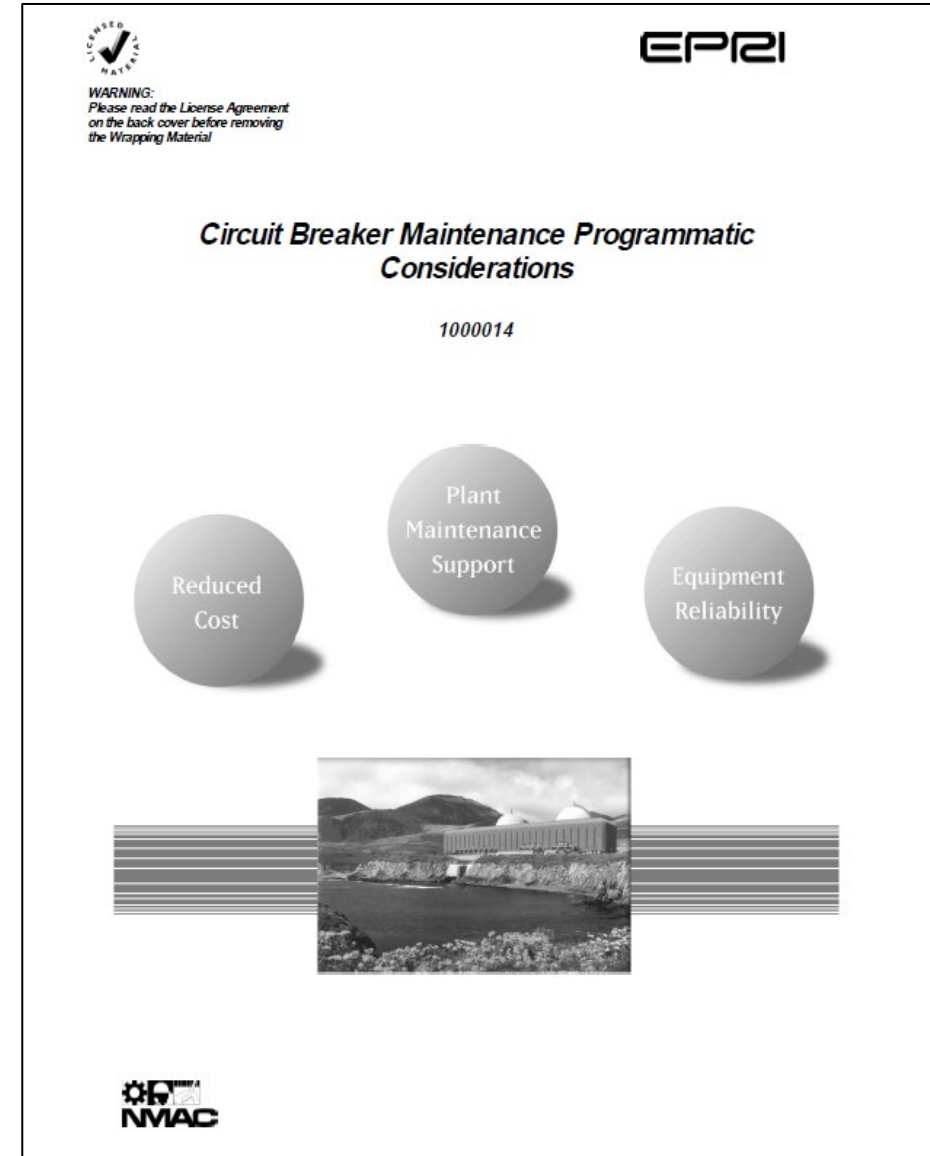
UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

April 29, 1999

NRC INFORMATION NOTICE 99-13:	INSIGHTS FROM NRC INSPECTIONS OF LOW- AND MEDIUM-VOLTAGE CIRCUIT BREAKER MAINTENANCE PROGRAMS
<ul style="list-style-type: none">• Addressees• Purpose• Description of Circumstances• Discussion<ul style="list-style-type: none">• I. General Programmatic Issues• II. Preventive Maintenance• III. Licensee/Vendor Interface• IV. Control Voltage Calculations• V. Operating Experience Review• Related Generic Communications• Conclusion	

Critical Documents

- [EPRI 1000014, Circuit Breaker Programmatic Considerations](#)
 - Attachment B – Insights from NRC Circuit Breaker Maintenance Program Inspections (Letter from NRC staff to EPRI)
-
- Organizational responsibilities
 - CB tracking and traceability
 - Supporting design basis
 - Control voltage calculations
 - Use of spares
 - Receipt inspections
 - Program self-assessments
 - As-found data
 - Condition and predictive maintenance
 - Reduced control voltage testing
 - Timing and travel analysis
- Maintenance intervals
 - Lubrication
 - Insulation resistance criteria
 - Maintaining knowledge/skill level
 - Troubleshooting
 - Quarantine procedures
 - Root cause investigations
 - Overhaul program guidance
 - Vendor interface
 - Training considerations
 - Parts procurement



Critical Industry Documents

- NRC

- [US NRC 99-13 - Insights from NRC Inspections of Low- and Medium-voltage Circuit Breaker Maintenance Programs](#)
- [US NRC IN 2007-34, Operating Experience Regarding Electrical Circuit Breakers](#)

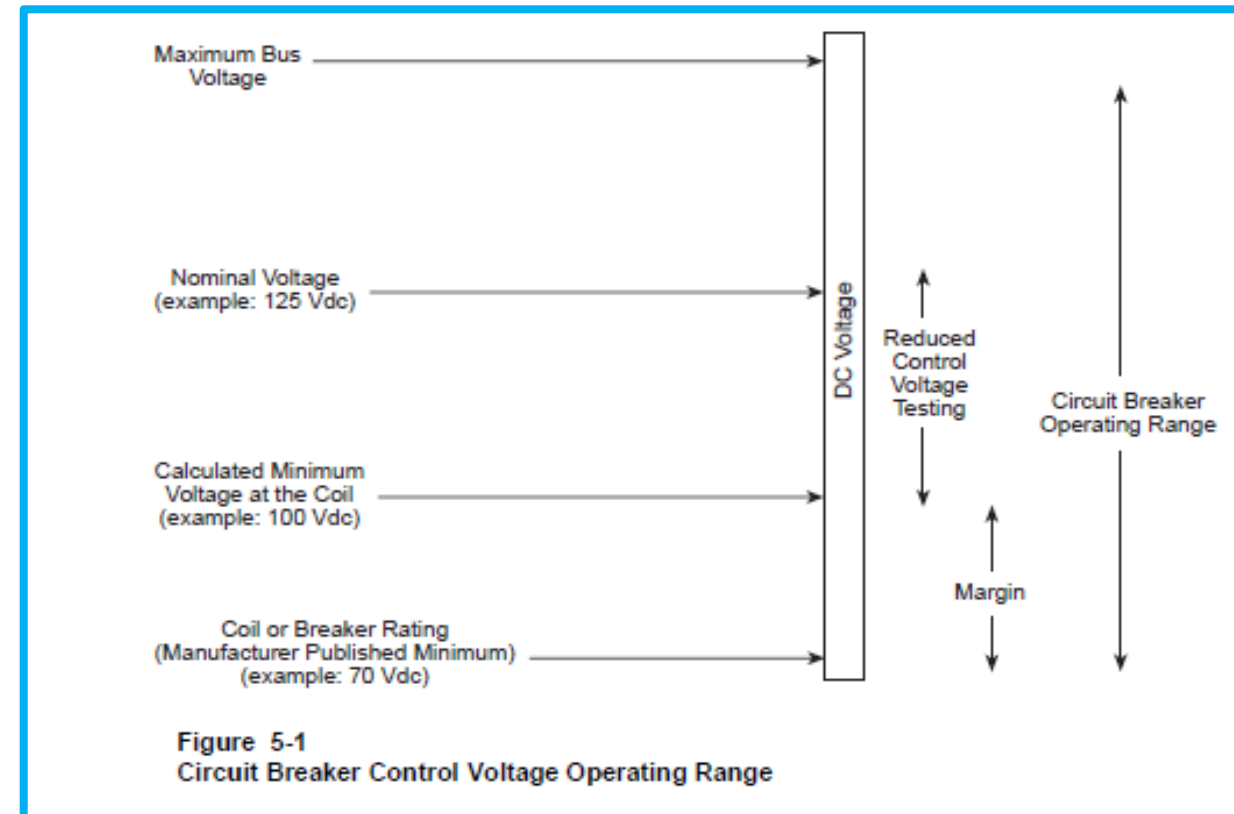
- EPRI

- [EPRI 1000014, Circuit Breaker Programmatic Considerations](#)
 - Attachment B –(Additional) Insights from NRC Circuit Breaker Maintenance Program Inspections
- [EPRI 3002018277, Considerations for Extending Circuit Breaker Maintenance Intervals; An Evaluation of Maintenance Practices Considering Value-Based Maintenance](#)
- Not critical, but important to know . . .
 - [EPRI TR-112814, Reduced Control Voltage Testing of Low and Medium Voltage Circuit Breakers](#)
 - [EPRI TR-112783, Circuit Breaker Timing and Travel Analysis](#)

Critical Documents

EPRI TR-112814, Reduced Control Voltage Testing

- Demonstrates circuit breaker operability at reduced control voltage
- Identifies margins to unsatisfactory performance
- Provides information only on the operation of the open and close coils and their interaction with trip and close components (latches, bushings, rollers, linkages, etc.)
- Performed prior to maintenance (as-found) and after maintenance (as-left)
- Considered a pass or fail test.



Critical Documents

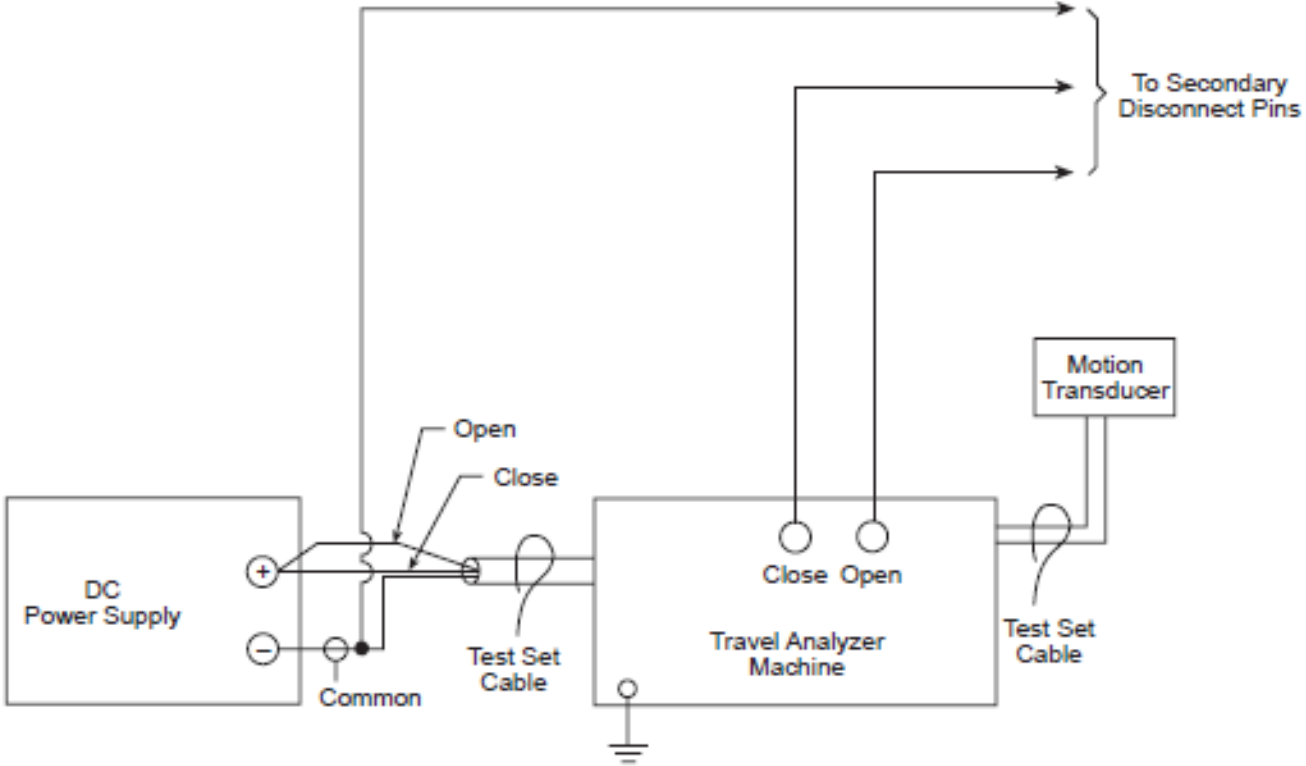
EPRI TR-112783, Circuit Breaker Timing and Travel Analysis

- Timing and travel analysis (tests) provides some indication of the condition of specific circuit breaker subcomponents but does not provide an assessment of the overall condition of a circuit breaker.

- Timing Tests
 - Closing: Time that elapses between electrical close signal and the arcing contacts touching
 - Opening: Time that elapses between trip signal and the instant the arcing contacts separating
 - Includes :
 - Coil response time
 - Mechanical response time
 - Time it takes the arcing contacts to travel the distance to either separate (open) or touch (close)

- Travel tests provide
 - Timing values, Velocity of the contacts, Travel distance, Penetration of the contacts, Rebound of the movable contacts, Contacts over-travel/under-travel

EPRI TR-112783, Circuit Breaker Timing and Travel Analysis



- Notes: 1) Motion transducer is mounted on the breaker.
 2) Close and open signal to the breaker is controlled by the travel analyzer machine.

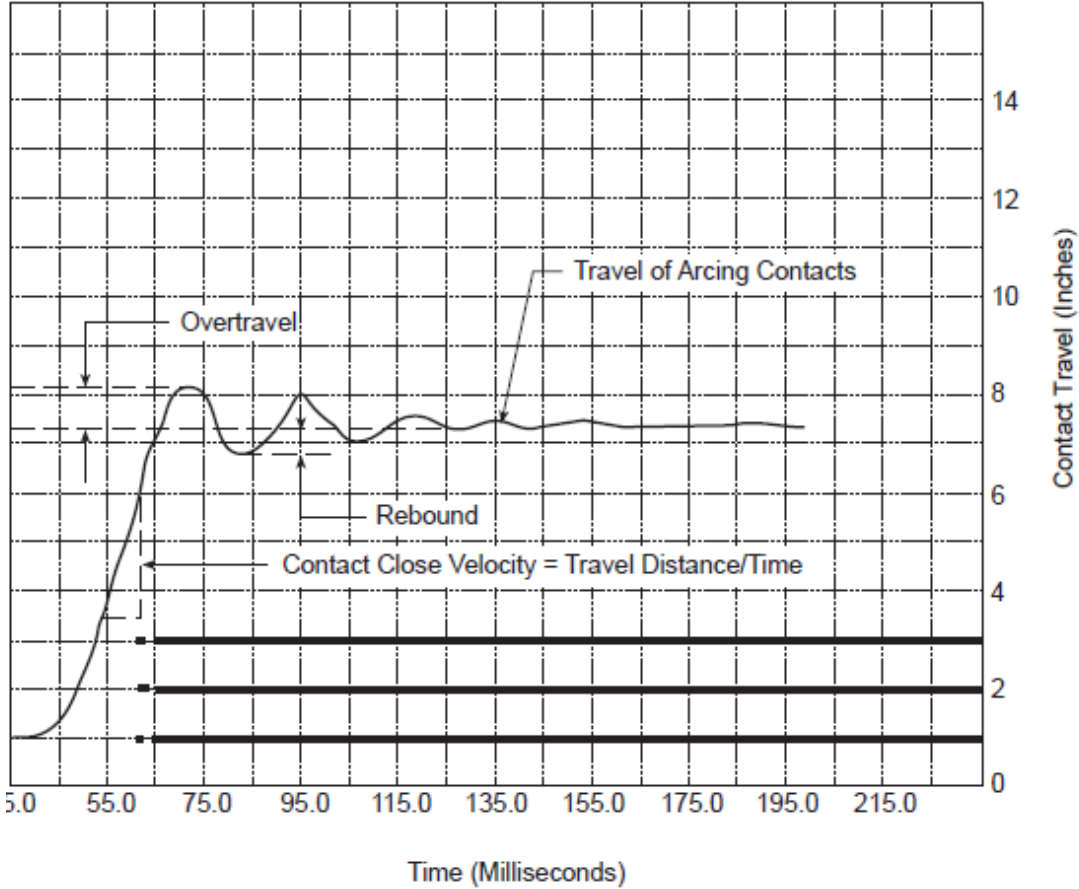


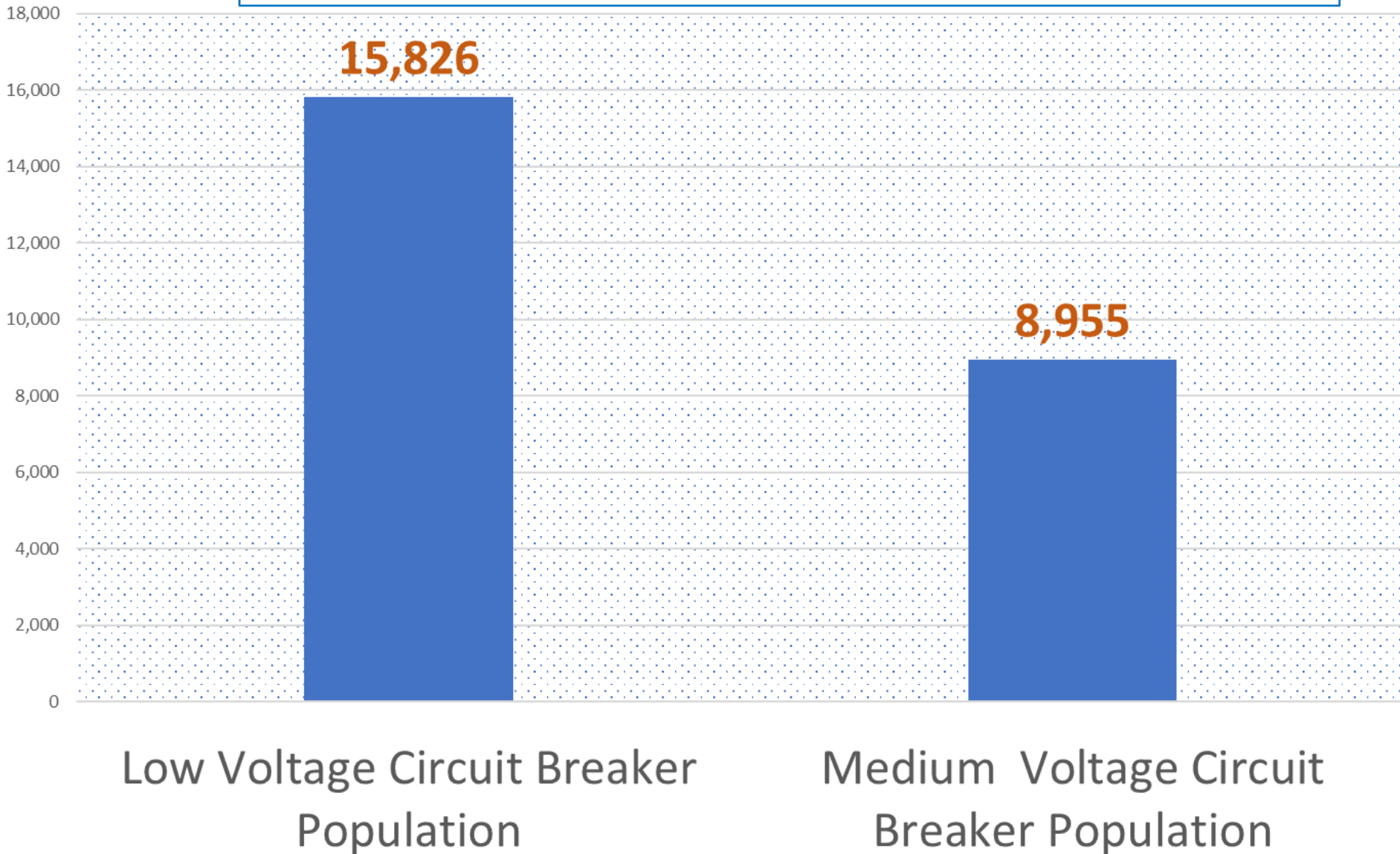
Figure 3-2
 Typical Open and Close Timing and Travel Test Set-Up



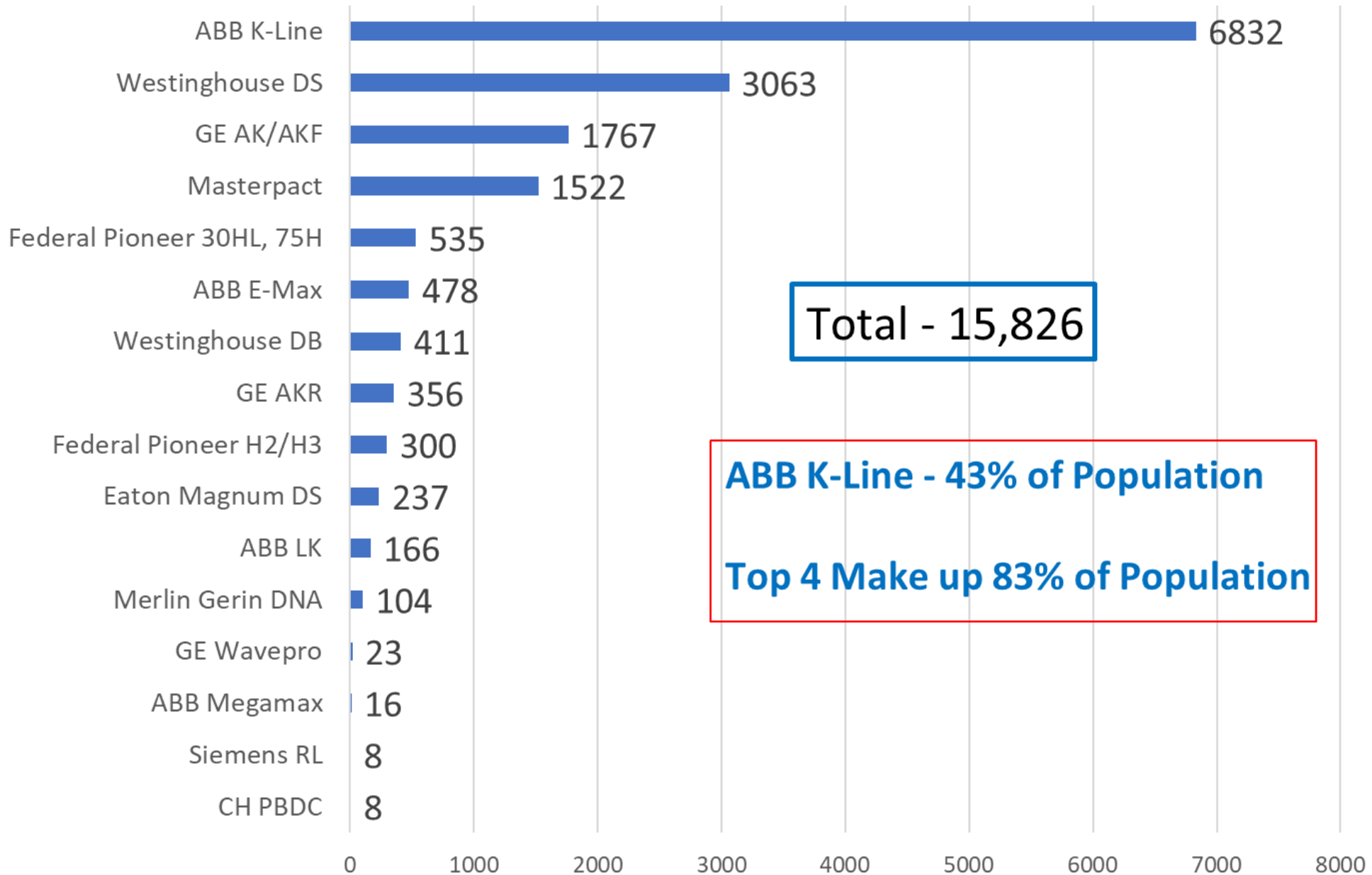
Circuit Breaker Populations

Medium & Low Voltage Circuit Breaker Populations

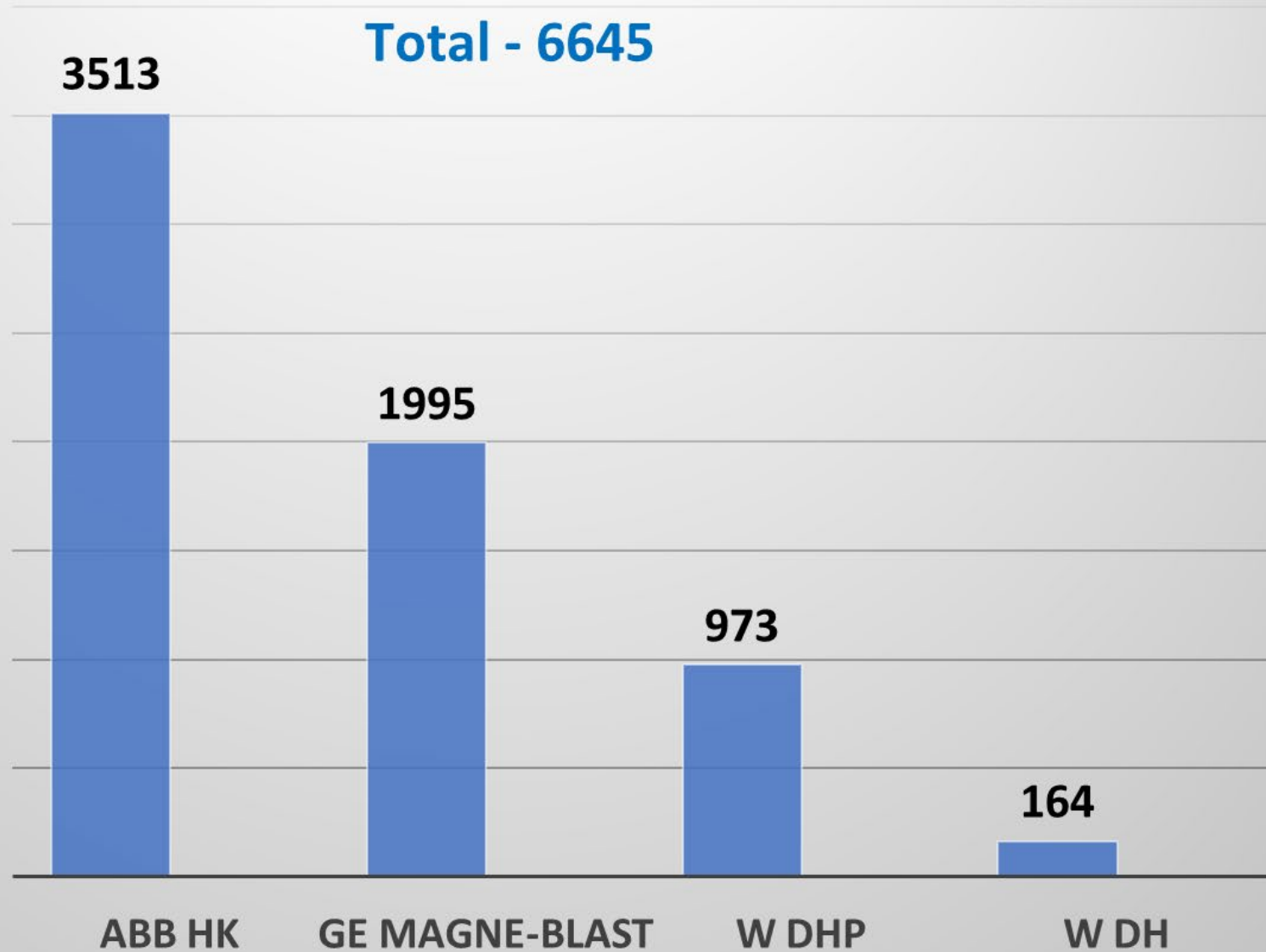
Total - 24,781



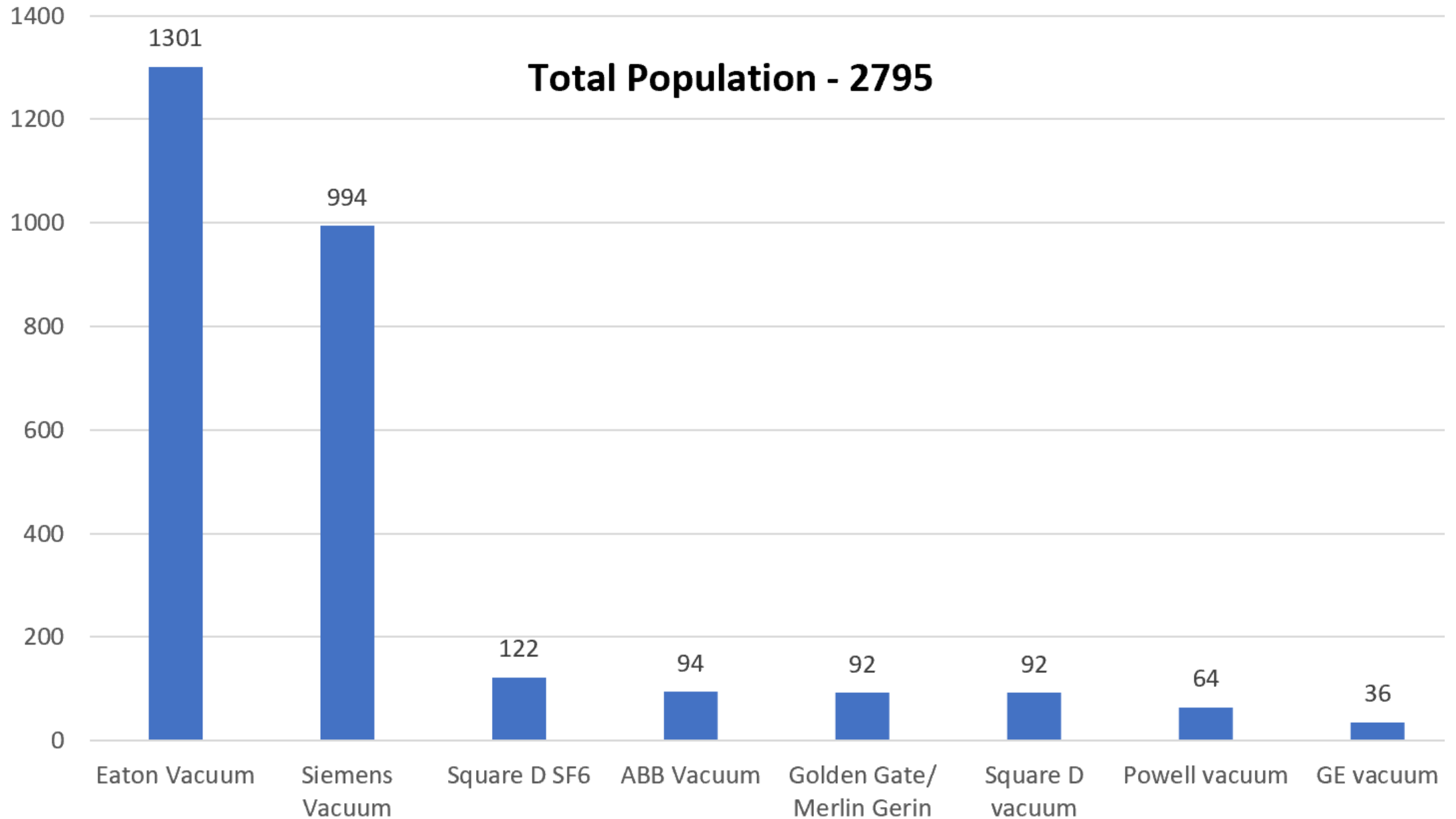
Low Voltage Breaker Population (MFR/Type)



Medium Voltage Air Magnetic Breaker Populations

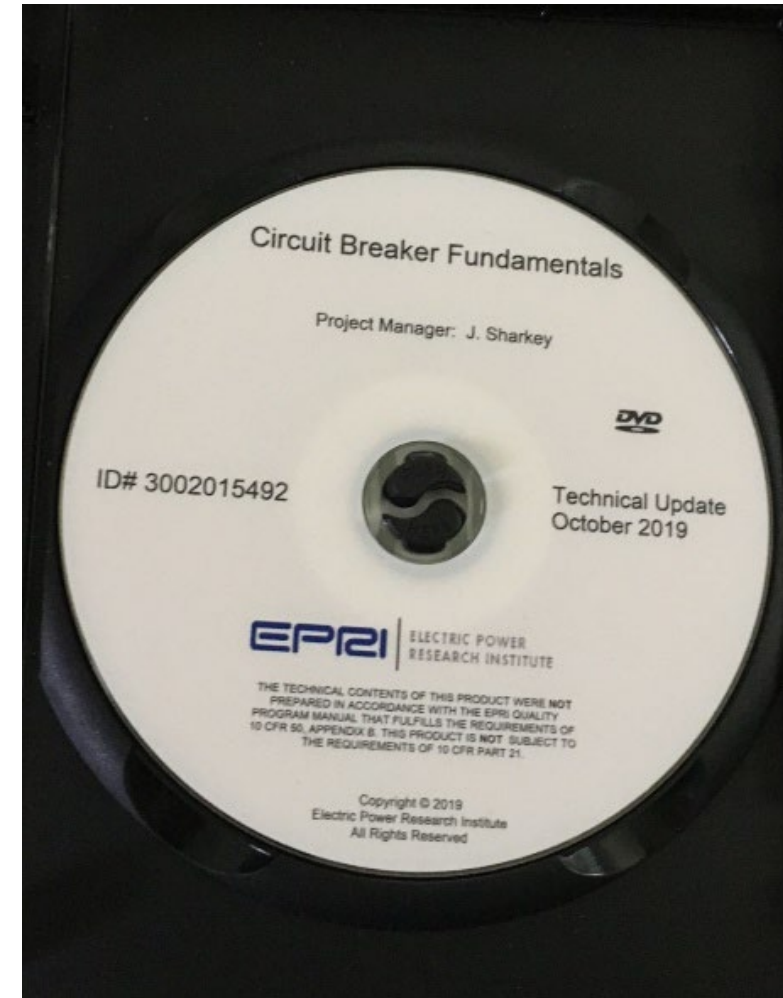


Medium Voltage Vacuum & SF6 Breaker Populations



Circuit Breaker Training

- [EPRI 3002015492, Circuit Breaker Fundamentals \(Video Presentation\)](#)
 - Presented multiple times during CBUG meetings. Well-received by the industry
 - Workshop targets new, or relatively new System/Component Engineers that have minimal knowledge of circuit breakers and switchgear.
 - Includes topics that are not contained in manufacturer's model-specific courses, but are important to circuit breaker system engineers and technicians in a nuclear plant.
- Manufacturers Offer Training
 - Good Practice: Using manufacturer model-specific training courses for a plant's predominant circuit breaker population



Bus Monitoring and Arc Fault Mitigation

Utilizing modern digital relay technology

■ Objectives

- Discuss technologies used in monitoring/arc fault mitigation
- Describe how these systems work, the components, installation considerations and challenges
- Discusses challenges (Cyber security, Common cause failure)
- Identify advantages and limitations
 - Relay calibration labor costs
 - Working distances and personal protective equipment (PPE)
 - Forced-outage times resulting from faults
- Provide roadmap for members to implement these systems



Supplemental Information

EPRI Circuit Breaker/Switchgear Products Available

EPRI Circuit Breaker/Switchgear Products Available

▪ Special Topics

- Circuit Breaker Fundamentals, 3002015492 (2019)
- Circuit Breaker Timing and Travel Analysis, TR-112783 (1999)
- Reduced Control Voltage Testing of Low and Medium Voltage Circuit Breakers, TR-112814 (1999)
- Avoiding Equipment Outage Due to Indicating Lights, 3002022398 (2021)
- Switchgear Potential and Current Transformer Circuits, 3002023698
- Field Testing of Overcurrent Trip Units for Low Voltage Circuit Breakers Used in DC Applications, TR-104513 (1994)
- Evaluation and Testing of ABB Circuit Breakers with Mobilgrease 28, 1003087 (2001)
- Considerations for Conversion or Replacement of Medium-Voltage Air-Magnetic Circuit Breakers Using Vacuum or SF6 Technology: Revision to TR-106761, 1007912 (2003)
- Evaluation of Cracks in ABB HK Arc Chutes, 1012004 (2004)

EPRI Circuit Breaker/Switchgear Products Available

■ Program

- Circuit Breaker Maintenance Programmatic Considerations, 1000014, 2000
- Guidelines for the Development of Circuit Breaker Specialists, 1025241, 2012
- Considerations for Extending Circuit Breaker Maintenance Intervals, 3002018277

■ Bus Maintenance

- Switchgear and Bus Maintenance Guide, 1013457, 2006
- Lessons Learn from Exelon's Non-Segregated Bus Inspections, 3002000707, 2013
- Considerations for the Reliability and Maintenance of Bolted Bus Bar Connections, 3002011484, 2018

EPRI Circuit Breaker/Switchgear Products Available

- **NP 7410 Reports** (Prior to formation of the CBUG)
 - Westinghouse
 - Circuit Breaker Maintenance: Volume 1: Low-Voltage Circuit Breakers Part 3: Westinghouse DB Models, NP-7410-V1-P3, 1992
 - Circuit Breaker Maintenance: Volume 1: Low-Voltage Circuit Breakers, Part 4: Westinghouse DS Models, NP-7410-V1-P4, 1992
 - Circuit Breaker Maintenance: Volume 2: Medium Voltage Circuit Breakers; Part 3: Westinghouse Types DH and DHP, NP-7410-V2-P3, 1994
 - ABB
 - Circuit Breaker Maintenance Volume 1: Low-Voltage Circuit Breakers Part 1: ABB K-Line, NP-7410-V1-P1, 1993
 - Circuit Breaker Maintenance: Volume 2: Medium-Voltage Circuit Breakers, Part 1: ABB HK Models, NP-7410-V2-P1, 1993
 - General Electric
 - Circuit Breaker Maintenance Volume 1: Low-Voltage Circuit Breakers Part 2: GE AK Models, NP-7410-V1-P2, 1994
 - Circuit Breaker Maintenance: Volume 2: Medium Voltage Circuit Breakers; Part 2: General Electric Magne-Blast Circuit Breakers, NP-7410-V2-P2, 1995

EPRI Circuit Breaker/Switchgear Products Available

■ General Electric

- Routine Preventive Maintenance Guidance for AK and AKR Type Circuit Breakers: Supersedes NP 7410-V1P2, TR-112938, 1999
- Guidance on Routine Preventive Maintenance for Magne-Blast Circuit Breakers: Supplement to NP-7410-V2-P2, TR-109641, 1998
- Guidance on Overhaul of Magne-Blast Circuit Breakers: Supplements and Revises EPRI NP-7410-V2P2, 1000011, 2000
- Guidance on Overhaul of AK 15/25 Circuit Breakers: Supplements and Revises NP-7410-V1P2, 1002759, 2001
- Routine Preventive Maintenance for AK and AKR Type Circuit Breakers: Revision 1 of TR-112938; Supplements and Revises NP-7410-V1P2, 1003086, 2001

EPRI Circuit Breaker/Switchgear Products Available

■ ABB

- Routine Preventive Maintenance Guidance for ABB K-Line Circuit Breakers: Supplements and Revises NP-7410-V1P1, TR-113736, 2000
- Guidance on Overhaul of ABB K-Line Circuit Breakers: Supplements and Revises NP-7410-V1P1, 1000013, 2001
- Routine Preventive Maintenance Guidance for ABB HK Circuit Breakers: Supersedes NP-7410-V1P2, TR-109642, 1999

■ Westinghouse

- Routine Preventive Guidance for Westinghouse DS Circuit Breakers: Supplements and Revises NP-7410-V1P4, 1000246, 2000
- Routine Preventive and Condition-Based Maintenance for Westinghouse DHP Circuit Breakers: Revision 1 of 1000010, Supplements and Revises NP-7410-V2P3, 1002758, 2001

EPRI Circuit Breaker/Switchgear Products Available

▪ **Motor Control Centers and Molded Case Circuit Breakers**

- 1009832, Molded Case Circuit Breaker Application and Maintenance Guide (Revision 2)
- Motor Control Center End-of-Expected-Life Guidance, 3002000562, 2013

▪ **3-Dimensional Animation and Virtual Reality**

- K-Line 3-D Animated Circuit Breaker Maintenance Application, 3002000163, 2014
- Circuit Breaker Virtual Reality Application (K-1600); 3002018210 (2021)



Questions?

