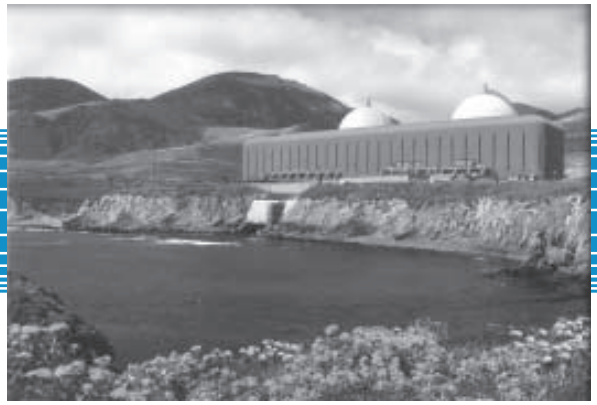
EPRI

Routine Preventive Maintenance Guidance for ABB HK Circuit Breakers

Supercedes NP 7410-V2P2



NMAC

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 BREAKING OR TEARING THE WARNING LABEL AND OPENING THIS SEALED PACKAGE.

BY OPENING THIS SEALED REPORT YOU ARE AGREEING TO THE TERMS OF THIS AGREEMENT. IF YOU DO NOT AGREE TO THE TERMS OF THIS AGREEMENT, PROMPTLY RETURN THE UNOPENED REPORT 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 report only for your own benefit and the benefit of your organization. This means that the following may use this report: (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 report outside of its organization or to use the report 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 report, 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 report, in any form, in whole or in part, or prepare any derivative work based on this report.

3. RESTRICTIONS

You may not rent, lease, license, disclose or give this report to any person or organization, or use the information contained in this report, 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 report. 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 report.

4. TERM AND TERMINATION

This license and this agreement are effective until terminated. You may terminate them at any time by destroying this report. 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 report, 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 REPORT, 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 REPORT 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 REPORT OR ANY INFORMATION, APPARATUS, METHOD, PROCESS OR SIMILAR ITEM DISCLOSED IN THIS REPORT.

6. EXPORT

The laws and regulations of the United States restrict the export and re-export of any portion of this report, and you agree not to export or re-export this report 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.

Routine Preventive Maintenance Guidance for ABB HK Circuit Breakers

Supercedes NP 7410-V2P2

TR-109642

Final Report, November, 1999

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, 207 Coggins Drive, P.O. Box 23205, Pleasant Hill, CA 94523, (800) 313-3774.

CITATIONS

This report was prepared by

ABB Circuit Breaker Users Group

Users Group Chairmen
S. Shah, Southern Nuclear
R. Ferrie, Duquesne Light

Users Group Co-Chairman
J. Wagner, Northern States Power

Nuclear Maintenance Applications Center (NMAC)
1300 W. T. Harris Boulevard
Charlotte, North Carolina 28221

This report describes research sponsored by EPRI.

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

Routine Preventive Maintenance Guidance for ABB HK Circuit Breakers: Supercedes NP 7410-V2P2, EPRI, Palo Alto, CA: 1999. TR-109642.

REPORT SUMMARY

This guidance provides a comprehensive list of preventive maintenance tasks for ABB (ITE/Gould/BBC) HK type circuit breakers. In addition, this document establishes a consensus on the maintenance of these circuit breakers among utility personnel considering the manufacturer's recommendations and the unique application of these circuit breakers within the nuclear industry.

Background

From 1990 to 1994, EPRI-NMAC published EPRI NP-7410, commonly known as the circuit breaker maintenance guide series. These documents, although comprehensive, lacked the complete participation and extensive input from utility personnel. In addition, a procedure format was followed in NP-7410 that complicated application of the guidance. To resolve these issues, EPRI-NMAC began forming circuit breaker users groups in 1994. These groups of cognizant, responsible plant personnel tasked themselves with revising the guidance 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 supercedes the guidance found in NP-7410.

Objectives

- To provide general guidance on routine preventive maintenance for ABB HK type medium-voltage circuit breakers
- To identify and list routine preventive maintenance tasks for these circuit breakers and, where appropriate, to provide the purpose, justification, and description of each maintenance task
- To develop a consensus on maintenance practices among utility personnel considering the manufacturer's recommendations and the unique application of these circuit breakers within our industry
- To develop a technical basis for proper maintenance so utilities can enhance and justify their site-specific 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 cognizant, responsible utility personnel, the manufacturer, and other organizations. After initial development, the draft was provided to the entire BBB Circuit Breaker Users Group and the manufacturer for review and comment. Both

ABB Power T&D and ABB Service, Inc., have participated in the development and review of this document. This effort was a collaborative industry effort with numerous utility and non-utility 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 what maintenance tasks may be considered for their maintenance program and to provide general guidance with respect to maintenance of these specific breakers. This guidance is applicable to the following ABB HK circuit breakers: 5HK250, 5HK350, 7.5HK500, 15HK500, 15HK750, and 15HK1000.

Results

This document identifies routine preventive maintenance tasks for ABB HK circuit breakers. Each task attempts to clearly identify the purpose of the task and the justification (or basis) for each task and, where appropriate, to provide additional description of the task. Guidance on lubrication, troubleshooting, and preventive maintenance intervals is also provided.

EPRI Perspective

Through the process of developing this guidance 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 development of these documents and various working group and users group meetings, utilities have increased their quantity and quality of communication, improved maintenance procedures, and educated system engineers about breaker maintenance and maintenance programs. This process has raised the general awareness of circuit breaker maintenance within the industry. The efforts of these users groups have also improved the relationship and communication between utility personnel and their circuit breaker manufacturers and service providers.

TR-109642

Keywords

Circuit breaker
Maintenance
Preventive maintenance
Switchgear

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 EPRI/NMAC and the ABB Circuit Breaker Users Group. 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 consensus of the ABB Circuit Breaker Users Group, the manufacturer, and other contributors. There may be other techniques or means of performing the work or activities described here. Questions concerning use of this material should be directed to EPRI's Nuclear Maintenance Applications Center (NMAC).

ACKNOWLEDGMENTS

This guidance was prepared by the ABB Circuit Breaker Users Group under the sponsorship of the EPRI Nuclear Maintenance Applications Center (NMAC). EPRI-NMAC and the ABB Circuit Breaker Users Group would like to acknowledge the participation and contributions of the following companies and their representatives.

Gene Langley	ABB Service, Inc.
Dave Davis	ABB Service, Inc.
Wally Marcis	ComEd
Craig Gleason	Detroit Edison, Fermi 2
Chris Jones	Duke Energy, Catawba
Roger Bledsoe	Duke Engineering and Services
Ron Ferrie	Duquesne Light, Beaver Valley
Norman Pressler	Entergy Operations, River Bend
Jeffrey M. Wagner	Northern States Power, Prairie Island
Chris Dickey	Southern Nuclear, Vogtle
Tim Wright	Southern Nuclear, Vogtle
Sam Shah	Southern Nuclear Operating Company, Vogtle
Al Garza	TU Electric, Comanche Peak
Jon Pettit	TU Electric. Comanche Peak
Rickey Sparks	TVA

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1
BACKGROUND

Goals and Benefits

This document provides routine preventive maintenance (PM) guidance for ABB HK (ITE/Gould/BBC) medium voltage (4-16 kv) circuit breakers. It identifies PM tasks for these circuit breakers and, where appropriate, provides the purpose, justification, and description of the task.

This guidance represents a consensus between utility personnel considering the manufacturer's recommendations and the unique application of these circuit breakers within our industry. Guidance was developed through a collaborative industry effort based on the experience and knowledge of numerous utility and non-utility personnel.

PM guidance based on the collective experience of the Users Group enables utilities to establish a technical platform to justify and improve both their maintenance programs and their specific site procedures for these circuit breakers.

This effort is designed to develop guidance to be used in-lieu of guidance provided in EPRI Report NP-7410-V2-P1, *Circuit Breaker Maintenance; Volume 2: Medium Voltage Circuit Breakers, Part 1: ABB HK Circuit Breakers*, October, 1993. [1]

Scope

This document identifies PM tasks, provides guidance on PM intervals, and discusses other issues such as condition-based maintenance and predictive maintenance. 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 what 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. 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 the Users Group to develop the level of detail of a plant procedure, but to identify PM tasks that will reasonably ensure a breaker is properly maintained.

Breaker Model Applicability

This guidance is applicable to the following type circuit breakers manufactured by ABB (ITE/Goud/BBC):

- 5HK250
- 5HK350
- 7.5HK500
- 15HK500
- 15HK750
- 15HK1000

Approach

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

- Name
- Purpose
- Justification
  Applicable NRC Information Notices, Licensee Event Report, CFR Part 21 notice, SERs, SENs, OEs, O&MRs, manufacturer's service advice letters or bulletins, good industry practice, and personnel safety.
- Description
  Additional information to clarify the task or uniquely identify the task. If the task is complex or if there is more than one acceptable method to complete the task or confusion regarding the nature or intent of the task, the guidance might provide a more elaborate task description. 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 AK/HK 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 to this document must 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: *www.epri.com*
An ID and password are needed to access this web site.

Mail: EPRI-NMAC
Circuit Breaker Users Groups Project Manager
1300 Harris Boulevard; Charlotte, NC 28262

Information Sources

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

- Selected plant procedures
- Utility personnel experience
- ABB Instruction Bulletins and Maintenance Surveillance Manuals [2-6]
- ABB T&D and ABB Service, Inc. personnel experience
- Industry good practices
- NRC Information Notices
- Licensee Event Reports
- EPRI Report NP-7410-V2-P1, *Circuit Breaker Maintenance; Volume 2: Medium Voltage Circuit Breakers, Part 1: ABB HK Circuit Breakers*, October, 1993 [1].

Manufacturer Review and Participation

ABB Service, Inc. and ABB Power T&D have reviewed draft revisions of this document. The ABB Circuit Breaker Users Group has enjoyed the support and participation of ABB Service and ABB Power T&D in this effort.

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.

Illustrations

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

Terminology

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

Task Sequence

During preventive maintenance, it is not necessary to perform tasks listed in this document in sequential order. However, these tasks are in a reasonable sequence intended for ease of performance.

Personnel Qualification and Training

Only task-trained and qualified personnel using plant-approved procedures should perform maintenance on these circuit breakers.

Special Tools

Only go/no-go gauges are required for preventative maintenance. Drawings for specialty tools for go/no-go gauges can be obtained from ABB Service, Inc.

Go/no-go gauges:

- 7/64" minimum, 3/16" maximum for main contact pressure
- 1/32" for arcing contacts

Other EPRI Guidance on Circuit Breakers

This guidance developed by the ABB Circuit Breaker Users Group should be used in-lieu of guidance provided in EPRI NP-7410-V2-P1 [1]. Guidance provided within this document and EPRI-7410-V2-P1 will be combined in the future by the users group.

The guidance contained in this document is detailed and specific to ABB HK circuit breakers. Consequently, this guidance should be used in-lieu of guidance provided in *Preventive Maintenance Program Basis: Medium Voltage Switchgear,* EPRI TR-106857-V2, July, 1997 [7].

2
PREVENTIVE MAINTENANCE INTERVALS (FREQUENCIES)

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 plants particular situation.

It is impossible to develop a routine preventive maintenance (PM) interval that is applicable to all plants in all situations. When determining a routine PM interval, plant personnel should consider their particular situation and the factors listed under "Factors Affecting Maintenance Intervals."

The ABB Circuit Breaker Users Group has identified typical PM 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, utilities should review for adequacy any maintenance interval that falls well outside the manufacturer's recommendation or generic guidance provided by industry.

During the June, 1998 and June, 1999 ABB Circuit Breaker Users Group meetings, the group agreed that routine PM should not exceed six years on ABB HK circuit breakers. This guidance was based on the typical PM intervals of participating plants.

It is the consensus of the

ABB Circuit Breaker Users Group

not to exceed a six-year preventive maintenance interval.

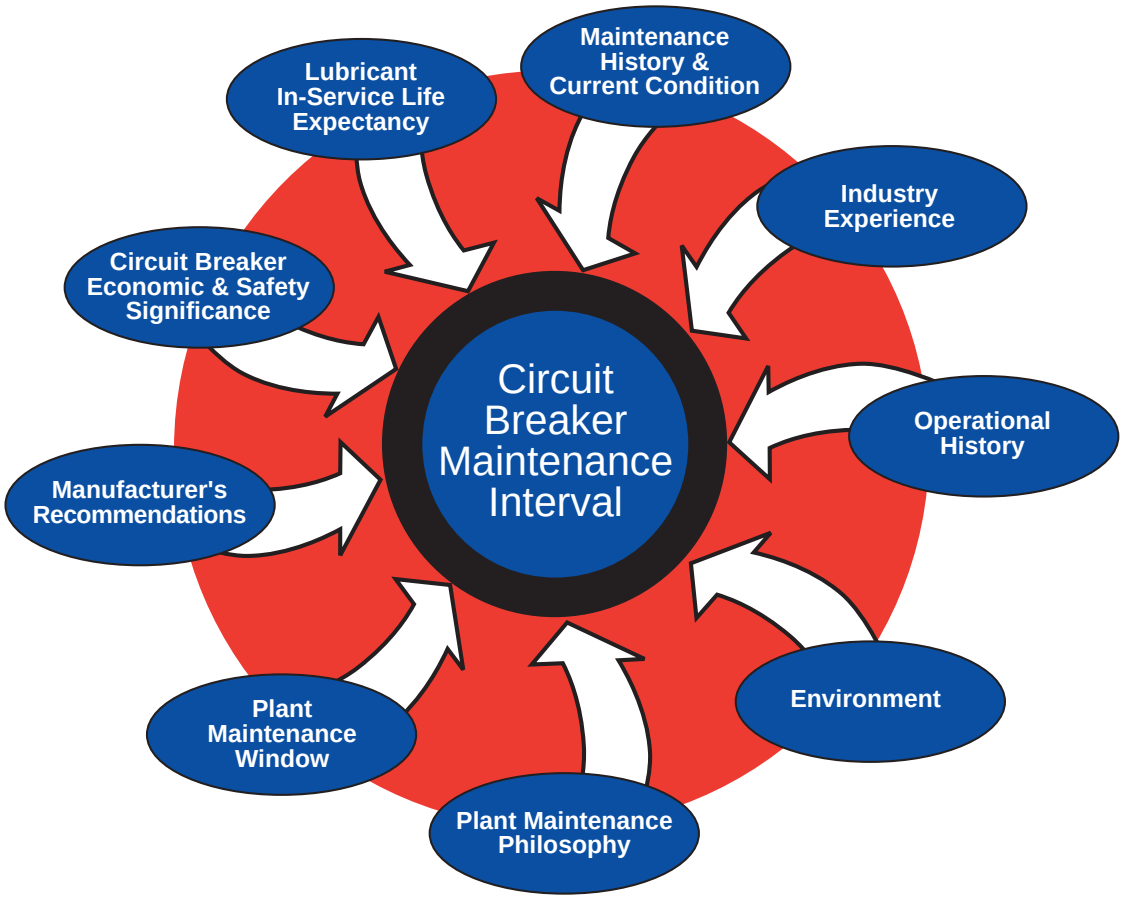


Figure 2-1
Factors Affecting Maintenance Intervals

Manufacturer's Recommendations

The ABB Maintenance and Surveillance (MS) 3.2.1.9-1 [6] discusses PM intervals for HK circuit breakers. This MS states:

> *Suggested time frames in the program are not absolute, they represent the best generalized advice of the manufacturer….*

The ABB MS also states that maintenance should be performed based on a breaker's environment, application, and number of operations since last serviced with an elapsed time limit. The MS is not entirely clear when discussing maximum PM intervals. PM intervals (frequencies) range from 12 months to five years.

Considering Manufacturer's Recommendations

A common myth among industry personnel is that the manufacturer's guidance must be followed without deviation. Manufacturer's guidance, by their own admission, represents the manufacturer's best generalized advice and includes assumptions about the circuit breaker's

environment, lubrication, previous maintenance, and operational history. But 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, deviations from these recommendations should be justified and this justification should be documented.

Factors Affecting Maintenance Intervals

The following factors can affect circuit breaker maintenance intervals. Plants may wish to consider these factors in their maintenance program. The degree to which these factors will affect your maintenance program will vary.

Industry Experience

- Industry experience with maintenance of circuit breakers with similar design, age, lubrication, environment, and maintenance and operational history.
- Other significant industry experience which may be applicable or affect the maintenance interval.

Lubrication

- Inservice anticipated life of the lubricant
- Actual or typical lubricant condition at your plant

Maintenance History and Current Condition

- Previous maintenance performed.
- Previous lubrication practices.
- Previous environmental effects.
- Previous routine maintenance intervals.
- Findings or deficiencies found during preventive maintenance are considered part of a maintenance history.
- The current condition of circuit breakers can be evaluated to the extent possible and considered when determining PM intervals. This could be performed via sampling and inspecting typical circuit breakers. In addition, "as-found" data can be useful in determining the current condition of a circuit breaker.

Operational History

- Number of operations since last maintenance performed
- Duty cycle (that is, rough percentage of carrying load and percentage of breaker rating this represents)

- Quantity and severity of fault interruptions or overcurrent conditions since 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)
- Degree of breaker "exercising"

Circuit Breaker Significance

The importance of the breaker, which includes:

- Its safety significance (use of probabilistic risk assessment and IPE for prioritization of circuit breakers for maintenance)
- Its commercial or economic significance

Maintenance Philosophy

- The current breaker maintenance program and philosophy of the utility or plant

Environment

- Past and current service condition or environment

Maintenance Windows

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

Manufacturer's Recommendations

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

3
LUBRICATION

Approved Lubricants

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

Table 3-1
Manufacturer-Approved Lubricants

Lubricant	Useage
Anderol 757 (Tenneco Chemical Corp.)	All mechanism parts, bearings, pins, etc. [6]
NO-OX-ID "A" Special Lubricant (Sanchem Chemical Corp)	Electrical contact compound [6]
Mobilgrease 28 [8]	All mechanism parts, bearings, pins, etc., and electrical contacts

Alternate Lubricants

In early 1999, ABB issued a letter stating that Mobilgrease 28 is acceptable for use during refurbishment with ABB circuit breakers [8, 9].

Caution

If using Mobilgrease 28, maintenance personnel should exercise caution to ensure that Mobilgrease 28 and Anderol 757 are not intermingled. Mobilgrease 28 should not be used on a circuit breaker's primary disconnects or ground disconnects unless Mobilgrease 28 has also been applied to the switchgear bus (cubicle stabs).

Users Group Guidance

In addition to the manufacturer's recommendation of lubricating the primary disconnect assemblies [6], the Users Group, based on industry experience, recommends lubricating the following:

- Ground disconnects (NO-OX-ID "A" Special)
- Racking mechanism (Anderol 757 or Mobilgrease 28)

Manufacturer's Recommendations

ABB's Instruction Bulletin 6.2.3.7B [5] states:

> *HK breakers are lubricated during factory assembly as follows:*
>
> *All mechanism parts, bearings, pins, etc., have been lubricated with Anderol 757 manufactured by Nuodex, Inc. (formerly Tenneco Chemical, Inc.) (ABB No. 712994A, 4 oz. lube).*
>
> *The mechanism should be periodically inspected for lubrication contamination; frequency of inspection is dependent on operating environment.*
>
> *Do not use light oil to lubricate any mechanism parts. In emergency situations, Anderol 732 may be used as a temporary lubricant* (see Note).*In these cases, allow time for the solvents to evaporate prior to any mechanical operations. It is mandatory that the breaker undergo thorough lubrication with Anderol 757 at the next maintenance interval. Use of solvent to free contaminated lubricant is strictly forbidden without immediate relubrication using Anderol 757. Note that bearing surfaces must be repacked and will require disassembly of the mechanism. Do not operate the circuit breaker without completing this procedure.*
>
> *The charging motor is sealed and no lubrication is required.*

Note: The Users Group does not recommend use of Anderol 732 [10, 11].

4
MAINTENANCE TASKS

This section contains a list of maintenance tasks that represent the collective experience of the ABB Circuit Breaker Users Group.

As-Found Inspections and Tests

Purpose
The purpose of taking "as-found" data is to document, to the extent possible and practical, the condition of the circuit breaker prior to maintenance and, thus, to provide a maintenance history in the plant records. This maintenance history can serve as one input to the overall circuit breaker maintenance program. Collecting and reviewing the as-found data of the aggregate circuit breaker population can be useful in adjusting maintenance intervals, if adjustment is desired in the future. An additional, more practical benefit of taking as-found data is to determine any degraded conditions early during maintenance to facilitate work scheduling and ordering parts.

Justification
Good industry practice

Description
The following tests can be performed before maintenance to determine the as-found condition. Each of these tests and inspections is listed below as a separate task.

- Record counter readings (if applicable)
- Primary contact resistance (prior to cleaning)
- Manual and electrical operational check/anti-pump operational check
- Reduced control voltage test

Record Counter Readings (If Applicable)

Purpose
Document number of breaker cycles.

Justification
Good industry practice (see Section 5.1 of IB 6.2.1.7D [3])

Description
If cycling is excessive, more frequent servicing may be required per ABB MS 3.2.1.9-1D [6].

Primary Contact Resistance

Purpose
Verify that the contacts are clean and resistance is within acceptance criteria to avoid internal heating.

Justification
Good industry practice and recommended by the manufacturer

Description
Measure the contact (phase) resistance of each phase using either a micro-ohmmeter, digital low resistance ohmmeter, ductor, or millivolt drop test. If phase resistance is high, the reason for the high resistance should be isolated to either the stationary contact assembly or the movable contact assembly. If contact resistance is high, isolate and clean the high resistance joint. Adjust the bridge pivot as necessary. Refer to task on Bridge Pivot Pressure [3, 4].

Manual and Electrical Operational Check

Purpose
Ensure proper operation of all mechanical and electrical breaker functions.

Justification
Good industry practice and recommended by ABB IB 6.2.1.7D & and 6.2.2.7-1G [3, 4]

Description
Verify that the breaker operates properly without binding or tripping free. Verify that the breaker charges, closes, and trips electrically and manually with actuation of the trip counter. Inspect for sluggishness or grinding.

Note: If breaker is equipped with undervoltage (UV) device, the UV device will hold the breaker in a trip-free condition unless energized or mechanically defeated. Ensure that the latch check switch, if installed, is functioning correctly.

Anti-Pump Operational Check

Purpose
Prevent circuit breaker from re-closing if a close input is maintained during a trip-free condition.

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

Description
Close the breaker electrically, and maintain the close signal (keep the close button depressed). While maintaining the close signal, trip the circuit breaker electrically or mechanically. Verify that the circuit breaker does not re-close.

Reduced Control Voltage Test

Purpose
The purpose of reduced voltage testing is to demonstrate conservatively 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 operation control voltage is determined and then applied to the circuit breaker's close and trip control circuitry. Then, the circuit breaker is cycled open and closed, and the breaker's operation is verified [12]. Verify the operation of the circuit breaker at the minimum required control voltage for the specific plant, which is not necessarily the minimum design voltage (see ABB IB6.2.1.7D and 6.2.2.7-1G, Section 5.15 [3, 4]) for minimum designed control voltage).

Circuit Breaker Visual Inspection

Purpose
Visually inspect the circuit breaker for loose, broken, or damaged parts.

Justification
Good industry practice and recommended by the manufacturer

Description
Check all hardware and subcomponents for loose, broken, or damaged components. Plants may wish to consider including the following items in their inspection:

- Check tightness of spring charging motor mounting bolts (see NRC IN-88-42 [13]; OE 2715 [14]; NRC IN 87-41 [15]); SER-1487 [16].
- Inspect the circuit breaker for dirt, overheating, and corrosion.
- Inspect placement of retainers, fasteners, and pins and for broken, bent, or missing parts (see SER-0797 [17] and Section 5-1 of ABB IB 6.2.1.7.D and IB 6.2.2.7-1G [3, 4]). Identify missing and loose hardware (crimp retainers, nylon hardware, snap rings, cotter pins, nuts, bolts, and lock-washers).
- Inspect control wiring and connections for any damage, cracks, or overheating. Inspect all wiring, including motor and coil leads.To the extent possible, visually check wiring for proper routing, anchoring, and terminations and for abrasions, cuts, nicks, or breaks.

- Inspect charging motor toggle switch and electrical pushbuttons for damage, loose connections, missing parts, and wiring conditions.
- Visually inspect the silver plating on electrical contact areas.
- Check for loss of zinc plating which may be evident by the presence of oxidation on steel parts.
- Inspect primary disconnects for excessive loss of silver plating on copper fingers, melting or deformation, and damaged or missing springs.
- Inspect control device for cracks, chips, or breaks in phenolic housing and terminal block assembly. Check for binding of limit switch actuator.
- Inspect auxiliary switch for cracks, chips, or breaks in housing assembly; excessive burning or pitting of contacts (check with mirror when operating breaker manually); and damage to operating linkage.
- Inspect secondary disconnect assemblies and support bracket for cracks, chips or breaks on phenolic molding; damage, deformation, or melting of contact fingers; and free operation of contact fingers.
- Inspect operations counter for cracks or chips in housings and proper operation.
- Inspect inter-phase barriers and dead-front for burning, tracking, or excessive warping and also for cracks or separations. Ensure that all insulating nuts are in place with no exposed metal parts inside the dead front area.
- Inspect support leads (chair assemblies) for cracks, deep scratches, breaks, chips, burning, tracking, carbon buildup, and excessive wear at stab openings.
- Inspect racking mechanism for smooth operation.
- Inspect that shutter kick pin and cell switch pin are each in the correct hole for application.

Main and Arcing Contact Cleaning and Inspection

Purpose
Maintain contacts in good clean condition. Proper electrical contact and arc interruption are dependent upon contact condition and cleanliness.

Justification
IB Section 5.3 of IB 6.2.1.7D and IB 6.2.2.71G [3, 4] (see Vogtle EM12354 [18])

Description
Inspect arcing and main contacts for cracking and breakage. Inspect stationary arcing contacts for eroded tips. Ensure that arcing contact springs are not fully compressed with breaker closed. Inspect contact for hairline cracks, pitting, roughness, galling, or discoloration. Minor burning or pitting of the contact surfaces is normal and does not adversely affect breaker operation. A Scotch-Brite pad may be used to dress the surfaces. Do not use a file as recommended in instruction bulletins. Clean per IB Section 5.3. Replace contacts if the working surface is reduced to less than 50%. [19, 20]

Contact Pressure

Purpose
Ensure the proper contact pressure and contact sequence (simultaneous make).

Justification
5HK: IB 6.2.1.7D, Section 5.2 [3]

Description
Ensure that the contacts touch within 1/32" and that the proper contact pressure (7/64" to 3/16") is achieved once the breaker is fast closed.

Puffer Inspection

Purpose
Verify that the puffers are not damaged, and ensure their proper operation.

Justification
Sect. 5.5, IB 6.2.1.7D and IB 6.2.2.7-1G [3, 4]

Description
The puffers ensure proper arc extinguishing. Each puffer should provide a moderate blast of air at the breaker contacts on opening of the circuit breaker. On ABB 5HK models, inspect nozzles for cracks and broken piston rods, and inspect puffer piston seal rings for cracks and hardened or embrittled material. Verify air movement upon opening of the breaker at all three phases.

Insulation Cleaning

Purpose
The purpose of cleaning the insulation is to assist in maintaining the dielectric strength between ground and between phases.

Justification
Contamination at 4KV and above can result in carbon tracking (see IB 6.2.1.7D and IB 6.2.2.7G, Section 5.3 [3, 4]). Good industry practice.

Description
All contaminants—including dirt, soot, and grease—should be removed. Use approved solvent, such as isopropyl alcohol.

Arc Chute Inspection

Purpose
Inspect for signs of physical damage and deterioration.

Justification
Arc chutes are necessary component for interrupting load and fault currents. The interrupting feature can only be confirmed by examination of physical properties (see IB 6.2.1.7D / 6.2.2.7-1G, Section 5.8 [3, 4]).

Description
The purpose of this task is to ensure that the arc chutes are not damaged or contaminated to the point that proper operation is in question. Each arc chute should be inspected for contamination and damage in the throat area, damage to the ceramic fins, and damage to the arc runners. Inspect for the following:

- Breakage to arc chute throat, liners, and splitters
- Exterior damage or deformation
- Excessive erosion or crust forming on the arc liners (remove crust with scraper or carborundum stone)
- Presence of foreign particles
- Glass coating on the leading edges of splitters
- Loose lock washers
- Continuity of blow out coil connection (check with a meter)

Latch Check Switch Check and Adjustment (If Applicable)

Purpose
Prevent the breaker from re-closing before trip latch is reset.

Justification
IB 6.2.2.7-1G [4]

Description
Latch check switch, an option offered by the vendor, is not common in most nuclear plants (see ABB manual, pages 5-9 [6] and ABB IB 6.2.2.7-1G, p. 9, Figure 6 [4]).

Control Relay Adjustment

Purpose
Allow charging motor to cycle to charge closing springs.

Justification
IB 6.2.1.7D, Figure 6 [3] and IB 6.2.2.7-1G, Figure 7 [4]

Description
Verify the gap between the control device lever and the limit switch crank. This gap and adjustment method of adjustment vary depending on the type of breaker. Refer to the applicable instruction bulletin.

The following information about gap sizes and adjustments is typical. Refer to ABB Instruction Manual [6] for correct gap measurement and method of adjustment.

Table 4-1
Typical Gap Measurements and Adjustments

Breaker Type	Instruction Bulletin	Adjustment	Gap (inches)
5HK250 1200 & 2000 amp	IB 6.2.1.7D	Shimming	0.010 - 0.090 (see ABB Erratta in Appendix B)
5HK350 1200 & 2000 amp	IB 6.2.1.7D	Shimming	0.010 - 0.090 (see ABB Erratta in Appendix B)
5HK350, 3000 amp	IB 6.2.1.7D	Head screw / Shimming	0.030 – 0.090 [21]
7.5HK500	IB 6.2.2.7-1G	Head screw	1/64-1/32 (0.015-0.031)
15HK500	IB 6.2.2.7-1G	Head screw	1/64-1/32 (0.015-0.031)
15HK750	IB 6.2.2.7-1G	Head screw	1/64-1/32 (0.015-0.031)

Per ABB Power T&D, the specification for 5HK350 3000 amp is now 0.030 inches to 0.090 inches. ABB Power T&D has been requested to provide the industry a letter documenting this change. [21]

Spring Discharge Interlock Functional Check

Purpose
Ensure proper operation of spring discharge interlock for personnel safety.

Justification
Good industry practice and personnel safety check [22, 23]

Description
This functional check is normally performed by physical removal of the breaker from the cubicle and by verifying that the closing spring discharge interlock automatically discharges the closing springs when the breaker is removed from its cubicle. The spring discharge interlock is a safety feature that automatically discharges the closing springs when the breaker is removed from the cubicle. This happens when the lower extension of the manual closing lever passes over the raised section of the cubicle floor. This effectively operates the primary close latch; the breaker goes trip free due to racking interlock with trip latch.

Racking Mechanism and Safety Interlock Functional Check

Purpose
Ensure proper operation of the interlocks for personnel safety.

Justification
Personnel safety check (see IB 6.2.1.7D, Sec 5.11, Figure 7 [3])

Description
Aggitate the lever once the breaker has closed. Perform a trip-free check by ensuring that the breaker will not close with the racking release lever all the way out.

Lubrication

Purpose
Ensure smooth penetration of the contact stabs into the primary disconnects (tulips) and ground disconnects. Ensure optimum operation of the racking mechanism.

Justification
MS 3.2.1.9-1D [6] and good industry practice [3, 4]

Description
For a routine preventive maintenance, the only components to be lubricated are:

- Primary disconnect assemblies (based on MS 3.2.1.9-1D [6]). NO-OX-ID “A” Special
- Ground disconnects (based on industry experience). NO-OX-ID “A” Special
- Racking mechanism (based on industry experience). Anderol 757

Remove old grease and contaminants with approved cleaning solvents, and then apply a thin film of NO-OX-ID “A” Special grease to the primary disconnect fingers and ground disconnect fingers.

In early 1999, ABB issued a letter stating that Mobilgrease 28 is an acceptable for use during refurbishment with ABB circuit breakers [9]. If using Mobilgrease 28, maintenance personnel should exercise caution to ensure that Mobilgrease 28 and Anderol 757 or NO-OX-ID “A” Special are not intermingled. Mobilgrease 28 should not be used on a circuit breaker’s primary

disconnects or ground disconnects unless Mobilgrease 28 has also been applied to the switchgear bus (cubicle stabs).

Based on industry experience, spray lubricants such as Anderol 732 should not be used. Problems were encountered with this lubricant [24, 11].

As-Left Inspections and Tests

Purpose
Ensure that the breaker is ready for service.

Justification
Good industry practice

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

- Timing test
- Primary contact resistance
- Manual and electrical operational check/anti-pump operational check
- Reduced control voltage test
- Insulation resistance test of primary (current carrying) components
- Insulation resistance of control wiring
- Insulation resistance of charging motor
- Record counter readings (if applicable)

Timing Test

Purpose
Timing tests provide some indication of the condition of a few specific circuit breaker subcomponents.

Justification
This test is useful to determine if there are any binding problems with the mechanism. IB 6.2.1.7D [3] and IB 6.2.2.7-1G [4] recommend performing timing tests after a number of operations, based on breaker type, or after a change in bridge pivot adjustment. However, timing may be required for time response, breaker coordination, or other plant requirement.

Description
The closing time is the time that elapses between initiating an electrical close signal and the arcing contacts of the phase under test just touching. The opening time is the time that elapses between initiating an electrical trip signal and the arcing contacts of the phase under test just separating. Breaker opening time helps to ensure the proper arc cessation should the breaker trip

on fault or open under load. ABB's minimum and maximum specifications are based upon 125 Vdc control voltage. Failure to meet vendor acceptance criteria requires detailed troubleshooting. Criteria for closing and opening times can be obtained in the applicable ABB instruction book (see EPRI TR-112783, *Circuit Breaker Timing and Travel Analysis*, May 1999 [25]).

Primary Contact Resistance

See description in "As-Found Inspections and Tests" section.

Manual and Electrical Operational Check/Anti-Pump Operational Check

See description in "As-Found Inspections and Tests" section.

Reduced Control Voltage Test

See description in "As-Found Inspections and Tests" section.

Insulation Resistance Test of Primary (Current Carrying) Components

Purpose
Measure the insulation resistance of the primary circuits.

Justification
Good industry practice and recommended by the manufacturer (see Section 5.13, IB 6.2.1.7D and IB 6.2.2.7-1G [3, 4]

Description
Measure the insulation resistance of:

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

This can be done with either an ac or dc overpotential (hi-pot) test or a megger (see Appendix A [26])

Insulation Resistance of Control Wiring

Purpose
Measure the insulation resistance of the control wiring to ground.

Justification
Good industry practice and recommended by the manufacturer

Description
Megger control wiring at secondary disconnects.

This can be done with either an ac or dc overpotential (hi-pot) test or a megger [26].

Insulation Resistance of Charging Motor

Purpose
Check the electrical characteristics of the charging motor.

Justification
Good industry practice

Description
Megger the charging motor, and inspect for cracked housing. Inspect the eccentric pivot of the charging motor for abnormal wear or damage.

Record Counter Readings

See description in "As-Found Inspections and Tests" section.

Cubical Inspection

Purpose
General visual inspection

Justification
Good industry practice [27, 28]

Description
Cubicle inspection items may be included in separate cubicle inspection. Consider the following items:

- Loose, broken, or missing hardware
- Condition of wiring
- Secondary disconnects; male disconnects [29]
- Shutter assembly
- Cell ground contact
- Fuse holders
- Auto spring discharge detent
- Auxiliary/ cell switches
- Ground disconnect, if applicable

5
REFERENCES

1. *Circuit Breaker Maintenance; Volume 2: Medium Voltage Circuit Breakers, Part 1: ABB HK Circuit Breakers.* EPRI, Palo Alto, CA: 1993. NP-7410-V2-P1.
2. ABB Instruction Bulletin 6.2.1.7B.
3. ABB Instruction Bulletin 6.2.1.7D.
4. ABB Instruction Bulletin 6.2.2.7-1G.
5. ABB Instruction Bulletin 6.2.3.7B.
6. ABB Maintenance and Surveillance Manual 3.2.1.9-1D.
7. *Preventive Maintenance Program Basis: Medium Voltage Switchgear,* EPRI TR-106857-V2, July, 1997.
8. ABB letter to EPRI-NMAC regarding use of Mobil 28 lubricant in ABB circuit breakers.
9. *ABB Lubricant Equivalency Evaluation.* EPRI, Palo Alto, CA: April 2, 1999.
10. Institute of Nuclear Power Operations Operating Experience Report 7130.
11. DC Cook Part 21 on Anderol 732.
12. *Reduced Control Voltage Testing of Low and Medium Voltage Circuit Breakers.* EPRI, Palo Alto, CA: 1999. TR-112814.
13. Nuclear Regulatory Commission Information Notice 88-42.
14. Institute of Nuclear Power Operations Operating Experience Report 2715, North Anna.
15. Nuclear Regulatory Commission Information Notice 87-41, Beaver Valley and River Bend.
16. Institute of Nuclear Power Operations Safety Evaluation Report 1487, River Bend.
17. Institute of Nuclear Power Operations Safety Evaluation Report 0797.
18. Vogtle Plant Procedure EM12354, Southern Nuclear, Birmingham, AL.

19. ABB Checklist for HK Refurbishment provided to the users group during the Summer, 1997 meeting in Baltimore, MD. This checklist contains original contact thickness for all HK styles (main and arcing contact cleaning and inspection).

20. ABB Service letter to CP&L dated May 24, 1994, regarding main and arcing contact thickness.

21. Electronic mail from ABB Service to ABB T&D (Shannon Soupiset) dated August 15, 1997, regarding 5HK control device adjustment.

22. Institute of Nuclear Power Operations Operating Experience Report 6053.

23. Institute of Nuclear Power Operations Operating Experience Report 6030.

24. Institute of Nuclear Power Operations Operating Experience Report 3170.

25. *Circuit Breaker Timing and Travel Analysis*. EPRI, Palo Alto, CA: May 1999. TR-112783.

26. *Maintenance and Testing Specifications for Electrical Power Distribution Equipment and Systems.* The National Electrical Testing Association: MTS-1997.

27. Institute of Nuclear Power Operations Operating Experience Report 3808.

28. Institute of Nuclear Power Operations Operating Experience Report 7110.

29. San Onofre Nuclear Generating Station Report dated 8-11-95.

A
NETA INSULATION RESISTANCE CRITERIA RECOMMENDATIONS

The National Electrical Testing Association's (NETA*) 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). The table from NETA MTS-1997 is provided below.

Voltage Rating	Minimum dc Test Voltage	Recommended Minimum Insulation Resistance in Megohms
0–250	500	50
251–600	1000	100
601–5000	2500	1000
5001–15000	2500	5000
15001–25000	5000	20000

B
ABB ERRATTA FOR IB 6.2.1.7D

The following information is cited from ABB ERRATTA FOR IB 6.2.1.7D, page 10:

5.10 CONTROL DEVICE ADJUSTMENT (See Figure 6)

Note: The following procedure supercedes the procedure in Section 5.10 for all 5HK breakers, except for 5HK 350MVA.

The control device does not normally require any adjustment in the field. The gap between the control device lever and the limit switch crank, with the close springs charged (top of travel), is not as critical as the gap between the control device lever and the lit switch crank with the close springs discharged (bottom of travel). It is necessary to have a gap at the top of the travel, but the gap can vary from .010" to .090". The gap range at the bottom of travel is set between .200" to .275".

This gap can be checked by first disabling the close spring charging motor then discharging the closer springs (closing the circuit breaker). The gap is then checked by moving the control box lever to its full downward travel and checking the gap between the control device lever and the limit switch crank (should be between .200" to .275"). If necessary the gap can be adjusted by either adding or removing shims at the lever pivot bracket, or by changing the thickness of the front two flat washers on the control device.

After the adjustment, connect the power back to the charging motor to allow the limit switch crank to move to the top of its travel (close springs charged). Make sure that there is a gap between the control device lever and the limit switch crank. As stated above, this gap can be anywhere between .010" to .090".

Note: When using a feeler gauge, to check the above gaps, be careful not to force the gauge and bend the control device lever. Only a small drag on the feeler gauge is necessary to determine the gap.