EPRI

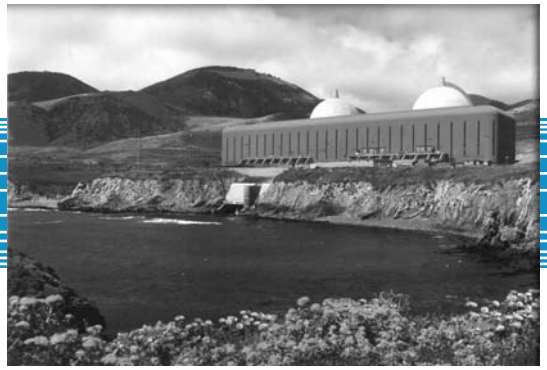
Guidance on Overhaul of ABB K-Line Circuit Breakers

Technical Report

Reduced Cost

Plant Maintenance Support

Equipment Reliability



NMAC

Guidance on Overhaul of ABB K-Line Circuit Breakers

Supplements and Revises NP-7410-V1P1

1000013

Final Report, February 2001

EPRI Project Manager
J. Sharkey

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

ORGANIZATION(S) THAT PREPARED THIS DOCUMENT

EPRI

ORDERING INFORMATION

Requests for copies of this report should be directed to the EPRI Distribution Center, 1355 Willow Way, Suite 2478, Concord, CA 94520, (800) 313-3774.

CITATIONS

This report was prepared by

Nuclear Maintenance Applications Center (NMAC)
1300 W.T. Harris Boulevard
Charlotte, NC 28262

This report describes research sponsored by EPRI.

The report is a corporate document that should be cited in the literature in the following manner:

Guidance on Overhaul of ABB K-Line Circuit Breakers: Supplements and Revises NP-7410-V1P1, EPRI, Palo Alto, CA: 2001. 1000013.

REPORT SUMMARY

This guidance provides a comprehensive list of overhaul tasks for ABB K-Line circuit breakers. In addition, it establishes a consensus among utility personnel that considers the manufacturer's recommendations and the unique application of these circuit breakers within the nuclear industry.

Background

From 1990 to 1994, the EPRI Nuclear Maintenance Applications Center (NMAC) published EPRI NP-7410, Volumes 1–3, commonly known as the Circuit Breaker Maintenance Guide series. These documents, although comprehensive, were developed by independent contractors and lacked complete participation and extensive input from utility personnel. In addition, a procedure format, which complicated application of the guidance, was followed in NP-7410. To resolve these issues, NMAC began to form circuit breaker users groups in 1994. These groups consisted of cognizant, responsible plant personnel who tasked themselves with revising the guidance found in NP-7410. In addition, the groups addressed other technical issues such as circuit breaker timing and travel analysis, reduced control voltage testing, trending, as-found testing, troubleshooting, lubrication, and receipt inspection guidance. The revised guidance developed by these users groups supplements and revises the guidance found in NP-7410.

Objectives

- To provide general guidance on overhaul maintenance for ABB K-Line low voltage circuit breakers
- To identify and list overhaul maintenance tasks for these circuit breakers and, where appropriate, provide the purpose, justification, and description of each maintenance task
- To develop a consensus on maintenance practices among utility personnel that considers the manufacturer's recommendations and the unique application of these circuit breakers within the nuclear industry
- To develop a technical basis for proper maintenance, such that utilities can enhance and justify their specific site procedures

Approach

A working group consisting of a subset of the nuclear power industry's ABB Circuit Breaker Users Group developed this document. The working group reviewed utility procedures and vendor manuals and obtained input from utility personnel, the manufacturer, and other organizations. After initial development, the draft was provided to the entire Circuit Breaker Users Group and the manufacturer for review and comment. Both ABB Transmission and Distribution (T&D) and ABB Service, Inc. (now Grand Eagle Services) have participated in the development and review of this document. Guidance was developed through a collaborative industry effort with numerous utility and nonutility personnel providing their experience and knowledge.

This guidance is not a procedure and is not intended to be used as a procedure. It is intended to assist plants in determining which maintenance tasks may be considered for their maintenance program and to provide general guidance with respect to maintenance of these specific circuit breakers.

Results

This document identifies overhaul maintenance tasks for K-Line circuit breakers and, where appropriate, provides the task's associated purpose, justification, and description. Guidance on lubrication, troubleshooting, and overhaul intervals is also provided.

EPRI Perspective

Through the development of this and similar guidance documents on other types of circuit breakers, the industry has made significant progress in addressing circuit breaker maintenance issues and improving circuit breaker maintenance. Through the development of these documents and various working group and users group meetings, utilities have increased the quantity and quality of their communication, improved maintenance procedures, and educated system engineers about circuit breaker maintenance and maintenance programs. This process has increased awareness of circuit breaker maintenance within the industry. The efforts of these users groups have also improved communication among utility personnel and their circuit breaker manufacturers and service providers.

Keywords

Circuit breaker
Maintenance
Switchgear

ACKNOWLEDGMENTS

The ABB Circuit Breaker Users Group under the sponsorship of EPRI's Nuclear Maintenance Applications Center (NMAC) prepared this guidance. NMAC and the ABB Circuit Breaker Users Group would like to acknowledge the participation and contributions of the following companies and their representatives:

Users Group Chairman	Ron Ferrie, FirstEnergy Nuclear Operating Company, Beaver Valley
Working Group/Technical Leader	Mark Heon, North Atlantic Energy Services Corp., Seabrook Station
Donald Barna	Public Service Electric & Gas Co., Hope Creek
Roger Bledsoe	Duke Engineering & Services
Curt Curtis	Virginia Power Co., Surry
Dave Davis	ABB Service, Inc.
Craig Gleason	Detroit Edison Co., Fermi
Elias Haddad	Virginia Power Co., Surry
David Hatfield	ABB Service, Inc.
Glen Hopkins	North Atlantic Energy Services Corp., Seabrook
Andrew Mantey	PECO Energy Co., Limerick
David Ricca	Pacific Gas & Electric Co., Diablo Canyon
Sam Shah	Southern Nuclear Operating Co., Vogtle Plant
Dave Watkins	FirstEnergy Nuclear Operating Company, Perry

IMPORTANT NOTICE

Use of this document is voluntary. It is not intended for regulatory or enforcement purposes. It is offered for consideration and use by members of NMAC. Use of this document and its contents by anyone other than those for whom it is intended is not authorized. This document is based on the consensus of utility personnel, the manufacturer, and other contributors. There may be other techniques or ways to perform the work or activities described here. Questions concerning use of this material should be directed to NMAC.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1
BACKGROUND

Goals and Benefits

This document provides guidance on overhaul of ABB K-Line low voltage metal-clad circuit breakers. It identifies overhaul tasks for these circuit breakers and, where appropriate, provides the task's associated purpose, justification, and description.

This guidance represents a consensus among utility personnel that considers the manufacturer's recommendations and the unique application of these circuit breakers within the nuclear industry. Guidance was developed through a collaborative industry effort with numerous utility and nonutility personnel providing their experience and knowledge.

By providing guidance on overhaul maintenance that contains the collective experience of the ABB Circuit Breaker Users Group, utilities can establish a platform from which the entire industry can justify and improve maintenance programs for these circuit breakers. This effort was designed to develop a technical basis for proper overhaul so that utilities can enhance and justify their specific site procedures. This report was designed to supplement and, in some cases, supercede guidance provided in NP-7410-V1P1, *Circuit Breaker Maintenance, Volume 1: Low Voltage Circuit Breakers, Part 1: ABB K-Line Circuit Breakers*, March 1993.

Scope

This document identifies and discusses overhaul tasks and considerations for determining overhaul maintenance intervals. The following should be noted with respect to the scope of this document.

Guidance - Not a Procedure

This guidance is not a procedure and is not intended to be used as a procedure. It is intended to assist plants in determining which maintenance tasks may be considered for their maintenance program.

Detail of Task Descriptions

The level of detail for each task description is not limited and varies based on the discretion of the working group. However, the initial intent of the working group is not to provide a detailed description of each task or to provide corrective actions for all tasks if specifications are not met.

Rather, the initial intent is to identify maintenance tasks that represent a consensus of utility personnel, with input from the manufacturer and other organizations.

Future users group work may provide more detail on selected tasks, including corrective actions if specifications are not met. It is not the intent of users group to develop the level of detail of a plant procedure, but to identify overhaul tasks that will reasonably ensure that a circuit breaker is properly maintained.

Circuit Breaker Model Applicability

This document addresses overhaul tasks for the following K-Line circuit breakers:

- 225A
- 600A
- 800A
- 2000A

Approach

This guidance identifies individual overhaul tasks. Manufacturer's terminology is used whenever possible. The following information is included for each task:

- Name
- Purpose
- Justification - Applicable NRC Information Notices (INs), Licensee Event Reports, CFR Part 21 Notices, Institute of Nuclear Power Operations (INPO) SERs, SENs, OEs, and O&MRs, manufacturer's service advice letters or bulletins, good industry practice, and personnel safety
- Description - Additional information to clarify or uniquely identify the task. If the task is complex, or there is more than one acceptable method of completing the task, or there is any confusion on the nature or intent of the task, the guidance could provide a more elaborate description of the task. If a task is performed based on the results of another test or inspection, this should be identified.

Development

This document was developed by a working group consisting of a subset of the ABB Circuit Breaker Users Group. The working group 1) reviewed utility procedures and vendor manuals and 2) obtained input from utility personnel, the manufacturer, and other organizations. After initial development, the draft was provided to the remaining users group members and the manufacturer for review and comment.

Living Document

This is intended to be a living document. The users group is tasked with providing an annual forum or mechanism to incorporate additions or changes to this guidance. It is expected that the contents will be continually reviewed by utility personnel and the Circuit Breaker Users Group.

The users group currently provides two methods for utility personnel to recommend updates or changes to this document. Changes will be approved by the entire users group prior to incorporation into the document.

Recommendations for changes to this document can be submitted to the users group via:

- Internet: *http://www.epri.com.* An EPRI ID and password are necessary to access this web page.
- Mail:

  EPRI NMAC
  Circuit Breaker Users Groups Project Manager
  1300 W.T. Harris Blvd.
  Charlotte, NC 28262

Information Sources

The following sources of information were reviewed and considered in the development of this guidance:

- Selected overhaul procedures from the following plants: Virginia Power Co., Surry, North Atlantic Energy Services Corp., Seabrook; and Public Service Electric & Gas Co., Hope Creek
- Utility personnel experience
- Industry good practices
- Manufacturer instruction and maintenance manuals and letters
- Experience of manufacturer and service personnel
- NRC INs
- Licensee Event Reports
- EPRI Report NP-7410-V1P1, *Circuit Breaker Maintenance, Volume 1: Low Voltage Circuit Breakers, Part 1: ABB K-Line Circuit Breakers*, March 1993

Measurements and Clearances

The scope of this guidance includes various models and vintages of ABB circuit breakers. In some cases, measurements and clearances vary between breakers. Consequently, users must verify all criteria for measurements and clearances provided in this document. In many instances, this document refers to ABB's Instruction Bulletins (IBs) for clearances and criteria.

Illustrations

All illustrations are typical and may not be applicable to your circuit breaker model or vintage. Refer to the ABB IBs for information unique to your circuit breaker type and vintage.

Terminology

Where possible, manufacturer's terminology is used to reduce confusion and ensure consistency. Common industry terminology is also identified when appropriate.

Task Sequence

It is not necessary to perform the maintenance tasks listed in this document in sequential order. However, these tasks are presented in a reasonable and practical sequence.

Personnel Qualification and Training

INPO has published the Guidelines for Training and Qualification of Maintenance Personnel, ACAD 92-008, which provides the framework for maintenance personnel training and qualification programs at nuclear power plants. These guidelines incorporate the results of an industry-wide job and task analysis. The guidelines are intended to be used in combination with plant-specific job and task analysis to develop and revise training programs.

Utilities should use these guidelines in conjunction with plant-specific job and task analysis results when establishing, upgrading, or validating maintenance training programs.

Circuit breaker crews often consist of an experienced journeyman and an apprentice. In order to develop a training program and qualify crews, the total scope of work to be performed on-site should be defined. For the purposes of this maintenance guide, the scope of work will consist of three major areas: preventive maintenance, corrective maintenance, and circuit breaker overhaul.

Preventive and corrective maintenance will normally be performed by an experienced journeyman and possibly by an apprentice. The maintenance apprentice should be trained on the equipment to the extent that common failure mechanisms and operating principles of the circuit breaker are readily known. For both preventive and corrective maintenance, the journeyman should have specialized skills training. As a minimum, the journeyman should be able to demonstrate disassembly and assembly methods, adjustment and calibration steps, and repair and

part replacement techniques. The journeyman should also be proficient with all measuring and test equipment. Maintenance personnel should be trained on proper lubrication methods.

Circuit breaker overhaul is typically performed by individuals who are considered job specialists. Overhaul is not directly addressed by the INPO training document. During the utility phone survey, the overhaul process was discussed with site personnel. Most utilities that accomplish the process on-site utilize a vendor representative, journeyman, and an apprentice. The vendor representative conducts on-the-job training and provides technical guidance as needed. Most individuals felt confident after performing three to four circuit breaker overhauls.

If a utility chooses to establish a formal training program targeted to overhauls, it is recommended that the proposed instructor work with the OEM instructor until proficiency is established.

Other EPRI Guidance on Circuit Breakers

This guidance was developed by the ABB Circuit Breaker Users Group and should be used in lieu of guidance provided in EPRI Report NP-7410-V1P1, *Circuit Breaker Maintenance, Volume 1: Low Voltage Circuit Breakers, Part 1: ABB K-Line Circuit Breakers* , March 1993.

Guidance developed by the users groups should be used in lieu of EPRI's Preventive Maintenance Program Basis document: *Preventive Maintenance Program Basis for Low Voltage Switchgear,* August 1996. WO-4109-1.

2
OVERHAUL MAINTENANCE INTERVALS (FREQUENCIES)

This section provides guidance on overhaul intervals (frequencies) based on the consensus of the ABB Circuit Breaker Users Group, with input from the manufacturer and ABB Service, Inc. These intervals are guides only and are not requirements. Overhaul maintenance intervals (frequencies) should be based on a variety of plant-specific considerations and determined and adjusted by each utility based on individual plant experience.

Manufacturer's Recommendations

ABB Maintenance and Surveillance (MS) publication 3.1.1.9-2E [1] augmented by IB 6.1.2.7-1H [2] and IB 6.1.12.1-1A [3] provides the ABB recommendations for an equipment maintenance program for K-Line circuit breakers.

Considering Manufacturer's Recommendations

A common myth among industry personnel is that manufacturer's guidance, including that on maintenance intervals, must be followed without deviation. This guidance, by their own admission, represents their best generalized advice and includes assumptions about the circuit breaker's environment, lubrication, previous maintenance, and operational history. However, without exception, manufacturers encourage plant personnel to identify plant-specific considerations and modify their maintenance intervals as needed. Although deviations from manufacturer's recommendations are acceptable, they should be justified—and this justification documented.

Users Group Guidance

It is the responsibility of each licensee (plant) to determine its own circuit breaker maintenance intervals. Furthermore, it is recommended that the justification for these intervals be documented in the plant's maintenance program.

A variety of factors should be considered when determining circuit breaker maintenance intervals (frequencies). The following section, "Factors Affecting Maintenance Intervals," lists these factors. Factors vary in importance depending on a plant's particular situation.

It is impossible to develop an overhaul interval that is applicable to all plants in all situations. When determining an overhaul interval, plant personnel should consider their particular situation and the factors listed under "Factors Affecting Overhaul Intervals."

The ABB Circuit Breaker Users Group has identified typical overhaul intervals and established some generic guidance based on these intervals. Plant personnel may wish to consider this guidance when considering industry experience for these circuit breakers. Plant personnel should use caution and analyze their specific situation rather than merely accept a manufacturer's recommendation or generic guidance provided by industry organizations. In addition, any maintenance interval that falls well outside either of these two should be reviewed for adequacy.

During the June 1998 ABB Circuit Breaker Users Group meeting, the group agreed that an overhaul interval should not exceed 12 years on ABB K-Line circuit breakers. This guidance was based on typical overhaul intervals of participating plants.

Factors Affecting Overhaul Intervals

The following factors can affect circuit breaker maintenance intervals (see Figure 2-1). Plants may wish to consider these factors in their maintenance program.

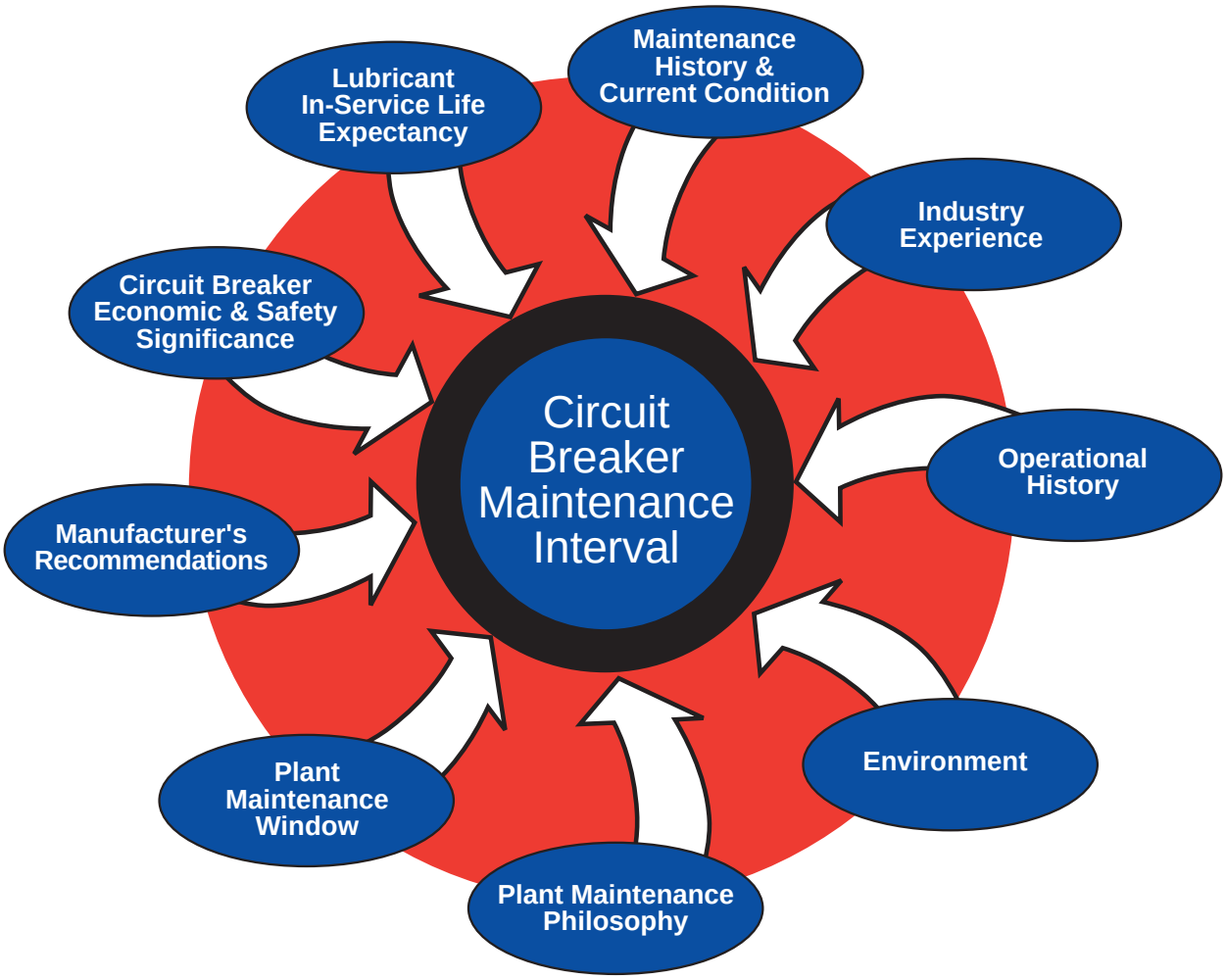


Table 2-1
Factors Affecting Maintenance Intervals

Industry Experience

- Industry experience with maintenance of circuit breakers with similar design, age, lubrication, environment, and operation and maintenance (O&M) history
- Other significant industry experience that may be applicable or affect the maintenance interval

Current Condition

- The current condition of circuit breakers can be evaluated to the extent possible and considered when determining maintenance intervals. This could be performed by sampling and inspecting typical circuit breakers.

Lubrication

- In-service anticipated life of the lubricant
- Actual or typical lubricant condition at your plant
- Type of lubricant used

Maintenance History

- Previous maintenance performed
- Previous lubrication practices
- Previous environmental effects
- Previous routine maintenance intervals
- Findings and deficiencies identified during preventive maintenance
- As-found data

Operational History

- Number of operations since the last maintenance performed (degree to which the circuit breaker is "exercised" or cycled)
- Duty cycle (rough percentage of carrying load and the percentage of circuit breaker rating this represents)
- Quantity and severity of fault interruptions or overcurrent conditions since the last maintenance interval—distinguishing between overloads (time overcurrent) and fault level currents (instantaneous operations)
- Number of clearances and associated racking-in/out (wear on main and auxiliary contact/connectors)

Circuit Breaker Significance

The importance of the breaker, which includes:

- Its safety significance (use of probabilistic risk assessment [PRA] for prioritization of circuit breakers for maintenance)
- Its commercial or economic significance

Maintenance Philosophy

- The utility's or plant's current maintenance program and philosophy

Environment

- Past and current service condition or environment

Maintenance Windows

- Availability of the circuit breaker for maintenance
- Outage (refueling) schedule
- Use of on-line maintenance
- Critical/noncritical nature of the circuit breaker (that is, LCOs and need for power production)

Manufacturer's Recommendations

- Recommendations provided by the manufacturer through manuals, letters, or bulletins

3
LUBRICATION

Alternate Lubricants

In April 1999, ABB issued a letter stating that Mobilgrease 28 is acceptable for use during refurbishment with ABB circuit breakers (see Appendix A). However, this letter did not address applying Mobilgrease 28 to electrical connections. Subsequently, ABB Power T&D has specifically recommended against the use of Mobilgrease 28 on electrical connections. Each plant should evaluate the use of Mobilgrease 28 on electrical connections. Maintenance personnel who use Mobilgrease 28 should ensure that Mobilgrease 28, Anderol 757, and NO-OX-ID "A-Special" are not intermingled between the circuit breaker's primary disconnects/ ground disconnects and the cubicle stabs.

General Lubrication Information

The following are general considerations on lubrication:

- After disassembly, cleaning, and inspection of the various subassemblies, lubricate bearings, pins, and sliding surfaces with either Anderol 757 or Mobilgrease 28
- Do not lubricate latch faces or roller surfaces
- Do not use lubricant on the secondary circuit

Manufacturer's Recommendations

Table 3-1 shows lubricants approved by ABB T&D.

Table 3-1
Manufacturer-Approved Lubricants

Lubricant	Usage
Anderol 757	All mechanism parts, bearings, and pins
NO-OX-ID "A-Special" Lubricant (Sanchem Chemical Corp.)	All mating surfaces of moving current carrying joints
Mobilgrease 28	All mechanism parts, bearings, and pins

Lubrication

ABB IB 6.1.2.7-1H states: “Proper relubrication requires disassembly, thorough cleaning by wiping, then reassembly using a brush or other means for reapplying the lubricants listed.”

ABB MS-3.1.1.9-2E states:

- “If parts become contaminated or if parts are replaced, relubrication with Anderol grease may be required.”
- “Primary disconnect fingers should be . . . relubricated with NO-OX-ID grease at each servicing.”
- NO-OX-ID should not be used on main or arcing contact parting surfaces.
- Do not use light oil to lubricate mechanism parts.
- “The spring charging motor is sealed, lubrication is not recommended.”

ABB IB 6.1.12.1-1A states:

“Anderol 757 and Mobil 28 are substantially incompatible greases. Before relubricating parts with either grease, thoroughly remove the existing lubricant. Furthermore, parts ordered for replacement are lubricated with Anderol 757, which must be removed before use with Mobil 28 lubricant.”

4
OVERHAUL MAINTENANCE TASKS

General industry practice is to disassemble the circuit breaker to the subassembly level (that is, contacts and operating mechanism) and then disassemble the subassemblies to a subcomponent level for adequate cleaning, inspection, and lubrication. The guidance in this report follows this general method.

As-Found Testing and Inspections

As-found data document the condition of the circuit breaker prior to maintenance. This maintenance history can serve as an input to the overall circuit breaker maintenance program. As-found data also indicate any degraded conditions early during the maintenance process.

Preconditioning of the circuit breaker through excessive cycling or other means may affect as-found data. Consequently, preconditioning should be minimized as much as practical when performing as-found tests and inspections.

As-Found Visual Inspection

Purpose
Identifies any components or subcomponents that may have abnormal degradation or need additional attention during the overhaul process.

Justification
As-found visual inspection findings can be used as a basis for adjusting maintenance intervals.

Description
Inspect the circuit breaker for dirt, overheating, and/or corrosion. Inspect the silver plating on the electrical contact areas for loss of zinc plating or degradation of painted surfaces, evident by the presence of oxidation or rust on steel parts. Inspect the inter-phase barriers for burning, tracking, excessive warping, cracks, and/or separations.

Record Counter Readings (If Applicable)

Purpose
Documents the number of circuit breaker cycles if the circuit breaker has a cycle counter.

Justification
Common industry practice. Per MS 3.1.1.9-2E, the circuit breaker must be replaced or refurbished prior to reaching a maximum number of cycles.

Description
Record the circuit breaker cycles (operations) prior to any cycling of the circuit breaker. Page 5 of MS 3.1.1.9-2E provides guidance on circuit breaker servicing based on the number of circuit breaker operations. It is generally agreed that the number of circuit breaker cycles should be one consideration in determining maintenance and can be one input for condition-based maintenance. Because circuit breakers in nuclear service typically do not experience a high number of cycles, maintenance programs typically are not based on number of operations.

Reduced Control Voltage Test

Purpose
Conservatively demonstrates that the circuit breaker will perform its function (to open and close) with reduced control voltage. Reduced control voltage testing may be performed prior to maintenance, as an as-found test, to determine if further corrective maintenance is necessary prior to checking mechanical adjustments.

Justification
Good industry practice.

Description
To perform a reduced voltage test, a minimum operating control voltage is determined and applied to the circuit breaker's close and trip control circuitry. The circuit breaker is then cycled open and closed, and the breaker's operation is verified. See EPRI TR-112814, *Reduced Control Voltage Testing of Low and Medium Voltage Circuit Breakers*, July 1999. ABB Service performs reduced control voltage testing on circuit breakers sent to their shops for repair or overhaul. K-Line circuit breakers are designed to close at 100 Vdc and trip at 70 Vdc.

Primary Contact Resistance Measurement

Purpose
Verifies that the contacts and associated electrical connections, including the bridge pivot point, are clean and resistance is minimized to avoid internal heating.

Justification
Good industry practice and recommended by the manufacturer in IB 6.1.12.1-1A.

Description
Measure the main contact resistance of each phase using a micro-ohmmeter, digital low resistance ohmmeter, ductor, or millivolt drop test. Readings will vary depending on the type of trip device installed. It is desirable to achieve some degree of consistency in the method of measurement. It is recommended that the measurement be taken between upper and lower terminals exclusive of the primary disconnects (see IB 6.1.12.1-1A for contact resistance specifications). It is also possible to measure the resistance of the contacts or the entire primary contact circuit between the primary disconnects (stabs).

Tripper Bar Load

Purpose
Verifies that the circuit breaker will trip during an overcurrent or undervoltage condition (if applicable).

Justification
Good industry practice.

Description
Measure the tripper bar load with a spring scale as shown in IB 6.1.2.7-1H and IB 6.1.12.1-1A. Per the IB, the tripper bar load for electromechanical/OD devices should be ≤ 29 ounces. For solid state trip devices, the tripper bar load should be ≤ 50 ounces.

Insulation Resistance Test of Primary (Current Carrying) Components

Purpose
Assesses the integrity of the insulating material to identify any degraded components prior to disassembly and reassembly.

Justification
Good industry practice. This task is included as a practical measure for the overhaul process and not to capture a value. It is intentionally not included in the as-found portion of the K-Line preventive maintenance guidance.

Description
Measure the insulation resistance of the following:

- Line to load with the circuit breaker opened
- Phase to ground with the circuit breaker closed
- Phase to phase with the circuit breaker closed

The National Electrical Testing Association's (NETA's*) Maintenance and Testing Specifications for Electrical Power Distribution Equipment and Systems* (NETA MTS-1997) provides insulation resistance test voltages and minimum insulation resistance (in megohms). See Table 10.1 in MTS-1997, which is provided below as Table 4-1.

Table 4-1
Insulation Resistance Tests

Voltage Rating	Minimum dc Test Voltage	Recommended Minimum Insulation Resistance in Megohms
0–250	500	50
251–600	1,000	100
601–5,000	2,500	1,000
5,001–15,000	2,500	5,000
15,001–25,000	5,000	20,000

Insulation Resistance Test of Control Wiring

Purpose
Ensures that no grounds exist in the control wiring and that the wiring insulation is satisfactory; assesses the integrity of the insulating material to identify any degraded components prior to disassembly and reassembly.

Justification
Good industry practice. This task is included as a practical measure for the overhaul process and not to capture a value. This test is intentionally not included in the as-found portion of the K-Line preventive maintenance guidance.

Description
The control circuits should be meggered from the secondary disconnects to ground. Refer to Table 4-1 provided in the previous task. If a Power Shield is installed, jumper all Power Shield terminal points together to the frame (ground) to prevent damage to the trip device.

Disassemble, Clean, Inspect, Lubricate, and Reassemble Subassemblies

Remove Power Shield

Purpose
Makes the mounting hardware accessible for removal of the arc chutes.

Justification
The mounting hardware for the right arc chutes is not accessible with the Power Shield mounted in place.

Description
Disconnect the control wiring, remove the Power Shield, mounting hardware, and brackets. Perform a visual inspection and verify the integrity of the wires and terminations.

Verify that SCR leakage is less than 100 microamperes with 400 Vdc applied to terminals 15 (+) 9. Non-safety-related Power Shield devices with serial numbers greater than 100,000 have the SCR replaced with a MOSFET transistor. Leakage testing on this board may be performed.

For Power Shield Logic Boxes with a serial number below 100,000, an internal inspection of solder board connection joints is required. Refer to 10 CFR Part 21 Notice on Power Shield Solder Joints, dated November 20, 1995.

Arc Chutes and Barriers

Purpose
Ensures that the arc chutes are not damaged or contaminated to the point that proper performance is compromised.

Justification
Arc chutes are a necessary component for circuit interruption, which can only be confirmed by examination of physical properties. The condition of the interrupters can indicate possible problems within the circuit breaker or with the load. See IB 6.1.12.1-1A.

Description
Inspect for signs of physical damage, deterioration, and contamination of the arc chutes. Inspect the insulation, arc runners (horns), and arc splitters (cooling plates) for burns or damage. Inspect the arc chute shell for through-shell cracks or damage. Clean the arc chutes with isopropyl or denatured alcohol (see Appendix B, “Statement on Asbestos in K-Line Arc Chutes”).

Escutcheon Assembly

Purpose
Makes accessible the motor cutoff switch, pushbutton switch, bell alarm, and lockout switch for disassembly, cleaning, inspection, lubrication, and reassembly as required.

Justification
Allows access to the switches and mounting hardware.

Description
Remove the four Phillips screws from the front escutcheon plate. Remove the dust plate and the four Phillips screws from the back of the black escutcheon box.

Control Components and Wiring

Spring Charging Motor

Purpose
To remove the spring charging motor, inspect the eccentric bearing (wheel on charging motor shaft) and lubricate. Clean, inspect, relubricate, and reassemble.

Description
The charging operation of the closing springs is accomplished by a high-speed gear motor that stretches the closing springs through the action of an eccentric, ratchet, and pawl assembly. Pay particular attention to the brush holder box set screws and the brush holder caps during the inspection process.

Control Device

Purpose
Disassembly, cleaning, inspection, and reassembly of the control device ensures proper electrical operation of the circuit breaker.

Justification
Good industry practice. Because of a high duty cycle, the limit switch (LS) that cycles the closing spring motor power should be replaced as necessary.

Description
A control device is furnished on electrically operated circuit breakers. The following guidance was provided by ABB Service, Inc. regarding the inspection of control devices for both HK and K-Line circuit breakers (see Appendix C).

- Contacts: inspect for pitting and proper riveting of the contact surfaces to the contact arm. Clean and polish as required; replace if necessary.
- Armatures: inspect for proper spring alignment, including installation of the ball bearing, slugs, or spring insert. Check for cracks in the molded surfaces.
- Magnets: inspect for the spreading of the mating surfaces, which could cause binding.
- Molded encasement: inspect for cracks or breaks.
- Coils: check the ohmic value to ensure that the coils are within specification.
- Terminals: inspect for proper crimping of lugs and oxidation of silver-plated terminals.
- Overall: inspect for dirt and/or contamination.
- Nylon nut: inspect for cracks or damage.

Auxiliary Switches

Purpose
Verifies proper operation of the auxiliary switch.

Justification
Good industry practice.

Description
Remove the rotary portion of the switch. During removal of the rotary contacts, care should be taken not to allow the rotary switch contacts to come off of the rotary shaft. Clean and inspect rotary and stationary contacts using isopropyl alcohol. Inspect the springs of the stationary contact assemblies for return pressure. Check the resistance of the contacts upon reassembly. Contact resistance measurements are typically less than 1 ohm. If removal of the rotary contacts from the shaft is deemed necessary, the position of the contacts must be marked in relation to the square of the shaft prior to removal.

If deemed necessary, the housing and stationary contacts can be disassembled, cleaned with isopropyl alcohol, inspected for degradation, lubricated with NO-OX-ID "A-Special," and reassembled. There should be approximately 1/8" travel of the stationary contacts when rotating the moving contacts rotary shaft of the auxiliary switch.

Secondary Disconnects

Purpose
The connections should be cleaned, inspected, checked for tightness, and lubricated when the circuit breaker is being overhauled.

Justification
Cleaning the secondary disconnects minimizes heating resulting from high resistance connections and maximizes control voltage available to the breaker. Under reduced control voltage conditions, this could be significant.

Description
The secondary disconnects are the control power interface between the cubicle and the breaker. Cleaning the disconnect fingers with Scotch-Brite® and alcohol facilitates inspection.

Control Wiring

Purpose
Provides a visual check of the control wiring for degradation and tightness of connections.

Justification
This check is considered a good industry maintenance practice. Although a control circuit insulation resistance test (megger test) is recommended for both preventive maintenance and overhaul activities, it should not be performed in lieu of this visual check.

Description
Clean and inspect the control wiring for degradation. This visual inspection should be made in order to detect any obvious damage to the control wiring that might not appear during the megger test, such as broken wire strands, improper lug crimps, and degraded insulation.

Operating Mechanism

Purpose
Removal, disassembly, cleaning, inspection, lubrication, and reassembly of the operating mechanism ensures proper operation.

Justification
Disassembly is required to replace any worn, missing, or damaged components and to properly clean and relubricate as required. Also, good industry practice.

Description
Replace all Torrington® needle bearings as necessary. Replace all conical springs as necessary (with the exception of the opening and closing springs).

It is preferable to replace all bearings and springs. The exception is to re-use existing bearings and springs. If re-use of bearings is necessary or deemed acceptable, then clean, inspect, and relubricate.

Replace all one-time use retainers, if removed (for example, ITE retainers, Waldes® Tru-arcs, and cotter pins). Replace any damaged hardware (such as nuts, bolts, screws, lock washers, and flat washer) as required.

Racking Mechanism and Safety Interlock

Purpose
Removal, disassembly, cleaning, inspection, lubrication, and reassembly of the racking mechanism and safety interlock ensures proper circuit breaker operation.

Justification
Ensures proper cleaning, inspection, and relubrication of the racking mechanism. If a racking safety interlock is not already installed, plant personnel should be aware of and consider new designs available for this device.

Description
Ensure that there is no binding or misalignment to ensure proper operation of the racking mechanism interlock, according to the manufacturer's recommendation in MS 3.1.1.9-2E. Ensure that the safety features of the circuit breaker are in working order. When desired, upgrade the circuit breaker with a new style of auto spring discharge lever and racking mechanism interlock cam.

Contacts

Primary Disconnects

Purpose
Removal of the primary disconnects for disassembly, cleaning, inspection, lubrication, and reassembly ensures proper circuit breaker operation.

Justification
Good industry practice. Ensures good connections for load carrying capabilities.

Description
K-600, K-800, and K-2000 primary disconnects are riveted together and require being cleaned and inspected as an assembly. The K-1600 primary disconnects can be disassembled, cleaned, and inspected, and individual fingers replaced as necessary. Inspect for loss of silver plating and replace as necessary.

Moving and Stationary Contact Assembly

Purpose
Removal, disassembly, cleaning, inspection, lubrication, and reassembly of the moving and stationary contact assembly ensures proper circuit breaker operation.

Justification
Verify and maintain good electrical properties of the circuit breaker's current carrying contacts. Recommended by the manufacturer per MS 3.1.1.9-2E and good industry practice.

Description
The following should be performed:

Disassembly - completely disassemble the moving and stationary contact assemblies, replacing all one-time use retainers, if removed. On the K-225, K-600, and K-800 models, the stationary contacts can simply be inspected and cleaned.

Contact Cleaning - remove all contamination, lubrication, and oxidation from all current carrying connections. Final cleaning to remove all residue should be performed using isopropyl alcohol. Burnishing tools or Scotch-Brite® can be used to dress and clean contacts as necessary.

Contact Inspection - inspect contacts for cracks. Any contacts with cracks should be replaced. Inspect contacts for pitting or discoloration from overheating. Minor pitting or roughening of the contacts does not indicate loss of ability to carry or interrupt current. Inspect for loss of silver plating. Ensure that contact parting surfaces are not lubricated and are free of contamination.

Lower Phase Molding Assembly Inspection (With CTs or OCTD)

Purpose
Provides cleaning and visual inspection of the lower phase molding.

Description
K-Line circuit breakers can be equipped with either electromechanical trip devices (OD) or solid state trip devices (Power Shield)

Inspection of Current Transformers (CTs)

- Perform a general visual inspection of the current transformers
- Inspect clearance between the mag-latch and the CTs

Electromechanical Overcurrent Trip Device (OD) Inspection

- Ensure that the pointer tabs are straight
- The air gap between the magnet and the armature is set to a fixed dimension at the factory and should not be changed
- Inspect for oil leaking from the dashpot
- Exercise the armature of the OD device
- Inspect for cracks in the boot
- Verify that the calibration springs are in place and not deformed
- OD devices are not to be lubricated

Circuit Breaker Truck/Frame Inspection

Purpose
To clean, inspect, straighten, lubricate, and reassemble as required.

Justification
Good industry practice.

Description
Check the circuit breaker frame (truck) for abnormalities, rust, corrosion, cracked welds, ground stab connection, and bent components. Repair or replace as required. Clean and inspect the upper phase moldings.

Jack Shaft

Purpose
Removal, disassembly, cleaning, inspection, lubrication, and reassembly of the jack shaft ensures proper circuit breaker operation.

Justification
Good industry practice. On the K-1600/2000 circuit breakers, the jack shaft incorporates two larger Torrington needle bearings that require cleaning and relubricating. The jack shaft on the K-225/600/800 circuit breakers pivots from an "oilite" bearing pressed into the circuit breaker side plates.

Description
Remove the opening springs and disassemble, clean, inspect, lubricate, and reassemble as required.

Circuit Breaker Reassembly

At this point, reassemble the circuit breaker using all refurbished subassemblies.

Mechanical Adjustments and Measurements

Contact Simultaneous Make and Pressure Checks

Purpose
Minimizes heat and electrical arcing under load conditions and ensures that a good electrical connection exists between the moving and stationary contacts.

Justification
Recommended in IB 6.1.2.7-1H, IB 6.1.12.1-1A, and MS 3.1.1.9-2E.

Description
Slow close the circuit breaker and verify that all phases make contact within the tolerances specified in the IBs. Refer to IB 6.1.2.7-1H and IB 6.1.12.1-1A for a detailed description.

Latch Engagement

Purpose
This adjustment sets the proper latch engagement (bite) of the latch to the roller.

Justification
Recommended by the manufacturer per IB 6.1.2.7-1H and IB 6.1.12.1-1A.

Description
Refer to IB 6.1.2.7-1H and/or IB 6.1.12.1-1A for a detailed description of how to make this adjustment.

Tripper Bar Latch Engagement

Purpose
This adjustment sets the proper tripper bar latch engagement.

Justification
Recommended by the manufacturer per IB 6.1.2.7-1H and IB 6.1.12.1-1A.

Description
Refer to IB 6.1.2.7-1H and/or IB 6.1.12.1-1A for a detailed description of how to make this adjustment.

Shunt Trip Adjustment

Purpose
This adjustment ensures proper actuation of a latch that allows the collapsible linkage to collapse, subsequently tripping the breaker.

Justification
Recommended by the manufacturer per IB 6.1.2.7-1H and IB 6.1.12.1-1A.

Description
Refer to IB 6.1.2.7-1H and/or IB 6.1.12.1-1A for a detailed description of how to make this adjustment for your circuit breaker type. There are two different types of shunt trip devices used on the various circuit breaker types.

Control Device Adjustment

Purpose
This adjustment sets the overtravel for the close latch release rod.

Justification
Recommended by the manufacturer per IB 6.1.2.7-1H and IB 6.1.12.1-1A.

Description
Refer to IB 6.1.2.7-1H and/or IB 6.1.12.1-1A for a detailed description of how to make this adjustment.

Magnetic Latch Trip Pre-Travel Gap Check (K1600/2000 Only)

Purpose
Checks the gap between the magnetic latch adjusting screw and the tripper bar.

Justification
Recommended by the manufacturer per IB 6.1.2.7-1H and IB 6.1.12.1-1A.

Description
Refer to IB 6.1.2.7-1H and/or IB 6.1.12.1-1A for a detailed description of how to make this adjustment.

Tripper Bar Load

Purpose
Verifies that the circuit breaker will trip during an overcurrent or undervoltage condition (if applicable).

Justification
Recommended by the manufacturer per IB 6.1.2.7-1H and IB 6.1.12.1-1A.

Description
Measure the tripper bar load using a spring scale (as shown in IB 6.1.2.7-1H). Per the IB, the tripper bar load for electromechanical/OD devices should be ≤ 29 ounces. For solid state trip devices, the tripper bar load should be ≤ 50 ounces.

OCTD Armature Trip Travel Adjustments and Clearance

Purpose
Verifies positive trip during the actuation of the overcurrent trip device (OCTD).

Justification
Recommended by the manufacturer per IB 6.1.2.7-1H and IB 6.1.12.1-1A.

Description
A detailed procedure for this adjustment is provided in the ABB IBs. Ensure that the vibrators have clearance and do not interfere with the tripper bar. Appendix D contains letters from ABB Power Distribution and ABB Service, Inc., regarding circuit breaker trip paddle adjustment.

UV Device Trip Adjustment (If Applicable)

Purpose
Verifies the proper adjustment and operation of the undervoltage trip device.

Justification
Recommended by the manufacturer per IB-6705 (see Appendix E).

Description
Refer to ABB IB-6705, Section II, Part (e).

Bell Alarm (If Applicable)

Purpose
Verifies the correct operation of the bell alarm so that the cause (overcurrent or control circuit) of an unexpected circuit breaker trip can be determined.

Justification
Good industry practice.

Description
Verify that the contacts "make" upon actuation of the auto-trip indicator and that the bell alarm does not operate unless an overcurrent condition trips the circuit breaker (as this requires manual reset).

As-Left Inspections and Tests

Purpose
Ensures that the circuit breaker is ready for service.

Justification
Good industry practice.

Description
The following tests and inspections should be performed prior to placing the circuit breaker in service.

Racking Mechanism and Safety Interlock

Purpose
Verifies proper operation of the racking mechanism and safety interlock.

Justification
Ensures proper cleaning, inspection, and relubrication of the racking mechanism. If a racking safety interlock is not already installed, plant personnel should be aware of and consider new designs available for this device.

Description
Verify that the circuit breaker draw-out mechanism cannot be operated with the circuit breaker closed in the connect position. Verify that the circuit breaker cannot be closed when placed between racking positions. Verify that with the shutter lifted, the circuit breaker cannot be closed.

Final General Circuit Breaker Inspection

Purpose
Performs a final visual inspection to ensure that the circuit breaker has been properly and completely reassembled.

Justification
Good industry practice.

Description
Inspect for any obvious physical damage and placement of retainers, fasteners, pins, and missing parts. Identify missing and loose hardware (crimp retainers, nylon hardware, snap rings, cotter pins, nuts, bolts, and lock-washers). Inspect the control wiring and connections to ensure proper routing, anchoring, and terminations, and that no abrasions, cuts, nicks, or breaks are present. Wiring includes CTs and motor, coil, and device leads. Inspect switches and electrical pushbuttons for damage, loose connections, missing parts, and wiring conditions. Inspect for proper placement of trip coil wires and the wiring harness.

Manual and Electrical Operational Check

Purpose
Ensures proper operation of all mechanical and electrical circuit breaker functions.

Justification
Good industry practice and recommended by the manufacturer per MS 3.1.1.9-2E.

Description
Verify that the circuit breaker operates properly without binding or tripping free. Verify that the circuit breaker charges, closes, and trips electrically and manually and that the cycle counter (if applicable) operates without binding.

Note: If the circuit breaker is equipped with an undervoltage device, it will hold the circuit breaker in a trip-free condition unless it is energized or mechanically defeated. Verify the trip-free operation of the circuit breaker (see IB 6.1.12.1-1A, page 23, “Trip Free Mechanism”).

Reduced Control Voltage Testing

Purpose
Conservatively demonstrates that the circuit breaker will perform its function (to open and close) with reduced control voltage.

Justification
Good industry practice.

Description
To perform a reduced voltage test, a minimum operating control voltage is determined and

applied to the circuit breaker's close and trip control circuitry. The circuit breaker is then cycled open and closed, and the circuit breaker's operation is verified. See EPRI TR-112814, *Reduced Control Voltage Testing of Low and Medium Voltage Circuit Breakers*. ABB Service performs reduced control voltage testing on circuit breakers sent to its shops for repair or overhaul. K-Line circuit breakers are designed to close at 100 Vdc and trip at 70 Vdc.

Anti-Pump Operational Check

Purpose
Prevents the circuit breaker from reclosing if a close input is maintained during a trip-free condition.

Justification
Good industry practice. This is a check of a design feature to protect the circuit breaker from mechanical damage.

Description
Close the circuit breaker electrically and maintain the close signal by keeping the close button depressed. While maintaining the close signal, trip the circuit breaker electrically or mechanically. Verify that the circuit breaker does not reclose.

Primary Contact Resistance Measurement

Purpose
Verifies that the contacts and associated electrical connections, including the bridge pivot point, are clean and resistance is minimized to avoid internal heating (see Appendix F).

Justification
Good industry practice and recommended by the manufacturer in IB 6.1.12.1-1A.

Description
Measure the main contact resistance of each phase using a micro-ohmmeter, digital low resistance ohmmeter, ductor, or millivolt drop test. Readings will vary depending on the type of trip device installed. It is desirable to achieve some degree of consistency in the method of measurement. It is recommended that the measurement be taken between upper and lower terminals exclusive of the primary disconnects (see IB 6.1.12.1-1A for contact resistance specifications). It is also possible to measure the resistance of the contacts or the entire primary contact circuit between the primary disconnects (stabs) (see Appendix G).

Insulation Resistance (Dielectric) Test of Primary (Current Carrying) Components

Purpose
Measures the insulation resistance of the primary circuits.

Justification
Good industry practice.

Description
Measure the insulation resistance of the following:

- Line to load with the circuit breaker opened
- Phase to ground with the circuit breaker closed
- Phase to phase with the circuit breaker closed

The National Electrical Testing Association's (NETA's*) Maintenance and Testing Specifications for Electrical Power Distribution Equipment and Systems* (NETA MTS-1997) provides switchgear insulation resistance test voltages and minimum insulation resistance (in megohms). See Table 10.1 in MTS-1997, which is provided below as Table 4-2.

Table 4-2
Insulation Resistance Tests

Voltage Rating	Minimum dc Test Voltage	Recommended Minimum Insulation Resistance in Megohms
0–250	500	50
251–600	1,000	100
601–5,000	2,500	1,000
5,001–15,000	2,500	5,000
15,001–25,000	5,000	20,000

Insulation Resistance Test of Control Wiring

Purpose
Ensures that no grounds exist in the control wiring and that the wiring insulation is satisfactory.

Justification
Good industry practice.

Description
The control circuits should be meggered from the secondary disconnects to ground. If a Power Shield is installed, jumper all Power Shield terminal points together to the frame (ground) to prevent damage to the trip device (see Table 4-2).

Primary Current Injection Testing

Purpose
Performs primary current injection testing.

Justification
Newly purchased or overhauled circuit breakers should be tested with primary current injection. Recommended by the manufacturer per IB 6.1.2.7-1H (for both electromechanical and Power Shield) and IB 6.1.2.7-4D [4] (for Power Shield, secondary testing). This is also common industry practice.

Description
K-Line circuit breakers can be equipped with either electromechanical trip devices (OD) or Solid State trip devices (Power Shield). See IB 6.1.2.7-4D for Power Shield primary current injection testing.

Ensure that the short-time levers for the delay bands match your set-point documents or data sheets.

Typical overcurrent trip device tests include long time delay and pickup, short time delay and pickup, instantaneous pickup, and ground fault delay and pickup.

A one-time (initial) inspection should be performed to ensure the proper polarity of the CT. This CT polarity check should also be performed after circuit breaker refurbishment or CT replacement. In addition, this inspection should include verification to ensure that the overcurrent devices (for example, CTs, magnetic latch, and Power Shield) are wired per the physical wiring diagram (see IN-98-03 [5] and ABB Letter to the NRC dated 4-24-97 [6]).

Note that OD devices are not manufactured with a ground trip function.

Overcurrent trip unit time-current curves and information for testing dc circuit breakers can be obtained from ABB T&D and are referenced in IB 6.1.12.1-1A.

Record Counter Readings (If Applicable)

Purpose
Documents the number of circuit breaker cycles if the circuit breaker has a cycle counter.

Justification
Common industry practice. Per MS 3.1.1.9-2E, the circuit breaker must be replaced or refurbished prior to reaching the maximum number of cycles.

Description
Record the circuit breaker cycles (operations).

5
REFERENCES

1. ABB MS 3.1.1.9-2E, “Maintenance and Surveillance, Low Voltage Switchgear Equipment K-Line Switchgear.”

2. ABB IB 6.1.2.7-1H, “Installation/Maintenance Instructions, Low Voltage Power Circuit Breaker Types K-225 through 2000 and K-600S through 2000S.”

3. ABB IB 6.1.12.1-1A, “Installation/Maintenance Instructions, Low Voltage Air-Magnetic Power Circuit Breakers, K-Line 225A through 2000A,” July 1999.

4. ABB IB 6.1.2.7-4D, “Installation/Maintenance Instructions, Power Shield–Solid State Trip Device (Gray Case) and 504 Test Set for Circuit Breakers Types K-800S, K-2000S, K3000S, K4000S, and K-DON - K600S, K-800S, and 1600S.”

5. NRC IN 98-03, “Inadequate Verification of Overcurrent Trip Set Points in Metal-Clad, Low Voltage Circuit Breakers,” January 21, 1998.

6. ABB Letter to the NRC, “Notification of Potential Defect per 10CFR21, K-Line Low Voltage AC Breakers,” April 24, 1997.

A
LETTER FROM ABB POWER T&D COMPANY, INC., REGARDING USE OF MOBIL 28 LUBRICANT IN ABB CIRCUIT BREAKERS

EPRI - NMAC
1300 W.T. Harris Blvd.
Charlotte, North Carolina 28262

Attention: Mr. James Sharkey, NMAC Project Manager

Subject: **Use of Mobil 28 Lubricant in ABB Circuit Breakers**

Dear Mr. Sharkey:

For the past several weeks, ABB Power T&D Company, Inc. has had several conversations with the EPRI users group on the use of Mobil 28 grease in ABB circuit breakers such as K-line low voltage circuit breakers and HK medium voltage circuit breakers. This letter addresses ABB's position on such use.

After review of the forwarded ***ABB Circuit Breaker Lubricant Equivalency Evaluation*** dated April 2, 1999, we have come to the following conclusion:

Mobil 28 grease is acceptable for use during refurbishment with ABB circuit breakers as an alternative to standard Anderol 757. Mobil 28 demonstrates sufficient comparable properties such that the qualification and design testing of the circuit breakers is not compromised. In addition to the laboratory testing performed by EPRI experts, ABB has done practical (no-load mechanical endurance) testing with Mobil 28 on a similar product which uses the K-line operating mechanism, with satisfactory results.

The following cautions apply when using Mobil 28:

ABB has several decades of experience with Anderol 757. Although some users possess the opinion that Mobil 28 is superior to Anderol 757, we do not have history to confirm that conclusion. Although most ASTM testing demonstrates certain superior characteristics of Mobil 28, circuit breakers are extremely specialized mechanical devices whose true operating parameters may not be captured by these simple tests.

ABB does not currently endorse the concept of increasing maintenance periodicity solely through the use of Mobil 28. Mobil 28 does possess superior oxidation limiting properties, but lubricant life is also dependent largely on the operating environment of the mechanism and the affect of contaminants on lubricant properties. End users should continue to exercise good judgement on the required maintenance intervals of their units.

Mobil 28 has been confirmed to be incompatible with Anderol 757. ABB requires that prior to using Mobil 28 in refurbishment programs, all previous lubricants must be removed with denatured alcohol or a similar solvent to prevent contamination of the Mobil 28 with Anderol 757.

Component parts received from ABB Component Sales often come lubricated with Anderol 757 or a similar compatible grease. Prior to using these parts in Mobil 28 refurbishment programs, all existing lubricant must be removed prior to lubrication with Mobil 28. Unfortunately, ABB is not able to supply component parts, assemblies, or entire circuit breakers specially ordered with Mobil 28.

Thank you for your assistance in this matter. ABB is pleased to work with user groups like EPRI in assisting ABB customers in situations like this. User groups are our most important link to the long-term performance of our products, and you continue to be an asset in this regard. If you have further questions, please contact me at your convenience.

Sincerely,

Shannon R. Soupiset, P.E.

Product Engineering Manager

ABB Power T&D Company, Inc.

Distribution Systems Division

Cc: Bryan Powell, ABB

Dave Davis, ABB

Bob Behl, ABB

B
STATEMENT ON ASBESTOS IN K-LINE ARC CHUTES

Prior to second quarter 1987, K-225 through K-2000 ampere arc chutes was made from a mixture of asbestos fibers bound in Portland cement. K-3000 and K-4000 circuit breaker arc chutes used this material through the fourth quarter of 1987. Because the asbestos fibers are encapsulated in the Portland Cement arc chute moldings, there's little chance of fiber release when in use on the circuit breaker.

From the first quarter of 1988 to the first quarter 1991, all forms of the K-line breakers have used non-asbestos moldings containing a mixture of Portland cement and wollastonite. This molding material was tested in short circuit tests and was proven satisfactory. Because this material has lower mechanical strength than the old asbestos material, ABB developed another asbestos free arc chute material with improved mechanical properties. This new melamine-like cold-molded product is used on K-225 through K-2000 circuit breakers; K-3000 and K-4000 arc chutes continue to use the wollastonite arc chutes presently; in the fourth quarter of 1991, these arc chutes will be changed to a special polyester glass molding material.

Asbestos arc chutes can be distinguished from ABB's newer arc chutes by their mottled cement gray/white color. The wollastonite arc chutes have a uniform cement gray color and tend to be more ceramic-like than the asbestos moldings. The new melamine-like moldings are solid black and the proposed K-3000 and 4000 polyester arc chutes will be red.

ABB offers only the melamine-like black arc chutes for renewal parts for K-225 through K-2000. These duplicate in form, fit, and function the arc chutes used earlier. The wollastonite arc chutes will remain available on K-3000/4000 until the switch to polyester glass.

Below is a listing of arc chute part numbers:

Breaker	**Asbestos Arc Chute**	**Replacement Arc Chute**
225/600/800	706775-T03	706775-T13
1600/2000	706775-T02	706775-T12
3000/4000	706745-T03	706745-T03

On K-3000/4000 part numbers are the same but component parts in those assemblies new part numbers. Polyester-glass K-3000/4000 arc chutes will get revised part numbers.

ABB requires that disposal of asbestos arc chutes be performed in association with environmentally approved disposal agencies.

C
LETTER FROM ABB SERVICE, INC., REGARDING ITE/ABB CIRCUIT BREAKER CONTROL DEVICE INSPECTION

Letter from ABB Service, Inc., Regarding ITE/ABB Circuit Breaker Control Device Inspection

Chesapeake Service Center
9050-A Red Branch Road • Columbia, MD 21045
Phone (410) 884-4414 • Fax (410) 884-9476

Date: December 2, 1997 Cover + 0 Pages

To: Glenn Hopkins

cc: Mark Heon
Kevin Mullen

From: Dave Davis
Manager, Nuclear Services
Northeastern US Region

Re: ITE/ABB Circuit Breaker Control Device Inspection

Glenn,

Here are our recommendations with regard to inspecting the control device on ITE/ABB Type HK Medium Voltage and K-Line Low Voltage Circuit Breakers.

- Contacts: Inspect for pitting and proper riveting of the contact surfaces to the contact arm. Clean and polish as required. Replace if necessary.
- Armatures: Inspect for proper spring alignment, including installation of the ball bearing (or spring insert). Check for cracks in the molded surfaces.
- Magnets: Inspect for the spreading of the mating surfaces which could cause binding.
- Molded Encasement: Inspect for cracks/breaks.
- Coils: Check the ohmic value to ensure the coils are within specification. Call our office for values which correspond to your operating control voltage.
- Terminals: Inspect for proper crimping of lugs and oxidation of silver plated terminals.
- Overall: Inspect for dirt and/or dust contamination.

The QA Managers of the four Centers of Excellence will be having a meeting in Cleveland December 7 and 8, 1997. One of the topics will be to standardize our maintenance procedures which will include refurbishment/inspection of the control device. I will promulgate more information when received.

Please call me if you have any further questions.

Best regards.

D
LETTERS FROM ABB REGARDING CIRCUIT BREAKER TRIP PADDLE ADJUSTMENT

ABB Power Distribution

FAX Transmission

From:	Sheila Scott	Date:	April 8, 1997
To:	Bob Brucci	Time:	10:39 AM
Company:	ABB Service - Chesapeake	FAX #:	410-884-9476
Total Pages:	2		

Message:
Bob,

Based on the problems you have been experiencing with the tripper paddle hitting the vibrator on the OD with breakers that shipped 9 years ago, two suggestions were made to correct the problem. I received a call on Monday imforming me that the suggestions did not work.

I spoke with the tester for this product which he indicated that he has seen this problem in the past. The following are ways the problem can be corrected:

1) Apply stress to the rod that the tripper paddles are mounted to create a bow in the rod. This will offset the tripper paddle by 1/16" and this will only work for A and C phases.

2) File the tripper paddles that is hitting the OD about 1/16".

3) Adjust the height of the vibrator, but the gap must remain within specification and the OD must be operable. The attached drawing from a factory spec. shows the gap as 1.145 max.

If any questions, please contact me at x257.

VOICE: 803-665-4144 FAX: 803-667-5109

P.O. Box 100524, I-95 & Mechanicsville Highway, Florence SC 29501-0524

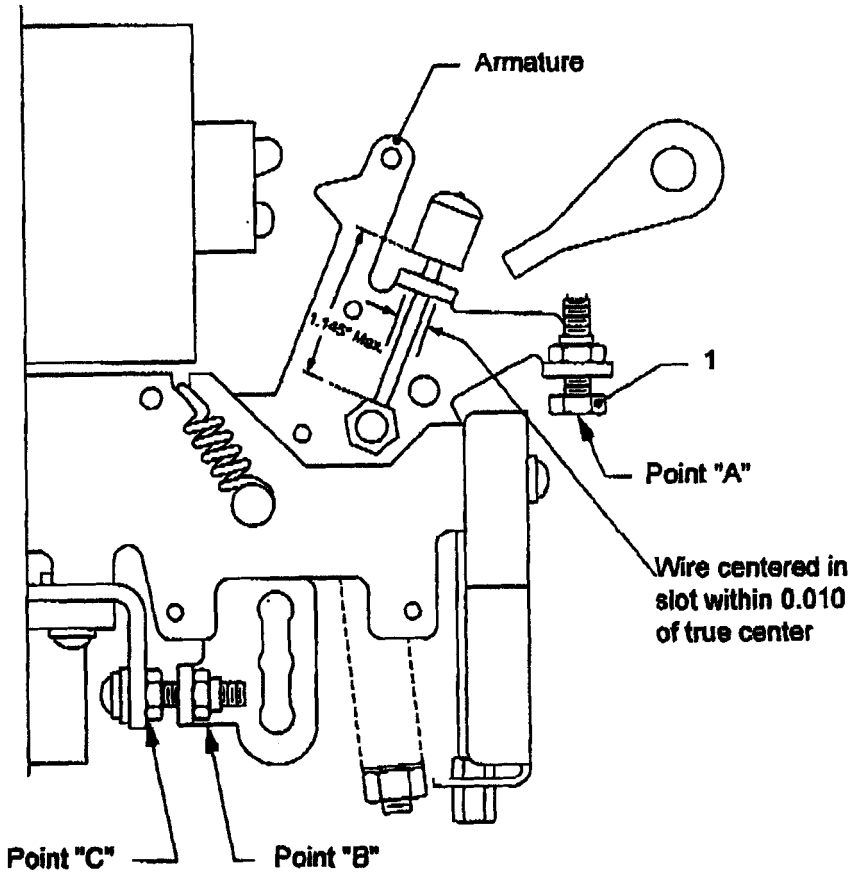

Armature
1.145" Max.
1
Point "A"
Wire centered in
slot within 0.010
of true center
Point "C"
Point "B"

ABB Service Inc.
Chesapeake Service Center
8050-A Red Branch Road • Columbia, MD 21045
Phone (410) 884-4414 • Fax (410) 884-9476

Date: September 18, 1998 1 Page Total

To: **Mark Heon**

From: Dave Davis
Nuclear Sales Manager

Re: K-Line Circuit Breaker Information

Mr. Heon,

In response to Glenn Hopkin's questions regarding modification of the K-1600 (DC) Circuit Breaker tripper paddles, normally only approximately 1/16" of the paddle is required to be removed to allow clearance of the OD vibrator. There is no maximum amount that can be removed. ABB Power Distribution (Sheila Scott, Senior QA Engineer) sees no reason why the original filed tripper paddles cannot remain in the circuit breaker as long as the part is not damaged and is able to continue to function normally. The decision to replace the paddles is determined by your refurbishment procedures.

Please call me, in our Columbia, MD office, if you have any questions. I am always available twenty-four hours a day, seven days a week, by paging 888-955-7263.

E
FIELD INSTALLATION INSTRUCTION BOOKLET, IB-6705

The current version of IB-6705 is included in this document for reference. The reader should be aware that the content of IB-6705 is subject to change with subsequent revisions from ABB. Users of this material should verify that the latest information from ABB is used.

IB-6705

FIELD INSTALLATION
INSTRUCTION BOOKLET
IB-6705

INSTRUCTIONS FOR FIELD INSTALLATION OF UNDERVOLTAGE TRIP DEVICE ON K-LINE CIRCUIT BREAKERS K-225 THROUGH K-2000, K-DON AND KSP.

ABB Power T&D Company Inc.
Distribution Systems Division

IB-6705

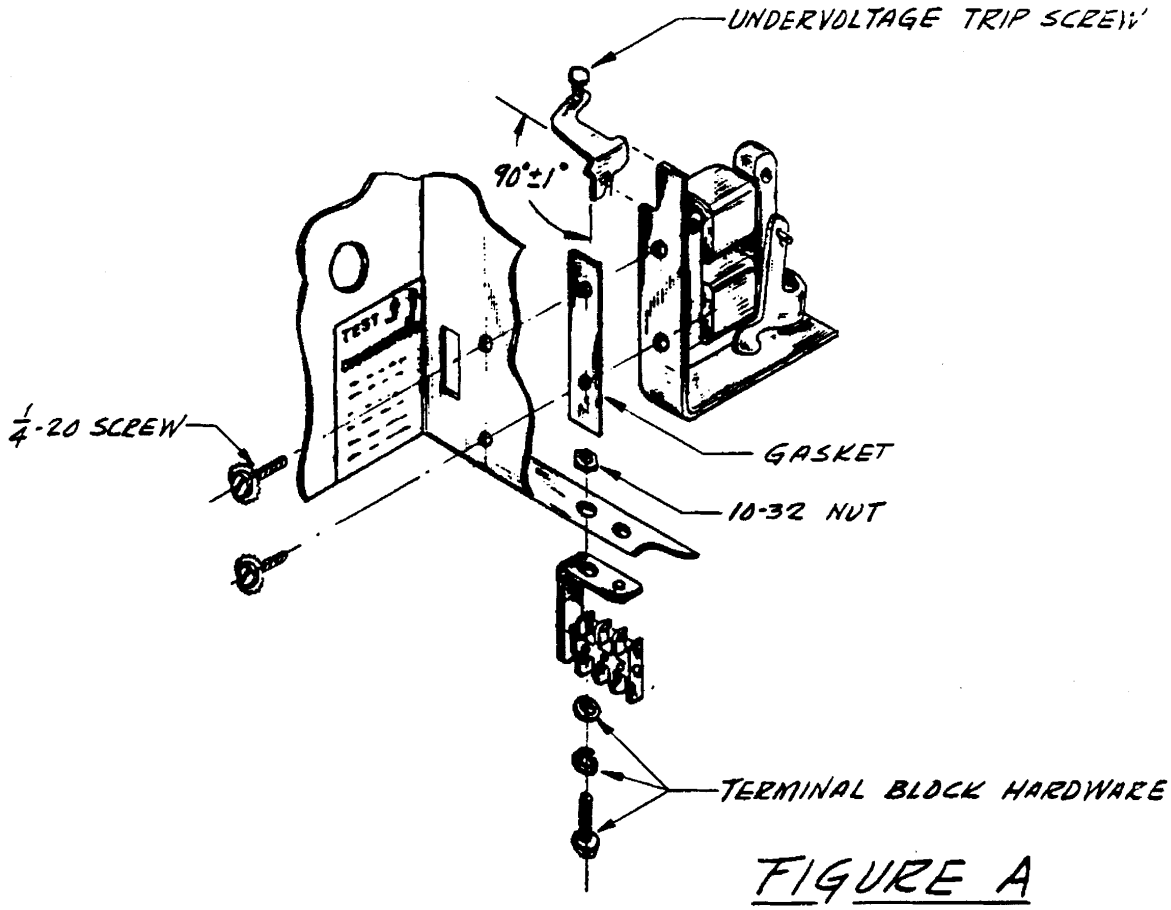


FIGURE A

The gasket provided should be placed between the undervoltage device and the mounting surface.

Add the trip plate to the tripper bar as shown in Figure B when reset indication is desired.

(c) Install the terminal block provided as shown in Figure A. Wire the leads as per FIG. C wiring diagram. On drawout breakers, additional leads will have to be connected to the secondary control contacts.

(d) Replace the charging motor on electrically operated breakers.

(e) Trip Adjustments

The trip adjustment must be made on the circuit breaker after the undervoltage trip device is completely mounted. Upon dropout due to a loss or drop in line voltage, the magnet assembly will open up and the trip screw will then strike either the extended latch pin (no reset indication) or the appropriate tripper bar attachment (reset indication).

To make the trip screw adjustment, it is first necessary to close the breaker. In order to do this, the undervoltage trip device will have to be blocked in the pickup position (either electrically or mechanically), and the trip screw must be backed off by turning in a counterclockwise direction. With the circuit breaker contacts closed, gently release the armature. The trip screw can now be advanced to the point where the breaker just trips. From the point that the breaker just trips, advance the trip screw two additional turns.

Latch Engagement (Bite)

The latch engagement adjusting screw is located to the right of the right-hand mechanism housing. It can be reached easily from the top of the circuit breaker.

To adjust the latch engagement, proceed as follows:

1. Back off adjusting screw to assure excessive latch engagement.
2. Close the circuit breaker.
3. Turn adjusting screw down slowly until the latch just releases, tripping the circuit breaker.
4. Back off the adjusting screw 2 turns.

Tripper Bar Latch Engagement

The tripper bar latch engagement adjusting screw is located adjacent to the latch engagement adjusting screw.

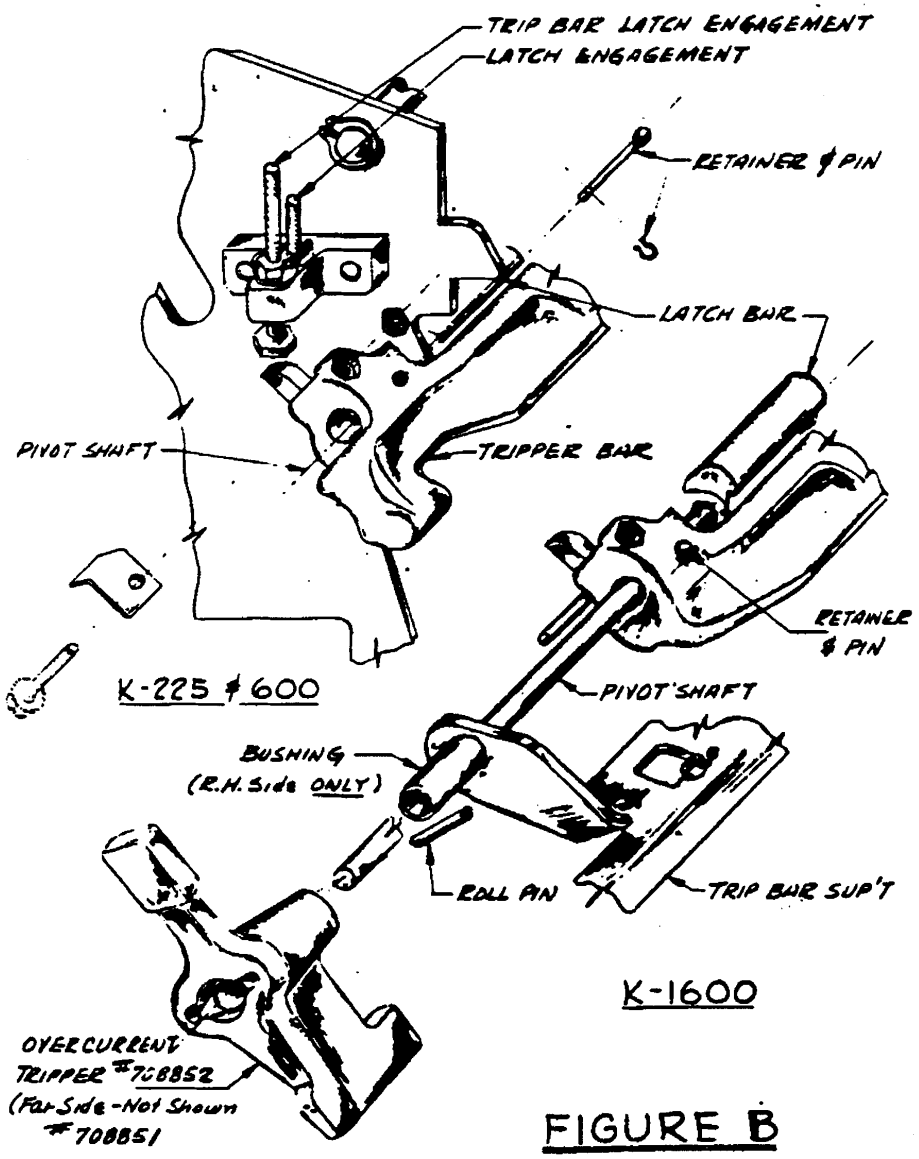
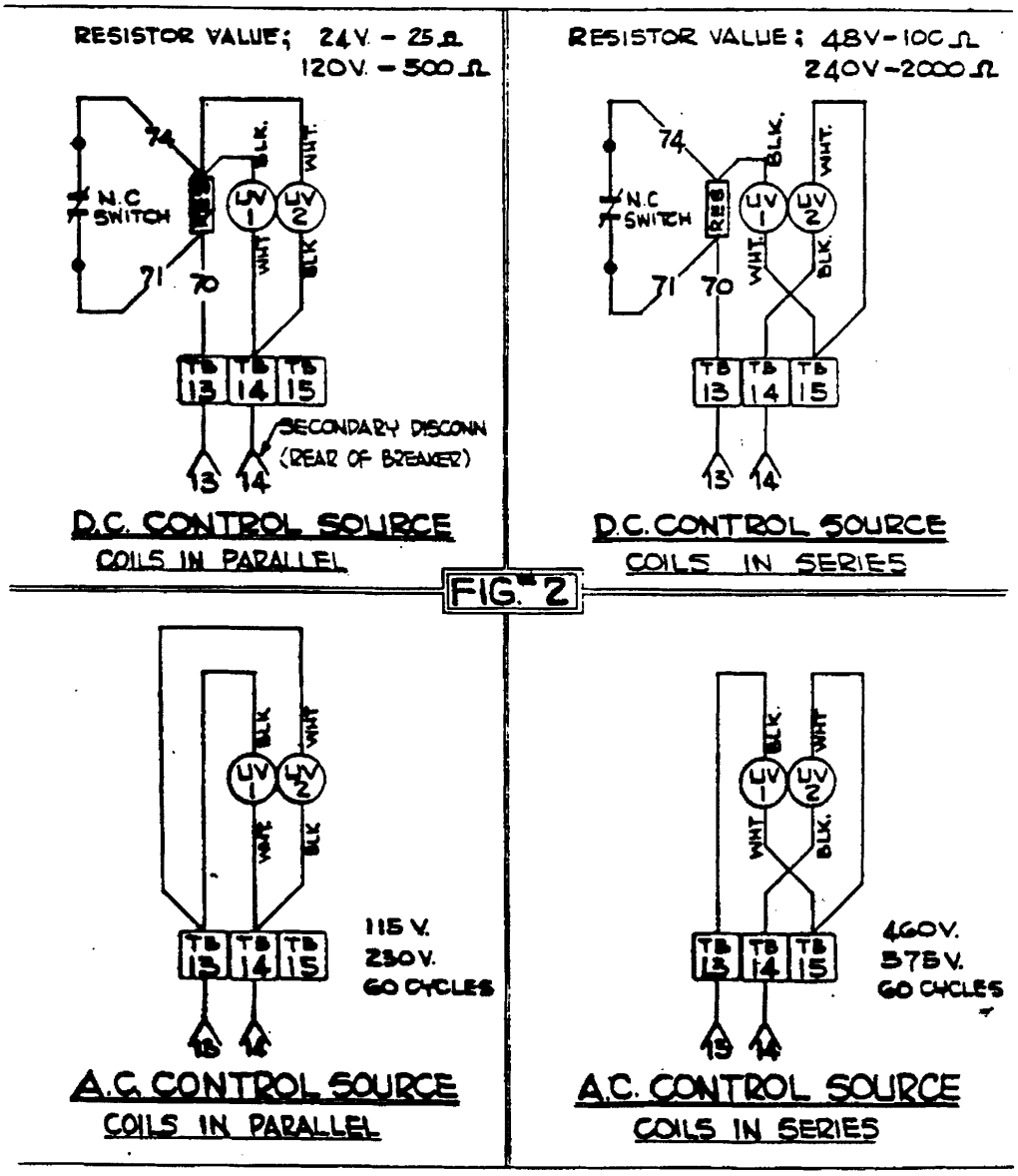
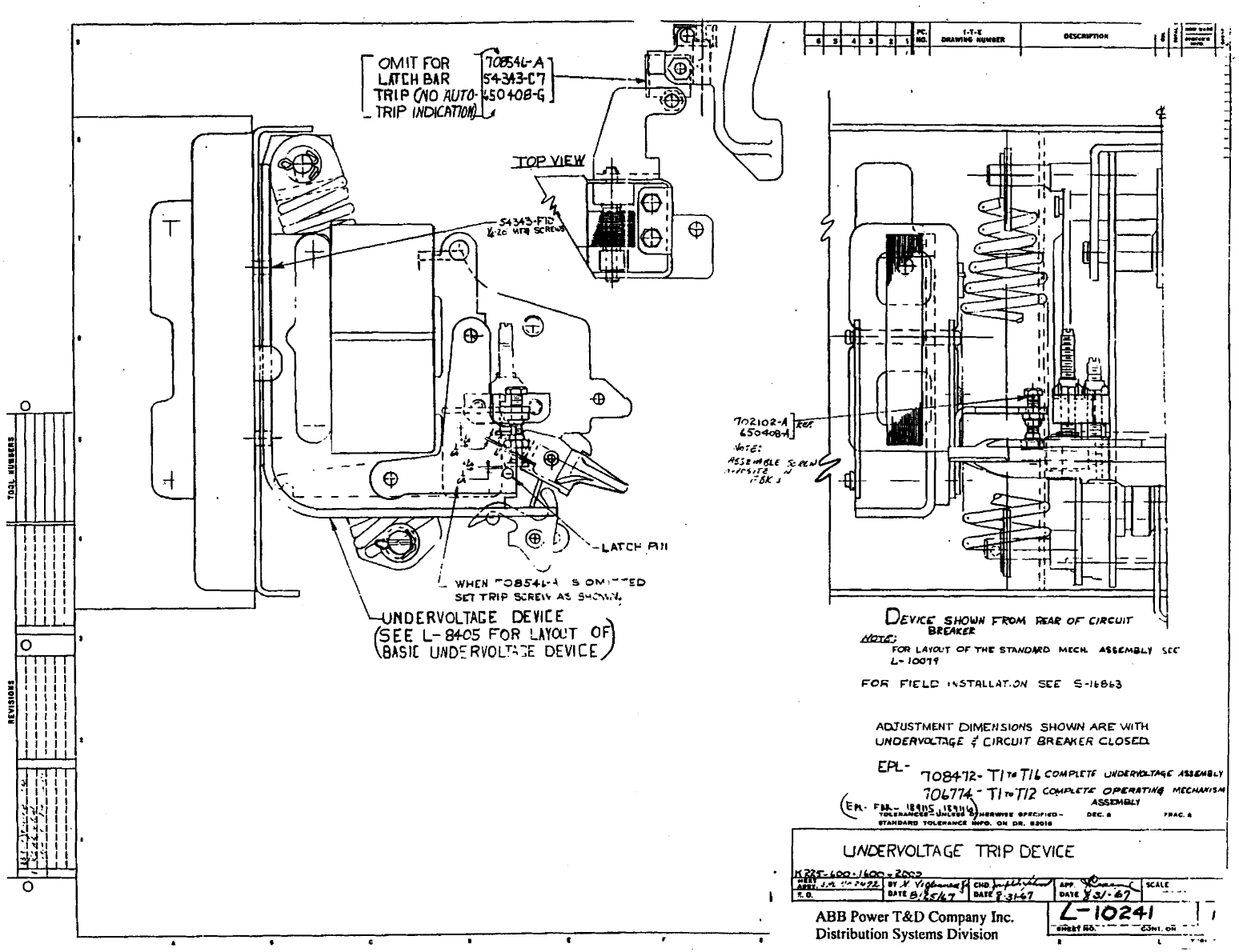

TRIP BAR LATCH ENGAGEMENT
LATCH ENGAGEMENT
RETAINER # PIN
LATCH BAR
PIVOT SHAFT
TRIPPER BAR
RETAINER # PIN
K-225 # 600
PIVOT SHAFT
BUSHING
(R.H. Side ONLY)
ROLL PIN
TRIP BAR SUP'T
K-1600
OVERCURRENT TRIPPER #708852
(Far Side - Not Shown #708851

FIGURE B


RESISTOR VALUE; 24V. - 25Ω
120V. - 500Ω
74
N.C SWITCH
71
70
BLK.
WHT.
UV 1
UV 2
TB 13
TB 14
TB 15
SECONDARY DISCONN (REAR OF BREAKER)
13
14
D.C. CONTROL SOURCE
COILS IN PARALLEL
RESISTOR VALUE; 48V-100Ω
240V-2000Ω
RES
D.C. CONTROL SOURCE
COILS IN SERIES
FIG. 2
115 V.
230V.
60 CYCLES
A.C. CONTROL SOURCE
COILS IN PARALLEL
460V.
575V.
60 CYCLES
A.C. CONTROL SOURCE
COILS IN SERIES


OMIT FOR LATCH BAR TRIP (NO AUTO-TRIP INDICATION)
708546-A
54343-C7
450408-G
TOP VIEW
54343-F15
LATCH PIN
WHEN 708546-A IS OMITTED SET TRIP SCREW AS SHOWN.
UNDERVOLTAGE DEVICE
(SEE L-8405 FOR LAYOUT OF BASIC UNDERVOLTAGE DEVICE
702102-A
650408-H
DEVICE SHOWN FROM REAR OF CIRCUIT BREAKER
NOTE:
FOR LAYOUT OF THE STANDARD MECH. ASSEMBLY SEE L-10079
FOR FIELD INSTALLATION SEE S-16863
ADJUSTMENT DIMENSIONS SHOWN ARE WITH UNDERVOLTAGE & CIRCUIT BREAKER CLOSED.
EPL-
708472-T1 to T16 COMPLETE UNDERVOLTAGE ASSEMBLY
706774-T1 to T12 COMPLETE OPERATING MECHANISM ASSEMBLY
UNDERVOLTAGE TRIP DEVICE
ABB Power T&D Company Inc.
Distribution Systems Division
L-10241

F
REPRINT OF ABB FAX REGARDING K-LINE RESISTANCE VALUES

Note: This is a reprint of an ABB fax to Gabe Paoletti of the ABB Service Center in Mt. Laurel, NJ from Dean Sigmon of ABB Power T&D in Florence S.C., dated June 20, 1994.

Re: K-Line resistance values

We have reviewed the letter from Al Ellington, who preceded the undersigned as product engineer on K-Line. We add our support to his letter as it is a position we still maintain, for the most part. We want to further clarify and amend this letter from 1983, however, as we have learned more over the years since that letter was written. Although monitoring resistance values can indicate a trend in the operation of the circuit breaker when tear down and lubrication are due, variation from the factory values for new breakers as minute as those shown in the handwritten note from Tim McClane is not a cause for alarm. We would expect variations from pole to pole in a given breaker and increasing resistance over time as service conditions take their toll.

Reasons for the somewhat higher resistance can usually be traced to service and maintenance conditions. Copper, over time, in the presence of alternating current, will tend to loosen at the joints. Tightening the hardware in those areas will alleviate some of the loss of conductivity. Simple accumulation of dust and dirt can cause higher resistance readings. Additionally, we are aware of certain environmental contaminants like hydrogen sulfide which react with the silver and exposed copper creating high resistance areas. Hydrogen sulfide occurs usually in the chemical industry and the paper industry. And finally, although we do not allow any type of solvent to be used on the circuit breaker parts, past cleaning practices by some service agencies have included the use of spray cleaners like dichlorodifluoromethane (Freon) on the assembled breaker. This tended to clean exposed areas but allowed dirt and debris to be washed into the bus joints and bridge pivots where it could not be wiped away. This, in turn, causes higher resistance. There is no way we can know that this has happened to these breakers, it is certainly a way that high resistance areas can be created. ABB Service has been alert to these situations and make sure that parts are properly cleaned by disassembling them, cleaning them, and wiping the parts dry.

We note that the readings obtained on the 70 ampere coil varied from the standard from 14 to 66 micro-ohms. We assume that the readings made previously were within specification; it is hard for us to understand how a coil with (sic) would now be out of tolerance according to the criteria they have been using. After all, these coils have no moving parts and no bus joints through which the measurement is made to influence the result. Dirt and dust accumulation or tester calibration are factors for variations this small. Possibly the tests this time are being performed from a point on the coil different from before.

Reprint of ABB Fax Regarding K-Line Resistance Values

We have reviewed the factory specification on the OD coil resistance and disagree with the statement in Mr. Ellington's letter that these are maximum values. We allow a plus or minus 5% tolerance on the OD coil resistance. For the breaker current carrying parts where joints and pivots are a factor we allow the following maximum resistance values (in micro-ohms):

K225	K600/800	K1600/2000	K3000/4000
200	100	50	20

Again, when calculating the total resistance of the breaker (exclusive of the primary disconnects) you must add the value for the current parts to the value for the OD coil.

What does all this mean? If the resistance is beyond the allowable maximum, how does that influence breaker performance? If the resistance were above the allowable value and the breaker were conducting its rated, continuous load (in other words, 100% of its frame rating), then the increased resistance would cause additional heating of the circuit breaker current carrying parts. ANSI C37.13 allows the contact tips to be 85°C rise over the ambient. The primary disconnect area is allowed a 55°C rise over ambient. So if the resistance is somewhat over allowable, these temperatures may be reached. Breakers are designed with insulating materials to tolerate these temperatures if necessary.

There are several factors which work in favor of applications at nuclear plants, however. Breakers are seldom loaded up to their continuous current capability. More typically, they are loaded to 80% of this value. Therefore, the allowable rise-over-ambient would not be reached even if the breaker resistance is above allowable. Loading is usually based on the maximum expected current draw if all loads are energized; this is seldom true in actual practice. Actual current passing through the breaker will be less than its loading making the actual heating from the resistance in the current carrying path even less.

We have included all of this discussion to put across the point that the values of resistance we see here cause us little concern.

Signed

Dean Sigmon

Low Voltage Product Manager.

G
LETTER FROM ABB REGARDING CHANGED COIL RESISTANCE VALUE

The following letter from ABB T&D company pertains to Table A5, "OD Coil Assembly Resistance Based on Device Rating and Circuit Breaker Frame Size," which is found in ABB IB 6.1.12.1-1A.

Letter From ABB Regarding Changed Coil Resistance Value

ABB

ABB Power T&D Company, Inc.
Florence, SC

August 11, 2000

To: K-Line Users and Service Organizations

Subject: Changed Coil Resistance Value
Reference K-Line 11-turn coil used for 125, 100, and 90 A device ratings.

The published allowable coil resistance value of 600 μΩ has been changed to 750 μΩ. The values in years past may have been closer to the 600 value, however, values typically measure about 690 μΩ. Factory testing was used to substantiate the new resistance value as adequate, yet still a value that is conservative with respect to heating.

For this coil, the hottest condition will be for a 125 A maximum continuous current through a 125 A calibrated device. For current above this, the LT function will open the circuit breaker. Specifying the insulation conservatively as class 105 °C insulation, the level of current needed to heat any part of the device to the temperature limit is considerably above 125 A. For testing performed on several 100 A devices, approximately 175 A were required to reach the device temperature limit.

This letter will serve as notification of the value change until affected documents are revised accordingly.

Bryan Powell
Low Voltage Product Engineer

Target:
Nuclear Power

About EPRI

EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

EPRI. Electrify the World

SINGLE USER LICENSE AGREEMENT

THIS IS A LEGALLY BINDING AGREEMENT BETWEEN YOU AND THE ELECTRIC POWER RESEARCH INSTITUTE, INC. (EPRI). PLEASE READ IT CAREFULLY BEFORE REMOVING THE WRAPPING MATERIAL.

BY OPENING THIS SEALED PACKAGE YOU ARE AGREEING TO THE TERMS OF THIS AGREEMENT. IF YOU DO NOT AGREE TO THE TERMS OF THIS AGREEMENT, PROMPTLY RETURN THE UNOPENED PACKAGE TO EPRI AND THE PURCHASE PRICE WILL BE REFUNDED.

1. GRANT OF LICENSE

EPRI grants you the nonexclusive and nontransferable right during the term of this agreement to use this package only for your own benefit and the benefit of your organization. This means that the following may use this package: (I) your company (at any site owned or operated by your company); (II) its subsidiaries or other related entities; and (III) a consultant to your company or related entities, if the consultant has entered into a contract agreeing not to disclose the package outside of its organization or to use the package for its own benefit or the benefit of any party other than your company.

This shrink-wrap license agreement is subordinate to the terms of the Master Utility License Agreement between most U.S. EPRI member utilities and EPRI. Any EPRI member utility that does not have a Master Utility License Agreement may get one on request.

2. COPYRIGHT

This package, including the information contained in it, is either licensed to EPRI or owned by EPRI and is protected by United States and international copyright laws. You may not, without the prior written permission of EPRI, reproduce, translate or modify this package, in any form, in whole or in part, or prepare any derivative work based on this package.

3. RESTRICTIONS

You may not rent, lease, license, disclose or give this package to any person or organization, or use the information contained in this package, for the benefit of any third party or for any purpose other than as specified above unless such use is with the prior written permission of EPRI. You agree to take all reasonable steps to prevent unauthorized disclosure or use of this package. Except as specified above, this agreement does not grant you any right to patents, copyrights, trade secrets, trade names, trademarks or any other intellectual property, rights or licenses in respect of this package.

4. TERM AND TERMINATION

This license and this agreement are effective until terminated. You may terminate them at any time by destroying this package. EPRI has the right to terminate the license and this agreement immediately if you fail to comply with any term or condition of this agreement. Upon any termination you may destroy this package, but all obligations of nondisclosure will remain in effect.

5. DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITIES

NEITHER EPRI, ANY MEMBER OF EPRI, ANY COSPONSOR, NOR ANY PERSON OR ORGANIZATION ACTING ON BEHALF OF ANY OF THEM:

(A) MAKES ANY WARRANTY OR REPRESENTATION WHATSOEVER, EXPRESS OR IMPLIED, (I) WITH RESPECT TO THE USE OF ANY INFORMATION, APPARATUS, METHOD, PROCESS OR SIMILAR ITEM DISCLOSED IN THIS PACKAGE, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, OR (II) THAT SUCH USE DOES NOT INFRINGE ON OR INTERFERE WITH PRIVATELY OWNED RIGHTS, INCLUDING ANY PARTY'S INTELLECTUAL PROPERTY, OR (III) THAT THIS PACKAGE IS SUITABLE TO ANY PARTICULAR USER'S CIRCUMSTANCE; OR

(B) ASSUMES RESPONSIBILITY FOR ANY DAMAGES OR OTHER LIABILITY WHATSOEVER (INCLUDING ANY CONSEQUENTIAL DAMAGES, EVEN IF EPRI OR ANY EPRI REPRESENTATIVE HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES) RESULTING FROM YOUR SELECTION OR USE OF THIS PACKAGE OR ANY INFORMATION, APPARATUS, METHOD, PROCESS OR SIMILAR ITEM DISCLOSED IN THIS PACKAGE.

6. EXPORT

The laws and regulations of the United States restrict the export and re-export of any portion of this package, and you agree not to export or re-export this package or any related technical data in any form without the appropriate United States and foreign government approvals.

7. CHOICE OF LAW

This agreement will be governed by the laws of the State of California as applied to transactions taking place entirely in California between California residents.

8. INTEGRATION

You have read and understand this agreement, and acknowledge that it is the final, complete and exclusive agreement between you and EPRI concerning its subject matter, superseding any prior related understanding or agreement. No waiver, variation or different terms of this agreement will be enforceable against EPRI unless EPRI gives its prior written consent, signed by an officer of EPRI.

Printed on recycled paper in the United States of America

1000013

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com