ASEA BROWN BOVERI

MS 3.2.1.9-1B

Maintenance and Surveillance

I-T-E Medium-Voltage Switchgear Equipment

HK Switchgear
IB 3.2.1.7-1

5HK 250 and 350
IB 6.2.1.7-1

7.5HK 500 and 15HK 500/750
IB 6.2.2.7-1

15HK 1000
IB 6.2.3.7-1

RECOMMENDED MAINTENANCE & SURVEILLANCE 5HK, 7.5HK & 15HK SWITCHGEAR EQUIPMENT

EQUIPMENT MAINTENANCE PROGRAM

This Bulletin augments the information and instructions provided in Instruction Bulletin 3.2.1.7-1.

Switchgear installations which require exceptional dependability due to serious safety or economic consequences of operating problems should be given comprehensive maintenance and surveillance attention. This program recommendation has been developed specifically for use in Nuclear Power Generating Stations but it is applicable to any installation where exceptional reliability is desired and a preventive maintenance program is to be implemented.

Some maintenance activities are considered essential, therefore ACTIVITIES WHICH ARE MOST IMPORTANT TO ASSURE AVOIDANCE OF PREDICTABLE PROBLEMS ARE UNDERLINED.

FREQUENCY OF MAINTENANCE

Suggested time frames in the program are not absolute, they represent the best generalized advice of the manufacturer for equipment installed in a clean, uncontaminated environment such as may be found in a power generating station. If equipment is in an area where corrosive or conductive contaminents are present, or if large amounts of airborne contaminants will be experienced, the shortest interval of the range shown in the equipment maintenance program should be used. Further, in highly contaminated areas as described, circuit breaker servicing should be accomplished at a maximum of two year intervals.

If it becomes apparent after several maintenance cycles that certain activities are not needed as frequently as suggested, or that increased frequency would be prudent, the program should be adjusted to meet the specific needs of the installation.

RECORDS

Records are a key factor in a preventive maintenance program and can provide vital data for evaluating equiment condition, when necessary, if the recording system is consistent, thorough and available when needed. As a minimum the records should contain the data and, for circuit breakers, the number of operations at last maintenance in addition to results of testing. If observations of equipment condition are recorded, a realistic basis for adjusting maintenance frequency will be available.

SPARE PARTS

A major factor in overall availability is down-time-per-failure or mean-time-to-repair and although switchgear and associated components enjoy favorable reliability expectations, random failure of a component can cause down-time or reduced capability if inadequate attention is given to the spare parts inventory. A spare parts recommendation for the switchgear equipment can be provided to assist in selection of appropriate parts. Storage of spares should be in a clean, dry area. Part access and identification should permit prompt availability, when needed.

1. GENERAL

CAUTION: BE SURE THAT ALL ELECTRICAL SUPPLIES ARE OFF BEFORE PERFORMING ANY MAINTENANCE INSIDE EQUIPMENT.

a. The following lubricants are recommended:

LUBRICANTS	
Mechanisms (anti-friction)	ANDEROL 757 Tenneco Chem. Inc.
Electrical Contact Compound	NO-OX-ID "A Special" Sanchem Chem. Co.

Use of other lubricants risks incompatibility with original materials or unproven performance.

b. In tightening bolted conductor connections, use of a torque wrench is recommended. The following torque levels will assure good connections:

DRY THREAD TORQUE	
BOLT DIA.	TORQUE
3/8"	15-25 ft. lb.
1/2"	30-45 ft. lb.
5/8"	50-75 ft. lb.
3/4"	65-80 ft. lb.

c. A clean and dry environment should be a continuing goal of the maintenance program for all electrical equipment.

d. Operating and maintenance personnel should be alert for unusual sounds (sizzling or crackling) and smells (ozone or burning) when in the vicinity of electrical equipment.

2. RECEIPT AND STORAGE

Environmental conditions during transit and storage can have a substantial effect on equipment reliability. Extended periods of storage with original shipping covers in place must be avoided.

a. Upon receipt, equipment should be put into a ventilated storage area protected from the weather. Temperature should be maintained between 40°F and 120°F, humidity should be maintained at 50% relative* or below. Shipping covers and/or boxes should be removed.

*If relative humidity above 50% is anticipated, localized heat sources should be provided to maintain equipment temperature above the dew point. One means of accomplishing this is to energize internal equipment space heaters and store circuit breakers within the equipment enclosures. Note that equipment must be on a flat level surface to avoid floor distortion.

b. Under all conditions of transport and storage, equipment should be protected from direct impingement of water, flooding and heavy contamination, such as construction dust and dirt.

3. AT INSTALLATION (Repetition of some factory activity is suggested due to uncertainties of shipping, handling, etc.)

CAUTION: TURN OFF ALL POWER BEFORE WORKING INSIDE.

a. Equipment mounting should be on level rails embedded flush with the finished floor per installation dwgs.

b. Removal of all shipping supports and installation of all bus conductors (main and ground) across shipping splits should be verified.

c. Check all bolted bus connections for proper torque.

d. Check circuit breaker connection wipe by applying NO-OX-ID compound to stationary connection stubs and racking breaker into connected position, then out. Contact lines in compound verify contact.

e. Exercise each circuit breaker (close and trip twice.)

f. Inspect primary conductor insulation system, remove contamination accumulated in storage and installation.

g. Check primary cable connections for tight hardware and proper stress relief. Check all primary connections to other electrical equipment.

h. Check control wire connections - See 6b.

i. Check trip/racking interlock to verify no racking with breaker closed and no closing unless breaker is latched in position.

j. Millivolt drop and timing measurements on each circuit breaker provide useful preoperation checks and valuable comparative data for future use.

4. SIX TO EIGHTEEN MONTH INTERVALS

CAUTION: TURN OFF ALL POWER BEFORE WORKING INSIDE.

a. Identify and service circuit breakers which are due. See CIRCUIT BREAKER SERVICING section, Page 6 of this Bulletin.

b. Exercise all circuit breakers which are not due for service.

c. Inspect primary interface connections with other equipment for signs of excessive heat (Cable and bus connections, usually in the rear of the equipment.) Discoloration or embrittlement of adjacent insulating materials and conductor corrosion or discoloration may indicate a hot joint. See HOT JOINT MAINTENANCE, Page 5.

d. Inspect primary cables for chafing at conduits or supports and loose or missing stress relief grounds.

e. Exercise the racking mechanism.

5. ONE TO THREE YEAR INTERVALS (Nuclear - Alternate refueling shutdowns.)

CAUTION: TURN OFF ALL POWER BEFORE WORKING INSIDE.

a. Clean contamination from all primary insulation with vacuum, distilled water or a solvent approved by NIOSH or local authority, as necessary. Inspect for discoloration or other evidence of excessive heat. If found, proceed per HOT JOINT MAINTENANCE, below.

b. Inspect control wiring bundles for discoloration due to heat, chafing or other damage to insulation.

c. Clean stationary breaker connection stubs in the enclosure with a solvent approved by NIOSH or local authority. Inspect for evidence of contact galling, excessive heat, arcing or corrosion. If found, proceed per HOT JOINT MAINTENANCE, below. Reapply NO-OX-ID compound prior to reconnecting circuit breaker.

NOTE: Protective relays should typically be checked for accuracy of calibration at two to five year intervals, see manufacturers instructions for detail.

6. TEN YEAR MAXIMUM INTERVAL

CAUTION: TURN OFF ALL POWER BEFORE WORKING INSIDE.

a. All primary conductor connection bolts should be torqued to recommended values. (An alternative to retorquing may be use of infrared heat sensor (thermographic) techniques. These procedures are specialized, however, and require plans to overcome loading and safety difficulties.) See below.

b. Tighten all secondary control wire connections while checking for loose lug crimps and broken wire strands.

HOT JOINT MAINTENANCE - For primary joints which show evidence of excessive heat: (1) Open joint and inspect connection surfaces. (2) If surfaces appear reasonably smooth, with only minor pitting or corrosion, clean and dress contact surfaces minimizing removal of plating. (3) If surfaces are heavily pitted or corroded, or if there has been any melting of conductor material, the affected parts must be replaced. (4) Replace contact finger springs if breaker disconnects have been exposed to excessive heat. (5) Contact surfaces should be protected with NO-OX-ID before re-assembly. (6) Use recommended torque values in tightening bolted connections. (7) Before and after millivolt drop testing can provide some confidence that the problem has been corrected.

JOINT COVERS - During surveillance it may be necessary to remove joint covers. It is possible that the cover may crack when it is flexed for removal or replacement due to embrittlement from loss of plasticizer. An isolated incidence of such cracking indicates that the joint has been operating at higher temperatures than normal. A cracked cover should not be reused. An embrittled cover which has not cracked will provide insulating capability at least as long as it took to embrittle. Generalized embrittlement of joint covers is not expected for twenty years or more.

CIRCUIT BREAKER SERVICING

Circuit breakers require inspection and servicing periodically to assure operability. Servicing should be accomplished based on number of operations since last serviced, with an elapsed time limit. The appropriate frequency of servicing depends on the duty of the circuit breaker. As experience warrants, the recommended frequency of servicing shown below should be adjusted on specific breakers to account for more/less severe duty than initially expected, based on the breaker condition when serviced.

Recommended service frequency is shown for three general categories of duty:

LOAD CURRENT SWITCHING, UP TO RATED CONTINUOUS CURRENT ENVIRONMENT NORMAL, MINIMAL CONTAMINATION.

Service breaker every five (5) years or upon accumulating the number of operations shown below since last serviced, whichever comes first.

5HK-250, 7.5HK-500, 15HK-500/750 - 2000 operations.

5HK-350, 15HK-1000 - 1000 operations.

MOTOR START, CAPACITOR & REACTOR SWITCHING OR ANY DUTY IN A CONTAMINATED ENVIRONMENT.

Service breaker every two years or upon accumulating the number of operations shown below since last serviced, whichever comes first.

5HK-250, 7.5HK-500, 15HK-500/750 - 750 operations.

5HK-350, 15HK-1000 - 400 operations.

FAULT INTERRUPTION

Service a breaker which has interrupted short circuit current as soon as possible.

This service program qualifies a circuit breaker for the total number of operations shown below before replacement or factory refurbishment is required. The limit is suggested to provide margin.

5HK-250, 7.5HK-500, 15HK-500/750, Total Operations - 10,000, Suggested Limit - 9,000.

5HK-350, 15HK-1000, Total Operations - 5,000, Suggested Limit - 4,500.

The following should be accomplished at each service interval:

CLEAN, INSPECT & LUBRICATE PRIMARY DISCONNECTS.

CONTACT & INSULATION CLEANING.

PUFFER CHECK.

ARC CHUTE INSPECTION

OPERATION CHECK

CONTACT PRESSURE CHECK**

MILLIVOLT DROP TEST

Instructions follow which clarify the above.

In addition, the hardware (bolts, nuts, screws and pin retainers) should be checked with a thorough inspection to be sure that they are in place and secure. There are other adjustments which may be required due to the operating or test abnormalities below:

TIMING TEST*

Should be run before and after the bridge pivot pressure adjustment (below). Recommended as a pertinent periodic test to evaluate breaker condition.

CONTACT PRESSURE ADJUSTMENT**

Required if contact pressure check indicates a problem.

BRIDGE PIVOT PRESSURE ADJUSTMENT**

Required when the millivolt drop test is above limits (pressure too low - resistance too high.)

RACKING MECHANISM ADJUSTMENT**

Required if interlock fails to block closing while breaker is being racked in or out or racking latch is not blocked with breaker closed.

LATCH CHECK SWITCH ADJUSTMENT**

Required if circuit breaker fails to latch closed on reclosing.

LUBRICATION

The HK circuit breakers are lubricated during factory assembly as follows:

All mating surfaces of moving current-carrying joints have been lubricated with NO-OX-ID Special Grade "A" grease.

All other mechanism parts, bearings, pins, etc. have been lubricated with ANDEROL 757.

The circuit breaker mechanism does not ordinarily require lubrication in the usual moderate service environment expected. However, if operating difficulties are experienced, if grease becomes contaminated or if parts are replaced, relubrication with ANDEROL grease may be required. Contact the nearest Brown Boveri Electric district office for field assistance or factory refurbishing arrangements.

Primary disconnect fingers should be cleaned, with a solvent approved by NIOSH or local authority, inspected for corrosion or evidence of arcing and relubricated with NO-OX-ID grease at each servicing.

NOTES:

Do not use NO-OX-ID grease on arcing contact parting surfaces.

Do not use light oil to lubricate mechanism parts.

The spring charging motor is sealed, lubrication is not recommended.

*Specific guidance on the timing test is included in the following instructions: 5HK-250, 350 - IB 6.2.1.7-1, 7.5HK-500, 15HK-500/750 - IB 6.2.2.7-1 and 15HK-1000 - IB 6.2.3.7-1.

**Consult the circuit breaker Instruction Bulletin for guidance in making the contact pressure check and adjustments.

CONTACT AND INSULATION CLEANING

Any dirt, soot or grease should be removed from the circuit breaker contacts and surface of entire current carrying structure, as well as all insulation surfaces, with a cloth saturated with an approved solvent. Cleaning of the insulation is important because contamination can accumulate and, with moisture, can place the circuit breaker in jeopardy, dielectrically.

A degree of burning and pitting on the circuit breaker arcing contacts is to be expected from normal operation; on highly inductive or capacitive circuits and after major interruptions, some pitting may occur on the main contacts. When necessary to dress the contacts, cover the puffer nozzle with a cloth, then follow the contour of the contacts with a fine file. Do not attempt to eliminate pitting entirely. After this maintenance, the contact pressure and millivolt drop should be checked; adjustment should be made, if indicated.

NOTE: Replacement of contact need only be considered when after repeated dressing of contacts, less than 50% of the original contact material thickness is left, the tips of the stationary arcing contacts have been eroded away, or any contact has been broken, cracked or burned through.

PUFFER CHECK

The performance of the puffers can be readily checked during servicing. Each puffer should provide a moderate blast of air at the breaker contacts, on opening of the circuit breaker. This can be detected by holding a sheet of paper over the top of the contacts and opening the circuit breaker. All three poles must have puffing action or else the circuit breaker must not be placed in service.

CAUTION: FOR SAFETY, KEEP CLEAR OF ALL MOVING PARTS.

ARC CHUTE INSPECTION

The arc chutes should be inspected internally to insure that no breakage occured to the liner plates. Further, there may be a crust formed on the liner plates if the load current interruptions were close to the continuous current rating of the breaker or moderate faults were interrupted. This crust should be removed with arc chutes off the breaker by carefully using a carborundum stone or scraper. The arc chute should be blown out with dry air to remove the resultant dust and particles.

Arc plate and liner plate breakage should be carefully looked for, along with excessive erosion of the arc plates. The arc plates are made of ceramic material and perform the function of extracting heat from the arc as it is being forced into and elongated by them. The leading edges become coated with glass that comes to the surface from the extreme heat. A direct measure of use is the amount of ceramic surface with glass beads evident.

When the entire leading edge and portions of the flat arc plates are noted to be heavily encrusted with glass beads, the arc chute should be replaced. It should be noted that this condition will vary between arc chutes on the same breaker because of a single-phase fault and asymmetrical current incidences. If there are any questions, Brown Boveri Electric, Inc. Switchgear Systems Division should be consulted for recommendations.

OPERATION CHECK

During servicing it is desireable to verify breaker operability. It is recommended that this be done at the minimum

expected control voltage level. (Typically 80% of nominal).

MILLIVOLT DROP TEST

During servicing, the resistance of the circuit breaker current carrying parts can be checked with a millivolt drop test. This test should be performed regardless of circuit breaker duty or number of operations.

The following table lists millivolt drop and resistance values for the circuit breakers, from terminal to terminal, exclusive of the primary disconnects.

If the millivolt drop does not exceed 150% of the values, shown in the table on breakers with light loading, no contact maintenance is necessary. If the millivolt drop does exceed 150% of the values, the main and arcing contacts should be dressed with a fine file, cleaned and adjusted for proper contact pressure and then rechecked. If the values are still in excess of the 150% value, the bridge pivot pressure should be readjusted.

If breaker loading is 75% or more of rated current,it is recommended that the listed values be used as limits.

CURRENT RATING	MAXIMUM MV DROP(1)	MAXIMUM MICRO-OHMS
5HK250, 5HK350		
1200 Amp	9	45
2000 Amp	7	35
5HK350		
3000 Amp	4	20
7.5HK500, 15HK500		
15HK750		
1200	9	45
2000	7	35
2500	7	35
3000	6	30
15HK1000		
1200	11	55
2000	9	45
3000	6	30

(1) Millivolt drop with 200 Amperes flowing.

TIMING TEST

After a change in bridge pivot adjustment, and periodically, if a functional check is desired, the closing and opening times should be checked by use of a time-travel analyzer*, oscillograph or cycle counter to monitor the time from energizing the control to arcing contact touch or part.

The circuit breaker closing and opening times should be within the following time ranges for normal operation.

NOTES: Below 0°C, the closing times will increase, opening times will be within the limits.

If timing is outside the limits, the factory should be contacted for recommendations.

CIRCUIT BREAKER	CLOSING TIME RANGE - MS**	OPENING TIME RANGE - MS**
5HK250, 5HK350		
1200 Amp	50-90	23-35
5HK250		
2000 Amp	60-95	23-35
5HK350		
2000 Amp	50-90	23-35
3000 Amp	65-95	23-35
7.5HK500, 15HK500, 15HK750		
1200 Amp	105-140	25-42
2000 Amp	105-140	25-42
2500 Amp	105-140	25-42
15HK1000		
1200 Amp	85-125	25-42
2000 Amp	85-125	25-42
3000 Amp	85-125	25-42

** With 125VDC Control, timing may vary slightly at other control voltages.

*Analyzer mounting support and instructions available on special order.

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