

RECOMMENDED GUIDELINES on REPAIR or REBUILD and MAINTENANCE of CIRCUIT BREAKERS

(NOTE: Pictures used are only examples.)

Prior History of Rebuild/Repair Facility

Based on inspection history and complaints, has the vendor had any previous issues with repair/rebuild problems that have required the removal and/or repair of a breaker repaired/rebuilt by that vendor?

External Criteria for further inspection and/or removal from service

1. Labeling – if visible

- a. If the circuit breaker has been rebuilt by a third party facility, it should have the name of that rebuild facility attached.
- b. A new or OEM rebuilt breaker should have OEM labeling. Most OEM labeling can be identified by a label number. Comparison will show lack of a number; different font sizes; layouts not the same; and possible misspellings. OEM labels that have been reproduced may be an indication of problems. See pictures below.

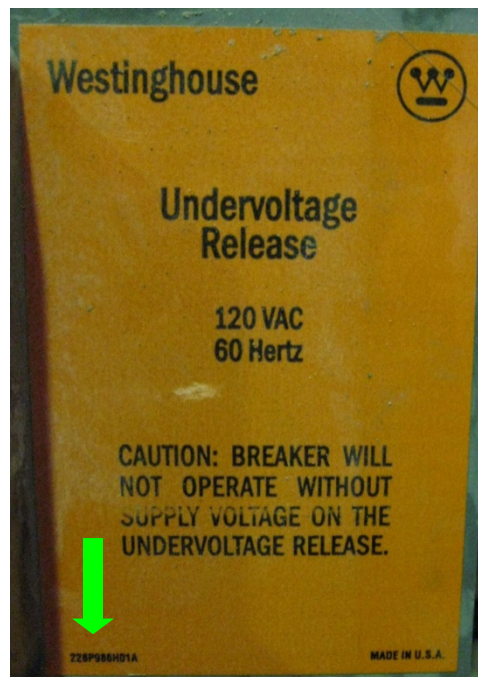


Figure 1: OEM Labeling

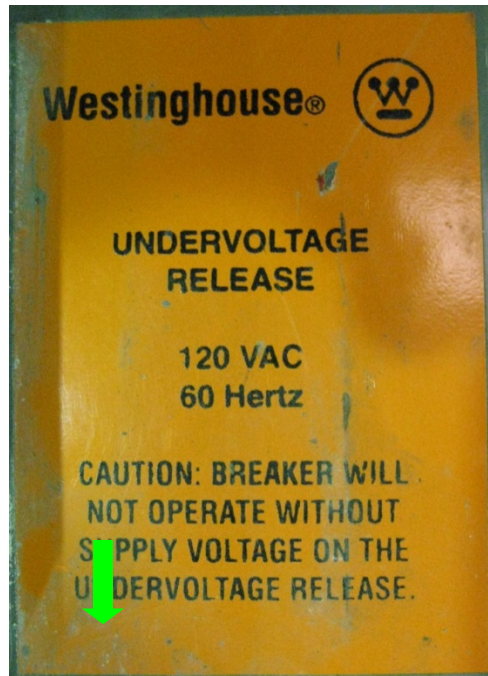


Figure 2: NON-OEM Labeling

- c. Circuit breaker full load current, voltage, and type should be present.
2. Shot Blasting
- Shot blasting removes resin from the case and may weaken the structure so that it could fail under a catastrophic event inside the breaker, such as an arc blast. This is an indicator for further inspection.



Figure 3: Shot Blasted and Painted

3. Paint

Paint on the outside of the case does not pose a hazard. However, painting could mask other hazards. Therefore, paint on the exterior of a circuit breaker case is cause to have the mine operator open the circuit breaker for a more in depth inspection.

4. Epoxy Repairs

Cases repaired and/or modified using epoxy can be hazardous. A damaged case can be weak enough that an event occurring inside the circuit breaker can cause the case to fail and rupture causing the epoxy to become shrapnel that can injure personnel nearby. The patching material may not be enough to restore the case's strength. Some patching material may be conductive and can cause a shock hazard.



Figure 4: Epoxy Repair to Case Corner



Figure 5: Epoxy Modification to Cover

5. Hairline Cracks, Broken Pieces

Hairline cracks and broken pieces on the case can present a serious hazard in that they compromise the integrity of the case in the event of a fault. Cracks in the case also compromise the electrical integrity of the circuit breaker and can pose a risk of arcing.

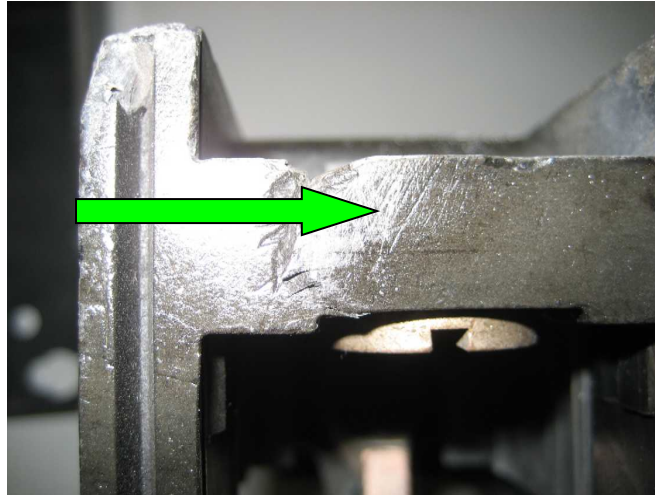


Figure 6: Cracked Case

6. Signs of Overheating

Signs of overheating (such as carbon smears, warped or melted case, and/or burnt areas) are cause for having the mine operator open a circuit breaker for a more in depth inspection or removal from service. These are indicators that the circuit breaker case integrity has been compromised. Signs of overheating are also indicators that the electrical insulation between the phases may have been compromised through carbon tracking.



Figure 7: Bubbled & Charred

7. Trip Unit Settings

If the circuit breaker trip unit is not properly set, it can cause damage to the cable it is protecting. It also poses the hazards of shock and fire. The trip unit must be visibly identified to ensure it is adjusted correctly.



Figure 8: Settings on High

8. Metallic Fixtures Attached to the Breaker Cover or Housing

Circuit breakers should not have anything attached to the case, and especially not with metallic fasteners. However, some of the older circuit breakers still in use have metallic ID tags fastened to the outside of the breaker with metal rivets. The metallic plate is an indicator to inspect for insulating material inside the breaker. These rivets must not extend to the inside of the case. If the rivet hole is drilled through, it must be insulated with a suitable dielectric. Failure to follow this requirement could allow a dangerous electric potential to be present on the exterior of the breaker, which could be contacted by personnel.



Figure 9: Metallic Tag (Painted)

Internal Criteria for further inspection and/or removal from service

1. Modifications

A modification is anything that changes the structure of the case. The Original Equipment Manufacturer (OEM) provides acceptable modification instructions for permitted accessory installation. Any other modification will be considered criteria for removal from service. Some instances of non-specified or unapproved modifications are:

- holes through the outside of the case, except as allowed by the OEM. Example: a hole for wire from an auxiliary switch to pass through from the inside of the case that is no longer used would be allowed
- cut-outs between the phases that compromise the electrical separation
- cut-outs that are not as specified by the OEM for mounting a UVR or other certified component

These types of modifications cause hazards that would allow:

- the potential for shock due to exposure of a miner to fault current
- arcing between phases
- case failure during an electrical fault

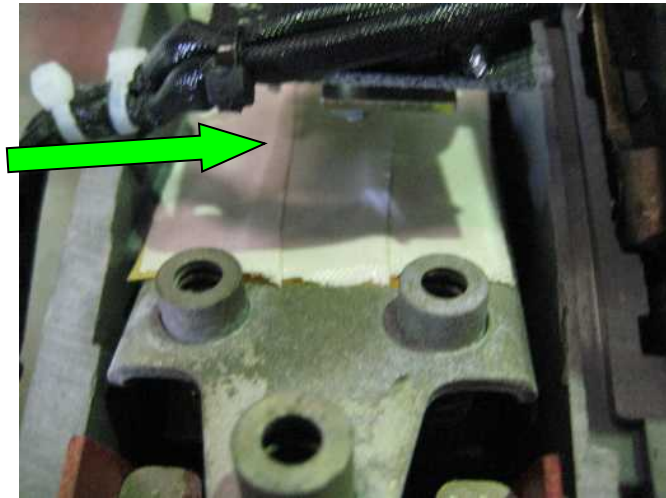


Figure 10: Tape Around Movable Arm

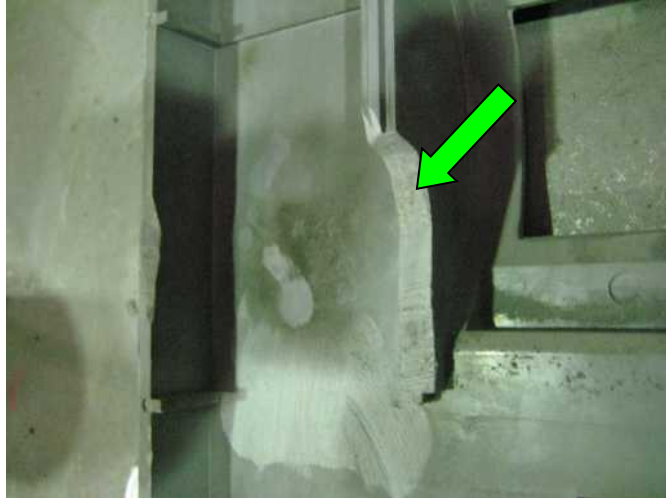


Figure 11: Case Phase Barrier Cut Away

2. Paint

Paint inside the case of a circuit breaker creates at least two hazardous conditions. The first is a change in insulation characteristics of the molded case. Over time, the paint can deteriorate from the heat and ionization that occurs in the circuit breaker. This can lead to carbon tracking between the phases and subsequent phase to phase and/or phase to ground faults. The second hazard is the addition of a potentially flammable component to a plasma ball occurring because of a fault. Be aware, some Westinghouse 1000 volt circuit breakers do have a dielectric coating that resembles paint inside the breaker case and cover.

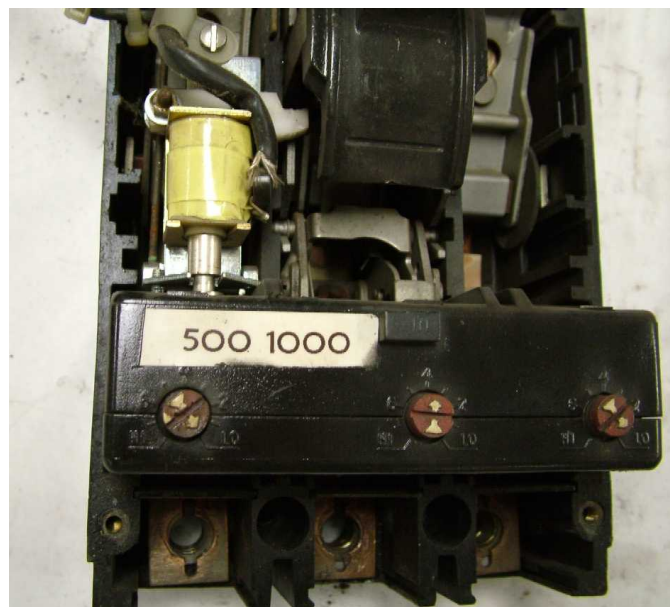


Figure 12: Painted & Shot Blasted

3. Shot Blasting

As noted above, any shot blasting may weaken the case integrity, but internal shot blasting also changes the insulating characteristics of the case, which can lead to arcing between the phases. This can happen when the exposed fibers catch conductive material that builds up and eventually leads to a track between phases.

4. Missing and/or Broken Parts

There are removable insulators (fish boards) within the circuit breaker case. If any of the fish boards, (cardboard like tabs around the tips), inserts along side of the reset handle that allow removal of the reset mechanism, or any of the top and/or bottom phase insulators are missing or broken, a short circuit hazard or electrical shock hazard is created. Missing components, such as missing or damaged arc chutes, can pose an arc flash hazard.

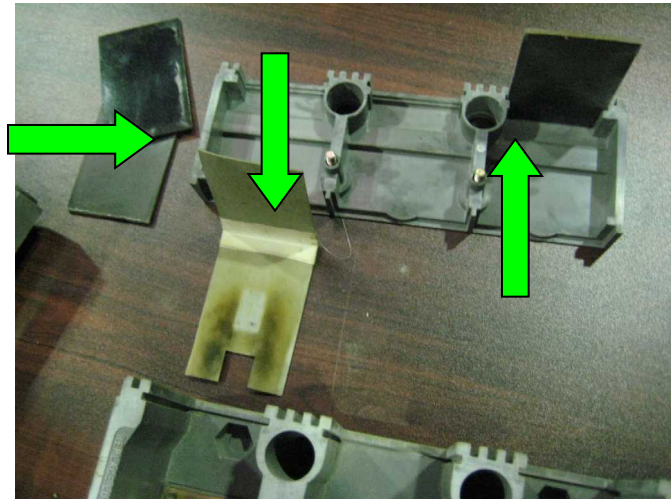


Figure 13: Fish Boards

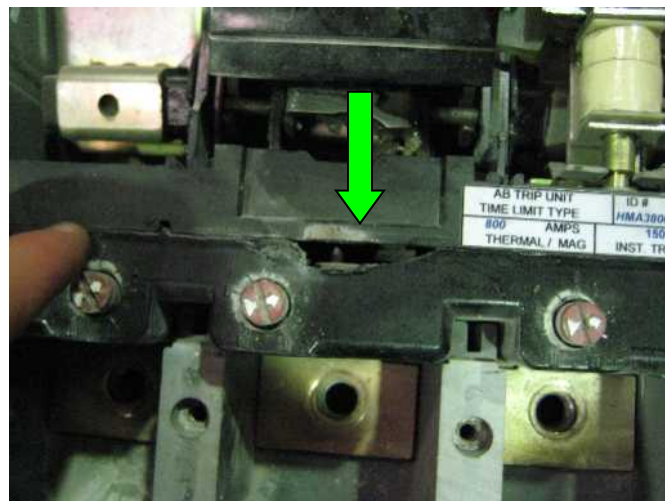


Figure 14: Broken Trip Unit Housing

5. Contact Tips

Contact tips used in mining circuit breakers are made of a special alloy that allows the tips to open under load without welding. The use of tips other than those specified by the circuit breaker manufacturer pose a risk of welding under load. The hazard is potentially life threatening and has caused the death of at least one miner and serious injuries to others.

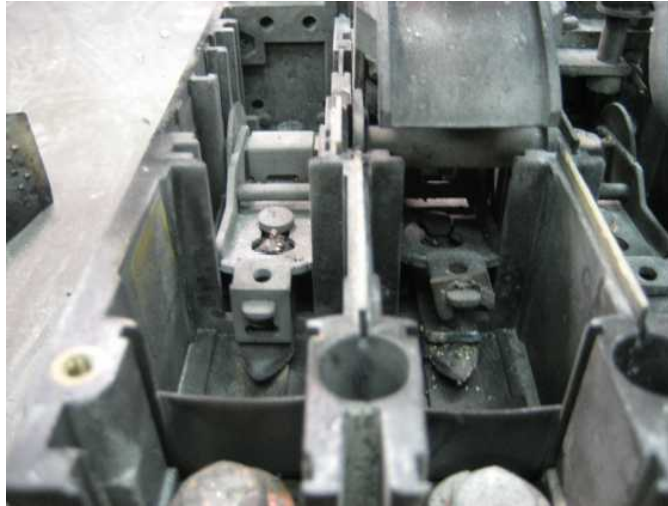


Figure 15: Welded Contact Tips

6. Painted or Damaged Arc Chutes

The arc chutes in a circuit breaker are designed to spread and cool the arc that occurs when the tips break. Paint covering the arc chute diminishes or prevents the arc from being extinguished in a controlled manner. In addition, the paint can contribute to the arc's heat and plasma ball. A damaged arc chute can also minimize the effect the arc chute has on extinguishing the arc. An uncontrolled arc can lead to a short circuit event inside the circuit breaker causing an arc explosion.

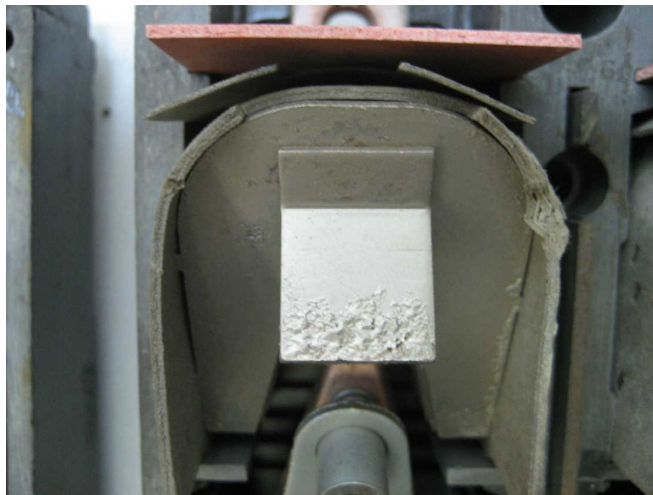


Figure 16: Painted Arc Chute

7. Insulation Between Phases

The circuit breaker case is designed to maintain the arc flash, caused by a breaker opening under load, inside the case and to prevent any shorting between the phases. The material of the case between the phases can be compromised through damage, such as cracks or broken pieces, or from modifications not approved by the manufacturer of the circuit breaker. This can cause the case to become weakened enough that it will no longer contain the force it was designed to contain and/or the electrical clearance between the phases could be compromised and allow an arcing short to occur. Either can cause injury to personnel in proximity to the breaker.

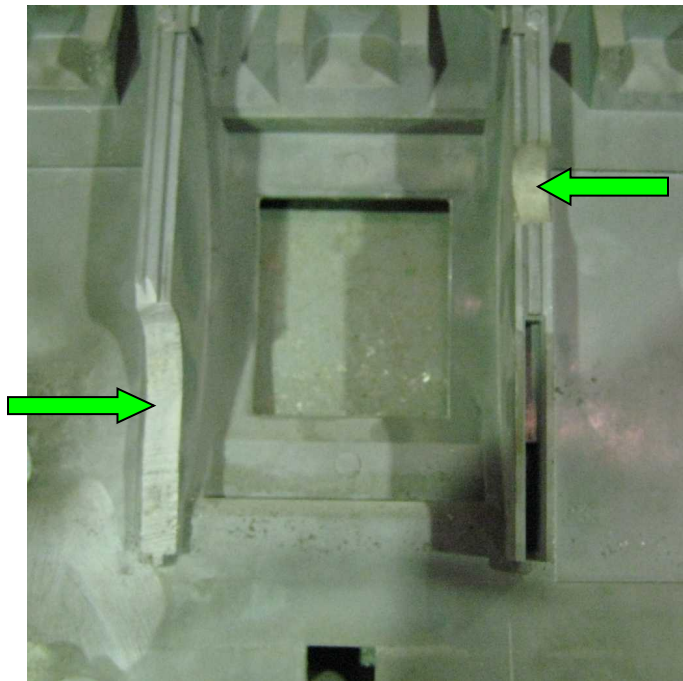


Figure 17: Cover Insulation Cut Away

8. UVR Undamaged and Adjusted Properly

The ground fault, ground wire monitor, and undervoltage protection circuits rely on the undervoltage release relay (UVR). If the relay is damaged or not properly adjusted, these safety circuits cannot operate the breaker. An inoperative UVR poses hazards of injury, fire, and death.

9. Trip Unit Visibly Identified

The trip unit must be visibly identified in order to ensure it is adjusted properly to protect the cable attached to the output connector. The identifier must be clearly visible and it must agree with the markings on the trip unit, if it is placed on the outside of breaker case. A trip unit that has had the identification markings removed or the wrong identification

attached through human error could allow the cable it is protecting to experience enough current on a fault to generate enough heat to cause a fire.

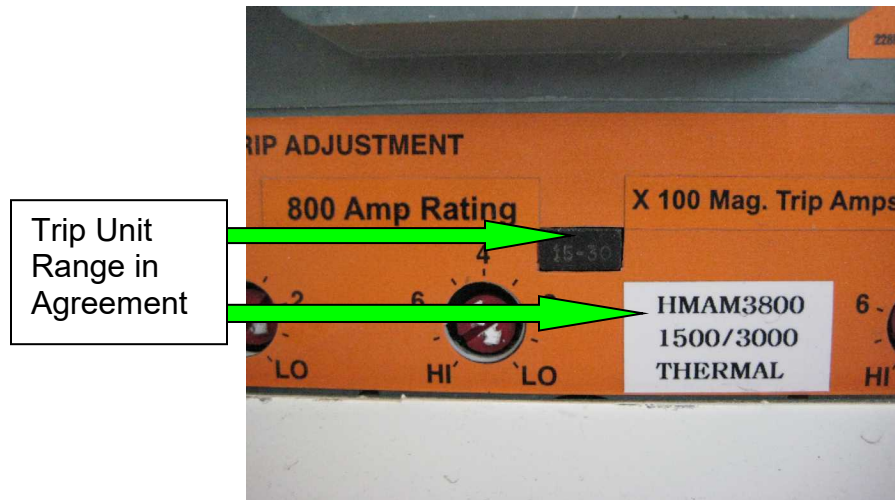


Figure 18: Trip Unit ID and Settings

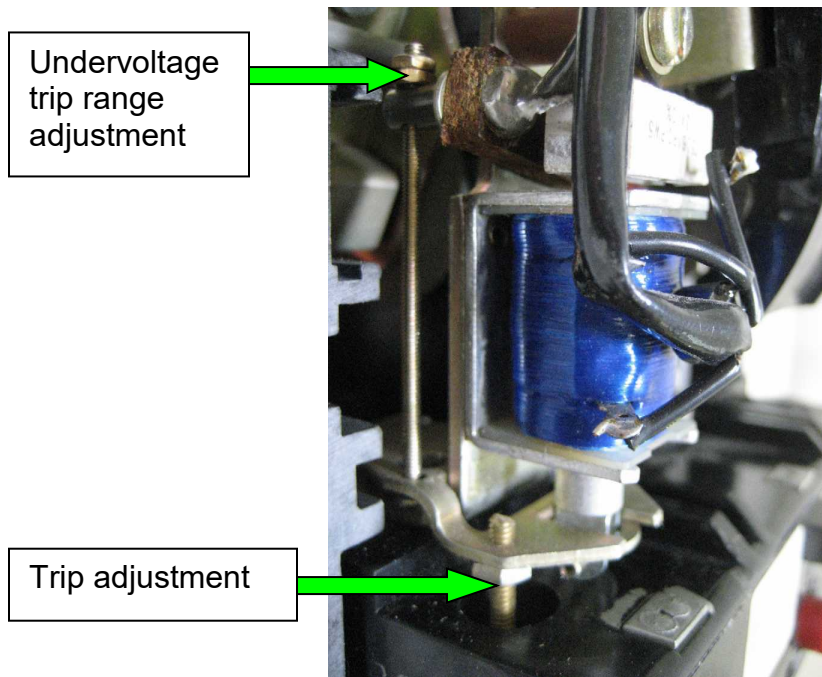


Figure 19: UVR Adjustment Points

10. 1000V - Swab Test Pass (Westinghouse Only)

Classic 1000 VAC Westinghouse (now Eaton/Cutler-Hammer) circuit breaker frames HMAM, HLAM and HKAM that are new or refurbished by the OEM can be verified as rated for 1000 VAC by performing a “swab test” of the inside of the circuit breaker. A 1000 VAC rated circuit breaker

is coated with a special insulator/anti-track paint that is necessary for the safety of the circuit breaker. A cloth or cotton tipped swab that has solvent applied to it and is wiped across the inside frame of the breaker at the arc chute area of the case will have blue tint from this coating. The inside of the cover at the arc chute area also has this coating applied. The cloth or cotton tipped swab with solvent applied to it will cause a minute amount of the coating to adhere to it, causing the blue color. If a new or OEM refurbished Westinghouse 1000 VAC breaker of these types does not return a blue color after being “swab tested”, it may not be able to handle the energy generated during a fault.

Operation

1. Trips on Operation of Safety Circuit

The circuit breaker must trip on overcurrent, grounded phase, short circuit, undervoltage, and loss of ground wire monitor. The circuit breaker must be tested for trip functionality at least monthly. The easiest and most generally used safety circuit to test the trip functionality is the ground-wire monitor circuit. It is recommended that the other safety circuits be occasionally utilized for testing tripping operation in order to ensure full functionality of the safety devices.