ABB Power T&D Company.
High Voltage Equipment Division
125 Theobold Avenue
Greensburg, Pa. 15601

33-210B

838-5224

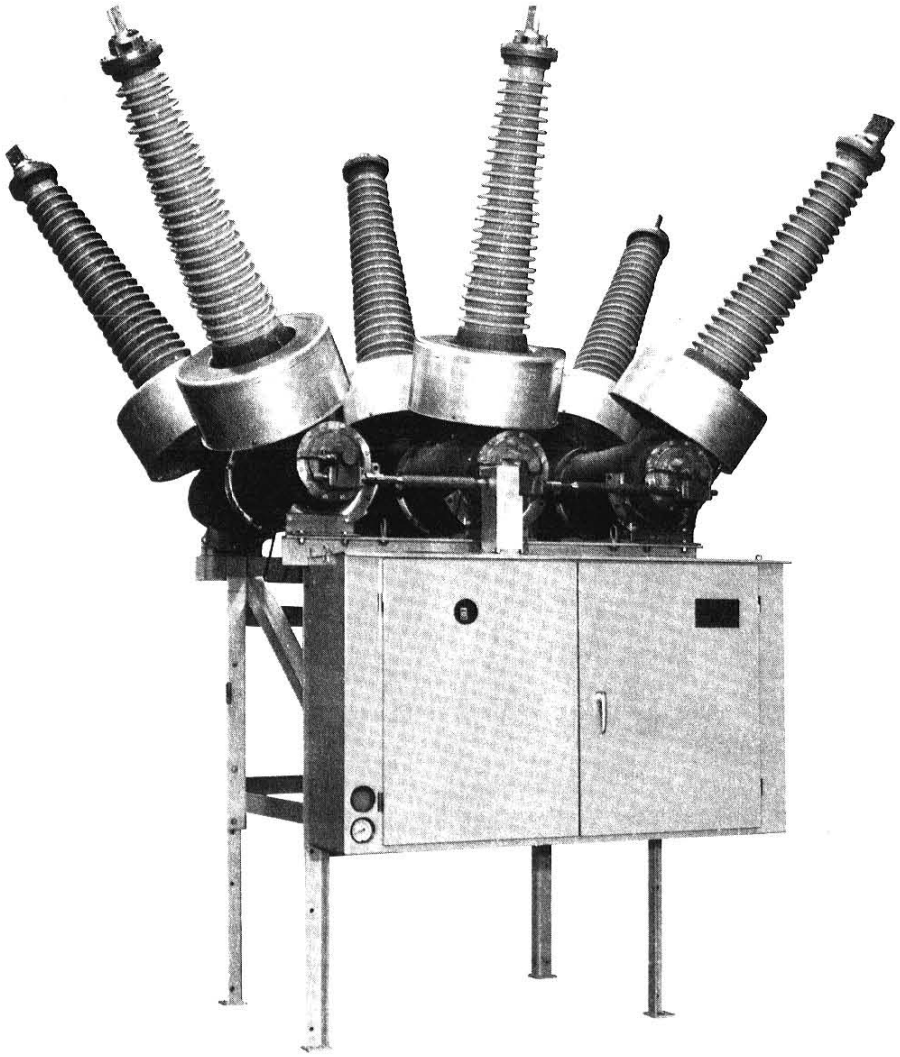
Power T&D Company

Revised 10-12-93
Supercedes 33-210A

Installation/Maintenance Instructions
SF6 Power Circuit Breaker

SF6 Single Pressure
Outdoor Power Circuit Breaker

121 PM40-12/16/20/30
145 PM40-12/16/20/30
169 PM40-12/16/20/30



WARNING

DE-ENERGIZE AND GROUND ALL EQUIPMENT BEFORE PROCEEDING WITH INSTALLATION OR MAINTENANCE. READ ENTIRE MANUAL BEFORE OPERATING.

INSTALLATION & MAINTENANCE NOTES

Notice 1

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145 PM Circuit Breaker Instruction Book

Module Listing

Module Title

Customer Data

Introduction

Installation

Pole Unit

Porcelain Entrance Bushings

Current Transformers

Interrupters

Interphase Linkage

Mechanism (FSA or HMB)

Control Circuits/SF_6 Gas Density Monitor

Safe Handling Practices for SF_6 Gas

Maintenance

Checklists

Spare Parts

145 PM Circuit Breaker

Customer Data©

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Spare Parts

SF_6 Circuit Breakers

Type PM

Publication No. 526P005-02

145 PM Introduction©

ASEA BROWN BOVERI

9 February 1993

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Notice 1

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Introduction

1 Introduction and General Description

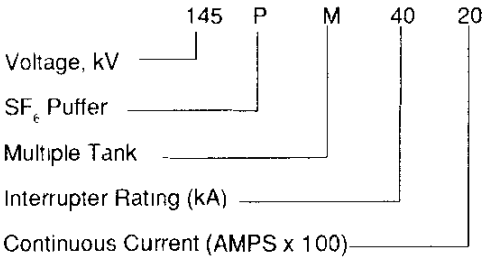
Instructions in this manual apply to any of the following types of multiple-tank, sulfur hexafluoride (SF_6) puffer-type circuit breakers manufactured by ABB:

- 121PM40 - 12/16/20/30
- 145PM40 - 12/16/20/30
- 169PM40 - 12/16/20/30

In this manual, reference to the *145 PM circuit breaker* also includes all of the other PM circuit breakers listed above.

1.1 Breaker Model Nomenclature

Breaker model nomenclature is defined as follows:



1.2 Conventions Used in This Manual

This manual is composed of *modules* which correspond to either a major breaker component or a major source of information, i.e. Pole Unit module, etc. Sections of text (and in some cases tables) make up a module. The term *section* refers to sequentially numbered segments of text in each module, i.e. section 1.3 in this module refers to safety instructions in this manual.

Sub-sections within a section have an extended digit in the section number. The sub-section contains supporting information that pertains to the higher level section. For example, section 1.2.1 Customer Data Module, is a sub-section of section 1.2 Conventions Used in this Manual.

Multiple-task procedures are usually listed in a step-by-step numbered sequence. It is very important to follow procedures in the step-by-step sequence given in this manual to ensure proper operation, maintenance, disassembly, and assembly of components.

Figures refer to drawings and schematics at the end of each module. *Illustrations* are drawings inserted within the text pages of the module. *Plates* refer to photos inserted within the sections of text.

1.2.1 Customer Data Module

The Customer Data module contains specific information pertaining to your circuit breaker, such as:

- Customer data sheet - identifies the breaker along with the customer name, address, and contact information and the publication number of this manual.
- Wiring diagrams
- Module Listing - lists all of the component module publications that pertain to your breaker.

1.2.2 Part Number References

Parts for the breaker are referred to in this manual as *index part numbers*. These index part numbers are classified as three types:

- Parts for major breaker components (refer to section 1.2.2.1);
- Special tools (refer to section 1.2.2.2);
- Hardware - nuts, bolts, washers, studs, and snap rings (refer to section 1.2.2.3).

When ordering parts for your breaker, in addition to your customer data, please include:

- Breaker serial number;
- Index part number used in the module;
- Publication number of the module (on the front page of each module and at the top of each page in the module).

1.2.2.1 Index Part Numbers for Major Breaker Components

Index part numbers for *major breaker components* fall within numbered groupings. With the exception of O-rings, each group categorizes parts pertaining to a specific major breaker component in a numbered series in increments of 10000 as follows:

- 10000 Pole Unit/ Interphase Linkage;
- 20000 Bushing;
- 30000 Interrupter;
- 40000 Resistor;
- 50000 Mechanism;
- 60000 Control Cabinet/SF_6 Gas Density Monitor;
- 70000 Current Transformers;
- 90000 O-Rings.

For example, the rupture disk is part of the pole unit and its index part number is 10017.

1.2.2.2 Index Part Numbers for Special Tools

Index part numbers for special tools used to handle and maintain these circuit breakers are prefixed with the letter **T** followed by a five-digit number. For example, the index part number for the deep socket tool is T13437.

1.2.2.3 Index Part Numbers for Hardware

In this manual, *hardware* refers to:

- Nuts;
- Bolts;
- Washers;
- Studs;
- Snap rings.

Index part numbers for hardware are prefixed with the letter **H** followed by an actual hardware part number. The index part number for a typical bolt, for example, is H420A30510.

1.3 Safety Instructions in This Manual - READ THIS

Follow the instructions in this manual to prevent accidents and failures. The instructions are written in terms that should be readily understood by well-trained, competent operators. Personnel should thoroughly understand the instructions in this manual before operating this equipment.

For convenient reference, keep this instruction manual in the slot within the control cabinet door of the breaker. Additional copies of the book also can be purchased from ABB.

Operating power circuit breakers and related electrical and mechanical components present inherent dangers. Therefore, adhere to the procedures presented herein in the step-by-step sequence for the safety of personnel and equipment.

Hazard alert nomenclature (safety precautions and tips) used in this manual are: danger, warning, caution, notice, and important. These terms comply with standards developed by the American National Standards Institute (ANSI) and set forth in ANSI Z535. These hazards are defined and appear in this manual as follows, starting with the most serious hazard alert term and descending to the least serious:

DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

Warning

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

Caution

CAUTION indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.

Notice: *NOTICE is used for hazards that may result in property damage only.*

Important: *IMPORTANT designates an operating tip or maintenance suggestion.*

2 Breaker Description

The 145 PM circuit breaker is a multiple-tank, sulfur hexafluoride (SF_6) puffer-type circuit breaker manufactured by ABB. This high speed, state-of-the-art circuit breaker ensures reliable switching performance and fault interrupting capability — a critically important function in power transmission systems. The key advantages of this high voltage, outdoor circuit breaker are:

- Easy installation;
- Low maintenance requirements;
- Reliability.

Drawing from its extensive experience in designing circuit breakers, ABB is on the cutting edge of breaker technology and strives to implement this expertise to provide circuit breakers that excel in performance and reliability and require minimal maintenance. All ABB circuit breakers are designed according to customer specifications and in compliance with the latest applicable NEMA and ANSI C37 standards for outdoor high voltage circuit breakers.

The 145 PM breaker is factory-tested and shipped as a complete unit — ready for easy and quick installation. After the breaker is installed, a quick verification of a few parameters is all that is required before placing the breaker into service.

The Customer Data module serves as a customized reference guide for wiring connections and installation requirements unique for your applications. The nameplate on the inside of the control cabinet door of the breaker indicates the location, accuracy and ratio of the current transformers.

Because of its advanced, yet uncomplicated, design, breaker maintenance is minimal, but is still essential in ensuring trouble-free operation. By following the maintenance procedures listed in this manual, the 145 PM circuit breaker will provide years of reliable, dependable service.

Notice: *The 145 PM circuit breaker should not be subjected to duties in excess of nameplate ratings unless agreed upon at the time of purchase.*

The 145 PM circuit breaker (Fig. 1) consists of several major components:

- Three pole units;
- Six porcelain entrance bushings;
- Bushing-type current transformers;
- Three interrupter units;
- Interphase linkages;
- Mechanism;
- Control cabinet.

Each of these components are briefly described in subsequent sub-sections in this module and in greater detail in respective modules in this manual.

2.1 Pole Unit

The 145 PM circuit breaker consists of three pole units coupled to a single operating mechanism through an interphase linkage assembly. The breaker is of a dead tank design in which an interrupter unit suspended by an insulating support tube, is housed within each grounded aluminum tank. Pressurized sulfur hexafluoride (SF_6) gas surrounds the interrupter units and fills the hollow porcelain entrance bushings. The gas functions as both an insulating and arc quenching medium.

Each pole unit contains the following main components:

- Cylindrical aluminum pole tank;
- Two entrance bushings (front and rear);
- Bushing-type current transformers;
- Interrupter unit (and bellcrank assembly);
- Rupture disk.

A carbon rupture disk is fitted to the rear of each tank. This disk protects against excess pressure build-up which otherwise could lead to catastrophic failure of pressurized components.

Refer to the Pole Unit module for maintenance to be performed on the pole unit.

2.2 Porcelain Entrance Bushings

The bushings are an integral part of the breaker and are specifically designed to connect to the high voltage line or bus and carry high voltage power to the interrupter while providing line-to-ground insulation.

Two plug-in type, porcelain entrance bushings are installed at obtuse angles on top of each pole unit. Top and bottom aluminum flanges are permanently cemented onto the insulators. The bottom flange of the bushing bolts onto a pocket on the tank. The bushings are hollow, high strength porcelain vessels filled with SF_6 gas which acts as the insulating medium. A conductor assembly (through rod) fits to the top flange of the bushing and extends through the hollow center of the bushing and attaches to the interrupter.

Refer to the Porcelain Entrance Bushings module for more details.

2.3 Current Transformers (CTs)

Bushing-type current transformers (CTs) are installed at the factory and are wired to short circuiting terminal blocks in the control cabinet. The CTs are provided as per customer specifications. Multi-ratio relaying class CTs are applied most commonly. However, single-ratio metering class CTs and linear couplers are available if requested.

Refer to the Current Transformers module for more details.

2.4 Interrupter

The type SW interrupter is a single pressure, single break, sulfur hexafluoride (SF_6) gas puffer-type unit capable of interrupting 40 kA terminal faults and 90 percent short-line faults at 40 kA without the addition of external line-to-ground capacitors. Each interrupter consists of a moving contact assembly and a stationary contact assembly. Both assemblies contain a main contact and an arcing contact.

Under normal conditions, the main contacts carry continuous current through the breaker. During interruption, the main contacts part first. Shortly afterward, the arcing contacts part, an arc propagates between them and the current eventually is interrupted. Because the arc is interrupted at the arcing contacts, the integrity of the main current carrying contacts is preserved.

The interrupting components are suspended by an insulating support tube situated within the grounded cylindrical tank of each pole unit. In the OPEN position, the moving and stationary contact assemblies are isolated from each other by an insulating interrupter tube. The moving contacts are driven by the bellcrank assembly, which converts the vertical motion of the operating mechanism to the horizontal motion of the interrupter contacts. An insulating pullrod connects the bellcrank assembly to the moving contacts.

Refer to the Interrupter module for more details.

2.5 Interphase Linkage

The three pole units are interconnected by an interphase linkage assembly and SF_6 gas density monitoring system. The Interphase Linkage module includes all components that join the individual pole units into a single breaker unit. These components are the interphase shafts and the SF_6 gas density monitoring system.

Refer to the Interphase Linkage module for more details.

2.6 Mechanism

The operating mechanism for the 145 PM circuit breaker is housed within the control cabinet. This breaker can incorporate either a pure spring mechanism, Type FSA-2, or a hydraulic mechanism, Type HMB. Refer to the Mechanism module for more details.

2.6.1 FSA-2 Spring-Operated Mechanism

In the case of the pure spring-operated mechanism, the interrupters have a direct mechanical link to steel coil springs, and are driven by the springs during both the opening and closing operations.

2.6.2 HMB Hydraulic Mechanism

The HMB hydraulic mechanism is driven completely hydraulically. A stack of disc springs serves as an energy storage system. During both opening and closing operations, hydraulic oil drives the piston/pullrod of the mechanism, consuming energy from the stack of disc springs. There is no direct mechanical link between the spring stack and the piston/pullrod. The storage springs are charged using a hydraulic pump; this stored energy provides the driving force for hydraulic oil as the breaker is opened and closed.

2.7 Control Cabinet

The control cabinet is mounted to the steel structural frame of the circuit breaker. Components housed in the cabinet include:

- Operating mechanism;
- CT shorting terminal blocks;
- Anti-condensation heaters;
- Control relays;
- SF_6 gas density monitor(s);
- Terminals for field connections;
- Auxiliary switches;
- Circuit breaker control panel.

Field wiring enters the control cabinet through a panel at the base of the cabinet and is terminated on the appropriate terminal blocks. The breaker control circuitry is wired and tested at the factory.

If required, the circuit breaker also can be fitted with a second control cabinet (not shown in Figure 1) mounted to the rear of the structural frame.

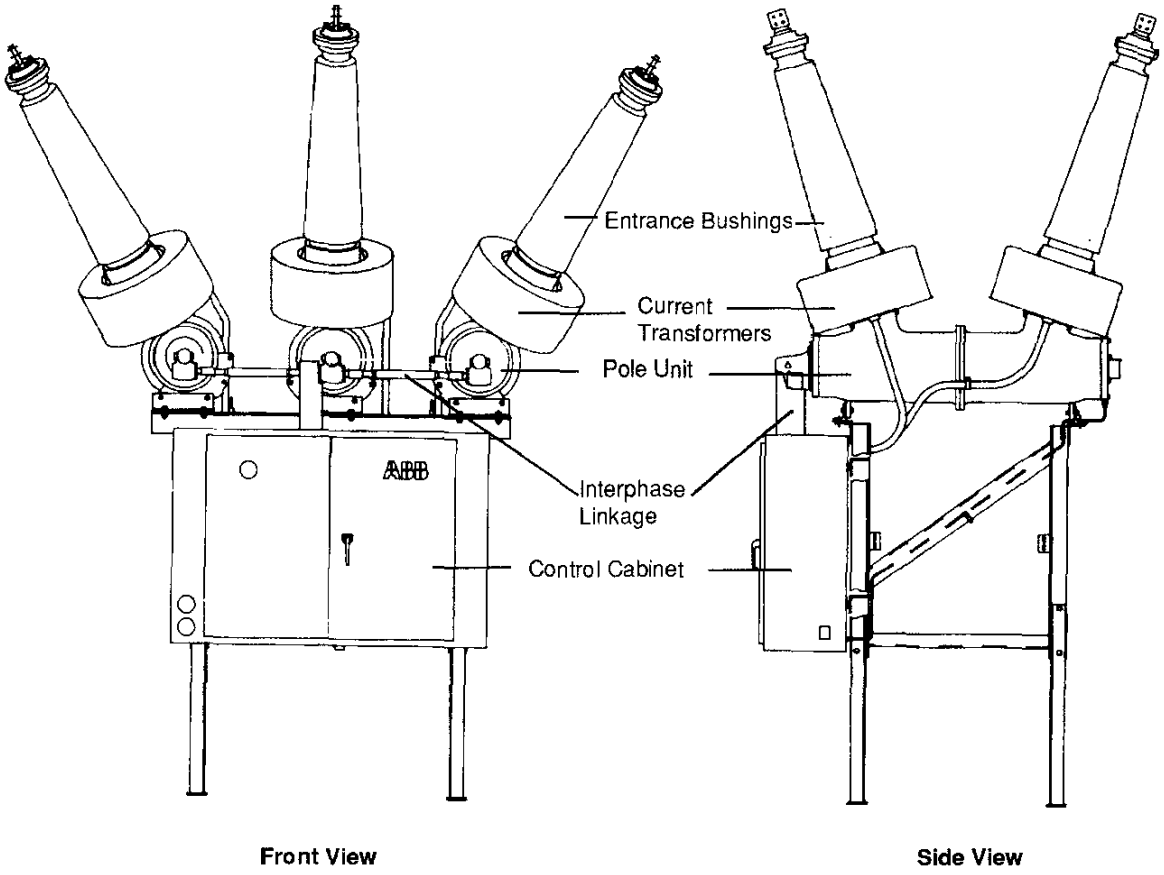


Figure 1
145 PM Circuit Breaker

SF_6 Circuit Breakers

Type PM

Publication No. 526P110-02©

145 PM Installation©

ASEA BROWN BOVERI

7 October 1993

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Notice 1

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Installation

1 Introduction

Instructions in this module pertain to receiving, handling, storing, and installing the 145 PM circuit breaker.

Important: *An installation and commissioning checklist is included in the Checklists module. This tabular checklist includes all of the tests and items to check when installing and commissioning the breaker. The checklist specifies allowable tolerances along with blank spaces for recording measured values for future reference and comparison.*

1.1 Installation Precautions - READ THIS

The breaker is shipped from the factory with a positive charge of sulfur hexafluoride (SF_6) gas of approximately 5 psig (34.5 kPaG). Eventually after the breaker is put in place and ready for testing and operation, it will be filled with SF_6 gas to a working pressure of 87 psig (600 kPaG) at 20°C (68°F) during commissioning. The procedures listed below must be performed in the following sequence before placing the circuit breaker into service:

1. Receive and lift the circuit breaker into place (with 5 psig (34.5 kPaG) of pressure in the tank); refer to sections 2 and 4.2.
2. Completely install the breaker (with 5 psig (34.5 kPaG)) before filling it with gas; refer to section 4.
3. Commission the breaker as follows (section 5):
   - Land power and control wiring connections; refer to section 5.1.
   - Connect the current transformers; refer to section 5.2.
   - Fill the circuit breaker with SF_6 gas to a working pressure of 87 psig (600 kPaG) at 20°C (68°F); refer to section 5.3.
4. Test the breaker; refer to sections 6 and 7.

DANGER

Never move or install a breaker that is fully pressurized with SF_6 gas. The breaker can be moved or installed only if the tank is at a slight positive pressure of approximately 5 psig (34.5 kPaG). After installation is completed and before the breaker is operated, fill the breaker with SF_6 gas.

Do not energize, test, or operate the breaker until it is completely filled with SF_6 gas.

2 Receiving and Handling the Breaker

When the circuit breaker reaches its destination, check the material actually received against the packing list immediately. Be certain that all parts have been received to avoid delays in installation. If the breaker is found to be damaged or is suspected of being damaged, file a claim immediately with the transportation company. Next, notify the local ABB representative of shortages or damaged equipment.

The breaker either can be installed or stored. To store the breaker, refer to section 3; to install the breaker, refer to section 4.

The breaker is shipped completely assembled except that the lower legs are retracted into the frame. The bushing top terminals are shipped with the field assembly materials and must be attached during installation.

A crane with a lifting capacity of at least 5 tons is the most efficient means of handling the circuit breaker. Lifting lugs are provided for this purpose. Refer to section 4.2 for lifting instructions.

2.1 Moving the Breaker

To move the breaker:

1. Be sure that the breaker is in the OPEN position and that the mechanism springs are completely discharged.
2. Reduce the SF_6 gas pressure to approximately 5 psig (34.5 kPaG).

DANGER

Never move or install a breaker that is fully pressurized with SF_6 gas. The breaker can be moved or installed only if the tank is at a slight positive pressure of approximately 5 psig (34.5 kPaG).

3. Lift the breaker as shown in Figure 1 and in Plate 1 as shown in section 4.2.
4. Remove the leg bolts H800A02703 (Fig. 1) and retract the extension legs into the breaker frame.
5. Refasten the legs into the retracted position using the leg bolts.
6. Mount the breaker to wooden skids at the foot pads to keep the breaker from tipping over during transport.
7. Secure the breaker with straps during transport.
8. Be careful not to damage the entrance bushings.

3 Storing the Circuit Breaker

The breaker can be stored indoors or outdoors. Any time a breaker is to be stored, maintain a slight positive pressure of dry, SF_6 gas (5 psig (34.5 kPaG)) to prevent corrosion of the internal components and absorption of moisture.

Important: *If the breaker is to be stored longer than 1 month, protect the operating mechanism and control cabinet from moisture and corrosion by closing the housing and energizing the anti-condensation heaters.*

Keep spare parts in a clean, dry room to minimize the possibility of moisture and corrosion damage.

Notice: *If a breaker which has been opened is to be stored, it must be evacuated and filled to a positive pressure with dry, SF_6 gas to approximately 5 psig (34.5 kPaG). Refer to the Maintenance module for instructions on evacuating and refilling a breaker which has been opened.*

4 Installing the 145 PM Circuit Breaker

When installing the 145 PM circuit breaker, refer to the outline and field assembly drawings in the Customer Data module and the flow chart on the opposite page. After installation is complete, commission the breaker. Refer to section 5.

DANGER

Upon installation, the tank pressure should be at the shipping pressure of approximately 5 psig (34.5 kPaG). Never move or install a breaker that is fully pressurized with SF_6 gas. The breaker can be moved or installed only if the tank is at a slight positive pressure of approximately 5 psig (34.5 kPaG). Do not fill the breaker with SF_6 gas until installation is complete.

4.1 Equipment Used in Installation

The following items are supplied by ABB with the 145 PM circuit breaker:

- One service kit (containing lubricants, electrical joint compound, touch-up paint, and Loctite);
- One instruction manual;
- One breaker field assembly drawing;
- One breaker outline drawing;
- One set of standard maintenance tools (including the travel recorder kit T13435);
- One set of wiring diagrams.

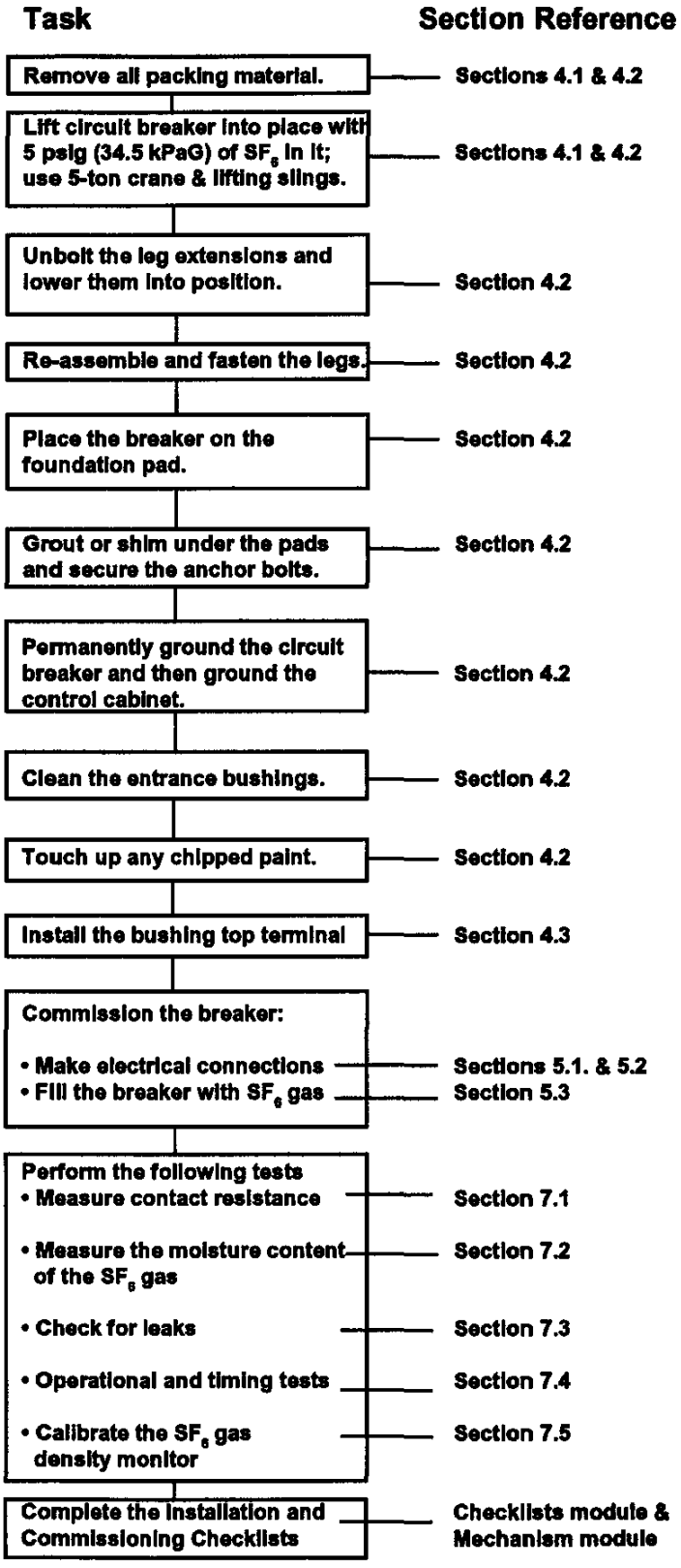
The following items are provided as options by ABB. Check if these materials were purchased with the breaker:

- Lifting sling assemblies;
- SF_6 gas;
- SF_6 gas regulator with filling hose and adapter fitting.

When installing the 145 PM circuit breaker, have on hand both the ABB-supplied equipment as well as the following equipment supplied by your company:

- Traveling crane, 5-ton capacity;
- Slings;
- Level;
- Leveling shims;
- Thermometer;
- Test Equipment:
  - Leak detector,
  - Moisture analyzer,
  - Timing devices,
  - Micro-ohm measurement equipment;
- Standard tools, screwdrivers, wrenches, etc.;
- Torque wrenches: 10 to 150 ft-lbs and 10 to 600 ft-lbs;
- Two, step ladders (10-feet size);
- Wire brush;
- Cleaning materials (denatured ethyl alcohol);
- Lint-free wipers.

Installation and Commissioning Flow Chart



DANGER

Proceed with extreme caution because installation often involves working near energized lines.

4.2 Installation Procedure

Prior to installing the 145 PM circuit breaker, be sure that the tank pressure is approximately 5 psig (34.5 kPaG). Do not install a fully pressurized breaker.

To install the 145 PM circuit breaker:

1. Remove all packaging material.
2. Lift the breaker using the crane and following the rigging arrangement shown in Figure 1 and Plate 1.

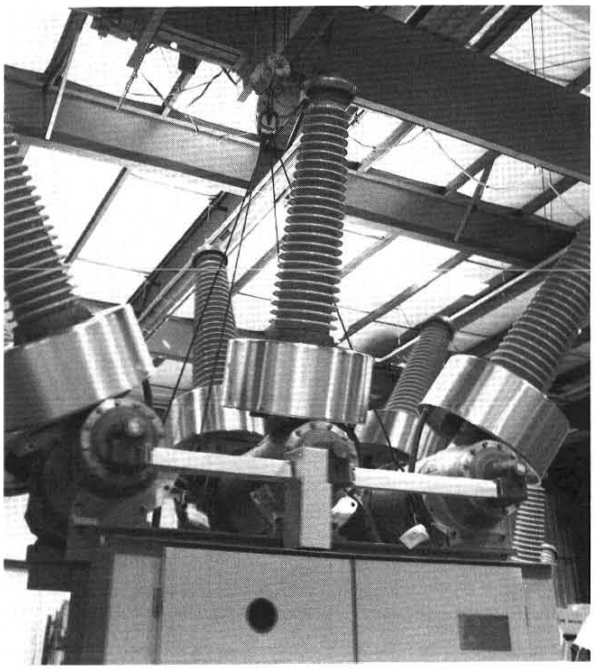


Plate 1: Lifting breaker

3. While the breaker is suspended, unbolt the leg extensions and lower them to the position shown on the outline drawing in the Customer Data module. Re-assemble the legs using the fasteners provided with the legs.
4. Place the breaker on its foundation pad. The unit does not require precise leveling; a level on the horizontal bracing will suffice.
5. Grout or shim under the breaker foot pads and secure the anchor bolts.
6. Permanently ground the circuit breaker structure. Two NEMA grounding pads, welded to the front and rear structural legs at opposite corners, are provided for this purpose. The ground cable should be able to carry the available fault current at the breaker location for the maximum duration of the protection scheme.

DANGER

A permanent low resistance ground is essential to adequately protect equipment and personnel.

7. Ground the control cabinet ground terminal 60011 (Fig. 2) located on the inside rear wall of the cabinet. A grounding stud extends through the rear wall and can be accessed from outside of the cabinet.
8. Clean the entrance bushings to remove any dirt or debris which may have accumulated during shipment and installation using standard cleaning procedures described in the Porcelain Entrance Bushings module.
9. Touch up any areas of damaged or chipped paint using the provided touch-up paint.
10. Complete the installation and commissioning checklist included in the Checklists module. This tabular checklist includes all of the tests and items to check when installing and commissioning the breaker. The checklist specifies allowable tolerances along with blank spaces for recording measured values for future reference and comparison.

4.3 Installing the Bushing Top Terminal

Each 145 PM circuit breaker is provided with six four-hole NEMA terminal pads 20311 (Fig. 15) as part of the field assembly materials. Refer to Plate 2.

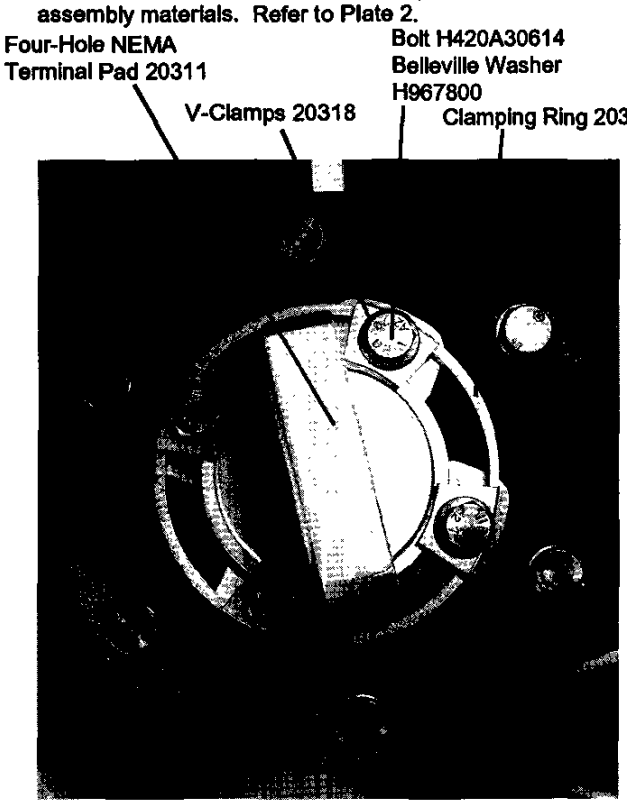


Plate 2: Installing the bushing top terminal

To install the terminal pad 20311 (Fig. 15) to the top cap of the bushing conductor:

1. Coat the mating surfaces between the terminal pad 20311 and top cap of the bushing with Alnox Electrical Joint Compound (found in the service kit). Abrade both contact surfaces with a wire brush to remove dirt and oxides. Completely wipe off the Alnox with a clean, lint-free wiper and immediately apply a new coat of Alnox to both mating surfaces to prevent oxidation.
2. Position the terminal pad on the top cap of the bushing.
3. Place a clamping ring 20317 over the terminal with the drip slots at the bottom of the clamping ring.
4. Place four V-clamps 20318 between the clamping ring 20317 and terminal pad and over the holes in the top cap of the bushing.
5. Place a belleville washer H967800 (Fig. 15) on each of the four M12 hex head bolts H420A30614. Apply Amber Petrolatum Grease to the bearing surfaces and the threads of each bolt. Place a bolt through each V-clamp, and screw the bolts into the four holes of the top cap of the bushing.
6. Turn the terminal pad to the desired orientation (the terminal can be turned 360 degrees) and torque the bolts to 61 Nm (45 ft-lbs).

4.4 Slow Close Operation

Since the slow close operation is only necessary when re-installing a stationary contact assembly during interrupter maintenance, this procedure is optional during *installation* because:

- The circuit breaker is shipped as a complete ready-to-install unit and contact inspection or alignment is not required during installation.
- A slow close operation is not required when using modern circuit breaker timing techniques;

Important: ***With the 145 PM circuit breaker, the mechanism cannot be jacked closed. The interrupters must be isolated from the mechanism.***

Refer to the Interphase Linkage module for the procedure to perform a slow close operation.

5 Commissioning the Breaker

Commissioning follows installation. Commissioning the breaker involves:

- Making electrical connections;
- Filling the breaker with SF_6 gas;
- Testing the breaker;
- Completing the installation and commissioning checklist (in the Checklists module);
- Completing the commissioning checklist for the mechanism (in the Mechanism module).

The breaker has been adjusted and tested at the factory and is shipped completely assembled except as noted in the previous sections. The breaker contains a partial charge of SF_6 gas and the full amount of desiccant. Therefore, it should not be necessary to open the breaker before commissioning.

DANGER

Do not fill the breaker with SF_6 gas until installation is complete. Refer to section 4 to install the breaker. Do not energize, test, or operate the breaker until it is installed and completely filled with SF_6 gas.

Once the breaker has been assembled completely and all electrical connections have been made, the breaker is ready for final commissioning. Commission the breaker in the following procedural sequence listed in Table 1.

Table 1

Commissioning Procedure Quick Reference Table

Commissioning Procedure	Section(s) to Refer to in This Module
Complete Commissioning	Sections 5.1 to 5.3 & 7
Control & Secondary Wiring	Section 5.1
Current Transformers	Section 5.2
Filling the Breaker with SF6 Gas	Section 5.3
Perform Tests: - Pole Resistance Measurement - Moisture Measurement - Leak Checking - Operational and Timing Tests - Density Monitor Calibration	Section 7
Complete Installation and Commissioning Checklists	Checklists Module & Mechanism Module

5.1 Control and Secondary Wiring

Control and auxiliary equipment inherent to the circuit breaker have been wired, adjusted and tested at the factory. Terminals blocks are provided for customer power and control connections (Fig. 2). Refer to the wiring diagram for external connections and to the mechanism nameplate for control voltages and operating pressures.

Use control and power wiring of adequate size to maintain voltages at the breaker terminals within ANSI Standard ranges.

Conduit for external control wiring should be terminated at the removable plate 60009 (Fig. 2) located in the bottom of the control housing. Refer to Plate 3. All conduit should be sealed at the cabinet to keep out dirt and moisture.

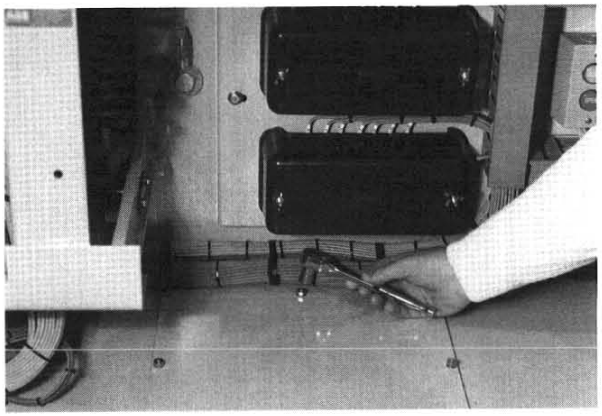


Plate 3: Removable plate

5.2 Current Transformers

Bushing-type current transformers (CTs) are installed at the factory and are wired to short circuiting terminal blocks in the control cabinet. The CTs are provided as per customer specifications. Multi-ratio relaying class CTs are applied most commonly. However, single-ratio metering class CTs and linear couplers are available if requested. A nameplate on the inside of the cabinet door indicates the location, accuracy and ratio of the current transformers.

Refer to the Current Transformers module for more details.

DANGER

Each current transformer secondary must be connected to a relaying or metering burden or be short circuited at all times.

5.3 SF_6 Gas Filling

The properties of the sulfur hexafluoride (SF_6) gas used in the breaker must meet the specifications for sulfur hexafluoride according to ASTM D2472-71. SF_6 gas is available in standard industrial type cylinders. The adapter needed for connecting to the gas cylinder is a CGA #590 male left-hand thread connector. Cylinders containing a charge of either 25 lbs or 115 lbs of gas are available. The pressure in the cylinder is 300 psi at 24°C (75°F).

The breaker should be filled with SF_6 gas to a pressure of 87 psig (600 kPaG) at 20°C (68°F).

Important: *When filling the breaker with SF_6 gas, compensate for temperature variation as shown in the pressure vs. temperature characteristics of Figure 3. The SF_6 Gas Filling and Density Monitor Calibration Chart in Figure 4 is a quick reference, tabular version of the characteristics in Figure 3. For example, at -1°C (30°F) the correct fill pressure would be 78.2 psig (539.2 kPaG).*

Before filling the breaker with gas either from a gas cylinder or gas service unit, review section 5.3.1. To fill the breaker with SF_6 gas from a cylinder, refer to section 5.3.2. To fill the breaker with SF_6 gas from a gas service unit, refer to section 5.3.3.

Warning

Do not over-pressurize the circuit breaker when filling the breaker with SF_6 gas. Over-pressurization may cause the rupture disk to fail.

5.3.1 Preparation Prior to Filling the Breaker with SF_6 Gas

When the breaker is shipped from the factory, it already is positively charged with SF_6 gas to approximately 5 psig (34.5 kPaG). As long as this initial charge of gas is present, the breaker can be simply topped off to the proper level on installation. However, *before* filling the breaker with SF_6 gas, make sure that this positive pressure has not been lost due to leakage or damage during shipping, etc.

If the positive charge of gas is gone, determine the cause and correct the problem. Refer to section 7.3 for leak checking procedures. When the leak has been corrected, refer to the Pole Unit module for instructions on replacing the desiccant bag. Then, follow the procedures for evacuating and filling a circuit breaker which has been opened as listed in the Maintenance module.

The SF_6 gas pressure gauge 60003 (Fig. 5) is mounted in the control cabinet and can be seen through a view port on the front wall to check the tank pressure. This gauge has an accuracy of 2 percent. It is good policy to periodically verify the calibration of this gauge using a test gauge with an accuracy of at least 1/4 percent, especially following shipment. The pressure gauge in the breaker is adjustable and can be re-calibrated as needed.

WARNING

If the positive shipping pressure has been lost or if the breaker has been opened for any reason, refer to the Maintenance module for procedures to fill an opened breaker.

5.3.2 Filling an Unopened Breaker from a Gas Cylinder

Filling the breaker with SF_6 gas from a gas cylinder should only be done if the pole tanks have not been opened and a positive pressure of approximately 5 psig (34.5 kPaG) at 20°C (68°F) remains in the tank. Using a portable in-line filter/drier is optional if filling from a gas cylinder.

Important: *The gas cylinder should be vertical at all times to prevent introducing liquefied gas into the circuit breaker. Particulate matter within the gas cylinder can be carried with the liquefied gas into the breaker.*

To fill the unopened breaker with gas from a gas cylinder:

1. Remove the cap from the 1/4-inch, 37-degree male flare fitting 60008 at location F (Fig. 5).
2. Purge the hose by allowing SF_6 gas from the cylinder to pass through the hose driving out air and moisture.
3. Shut off the gas and immediately connect the hose at location F. Refer to Figure 5 and Plate 4.

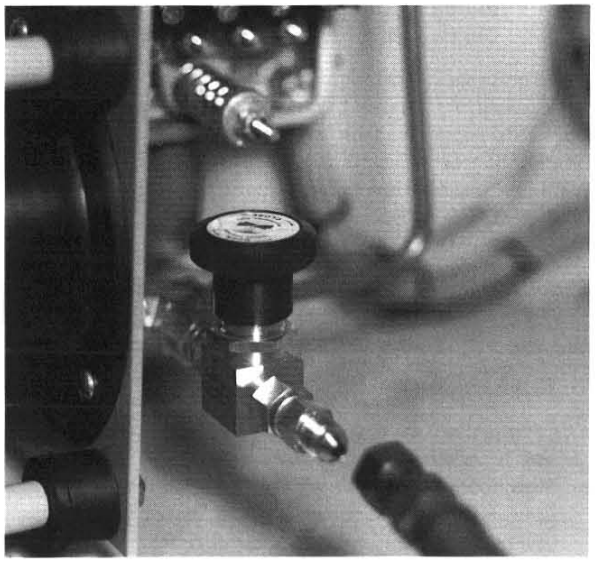


Plate 4: Connecting the fill hose

4. Open the sample valve 60007 (Fig. 5); then open the valve on the regulator at the SF_6 gas cylinder.

Warning

The gas regulator must be adjusted approximately to the final fill pressure of the breaker (87 psig (600 kPaG)) such that the SF_6 plumbing, density monitor, and gauge are not over-pressurized. Compensate for temperature variations as needed.

5. Slowly fill the breaker with gas to the pressure as shown in Figures 3 and 4 for the corresponding ambient temperature. Approximately 65 lbs. (30 kg) of SF_6 gas by weight will be required for the breaker.

One cylinder of gas will be sufficient to fill one breaker. Usable gas may remain in the cylinder after the breaker is filled.

When filling during cold ambient temperatures, the cylinder may be heated using any of the following methods to convert the liquid SF_6 in the cylinder to a gaseous state:

- An electric blanket heater;
- Immersing the gas cylinder upright in a drum partially filled with warm water so that approximately half of the cylinder is immersed. Heat the water with a portable gas or electric heater.

Warning

Never heat a gas cylinder with an open flame. Energize heaters only when transferring the gas. When heating the cylinder, be sure that the temperature in the cylinder does not exceed 100°F (38°C).

5.3.3 Filling an Unopened Breaker from a Gas Service Unit

Use a portable in-line filter/drier if filling the breaker from a gas service unit. A filter with 13x molecular sieve (desiccant) can be used. Place the filter vertically in the line between the breaker sample valve 60007 (Fig. 5) and the SF_6 gas service unit. Gas will be forced to flow through the desiccant in the filter/drier. Care must be taken to ensure that liquid SF_6 will not enter the portable filter or breaker.

Important: The 13x molecular sieve (desiccant) must be replaced after passing approximately 3500 pounds of gas through the filter.

To fill the breaker:

1. Purge the hose from the gas service unit with a quantity of SF_6 gas equal to approximately 10 tims the volume of the hose to eliminate air and moisture. (A quick blast purge through the hose is not sufficient to adequately eliminate air and moisture - especially if using a long hose with a large diameter.)
2. Turn off the gas flow and immediately make the necessary connection at location F (Fig. 5). Refer to Plate 4.
3. Open the sample valve 60007 and then open the appropriate valve on the gas service unit.
4. Slowly fill the breaker with gas to the pressure as shown in Figures 3 and 4 for the corresponding ambient temperature. Approximately 65 lbs. (30 kg) of SF_6 gas by weight will be required for the breaker.

6 Test Equipment

Equipment used in testing includes:

- Leak detector (section 6.1 for vendor sources);
- Moisture analyzer (section 6.2 for vendor sources);
- Timing devices (section 6.3);
- Micro-ohm measurement equipment (section 6.4).

6.1 Leak Detector

The suggested sources for leak detectors are:

TIF Halogen Leak Detector Model 5500
Halogen Leaktector, Code 23-7023
Bacharach Instrument Inc.
625 Alpha Drive
Pittsburgh, PA 15238

Gas Leak Detector
Calgon Corporation
Route 60 Cambells Run Rd.
Pittsburgh, PA 15230

6.2 Moisture Analyzer

The suggested source for moisture analyzers is:

Electrolytic Moisture Analyzer
Manufacturing Engineering and Equipment Corp. (MEECO)
250 Titus Avenue
Warrington, PA 18976

6.3 Timing Devices

Use any of the following devices to perform circuit breaker timing:

- Digital circuit breaker analyzer;
- Oscillographic circuit breaker analyzer;
- Mechanical time travel recorder.

6.4 Micro-Ohm Measurement Equipment

A Ductor or equivalent 100 amp DC micro-ohmmeter can be used to measure pole resistance.

7 Testing

The following should be performed when installing the breaker:

- Pole resistance measurement (section 7.1);
- Moisture measurement of the SF_6 gas (section 7.2);
- Leak checking (section 7.3);
- Operational and timing tests (section 7.4);
- SF_6 gas density monitor calibration (section 7.5);
- Completing the installation and commissioning checklist (in the Checklists module);
- Completing the commissioning checklist for the mechanism (in the Mechanism module).

7.1 Pole Resistance Measurement

Using a 100 A micro-ohmmeter (or millivolt drop meter), perform a contact resistance (or milliVolt drop) measurement on each pole of the breaker. The maximum resistance from bushing terminal to bushing terminal should not exceed 150 micro-ohms.

7.2 Moisture Measurement of the SF_6 Gas

Use a moisture analyzer (hygrometer) to measure the moisture content of the SF_6 gas in the breaker. Refer to section 7.2.1.

Important: *An adequate moisture content reading can be taken 1 hour after filling the circuit breaker with gas. However, if time permits, allow 24 hours or more for the gas system to stabilize before taking a moisture content reading. The additional time for stabilization will ensure a more accurate reading.*

The maximum moisture level permitted in the SF_6 gas is:

200 ppmV (by volume) at 68°F (20°C)

The maximum moisture content to be expected from an SF_6 gas cylinder is:

SF_6 Dew Point of -50°F (-45°C)

Caution

Should the moisture content of the SF_6 gas exceed 200 ppmV on filling, the SF_6 gas must be reclaimed and recycled through a drying filter. Before refilling, the circuit breaker must be evacuated to eliminate moisture using the procedure in the Maintenance module for filling a breaker that has been opened.

7.2.1 Measuring the Moisture

To ensure reliable moisture measurements, pay particular attention to cleanliness and prescribed procedure, particularly as it applies to preventing moisture from contaminating the moisture analyzer (hygrometer) and its connections. It is important that the recommendations of the analyzer supplier be followed carefully.

The gas is sampled through the 1/4-inch 37-degree male flare fitting 60008 (Fig. 5) located at the outlet of the sample valve 60007. Use only stainless steel tubing to connect the instrument. Cap the tubing immediately after taking the sample to keep moisture out.

7.3 Leak Checking

After the breaker has been opened or if an SF_6 leak is suspected, check the following threaded, O-ring and gasket connections with a hand-held halogen leak detector:

- Tube connections and fittings to the pressure gauge;
- SF_6 gas density monitor;
- SF_6 gas plumbing;
- Rupture disk;
- Bushing flanges;
- Rear tank cover assembly;
- Bellcrank housing;
- Interphase shaft seals with the breaker opened and closed.

7.4 Operational and Timing Tests

Before placing the breaker into service, perform operational and timing tests. Refer to section 7.4.1 for information pertaining to operational tests; refer to section 7.4.2 for details about circuit breaker timing tests.

7.4.1 Operational Tests

The control relays, protection devices, and schemes must be fully checked by operational tests to ensure that the breaker is ready for service. Because the control schemes are usually designed as per customer specifications, operational tests vary depending upon the particular control scheme. Refer to the breaker control schematic to determine the necessary operational tests to be performed.

Generally, operational tests include the following steps:

1. Assure that the circuit breaker will open and close electrically at both the local control switches and at the remote control switches. If a local/remote or maintenance test switch is used, verify that it is functioning properly.

2. Check the alarm and operation lock-out functions for proper actuation. The 145 PM breaker has two parameters which are monitored: SF_6 gas density and operating energy of the mechanism. To calibrate the SF_6 gas density monitor refer to section 7.5 of this module. To verify the operating energy of the mechanism, refer to the "Commissioning" section of the Mechanism module.

3. Verify that the anti-pumping circuitry (Y relay or X-Y relay scheme) is operating properly as per your particular control scheme.

4. Test any optional devices i.e., undervoltage relays, reclose time delay relays, etc.

7.4.2 Timing Tests

Timing tests are performed to verify that the circuit breaker contacts are opening and closing at acceptable velocities and within time limits that meet the design parameters of the circuit breaker and the high voltage system. Timing tests include:

- Measuring contact closing and opening times (section 7.4.2.1);
- Measuring contact velocity (section 7.4.2.2).

A full set of timing tests, including contact velocity measurements, are performed at the factory prior to shipping the breaker. Upon installation, contact timing tests as described in section 7.4.2.1 should be performed to verify closing and opening times. Contact velocity measurements are not required on installation, but should be performed during the 5-year scheduled maintenance as specified in the Maintenance module.

A wide variety of circuit breaker analyzers (timing equipment) are available to perform these tests. The two most common types of circuit breaker analyzers are oscillographic analyzers using light-sensitive chart paper and the more advanced digital timers. Either oscillographic or digital devices are acceptable, however, the digital devices are more accurate and tend to be easier to use. Circuit breaker analyzers are normally supplied with all test leads, motion transducers, and timing channels necessary to perform timing tests.

The actual procedures for using the analyzers vary by manufacturer. However, all circuit breaker analyzers provide the following:

- Timing channels which monitor the closing and opening of the main contact;
- Channels which monitor trip and close coil currents;
- Motion channels which monitor contact movement via motion transducers;
- Event charts showing distance (vertical units) vs. time (horizontal units).

Perform all timing tests with the gas system pressurized to 87 psig (600 kPaG) at 20°C (68°F) and with the mechanism fully charged.

Refer to Table 2 for timing specifications. Figures 6, 7, and 8 show typical oscillographic measurements of timing parameters; Figures 9 and 10 show typical oscillographic motion characteristics (distance vs. time) for breaker opening and closing.

Table 2
145 PM Timing Specifications

Opening Time	30 ms maximum
Opening Velocity for FSA-2 Spring Mechanism	3.8 to 4.2 m/s
	12.4 to 13.8 ft/s
Opening Velocity for HMB Hydraulic Mechanism (40 kA interrupting rating)	4.6 to 5.0 m/s
	15.0 to 16.4 ft/s
Opening Velocity for HMB Hydraulic Mechanism (50/63 kA interrupting rating)	4.3 to 4.8 m/s
	14.1 to 15.7 ft/s
Inter-Pole Spread Opening	2 ms maximum
Closing Time	50 to 65 ms
Closing Velocity for FSA-2 Spring Mechanism	2.5 to 2.8 m/s
	8.2 to 9.2 ft/s
Closing Velocity for HMB Hydraulic Mechanism (40 kA interrupting rating)	2.5 to 2.9 m/s
	8.2 to 9.5 ft/s
Closing Velocity for HMB Hydraulic Mechanism (50/63 kA interrupting rating)	2.1 to 2.5 m/s
	6.9 to 8.2 ft/s
Inter-Pole Spread Closing	2 ms maximum
Close-Open Time for FSA-2 Spring Mechanism	25 to 50 ms
Close-Open Time for HMB Hydraulic Mechanism (40 through 63 kA interrupting rating)	20 to 38 ms
Reclose Time	20 cycles minimum

7.4.2.1 Contact Closing and Opening Times

Contact closing and opening times must be within the specified limits shown in Table 2 to assure that the circuit breaker is functioning properly. As part of installation and commissioning, tests should be performed to verify the following:

Closing time (contact make) - time interval elapsed between energization of the close coil and the last arcing contact to make on closing (Fig. 7); units are in milliseconds (ms) or cycles (Hz).

Opening time (contact part) - time interval elapsed between energization of the trip coil and the last arcing contact to break on opening (Fig. 6); units are in milliseconds (ms) or cycles (Hz).

Close-Open time (trip-free time) - time interval elapsed between the last arcing contact to make on closing and the last arcing contact to break on opening (Fig. 8); units are in milliseconds (ms) or cycles (Hz).

Reclose time (open-close) - time interval elapsed between the energization of the trip circuit for an open operation and the making of the arcing contacts on the subsequent close operation; units are most commonly in cycles (Hz).

Inter-pole spread on closing - time interval between the first arcing contact to make and the last arcing contact to make on closing (Fig. 7); units are most commonly in milliseconds (ms).

Inter-pole spread on opening - time interval between the first arcing contact to break and the last arcing contact to break on opening (Fig. 6); units are most commonly in milliseconds (ms).

Caution

The *reclosing* time of a circuit breaker is defined as the time interval between energization of the trip circuit for an open operation and the making of the primary arcing contacts of the interrupter on the subsequent close operation.

The *rated reclosing* time of a circuit breaker is defined by ANSI Standards to be a minimum of 20 cycles. In practice, this time delay allows for deionization of fault current paths and to restore the arcing region of the breaker to its full interrupting performance level. The 145 PM breaker has been tested for this capability with the required time delay intentionally introduced by control circuits external to the breaker. For testing purposes, while the breaker is isolated from the system, the 145 PM breaker is fully capable of instantaneous reclose operations (no time delay), without sustaining mechanical damage. The instantaneous reclose time may be approximately 7 cycles. However, unless specified by contract documents, timing devices to achieve the required minimum 20-cycle delay are not provided as part of the local control circuit for the breaker. Prior to placing the breaker into service, ensure that the required time delay be part of the complete control circuit for the breaker.

ABB requires a minimum 20-cycle reclosing time.

7.4.2.2 Contact Velocity

Maintaining contact velocity within the specified limits shown in Table 2 is necessary to assure that the circuit breaker is functioning properly. Contact velocity (meters/second or feet/second) on breaker opening or closing is factory set prior to shipment. Since the contact velocity is dependent upon mechanism settings (e.g. spring pre-charge, etc.) which are unlikely to change in the relatively short time between shipment and installation, taking motion characteristics to determine contact velocity is optional during initial installation and commissioning. However, these measurements should be performed during the 5-year maintenance procedures and at major maintenance (10 years).

Contact velocity is deduced from motion characteristics of distance vs. time. Figures 9 and 10 show typical distance vs. time characteristics. To obtain motion characteristics, a motion transducer must be attached to the circuit breaker. The travel recorder kit T13435, installed as per Figures 11 and 12, will be needed to apply the motion transducer.

Once distance vs. time characteristics are obtained, contact velocity can be calculated. Contact velocity is defined as the average velocity between the two given speed measuring points as shown in Figures 9 and 10, i.e, the slope of the line drawn between these two points.

Important: *The speed measuring points for the FSA-2 spring mechanism are at 30 and 70 mm from the fully open position. The speed measuring points for the HMB hydraulic mechanism are at 40 and 70 mm from the fully open position.*

The distance traveled (on the vertical axis) between the two speed measuring points is always 40 mm (i.e. 70 mm - 30 mm = 40 mm) (Figs. 9 and 10) for FSA-2 spring mechanisms and 30 mm (i.e. 70 mm - 40 mm = 30 mm) for HMB hydraulic mechanisms. To calculate the contact velocity, the time taken to travel the distance between the two speed measuring points must be determined from the horizontal (time) axis. Contact velocity is calculated using the following formula:

$$\text{Contact Velocity} = \frac{\text{Distance } (mm)}{\text{Time } (ms)}$$

The value calculated from this formula for contact velocity will be in m/sec.

Important: *If contact velocity or the amount of overtravel is not within the specified limits as shown in Figures 9 and 10, refer to the Mechanism module for instructions on adjusting the mechanism.*

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7.5 SF_6 Gas Density Monitor Calibration

The SF_6 gas density monitor 60002 (Figs. 13 and 14) is calibrated at the factory as follows:

- The temperature probe is set at 20°C (68°F);
- Switch C (Fig. 14) is set to close at 76 psig (524 kPaG) (alarm point) with decreasing pressure;
- Switches B1 and B2 (Fig. 14) are set to close at 72 psig (496 kPaG) (breaker lock-out point) with decreasing pressure (unless alternate values are listed on the first page of the wiring diagrams in the Customer Data module).

DANGER

To prevent personal injury and damage to the equipment, before beginning any calibration or adjustment, de-energize the breaker and remove it from service.

Warning

Never change the switch settings from the factory-specified setpoints shown on the first sheet of the wiring diagrams in the Customer Data module - otherwise breaker failure could result.

To calibrate the SF_6 gas density monitor and adjust the pressure switches:

1. Refer to the SF_6 Gas Density Monitor Calibration Curve and Chart (Figs. 3 and 4) to determine the proper alarm and lock-out pressure settings for the current ambient temperature.
2. Determine the existing alarm and lock-out settings by closing the isolation valve 60006 (Fig. 13) to separate the SF_6 gas density monitor 60002 and SF_6 gas pressure gauge 60003 from the pole units.
   a. Bleed this negligible amount of gas through the sample valve 60007 until the alarm occurs.
   b. Read the setting points on the pressure gauge 60003. It is strongly recommended to use an accurate, calibrated, test pressure gauge to verify the integrity of the control cabinet pressure gauge and to ensure accurate alarm and lock-out settings.
3. If the pressure spread (differential) between pressure switches is correct, with all settings either high or low by the same amount, use the main pressure adjustment nut (Fig. 14) to make the necessary changes. Use the main pressure adjustment nut to adjust all of the pressure switches at one time. Turning this nut clockwise increases the settings of all of the pressure switches by the same increment, while turning it counter-clockwise decreases all of the settings.
4. To change the pressure setting of an individual pressure switch, use the individual pressure switch adjustment nut (Fig. 14). Turning the nut clockwise increases the alarm pressure setting, while turning it counter-clockwise decreases the alarm pressure setting.

Important: *Adjusting one of the individual switches will often affect the settings of the other pressure switches. Adjustments should be made in small increments and a final verification of all pressure switch settings should be performed.*

Always adjust in the order from high pressure switches to low pressure switches, i.e. start with switch C and then adjust switches B1 and B2.

5. After adjustments are complete, perform a final verification of all pressure switches.

Notice: *Never severely bend or kink the capillary tube.*

6. Be sure that the isolation valve 60006 (Fig. 13) is open.

Warning

The isolation valve must remain open for proper operation of the low density SF_6 alarm and lock-out controls. A closed isolation valve could result in low gas density operation and cause breaker failure or damage.

7. Complete the density monitor calibration section of the Installation and Commissioning Checklist in the Checklists module.

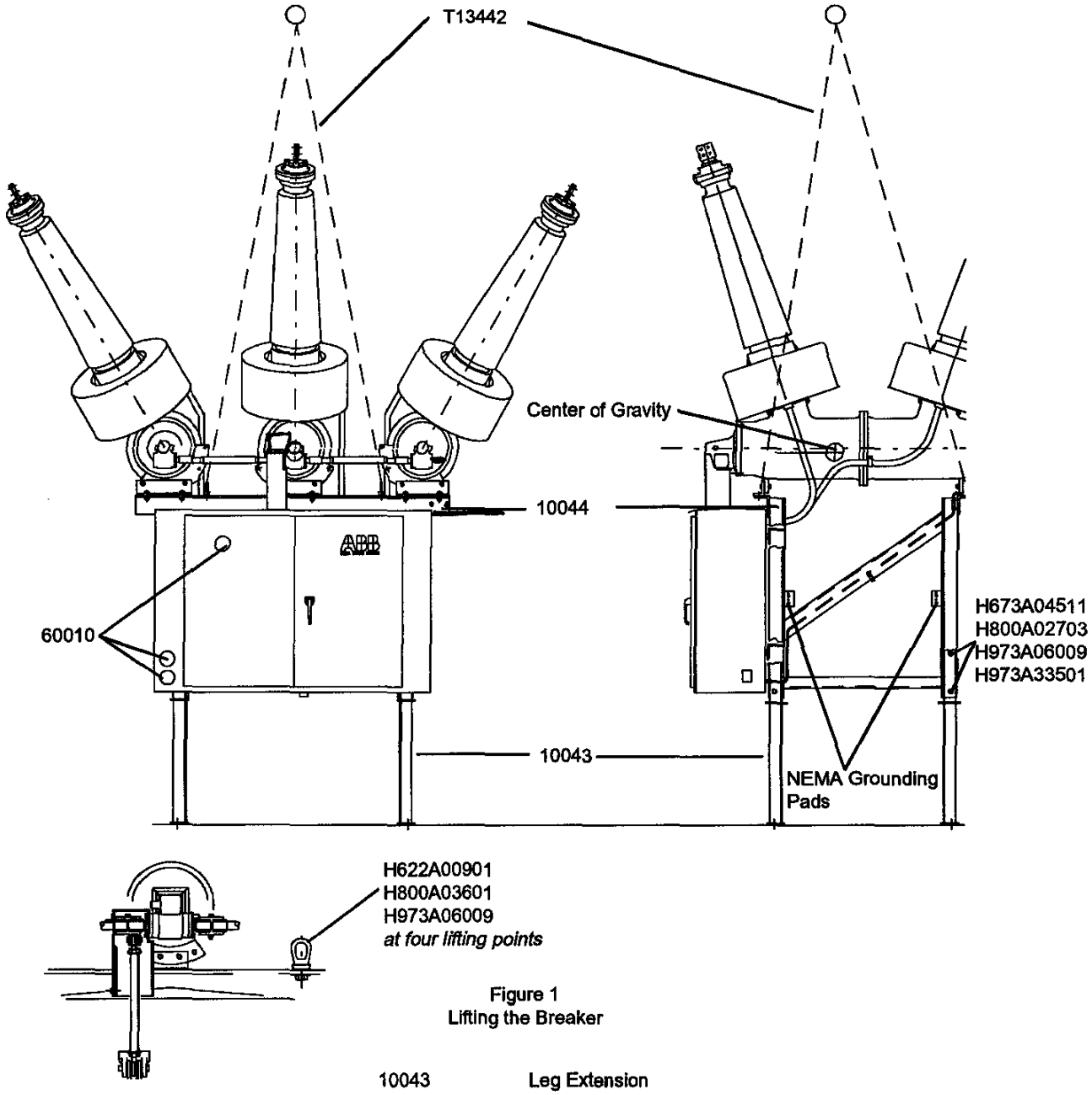


Figure 1
Lifting the Breaker

10043	Leg Extension
10044	Support Structure
60010	View Port Windows
H622A00901	Lifting Lug
H673A04511	Nuts
H800A02703	Leg Bolts
H800A03601	Bolt, 5/8-11 x 1-3/4-inch
H973A06009	Flat Washer, 5/8
H973A33501	Spacers
T13442	Sling

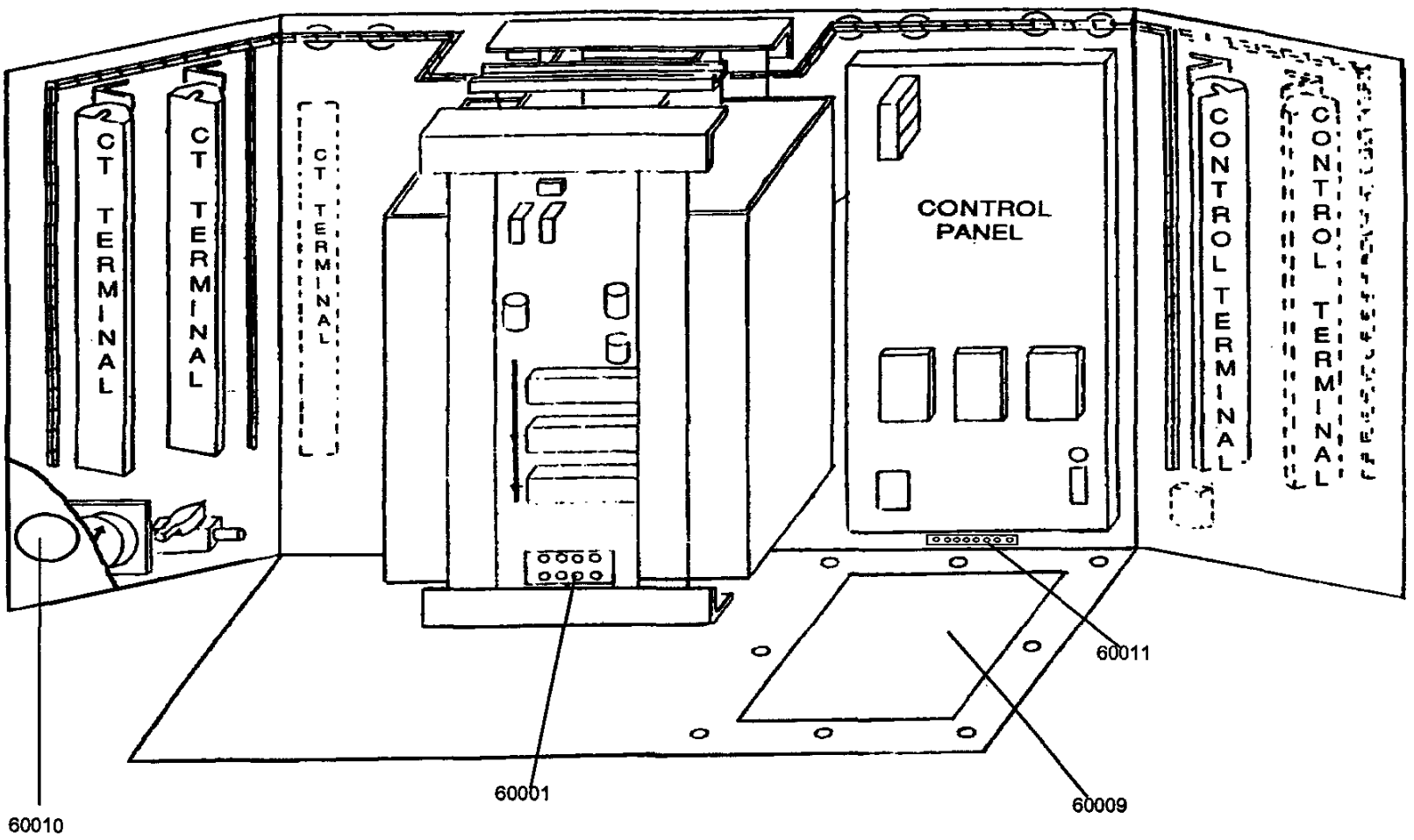
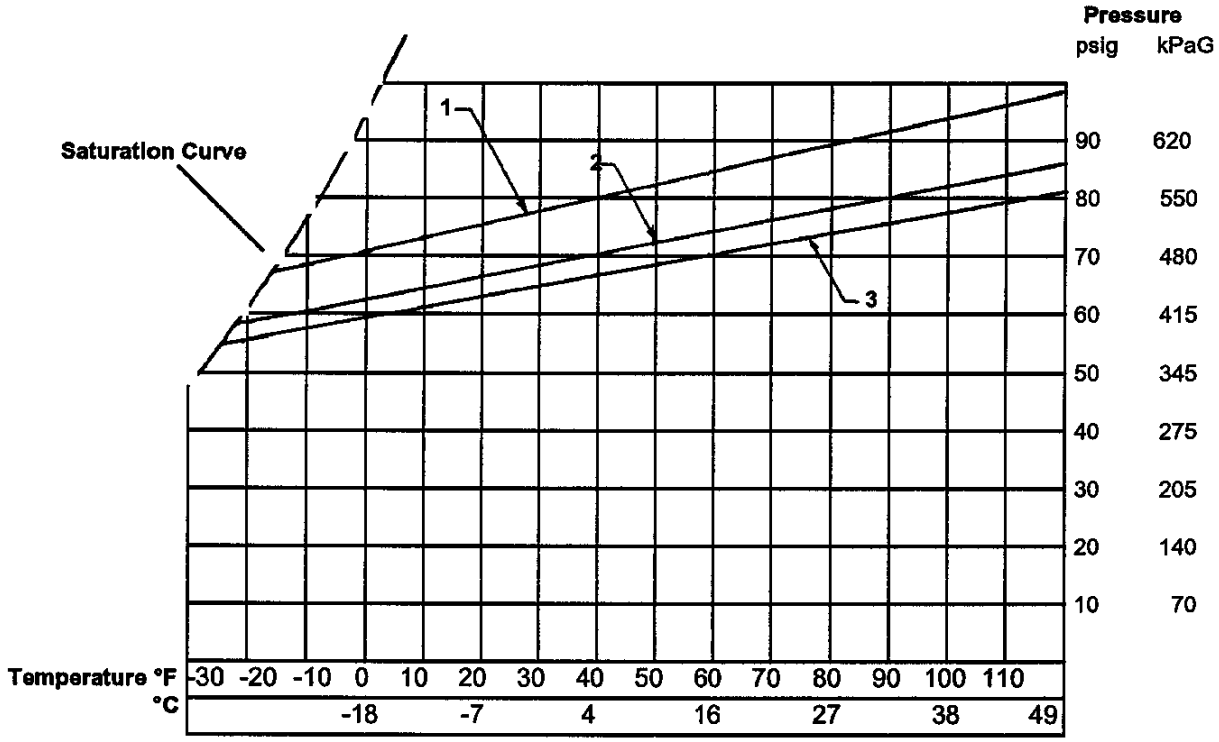


Figure 2
Control Cabinet 60000

60001	Anti-Condensation Heater
60009	Removable Plate
60010	View Port Window
60011	Control Cabinet Ground Terminal



1 Normal Filling Pressure psig or kPaG
2 Low Pressure Alarm (Contact 63-2C Closes)
3 Low Pressure Lock-Out (Contact 63-21B1 & 63-2B2 Close)

Figure 3
SF_6 Gas Density Monitor Calibration Curve for Pressure vs. Temperature

Important: Refer to Figure 4 for a tabular version of the characteristics above.

Tabular Version of the Pressure vs. Temperature Characteristics shown in Figure 3

Temp. F	Temp. C	*Fill psig	**Fill kPaG	*Alarm psig	*Alarm kPaG	*Lock-Out psig	*Lock-Out kPaG
-40	-40	Saturated	Saturated	Saturated	Saturated	Saturated	Saturated
-30	-34	Saturated	Saturated	Saturated	Saturated	Saturated	Saturated
-20	-29	Saturated	Saturated	58.0	399.9	54.9	378.5
-10	-23	68.8	474.4	60.0	413.7	56.9	392.3
0	-18	71.1	490.2	62.1	428.2	58.8	405.4
10	-12	73.4	506.1	64.0	441.3	60.8	419.2
20	-7	75.8	522.6	66.2	456.4	62.7	432.3
30	-1	78.2	539.2	68.1	469.5	64.7	446.1
40	4	80.5	555.0	70.2	484.0	66.6	459.2
50	10	82.8	570.9	72.3	498.5	68.5	472.3
60	16	85.2	587.4	74.3	512.3	70.4	485.4
68	20	87.0	599.8	76.0	524.0	72.0	496.4
70	21	87.6	604.0	76.4	526.8	72.3	498.5
80	27	90.0	620.5	78.5	541.2	74.2	511.6
90	32	92.3	636.4	80.5	555.0	76.2	525.4
100	38	94.7	652.9	82.7	570.2	78.2	539.2
110	43	97.1	669.5	84.8	584.7	80.1	552.3

* +/- 2 psig

** +/- 14 kPaG

Figure 4
SF_6 Gas Filling and Density Monitor Calibration Chart

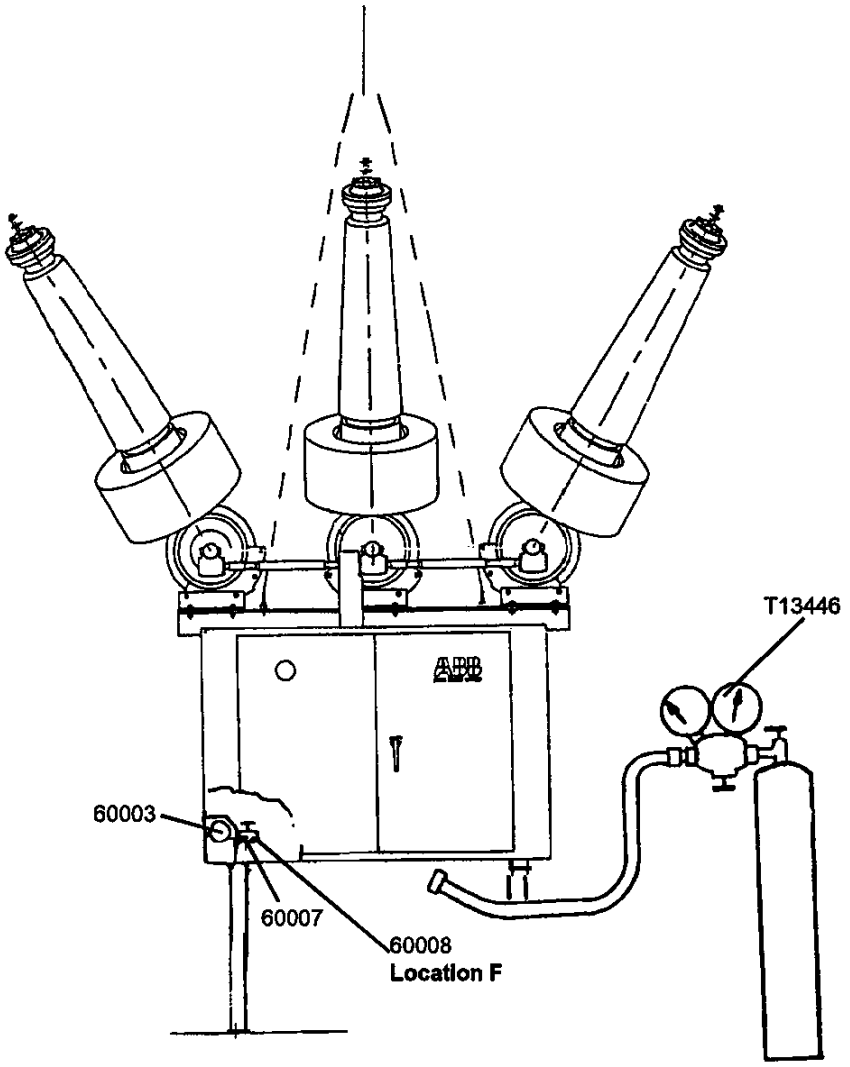
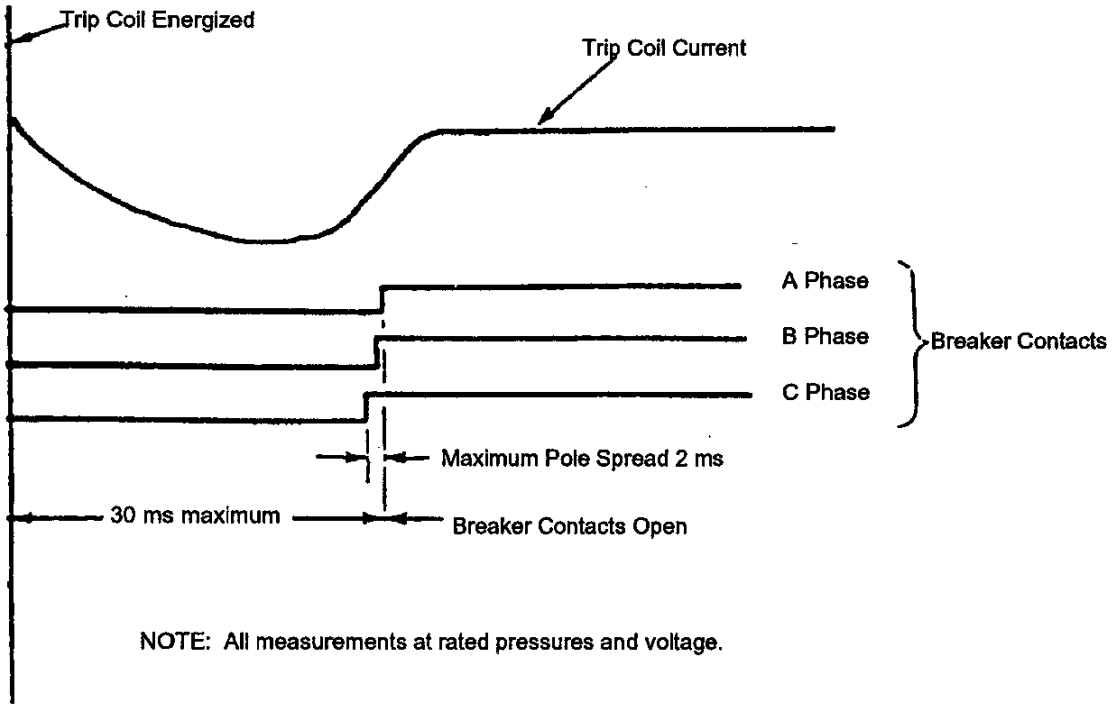


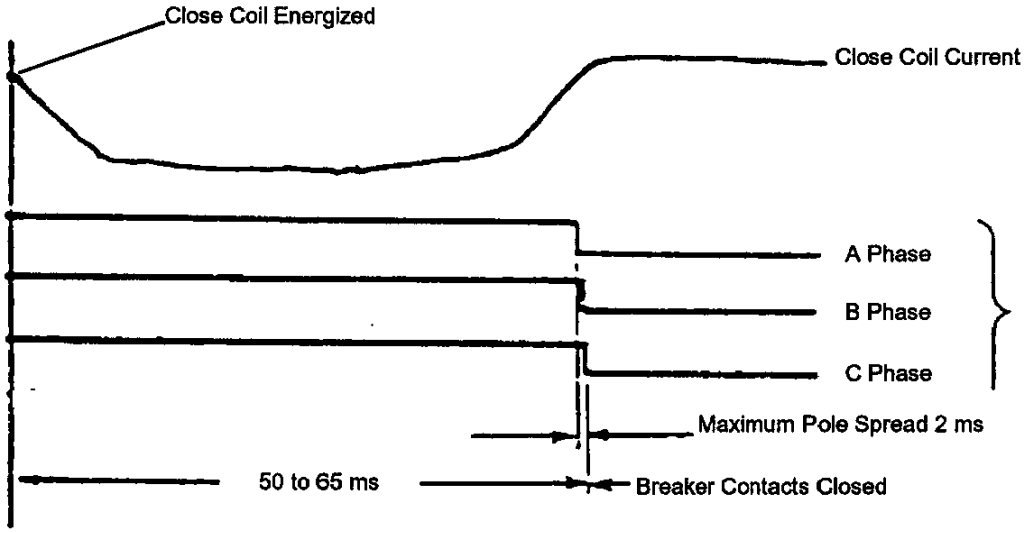
Figure 5
Gas Charging Arrangement

60003	SF_6 Gas Pressure Gauge
60007	Sample Valve
60008	Flare Fitting
T13446	SF_6 Gas Regulator and Hose



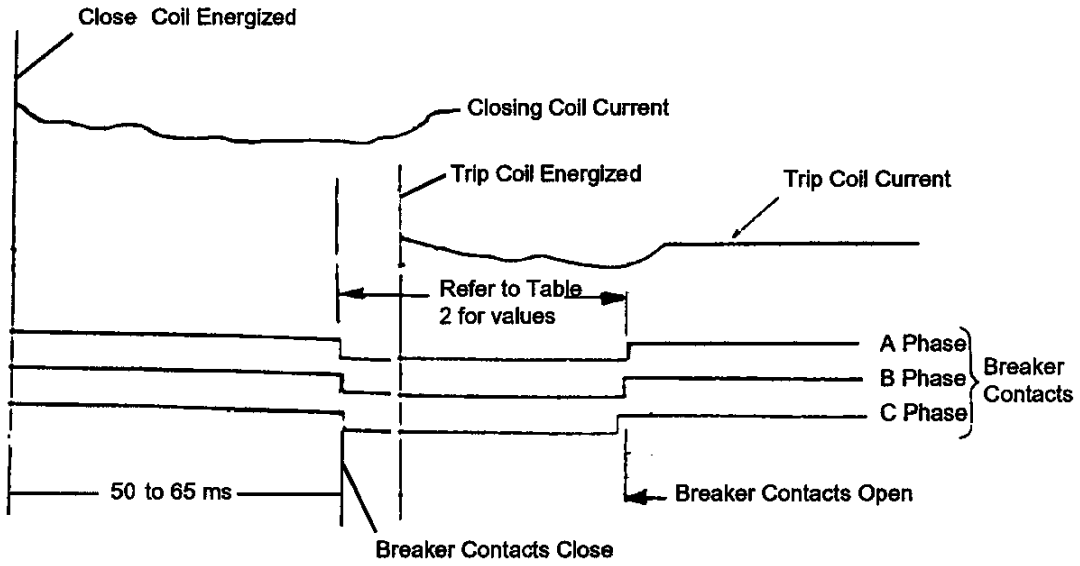
NOTE: All measurements at rated pressures and voltage.

Figure 6
OPEN Operation



NOTE: All measurements at rated pressures and voltage; does not include X-relay time.

Figure 7
CLOSE Operation



NOTE: All measurements at rated pressures and voltage.

Figure 8
CLOSE-OPEN Operation

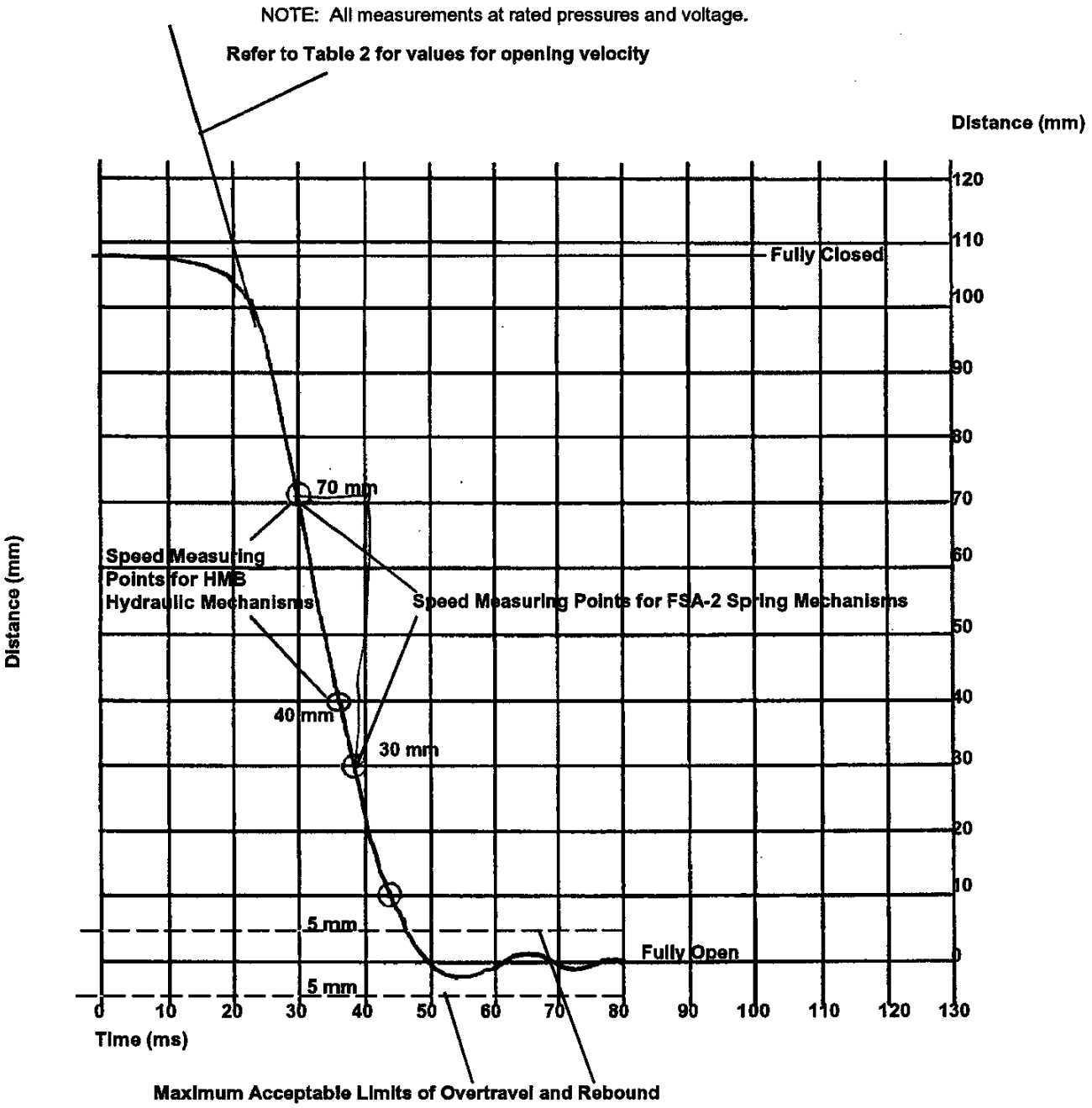
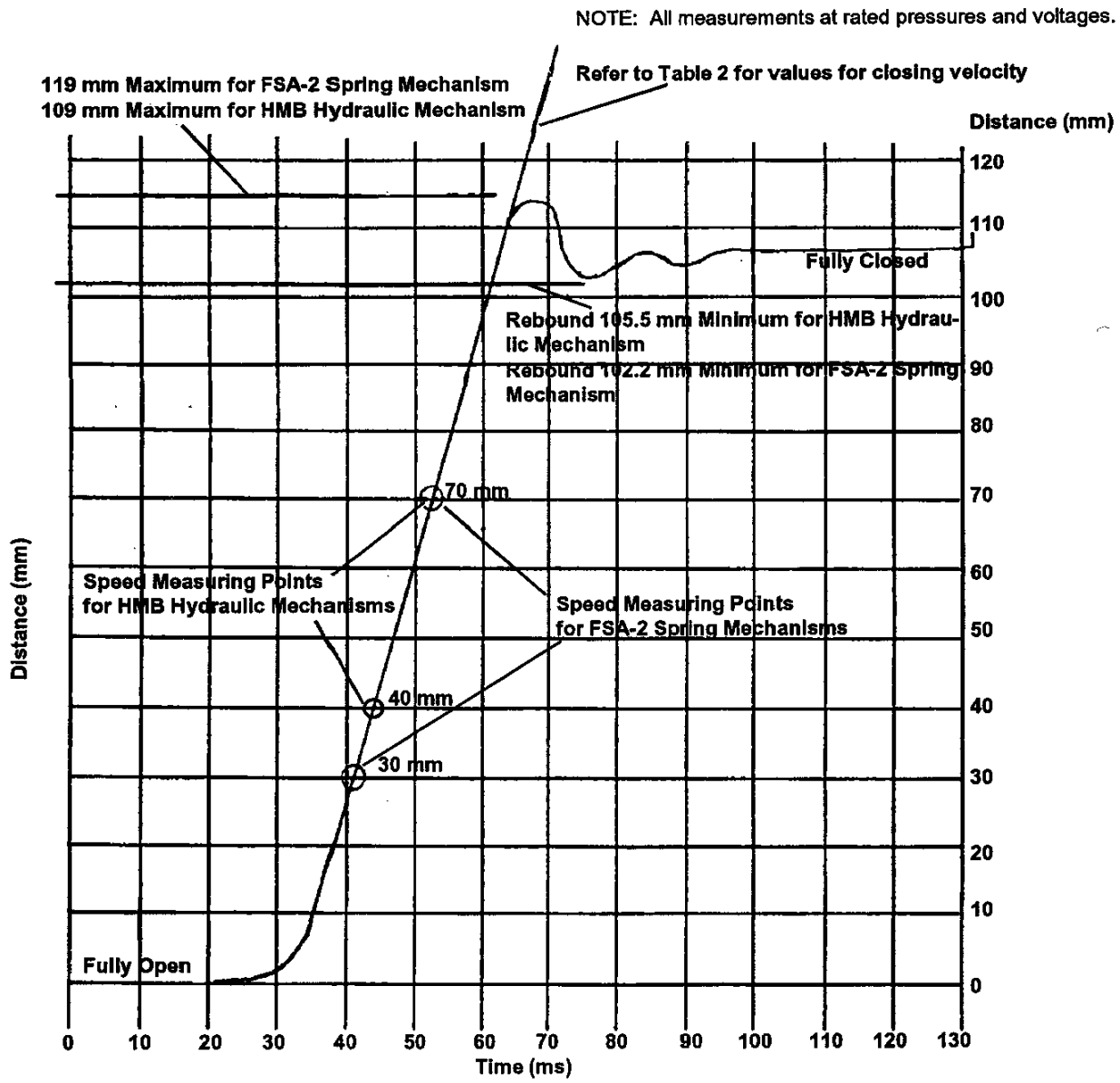


Figure 9
Typical Distance vs. Time Travel Curve for the Opening Operation



Breaker Stroke: 104.1 mm Minimum for FSA-2 Spring Mechanism

105.5 mm Minimum for HMB Hydraulic Mechanism

Figure 10
Typical Distance vs. Time Travel Curve for the Closing Operation

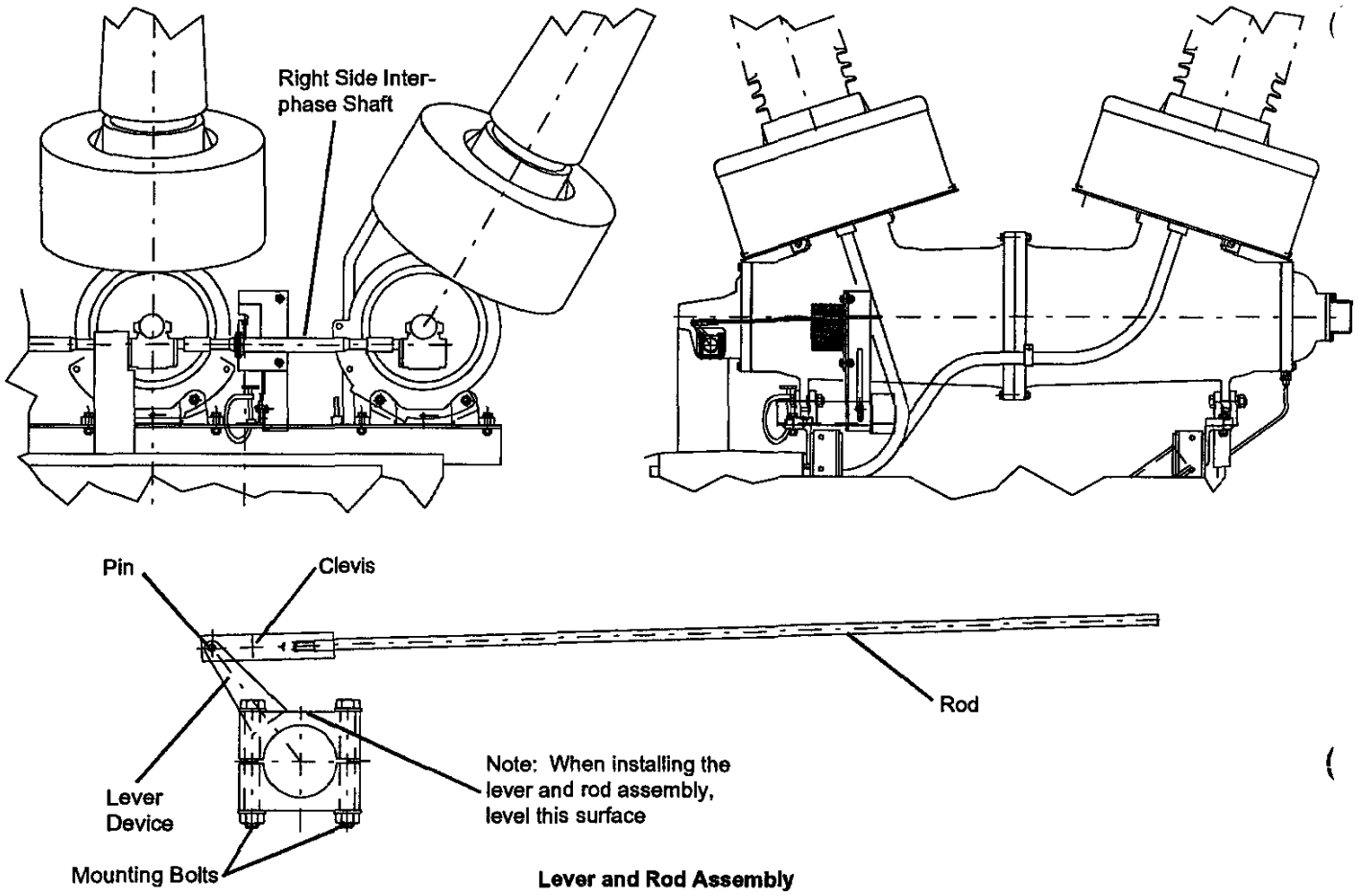


Figure 11
Travel Recorder Kit T13435

Travel Recorder Kit Mounting Instructions

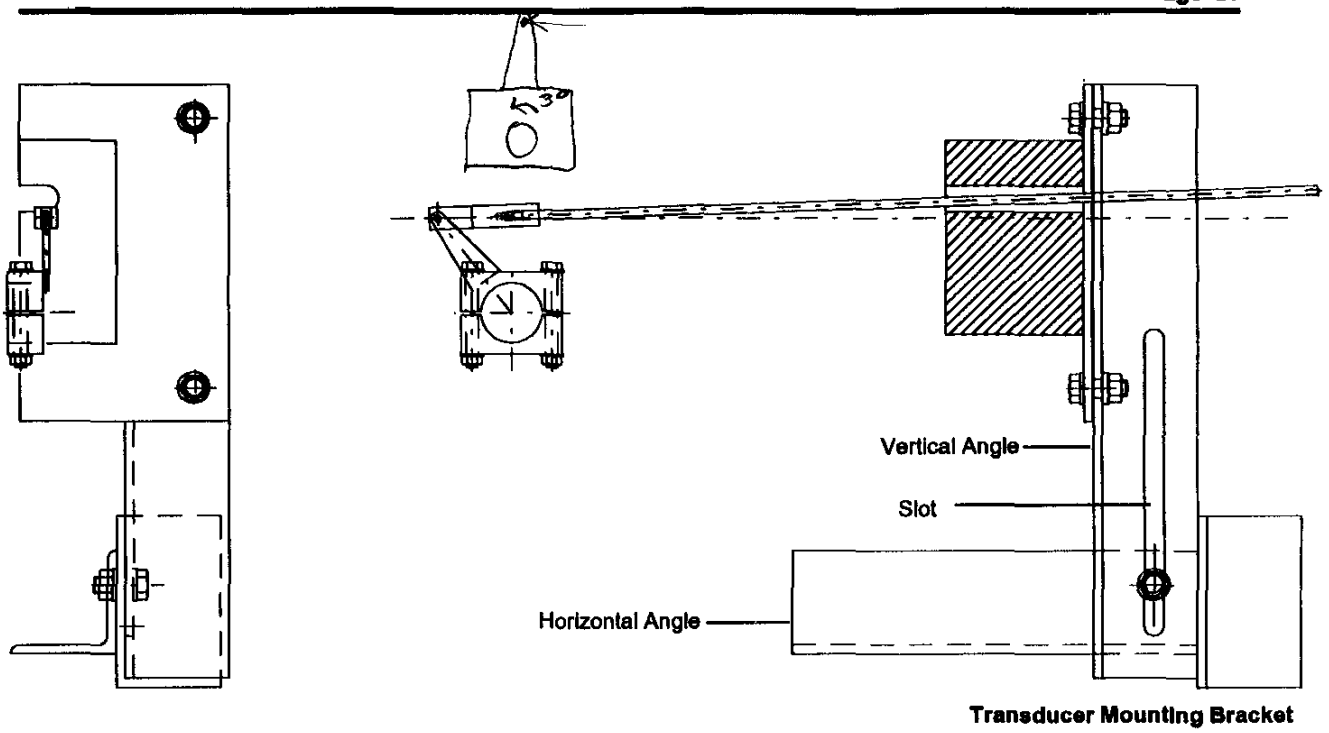
1. Open the circuit breaker and isolate it from the high voltage system. Properly ground the circuit breaker.
2. Discharge the mechanism (in the OPEN position) and disconnect all control and auxiliary power.
3. Remove the cover from the right side interphase shaft.
4. Loosely clamp the lever and rod assembly (Fig. 11) to the right side interphase shaft (at approximately the location shown in Fig. 11) using the mounting bolts provided with the kit. (The exact location where the assembly is clamped is not critical.)
5. While tightening the lever and rod assembly mounting bolts, place a level across the surface of the lever device as shown in Fig. 11 to level this surface of the lever device as closely as possible.

*Important: The travel recorder kit has been designed with enough flexibility so that it is not absolutely critical that the lever device be **exactly** leveled. Should the lever device be off level by a couple of degrees, it will not adversely affect the performance of the travel recorder kit.*

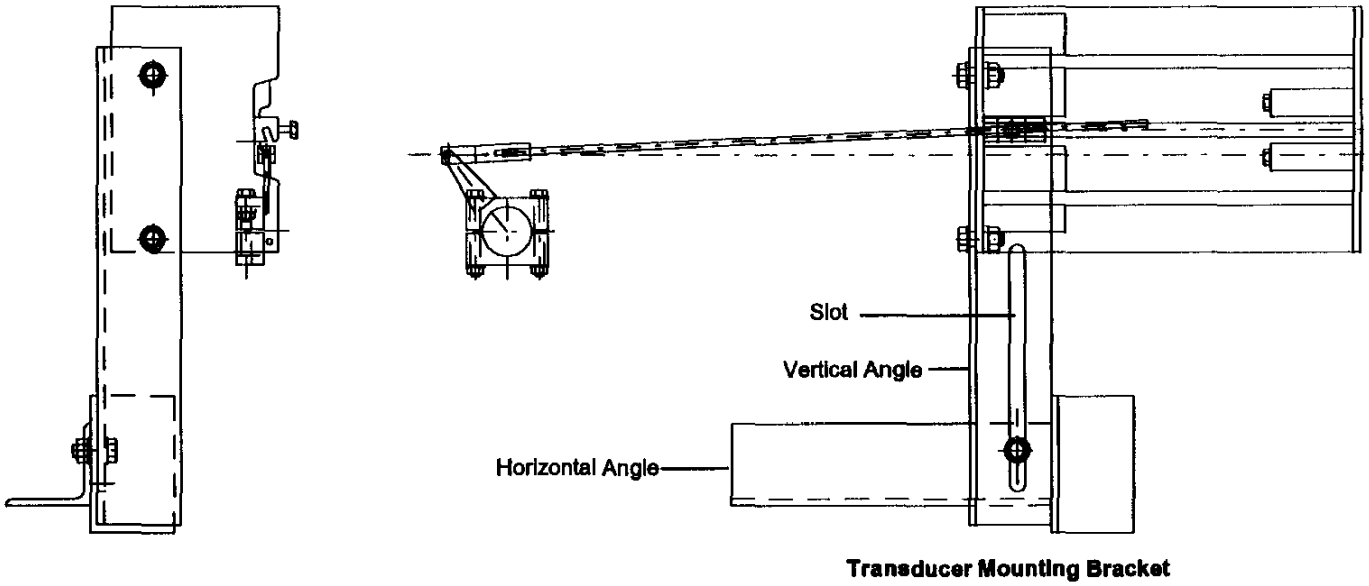
6. Assemble your transducer to the vertical angle of the transducer mounting bracket (Fig. 12) using either bolts or C-clamps. Figure 12 shows the mounting arrangement for two commonly-used transducer types.
7. Mount the transducer mounting bracket and transducer onto the horizontal member of the breaker structure (using C-clamps) as shown in Figure 11 so that the rod of the lever and rod assembly aligns with the slider or rollers, etc. of your transducer.
8. Adjust the height of the transducer by sliding the vertical angle of the transducer mounting bracket along the slot (Fig. 12) until the rod is visibly at a slight, upward angle as shown in Figure 12.

Important: Having the rod at an exact angle is not critical.

9. Connect the rod to the slider or rollers, etc. of your transducer.



Typical Mounting Arrangement for a Doble Roller-type Transducer



Typical Mounting Arrangement for a Doble Slider/Cable Transducer

Figure 12
Details for the Travel Recorder Kit Mounting

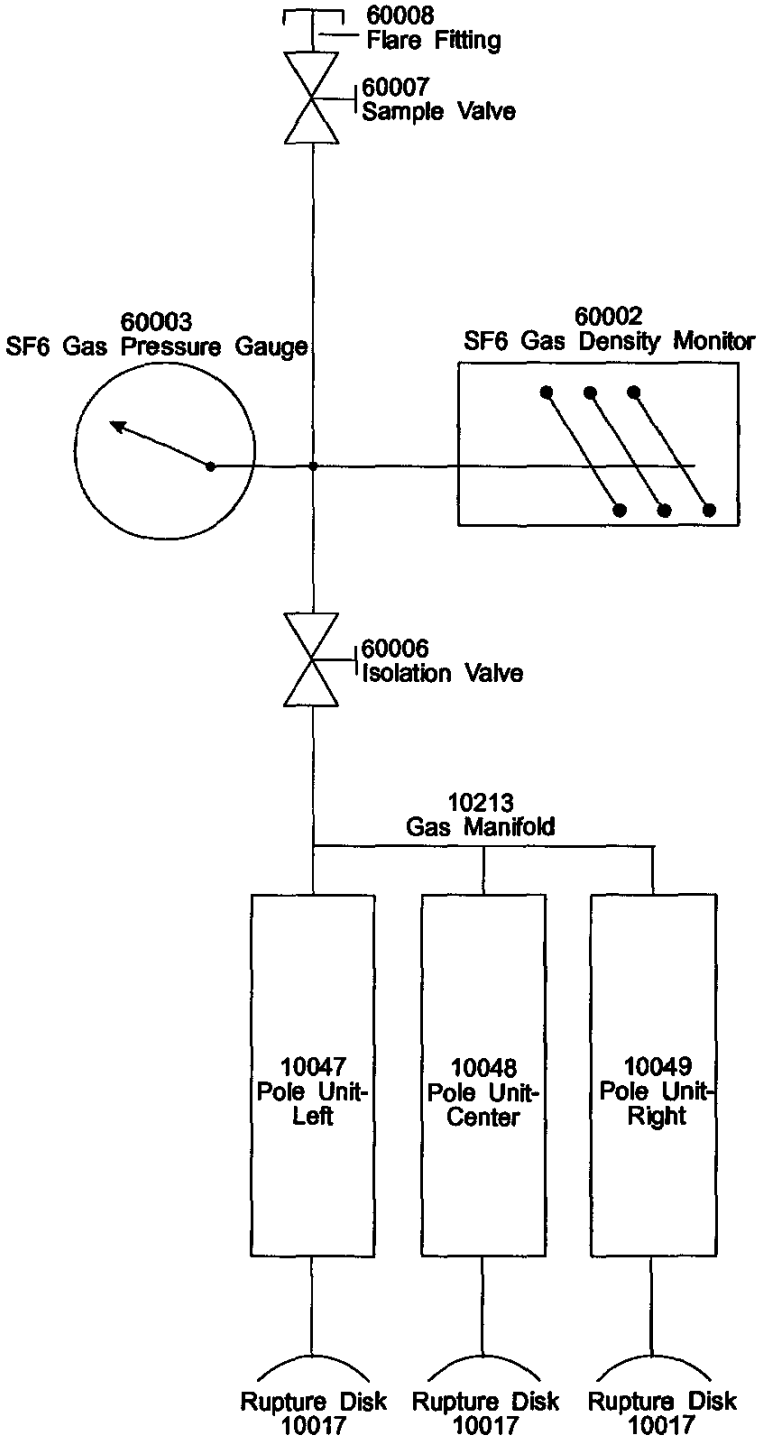
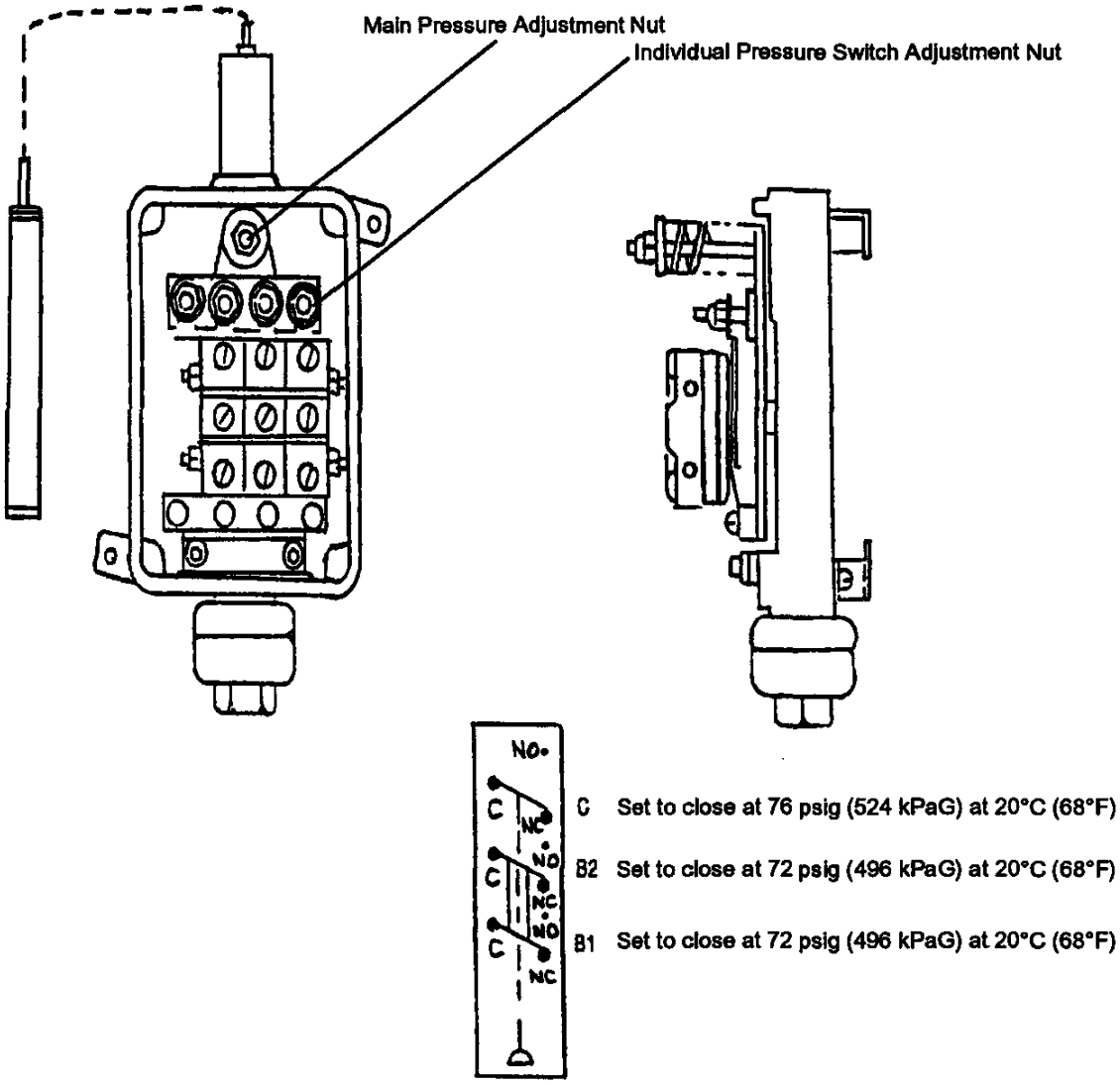


Figure 13
SF_6 Gas Schematic



Set each switch to the pressure indicated in Figures 3 and 4.

Figure 14
SF_6 Gas Density Monitor 60002

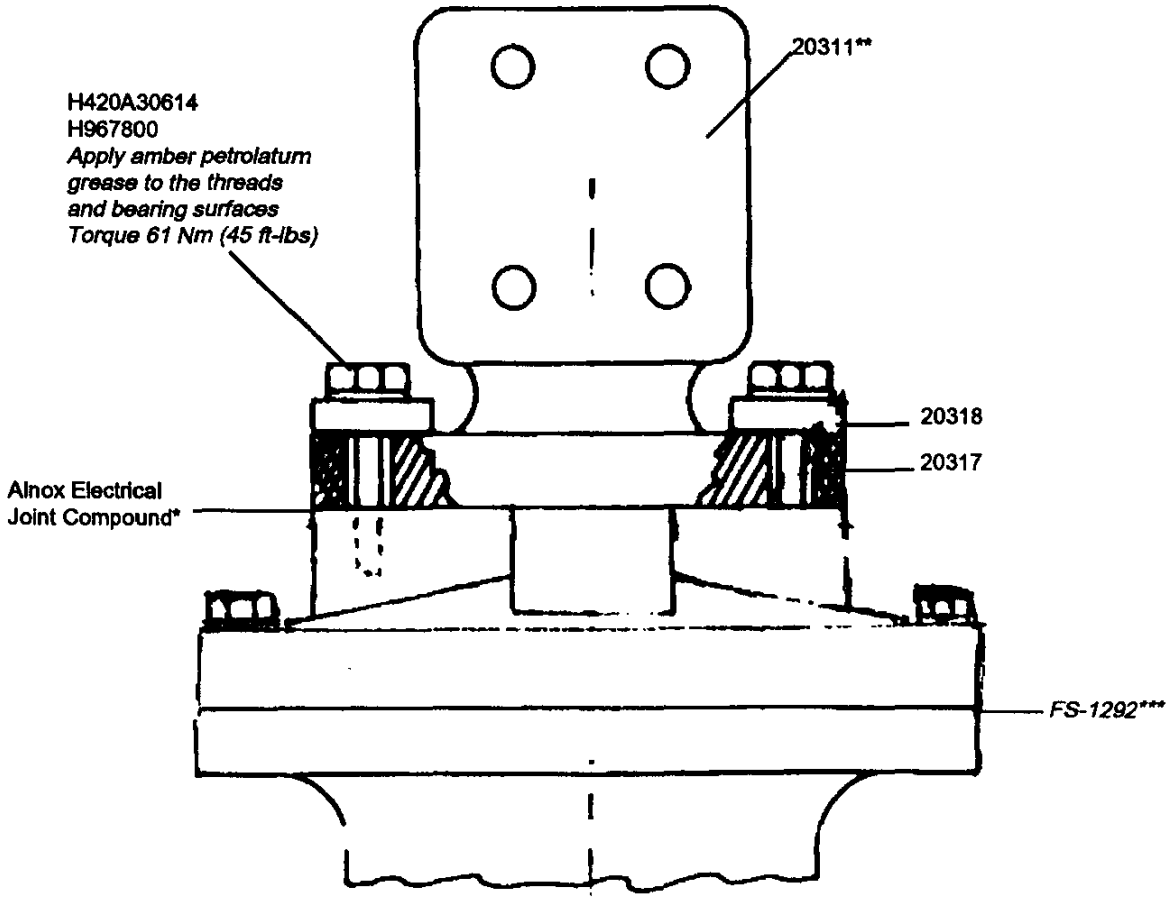


Figure 15
Terminal Pad 20311

20311	Terminal Pad
20317	Clamping Ring
20318	V-Clamps
H420A30614	Hex Head Bolt, M12 x 50
H967800	Belleville Washer, M12

*Requires surface preparation with Alnox Electrical Joint Compound as described in step 1 in section 4.3.

**Rotate to the desired orientation.

***Apply Dow Corning FS-1292 Grease to all flange surfaces outside of the O-ring groove to prevent corrosion.

Refer to Plate 2 for more details.

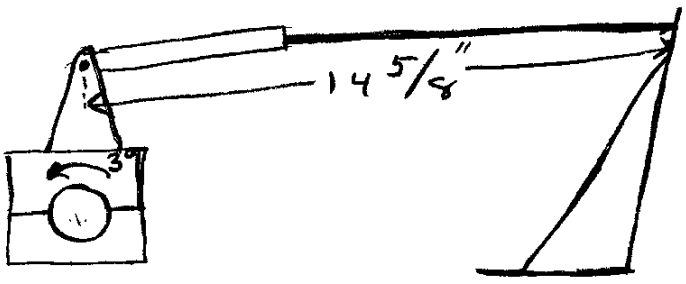
SF_6 Circuit Breakers

Type PM

Publication No. 720P008-02

145 PM Pole Unit®

PUT ON IN BKR OPEN POSITION



ASEA BROWN BOVERI

6 October 1993

Contents

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Notice 1

Based on our own experience, you will obtain the best possible operational reliability by following the recommendations given in these instructions. The data contained herein purports solely to describe the product, and it is not a warranty of performance or characteristics. It is with the best interests of our customers in mind that we constantly strive to improve our products and keep them abreast of advances in technology. This may lead to discrepancies between a product and these instructions.

Notice 2

Within the scope of these instructions, it is impossible to take into account every eventuality which may arise with technical equipment in service. Please consult our local salesman in the event of any irregularities, especially if not referred to herein.

Notice 3

We expressly decline liability for damages resulting from any incorrect operation or wrong handling of our equipment, even if these instructions contain no specific indication in this respect. We stress the fact that only genuine spare parts should be used for replacements.

Notice 4

This publication is a copyrighted work. Therefore, it is not permissible to disclose, reprint, copy, or reproduce any part of these instructions without express written permission from ABB.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the ABB Power T & D Company Inc. Power Circuit Breaker Division, 125 Theobold Ave., Greensburg, PA 15601, Phone No. (412) 838-5200.

Pole Unit

1 Introduction

A description of the pole units and related maintenance procedures for the 145 PM circuit breaker are given in this module. The procedure for isolating a pole unit is listed in the Interphase Linkage module.

1.1 Description

The 145 PM circuit breaker consists of three pole units coupled to a single operating mechanism through an interphase linkage assembly. Refer to the illustration on this page. The breaker is of a dead tank design in which an interrupter unit, suspended by an insulating support tube, is housed within a grounded aluminum tank. The cylindrical tank is made up of two identical halves bolted together in the center.

Each pole unit (Fig. 1) contains the following main components:

- Cylindrical aluminum pole tank;
- Two entrance bushings (front and rear);
- Bushing-type current transformers;
- Interrupter unit (and bellcrank assembly);
- Rupture disk.

Pressurized sulfur hexafluoride (SF_6) gas surrounds the interrupter and fills the tank and hollow porcelain entrance bushings. The gas functions as both an insulating and arc quenching medium.

A carbon rupture disk is fitted to the rear of each tank. This disk protects against excess pressure build-up which could otherwise lead to catastrophic failure of pressurized components. If the tank pressure exceeds 160 psig (well below the hydrostatic test pressures of all other pressurized components), the disk will rupture within a protective guard directing the exhausting gas and rupture disk fragments upward and away from personnel.

Porcelain entrance bushings are mounted to pockets at the front and rear of each tank. Bushing-type current transformers, mounted in protective covers, surround the pockets below the bushings. Refer to the respective module for further details about interrupters, bushings, and current transformers.

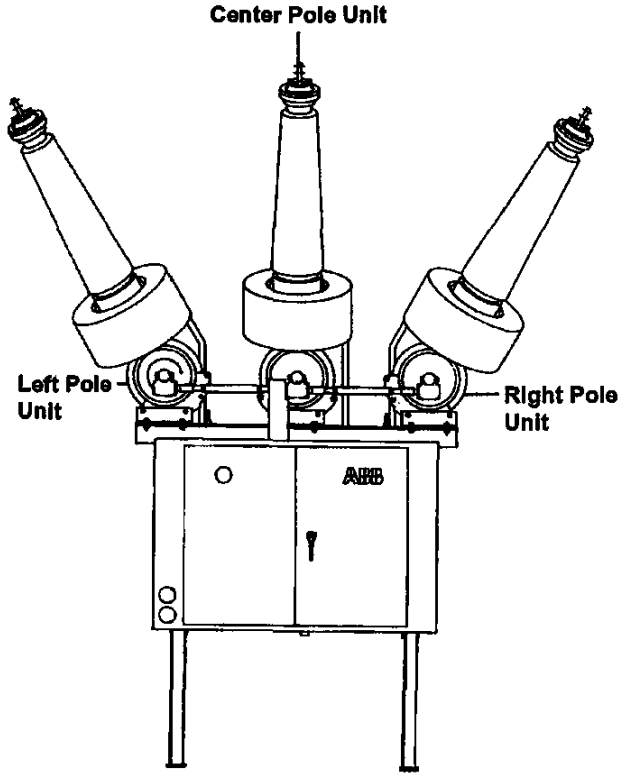
1.1.1 SF_6 Gas System

The pole tank and entrance bushings are pressurized to 87 psig (600 kPaG) at 20°C (68°F) with sulfur hexafluoride (SF_6) gas. Maintaining a proper gas density is critical to ensure the dielectric integrity of the pole unit.

The SF_6 gas density monitoring system compensates for pressure changes due to temperature variations and provides alarm and lock-out functions only if low gas density problems exist. Density monitor calibration and gas filling procedures are discussed in the Maintenance module of this manual.

1.1.2 Mechanical Interconnection

The three bellcrank assemblies (one for each pole unit) on the 145 PM breaker are tied together by the two interphase shafts (left and right) which are coupled to the mechanism pullrod through a crank at the center pole unit. The bellcrank assemblies are used to open and close the interrupters in the respective pole units. The crank at the center pole converts the vertical motion of the mechanism pullrod to the rotational motion of the interphase shafts. The bellcrank assemblies then convert this rotational motion to the horizontal motion of the interrupters. Refer to the Interphase Linkage module for more details.



2 General Maintenance Guidelines

The following sub-sections are general, recommended practices employed in the process of performing maintenance on the pole unit.

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance procedures.

2.1 General Cleanliness

Maintaining the cleanliness of the component surfaces in the breaker is an extremely important part of maintenance because the major insulating components in the breaker are subjected to high electrical stresses.

Because cleanliness is so important, care must be taken to perform internal breaker maintenance under clean, dry conditions.

Warning

The importance of cleanliness cannot be overstressed. Introducing loose dirt, especially metallic particles, into an open pole unit (SF_6 gas compartment) can cause dielectric failure. Insulating surfaces must be protected from physical, damage (nicks and scratches) and kept clean and dry at all times.

Loose dirt (especially metallic particles) as well as residue left from sweaty hands and atmospheric moisture can lead to dielectric failure. It is best to avoid handling critical insulating components with bare hands. Instead, wear snug-fitting cloth gloves when handling insulating parts and surfaces. To ensure cleanliness, wipe insulating surfaces with lint-free wipers dampened with denatured ethyl alcohol.

Important: Never clean an insulating component with the same wiper used to clean aluminum or metal parts.

2.2 Fastener Locking

Since the impact loading which the circuit breaker experiences during operation tends to loosen threaded hardware, Loctite Threadlocker must be applied to all critical bolted joints. Four types of Loctite are used for specific applications: 222, 242, 262, and 271. Table 1 specifies the recommended torque and type of Loctite to be applied to all fasteners in the breaker except where specified otherwise.

Clean the threads in blind holes if they can be adequately dried afterwards. Apply Loctite sparingly to the outermost edges of the thread. Two small drops of Loctite are enough even for large threads.

Hardware secured with Loctite usually can be unfastened with proper wrenches. In case of difficulty, the connection can be loosened by heating the joint to 150°C (300°F). Be careful not to damage materials which are sensitive to heat, such as insulation or sealing components.

Use particular care in applying Loctite to fasteners used in assembling current carrying connections. Apply Loctite only where specified. If used improperly, Loctite can squeeze between contact areas and may cause a high resistance joint. Ensure that excess Loctite does not squeeze into contact areas.

2.3 Seals

Sealing rings which have been in service will be deformed from being compressed into their sealing grooves. Therefore, when disassembling components with sealing rings, replace them. Replacements are available from ABB.

Maintenance tips pertaining to seals include:

1. Do not grease or lubricate O-rings or any other seals unless specified otherwise.
2. Never clean seals with abrasives even if they are very fine.
3. Use only lukewarm, soapy water to clean the seals.
4. Use a soft, dry cloth to dry the seals.
5. Always check seals for cracks, deformities, and brittleness before they are installed. Acceptable seals are flexible and free of cracks. Do not install seals that are cracked, brittle, or deformed.

2.4 Flange Corrosion Protection

The grease used in sealing joints (Dow Corning FS-1292) is intended to be used as a flange corrosion protectant only. This grease is to be applied to all flange surfaces outside of the O-ring seals, or in other words, to areas where water can become entrapped between metal-to-metal joints. Pay special attention to areas around bolts where moisture is most likely to enter. Apply Dow Corning Fluoro Silicone FS-1292 Grease in all such cases.

2.5 Treatment of Silverplating

Silverplated contact areas can be polished *lightly* with Scotch-Brite to remove surface oxide. Do not heavily abrade the silverplated surfaces to avoid rubbing off the plating.

In situations where sliding contact joints are used, such as in the case of the plug-in type bushing conductors or main breaker contacts, the silverplated areas must be lubricated with Shell Alvania No. 2 Grease. Thoroughly rub the grease into the microscopic pores of the silverplated surface; remove all excess grease so that only a light film remains.

Table 1

Recommended Fastener Torque
(If Not Specified)

Metric

		M5	M6	M8	M10	M12	M14	M16	M18	M20	
Metric Grade 5.8	ft-lbs	3	5	13	25	43	68	101	144	198	
	Nm	4	7	17	34	58	92	137	195	268	
Metric Grade 8.8	ft-lbs	5	8	20	38	66	105	156	223	306	
	Nm	6	11	27	52	89	142	212	302	414	
Metric Grade 10.9	ft-lbs	7	12	28	54	93	148	221	314	431	
	Nm	9	16	37	73	126	201	299	426	585	
{SS} GradeA2	ft-lbs	4	6	14	28	48	77	115	163	224	
	Nm	5	8	19	38	66	104	156	221	304	

U.S. Standard

		#10	1/4	5/16	3/8	1/2	9/16	5/8	3/4	7/8	1
SAE Grade 2	ft-lbs	3	6	12	21	51	72	99	171	219	327
	Nm	4	9	17	29	69	98	134	232	297	443
SAE Grade 5	ft-lbs	4	10	19	33	78	111	153	264	338	584
	Nm	6	13	26	45	106	151	207	358	459	792
SAE Grade 8	ft-lbs	6	14	27	47	110	157	216	373	631	942
	Nm	8	19	37	63	150	213	293	505	856	1278
18-8 SS Grade 2	ft-lbs	3	7	15	25	60	85	117	202	298	479
	Nm	4	10	20	34	81	116	158	274	405	649

Note: Do not exceed grade 5.8 torques when the fastener is threaded into cast aluminum or for button head socket bolts.

Note: Use Loctite 222 through 1/4-inch (M6) and Loctite 242 above 1/4-inch (M6). Keep Loctite off silverplated surfaces.

3 Pole Unit Maintenance Procedures

Pole unit maintenance includes all of the procedures listed in Table 2.

Table 2
Maintenance Procedure Quick Reference Table

Maintenance Procedure	Section(s) to Refer to in This Module
Complete Pole Unit Maintenance	Sections 3.2 to 3.11
Reclaiming SF6 Gas from the Pole Unit	Section 3.2
Opening the Rear Tank Cover Assembly and Cleaning the Tank	Sections 3.2 & 3.3
Removing the Interrupter	Sections 3.2, 3.3, & 3.4
Re-Installing the Interrupter	Section 3.5
Re-Installing the Bushing Top Terminal	Section 3.6
Replacing the Rupture Disk	Sections 3.3 & 3.7
Changing the O-Ring in the Pole Tank	Section 3.8
Replacing the Desiccant	Sections 3.2, 3.3, 3.9, & 3.10
Re-Installing the Rear Tank Cover Assembly	Section 3.10
Refilling the Pole Unit with SF6 Gas	Section 3.11

Important: When performing pole unit maintenance procedures, follow the maintenance guidelines discussed in section 2.

Because moisture can combine with the SF_6 decomposition products in an open breaker and form corrosive and conductive compounds, it is advised, if at all possible, to avoid performing internal breaker maintenance on rainy days or extremely humid days.

3.1 Equipment Required

The following materials and tools are required for pole unit maintenance (refer to the Maintenance module for vendors of special materials, i.e. grease, etc.):

- 1 Torque wrench - 10 to 150 ft-lbs;
- 1 Set box end and open end wrenches 5, 6, 7, 8, 9, 10, 13, 17, 19, 24, 41, and 46 mm;
- 1 Set box end and open end wrenches 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, and 15/16 inch;
- 1 Socket wrench, ratchet handle;
- 1 Set of sockets 4, 5, 6, 7, 8, 9, 10, 13, 17, 19, and 24 mm;
- 1 Set of sockets 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, and 15/16 inch;
- Slings, nylon 2-inches wide; 8 feet long;
- Portable vacuum cleaner;
- Sulfur hexafluoride (SF_6);
- Shell Alvania No. 2 Grease;
- Alnox Electrical Joint Compound;
- Amber Petrolatum Grease;
- Denatured ethyl alcohol;
- Loctite Threadlocker 242;
- Dow Corning Fluoro Silicone FS-1292 Grease;
- Scotch-Brite extra fine pads;
- Desiccant.

Special tools provided by ABB with each contract are:

- Bushing conductor removal tool T13441 (Fig. 2);
- Interrupter dolly T13445 (Fig. 3);
- DILO quick disconnect tool T13433 (Fig. 6).

DANGER

Before beginning any maintenance, isolate the breaker from high voltage and properly ground the breaker.

Warning

Discharge the mechanism springs. Open the disconnects in the control cabinet to all AC and DC power sources.

Any time a pole unit is to be opened, evacuate the system of all SF_6 gas and reclaim the gas using the procedure described in section 3.2.

3.2 Reclaiming SF_6 Gas from a Pole Unit

Use the procedure described in this section to reclaim SF_6 gas from a pole unit. The gas must be reclaimed any time a pole unit is to be opened.

DANGER

Remove the SF_6 gas before attempting to open the pole unit. Break the vacuum if the tank pressure is below atmospheric pressure.

Use a gas service unit to reclaim SF_6 gas from the pole unit. The gas service unit not only reclaims and stores the SF_6 gas but also, if equipped with the appropriate filters, can remove decomposition products from the gas.

Important: It is not economical or environmentally wise to exhaust the SF_6 gas to the atmosphere.

The gas service unit should be used to reclaim SF_6 gas only. Therefore, no air or other gases should ever be in the tank of the gas service unit. Check that air is purged from the unit and that the SF_6 gas already contained in the unit is of good quality (particularly in regards to gas moisture content). Use a moisture analyzer to check the moisture content of the gas in the gas service unit.

Review the manufacturer's instructions for the gas service unit if you are not already familiar with the unit.

To reclaim SF_6 gas from the pole unit:

1. Connect the flexible hose from the gas service unit to the DILO quick disconnect tool T13433 (Fig. 6) supplied with the standard breaker tools.
2. De-couple the pole unit to be serviced from the SF_6 gas manifold by loosening the self-sealing DILO quick disconnect fitting 10171 (Fig. 6) at the rear tank cover assembly 10032 (refer to Plate 1). The de-coupled fitting will seal on both sides so that no SF_6 gas can be lost from the pole units.
3. Evacuate the hose from the gas service unit to drive out air and moisture using the vacuum pump. (The de-coupled DILO quick disconnect tool will be sealed.)
4. Turn off the vacuum pump.
5. Connect the DILO quick disconnect tool to the rear tank cover half of the self-sealing fitting and let the high pressure gas flow from the pole unit to the service unit. Refer to Plate 1.

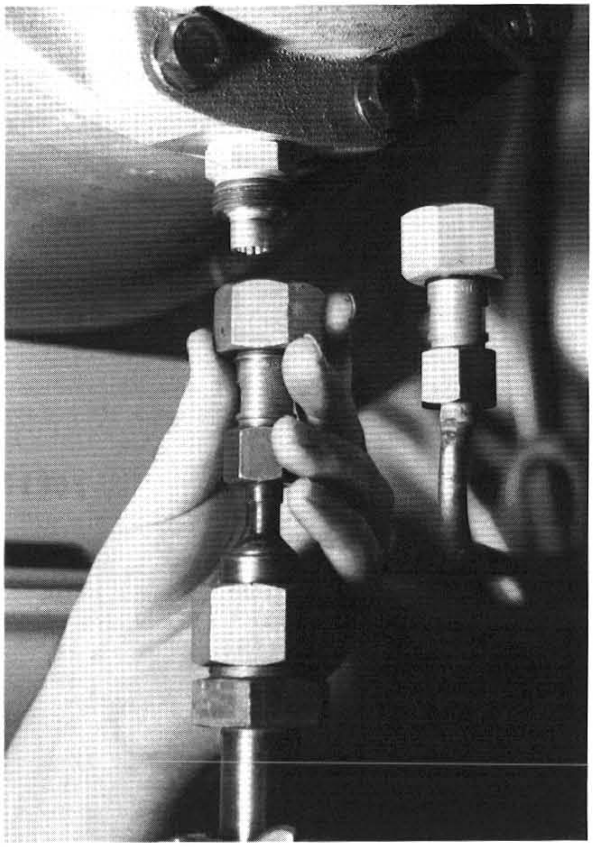


Plate 1: Quick disconnect fitting

6. Follow the gas service unit procedures step-by-step to reclaim the SF_6 gas until a vacuum of about 2 mm Hg is achieved. Then close all valves on the gas service unit. Break the vacuum.
7. Repeat this procedure for each pole unit to be opened.
8. Since breaking the vacuum fills the pole unit with moist atmospheric air, it is strongly recommended to open the pole unit and clean the internal components of the pole tank promptly after breaking vacuum. Refer to section 3.3.

3.3 Opening the Rear Tank Cover Assembly and Cleaning the Tank

When opening the rear tank cover assembly, certain precautions must be taken:

1. Reclaim the SF_6 gas from the pole unit as described in section 3.2.
2. Be sure to wear gloves, protective clothing, and a respirator before opening the rear tank cover assembly.
3. Review section 3.3.1 before opening the pole unit.

3.3.1 Precautions Before Opening the Pole Unit

When opening a pole unit, you could be exposed to SF_6 decomposition products (which are formed by heat produced during current interruption). Observe all safety precautions pertaining to handling SF_6 gas and its by-products. Before proceeding with any pole unit maintenance, refer to the module Safe Handling Practices for SF_6 Gas to review procedures on handling and disposing of SF_6 decomposition products.

Warning

In its natural state, SF_6 gas is colorless, odorless, tasteless and possesses a low level of toxicity. The danger in breathing SF_6 gas is that it displaces oxygen and can cause suffocation. If SF_6 is subjected to an electric arc, toxic decomposition products are formed. Sulfur fluorides are the most toxic and are in gaseous form. The less toxic metal fluorides are in the solid or powder form. The amount of decomposition is a function of the intensity and the duration of the arc.

Some of the SF_6 decomposition products form corrosive and conductive compounds when exposed to moisture in the air. These compounds, which can injure human beings, also are aggressive towards materials within the circuit breaker, especially insulating surfaces, if subjected to prolonged exposure. That's why it's best not to perform breaker maintenance on rainy or humid days.

Before opening the pole unit and performing an internal inspection, wear gloves, protective clothing, and a respirator.

Warning

Solid decomposition products could be harmful if swallowed by humans or animals. Do not inhale or allow decomposition products to come in contact with the skin, eyes, and respiratory system. Severe irritation or burning may result.

Use a gas service unit to reclaim SF_6 gas from the breaker by following the procedure described in section 3.2.

After vacuum is broken, open the pole unit and clean the tank to eliminate corrosive decomposition products. Refer to sections 3.3.2 and 3.3.3.

3.3.2 Opening the Pole Unit

Wearing the necessary safety gear and having evacuated the SF_6 gas from the pole unit, the rear tank cover is ready to be removed.

To open the pole unit:

1. Remove the twelve 1/2-inch hex head bolts H800A45711 (Fig. 1) holding the rear tank cover assembly 10032 in place.
2. Allow the tank to properly ventilate. Then proceed to clean the pole tank as described in section 3.3.3. Refer to Plate 2.

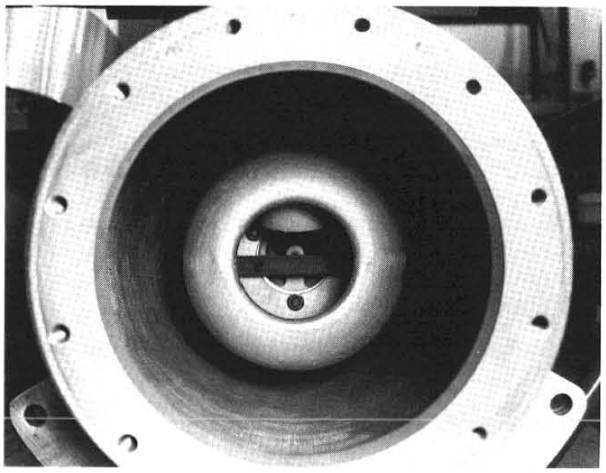


Plate 2: Opening the pole unit

3.3.3 Cleaning the Pole Tank

Before cleaning the pole tank, review the module Safe Handling Practices for SF_6 Gas.

To clean the pole tank:

1. Collect all powdered decomposition products with an approved vacuum cleaner.
2. Wipe all internal tank surfaces, especially insulating surfaces, with lint-free wipers dampened with denatured ethyl alcohol.
3. Remove the interrupter and bushing, if necessary, to clean out any lingering decomposition products. Refer to section 3.4 to remove the interrupter; refer to the Porcelain Entrance Bushings module to remove the bushing.

Caution

SF_6 decomposition products form aggressive compounds when exposed to moisture in the air. These compounds are detrimental to breaker components, especially insulating components, such as interrupter support tubes and porcelain entrance bushings. If decomposition products are present upon opening a tank, they must be cleaned away as quickly as possible. Cleaning may involve removing the interrupter unit as discussed in section 3.4 and the bushings as described in the Porcelain Entrance Bushings module.

To re-install the rear tank cover assembly with a new desiccant bag, refer to sections 3.9 and 3.10.

Important: *Do not leave the pole tank open overnight. Re-install the end covers with a few bolts to keep out debris and moisture.*

3.4 Removing the Interrupter Unit

Before removing the interrupter unit 30000 or 30121 or 30122 (Figs. 1 and 4) for expanded maintenance, the following maintenance procedures must be performed:

- Remove the appropriate interphase shaft(s) (refer to the Interphase Linkage module);
- Reclaim all SF_6 gas (refer to section 3.2 in this module);
- Open the rear tank cover assembly (refer to section 3.3 in this module).

To remove an interrupter unit:

1. Remove the rear tank cover assembly 10032 (Fig. 1), which contains the rupture disk by unscrewing the twelve 1/2-inch hex head bolts H800A45711. Store in a clean area. Clean the tank as per section 3.3.3.
2. Remove the two M8 nuts H420A50008 (Fig. 5) and washers H420A60008 mounting the deflector 30075 within the rear exhaust shield 30077 of the interrupter unit.
3. Remove the M12 nut H420A50012 fastening the rear exhaust shield to the bottom of the bushing conductor 20001 (Fig. 1).
4. Disconnect the high voltage connections to the entrance bushings of the pole unit at the (four-hole NEMA) terminal pad 20311 (Fig. 7).
5. Remove the terminal pads 20311 from the bushing top caps (front and rear) so that the bushing conductor removal tool T13441 (Fig. 2) can be attached.
6. Remove the six 1/2-inch hex head bolts H800A45708 (Fig. 1) and washers H420A64012 from the bushing top flange.
7. Pull each plug-in bushing conductor 20001 (front and rear) from their respective plug-in connections 30052 (Fig. 4) using the bushing conductor removal tool T13441 (Fig. 2) as detailed in the steps below. The bushing conductor removal tool is a puller used to withdraw the plug-in bushing conductors from their female connections on the interrupter. The tool is made up of a T-bracket, studs, horseshoe washers, and a jacking screw. To pull each bushing conductor from its plug-in connection:
   a. Screw the three studs of the bushing conductor removal tool into the bushing top flange 120 degrees apart (into the vacant holes from bolts removed in step 6).
   b. Bolt the jacking screw (Fig. 2) onto the top cap of the bushing using the bolts provided with the tool. (The jacking screw replaces the four-hole NEMA terminal pad.)

c. Place a horseshoe washer (Fig. 2) (provided with the tool) in the slot of each stud to support the T-bracket on the studs above the bushing cap. Secure the T-bracket to the studs using the provided nuts and flat washers.

d. Jack the bushing conductor from its plug-in connection by turning a nut onto the jacking screw. The bushing conductor will need to be raised approximately 2 inches until the conductor is disengaged.

e. Once the bushing conductor is free from its plug-in connection, remove the T-bracket, horseshoe washers, and the jacking screw.

f. Carefully lift the bushing conductor by hand while supporting it at its lower end. Lift the bushing conductor above the slots in the studs and re-install the horseshoe washers to allow the assembly to rest on the horseshoe washers.

g. Screw the three nuts provided with the tool back onto the studs to firmly fix the retracted bushing conductor in place.

h. Cover the open top of bushing with a plastic bag to prevent debris from entering the bushing.

8. Position the interrupter dolly T13445 (Fig. 3) under the rear exhaust shield 30077 (Fig. 4) of the interrupter unit. Refer to Plate 3.

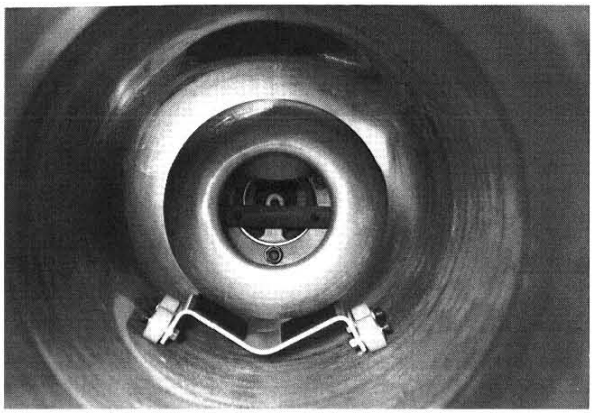


Plate 3: Positioning the interrupter dolly

9. To remove the interrupter, unscrew the twelve 1/2-inch hex head bolts H800A45711 (Fig. 1) at the bellcrank housing. (A line-up pin between the bellcrank housing and the tank prevents the interrupter from dropping.)

Important: The weight of interrupter and bellcrank is approximately 65 kg (143 lbs.).

10. With two persons on the bellcrank end of the interrupter, carefully roll the interrupter from the pole tank. A third person should support the rear exhaust shield end of the interrupter unit as the unit is withdrawn from the tank. Refer to Plate 4.

Caution

Protect the interrupter insulating support tube from being scratched or otherwise damaged.

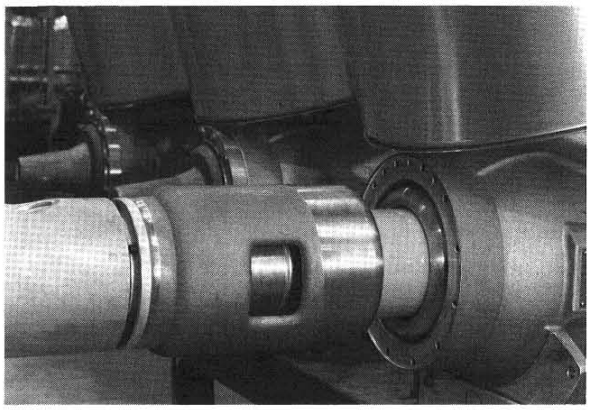


Plate 4: Removing the interrupter

11. Move the interrupter to a dry, clean area for disassembly. For instructions on disassembling and re-assembling the interrupter, refer to the Interrupters module of this manual.

3.5 Re-Installing the Interrupter Unit

Before re-installing an interrupter unit 30000 or 30121 or 30122 (Fig. 4), carefully clean the interrupter unit with lint-free wipers and denatured ethyl alcohol, paying special attention to the interrupter insulating tubes.

Important: Never clean an insulating tube with the same wiper used to clean aluminum or metal parts.

To re-install the now clean interrupter unit:

1. Place an O-ring 90002 (Figs. 1 and 4) over the interrupter unit and press it firmly and snugly into the groove at the bellcrank. Apply Dow Corning FS-1292 Grease to the flange surface outside of the O-ring to prevent corrosion. (Also, refer to sections 2.3 and 2.4 for general guidelines pertaining to O-ring seals and flange corrosion protection).

2. Grease the sliding surface area of the plug-in connections 30052 (Fig. 4) with Shell Alvania No. 2 Grease. Thoroughly rub the grease into the pores of the silver-plated surfaces; remove any excess grease so that only a light film remains.

3. Clean the inside surface of the pole tank 10015 (Fig. 1) with a vacuum cleaner and lint-free wipers dampened with denatured ethyl alcohol.

4. Since the O-ring in the top flanges of the bushings are disturbed when the interrupter unit is removed, these O-ring seals must be replaced as follows:

   a. Pull the old 90001 (Fig. 1) from the groove in the top cap of the bushing.

   b. Cut the O-ring to remove it.

   c. Drop a clean length of string through the hollow bushing and into the pole tank.

   d. Tie a new O-ring 90001 to the string and use the string to pull the O-ring over the bushing conductor 20001 up to the top cap.

   e. Thoroughly clean the O-ring groove with a lint-free wiper dampened with denatured ethyl alcohol.

   f. Firmly press the new O-ring into the groove.

   g. Apply Dow Corning FS-1292 Grease to the flange surface outside of the O-ring to prevent corrosion.

   h. Repeat steps **a** through **g** to replace all other affected top cap O-rings.

5. Position the interrupter dolly T13445 (Fig. 3) at the bottom of the pole tank, near the front. Refer to Plate 5.

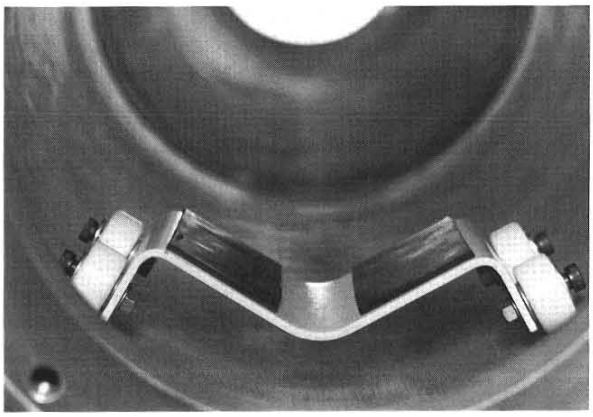


Plate 5: Interrupter dolly

6. With two persons on the bellcrank end of the interrupter unit and a third person at the rear exhaust shield, lift the interrupter unit into the pole tank placing the rear exhaust shield onto the interrupter dolly.

7. Using the interrupter dolly, roll the interrupter unit into place.

Caution

Protect the interrupter insulating support tube from being scratched or otherwise damaged.

8. Install the twelve 1/2-inch hex head bolts H800A45711 (Fig. 1) with washers H420A64012 at the bellcrank housing. Place a drop of Loctite 242 on each bolt and torque to 61 Nm (45 ft-lbs).

9. Remove the nuts and horseshoe washers (Fig. 2) holding the bushing conductor in the retracted position.

10. Carefully lower and push the bushing conductor into place.

11. Remove the studs from the bushing top flange and re-install the six 1/2-inch hex head bolts H800A45708 (Fig. 1) and washers H420A64012 at each bushing cap. Apply Loctite 242 and torque to 45 Nm (33 ft-lbs).

12. If the three M12 nuts H420A50012 (Fig. 5) that mount the rear exhaust shield 30077 to the stationary contact assembly 30019 of the interrupter are tight, loosen them to allow the rear exhaust shield to be centered within the pole tank as discussed in the next step.

13. Re-install the M12 nut H420A50012 and washer H973A32701 that connect the bushing conductor to the rear exhaust shield 30077. Apply Loctite 242 to the stud and turn the M12 nut H420A50012 to jack up the rear exhaust shield until it is approximately centered within the pole tank. (The nut will not need to be torqued or completely tightened; a fork on the deflector 30075 will lock the nut into position.) Use inside calipers to verify that the rear exhaust shield is approximately centered in the pole tank.

14. Re-tighten the three M12 nuts H420A50012 and flat washers H420A60012 which connect the rear exhaust shield 30077 to the stationary contact assembly 30019. Apply Loctite 242 and torque to 72 Nm (52 ft-lbs). (These were the nuts that were loosened in step 12.)

15. Re-install the two M8 nuts H420A50008 and washers H420A60008 mounting the deflector 30075.

Proceed to the respective sections for remaining tasks:

- Re-install the bushing top terminal (section 3.6);
- Replace the rupture disk (section 3.7);
- Replace the desiccant bag (section 3.9);

Finally proceed to sections 3.10 and 3.11 to re-install the rear tank cover assembly and refill the pole unit with SF_6 gas.

3.6 Re-Installing the Bushing Top Terminal

Each 145 PM circuit breaker is provided with six four-hole NEMA terminal pads 20311 (Fig. 7) as part of the field assembly materials. Refer to Plate 6.

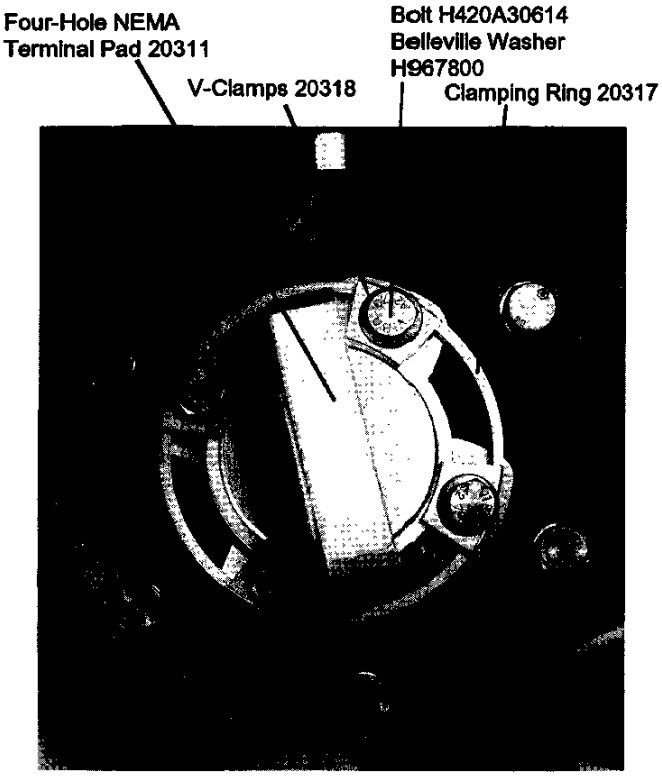


Plate 6: Installing the bushing top terminal

To install the terminal pad 20311 (Fig. 7) to the top cap of the bushing conductor 20001 (Fig. 1):

1. Coat the mating surfaces between the terminal pad 20311 (Fig. 7) and top cap of the bushing with Alnox Electrical Joint Compound (found in the service kit). Abrade both contact surfaces with a wire brush to remove dirt and oxides. Completely wipe off the Alnox with a clean, lint-free wiper and immediately apply a new coat of Alnox to both mating surfaces to prevent oxidation.
2. Position the terminal pad on the top cap of the bushing.
3. Place a clamping ring 20317 (Fig. 7) over the terminal with the drip slots at the bottom of the clamping ring.
4. Place four V-clamps 20318 between the clamping ring 20317 and terminal pad and over the holes in the top cap of the bushing.
5. Place a belleville washer H967800 (Fig. 7) on each of the four M12 hex head bolts H420A30614. Apply Amber Petrolatum Grease to the bearing surfaces and the threads of each bolt. Place a bolt through each V-clamp, and screw the bolts into the four holes of the top cap of the bushing.
6. Turn the terminal pad to the desired orientation (the terminal can be turned 360 degrees) and torque the bolts to 61 Nm (45 ft-lbs).

3.7 Replacing the Rupture Disk

Each pole tank is equipped with a carbon rupture disk 10017 (Fig. 6). If the disk ruptures (for example from over-pressurization due to over-filling or as the result of a defective disk, etc.) it needs to be replaced.

Before replacing the rupture disk, open the rear tank cover assembly as described in section 3.3.

To replace the rupture disk:

1. Remove the rear tank cover assembly 10032 (Fig. 1) by unscrewing the twelve 1/2-inch hex head bolts H800A45711 and flat washers H420A64012.
2. Lift off the cover and place it on a clean work surface.
3. Remove the three set screws H800A47608 (Fig. 6).
4. Remove the six bolts H800A47507 (one) and H800A47513 (five) which allow for removal of the rupture disk protective cover 10028 and rupture disk holding ring 10036.
5. Remove the 1/32-inch thick gasket 10040, rupture disk 10017, solid gasket 10039, and pressure gasket 10041.
6. Clean all *metal* parts with lint-free wipers dampened with denatured ethyl alcohol.
7. Grease the side wall and bottom of the rupture disk cavity in the rear tank cover flange 10035 with Dow Corning FS-1292 Grease.
8. Install a new pressure gasket 10041, solid gasket 10039, and rupture disk 10017 placing the flat side against the solid gasket.
9. Place the 1/32-inch thick gasket 10040 on top of the rupture disk. Re-position the rupture disk holding ring 10036 and rupture disk protective cover 10028 onto the rear tank cover flange 10035.
10. Re-install the six bolts H800A47507 (one) and H800A47513 (five) with washers HNB335050P609. Apply a drop of Loctite 242 to the threads of each bolt and torque to 27 to 32 ft-lbs (37 to 43 Nm).
11. Apply a drop of Loctite 242 to the three set screws H800A47608 and screw them back into their holes until they just touch the rupture disk holding ring 10036.
12. Proceed to turn each set screw H800A47608 1/2 turn at a time in a rotational sequence until each set screw has been turned a total of 1-1/2 turns.

Replace the desiccant bag with a new desiccant bag as described in section 3.9 and then re-install the rear tank cover assembly as described in section 3.10.

3.8 Replacing the Pole Tank O-Rings

The pole tank 10015 (Fig. 1) is made up of two identical halves 10052 bolted together in the center. The SF_6 gas is sealed by a double O-ring sealing system where the tank halves join.

Important: *When replacing these O-rings, the SF_6 gas (section 3.2), interrupter (section 3.4), and porcelain entrance bushings must be removed and then the tank must be lifted from the support structure. Figure 8 details the tank mounting hardware. Refer to the Porcelain Entrance Bushings module of this manual for instructions on removing the porcelain entrance bushings.*

To replace these O-rings (during major maintenance, etc.):

1. Remove the 1/2-inch hex head bolts H800A46315 (Fig. 1), washers H420A64012, and nuts H673A15609 which hold the halves together.
2. Thoroughly clean the O-ring grooves with lint-free wipers dampened with denatured ethyl alcohol.
3. Replace the inner and outer O-rings 90014 and 90015 with new O-rings.
4. Grease the flange surfaces outside of the O-rings with Dow Corning FS-1292 Grease.
5. Rejoin the tank halves, being certain that the O-rings are properly situated. Re-install the 1/2-inch hex head bolts H800A46315 (Fig. 1), washers H420A64012, and nuts H673A15609. Apply Loctite 242 and torque to 93 Nm (70 ft-lbs).

3.9 Replacing the Desiccant

"Desiccant" refers to a molecular sieve which removes moisture as well as SF_6 decomposition products from the gas. A desiccant bag 10008 (Fig. 6) is installed in every pole unit at the rear tank cover assembly 10032, just behind the rupture disk.

Important: *Any time that a pole unit has been opened or otherwise exposed to the atmosphere, replace the desiccant bag . The desiccant bag should be installed immediately before the pole unit is closed with the evacuation process following soon thereafter to prevent prolonged exposure to moist atmospheric air.*

Before replacing the desiccant bag, perform the following maintenance procedures:

- Remove all SF_6 gas from the tank as per section 3.2.
- Open the rear tank cover as described in section 3.3.

To replace the desiccant bag:

1. Obtain a new desiccant bag 10008 (Fig. 6). These bags are shipped in a hermetically sealed reinforced aluminum foil bag to prevent contamination due to atmospheric moisture. The date of manufacture is marked on the outer bag.

Important: *Do not use any desiccant bags marked with a date that is over two years old.*

2. Carefully open the outer aluminum bag at one end. If using a knife or scissors, be careful not to tear the inner bag when opening the outer bag. Immediately check that the dot on the moisture indicator tag included in the bag is blue. If it is not blue, the outer bag may have been damaged. In this case, do not use the new desiccant bag; discard it and get a new one.

   The protective outer bag is sealed under vacuum as indicated by the "tight-fit." However, in very warm ambient temperatures, the molecular sieve gives off air it has absorbed which may cause the outer bag to expand and look like a pillow. This does not necessarily indicate that the desiccant is ineffective; the desiccant bag still is usable.

3. Install the desiccant bag by removing the three M6 Phillips head bolts H420A20513 (Fig. 6), which hold the cover 10037 and spacers 10038 in place. Place the new desiccant bag between the cover and spacers and reinstall. Apply Loctite 242 and tighten each bolt. (Refer to Plate 7.)

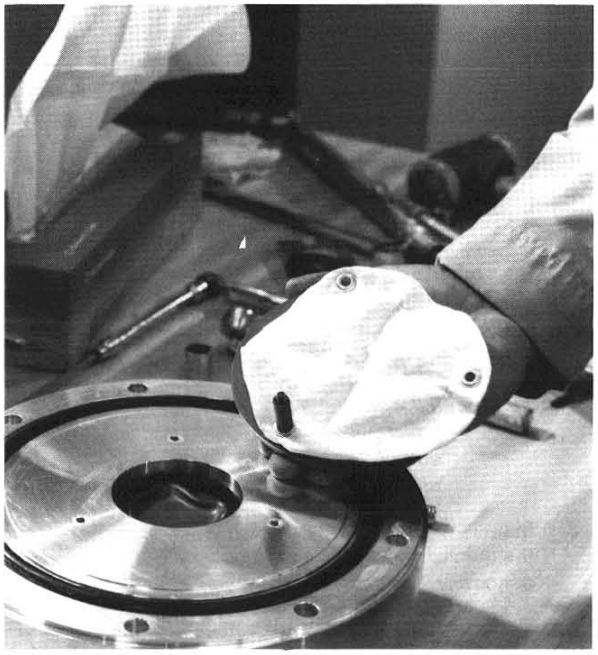


Plate 7: Installing the desiccant bag

4. Discard used desiccant bags with other decomposition products. Regenerating the desiccant for reuse, although possible, is not recommended. Use precautions described in section 3.3.1 when removing the desiccant bags.

Re-install the rear tank cover assembly and apply vacuum as soon as possible to avoid over-exposing the desiccant to moist atmospheric air. Refer to section 3.10.

3.10 Re-installing the Rear Tank Cover Assembly

To install the rear tank cover assembly 10032 (Fig. 6) with desiccant:

1. Grease the rear tank cover flange 10035 from the outer circumference of the O-ring groove to the outside edge of the flange with Dow Corning FS-1292 Grease.
2. Install a new O-ring 90002 by pressing it firmly into the groove. This O-ring does not require lubrication. (Refer to section 2.3 for guidelines about O-ring seals).
3. Be sure that desiccant was installed as per section 3.9.
4. Re-install the rear tank cover assembly 10032 using the twelve 1/2-inch hex head bolts H800A45711 (Fig. 1) with washers H420A64012. Apply Loctite 242 and torque to 61 Nm (45 ft-lbs).
5. Evacuate and refill the breaker with SF_6 gas; refer to section 3.11.

3.11 Refilling the Pole Unit with SF_6 Gas

General gas filling procedures are discussed in detail in the Maintenance module of this manual. After completing work inside the pole unit and immediately before closing the tank, install a new desiccant bag 10008 (Fig. 6) in the rear tank cover assembly 10032 (as per section 3.9) and re-install the rear tank cover assembly (as per section 3.10).

To fill the pole unit with SF_6 gas:

1. Install the DILO quick disconnect tool T13433 (Fig. 6) to the hose of the gas service unit.
2. If it was not already done, de-couple the DILO quick disconnect fitting 10171 at the rear tank cover assembly, separating the gas manifold from the single pole assembly.

Important: *If the gas manifold was not decoupled from the pole units, all of the pole units will have been emptied of gas and will need to be evacuated and refilled with gas.*

3. Install the DILO quick disconnect tool from the hose to the quick disconnect coupler half on the rear tank cover assembly.
4. Pull a vacuum to below 1.0 mm Hg absolute measured with an accurate electronic vacuum gauge. Hold the vacuum for 1 hour.
5. Fill the pole tank with SF_6 gas to 87 psig (600 kPaG) at 20°C (68°F). Refer to the Density Monitor Calibration Chart in the Maintenance module for pressures at other temperatures.
6. Repeat the previous steps for all pole units which have been opened.
7. Re-connect the gas manifold when all poles have been refilled with SF_6 gas.

Warning

The gas manifold must be connected at all pole units to properly monitor the SF_6 gas density at all poles.

Do not over-pressurize the circuit breaker when filling the breaker with SF_6 gas. Over-pressurization may cause the rupture disk to fail.

4 Testing

After performing pole unit maintenance, the following tests must be performed to ensure optimum operation of the system:

- SF_6 gas moisture content;
- Pole resistance measurement;
- Leak checking;
- Operational and timing tests.

Refer to the Maintenance module for instructions to perform the tests listed above.

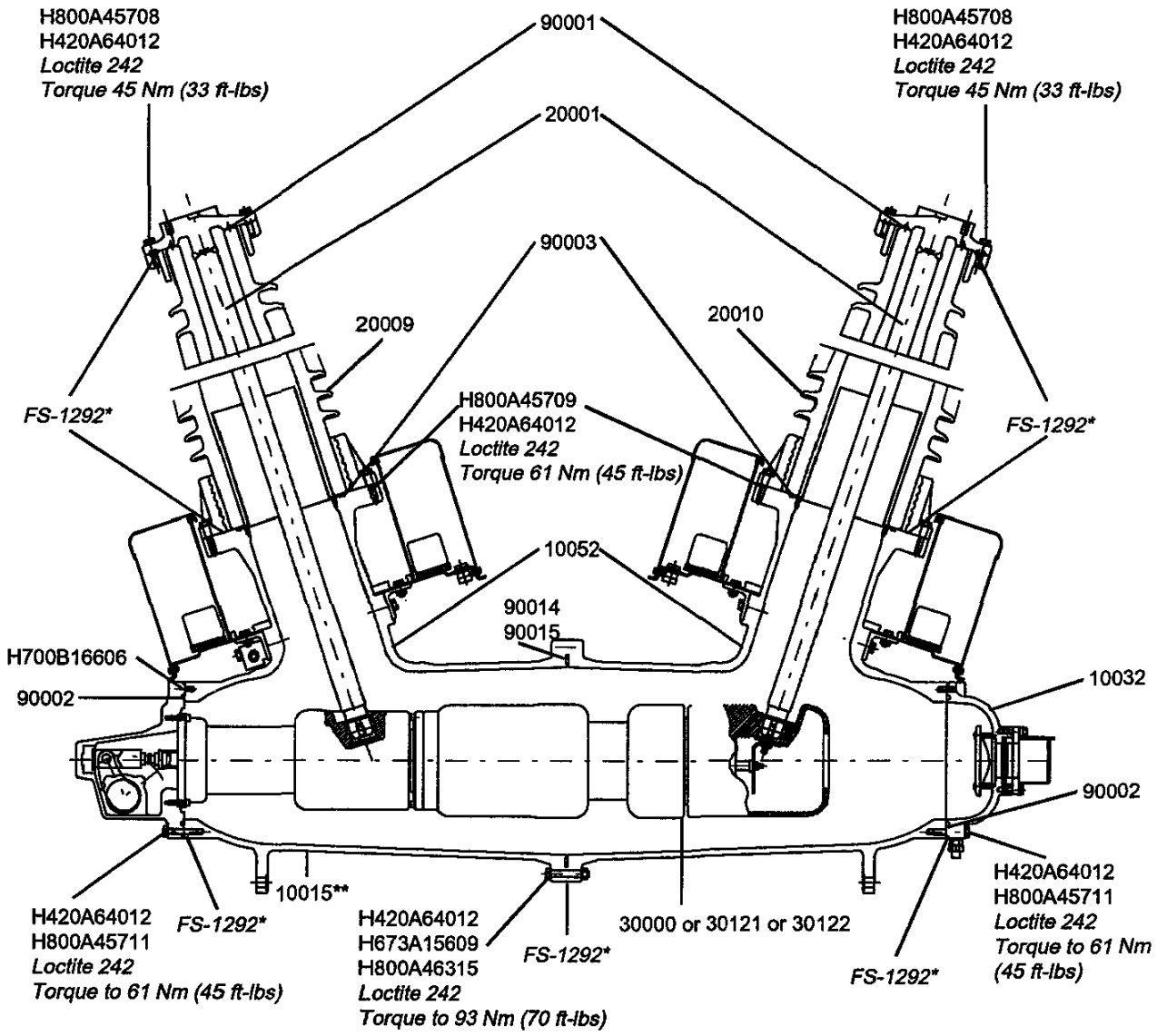


Figure 1
Pole Unit Assembly (Left, Center, or Right)
10047 or 10048 or 10049

10015	Pole Tank	90001	O-Ring, Top Flange
10032	Rear Tank Cover Assembly	90002	O-Ring, Tank End
10047	Left Pole Unit Assembly	90003	O-Ring, Bottom Flange
10048	Center Pole Unit Assembly	90014	O-Ring, Tank Center (Inner)
10049	Right Pole Unit Assembly	90015	O-Ring, Tank Center (Outer)
10052	Tank Half	H420A64012	Flat Washer, M12
20001	Bushing Conductor	H673A15609	Nut, 1/2-13
20009	Front Bushing Assembly	H700B16606	Alignment Pin
20010	Rear Bushing Assembly	H800A45708	Hex Head Bolt, 1/2-13 x 1-1/2 inch
30000	Interrupter Unit (Center)	H800A45709	Hex Head Bolt, 1/2-13 x 2 inch
30121	Interrupter Unit (Left)	H800A45711	Hex Head Bolt, 1/2-13 x 2-1/2 inch
30122	Interrupter Unit (Right)	H800A46315	Hex Head Bolt, 1/2-13 x 3-1/2 inch

*Apply Dow Corning FS-1292 grease to all flange surfaces outside of the O-ring groove to prevent corrosion.
**The pole tank 10015 is composed of two tank halves 10052.

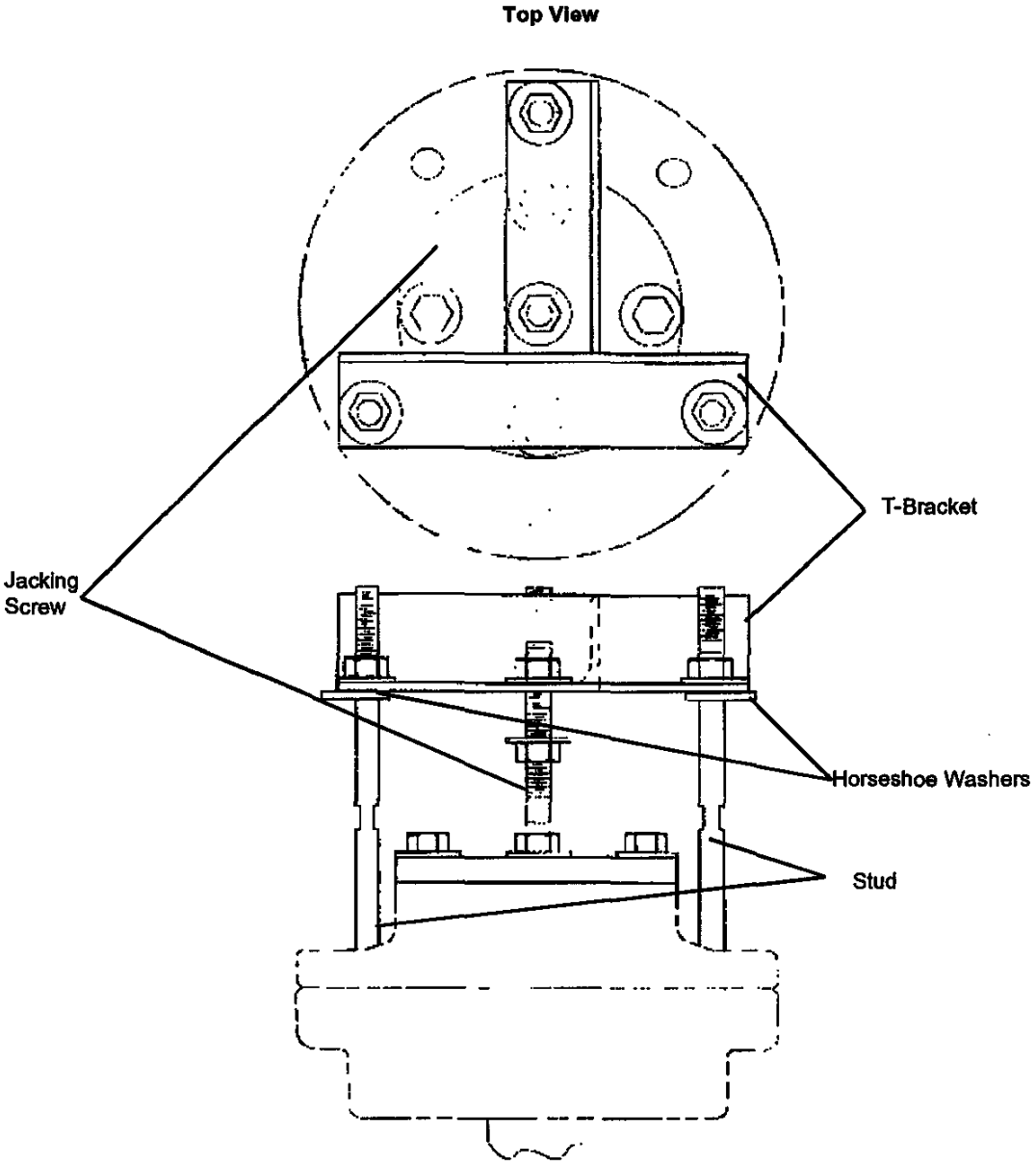


Figure 2
Bushing Conductor Removal Tool T13441

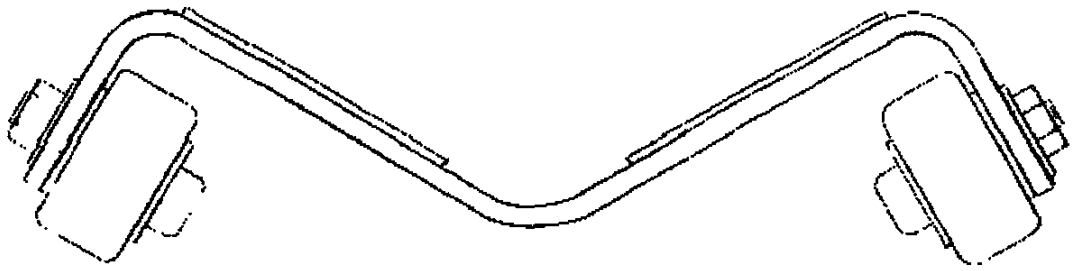


Figure 3
Interrupter Dolly T13445

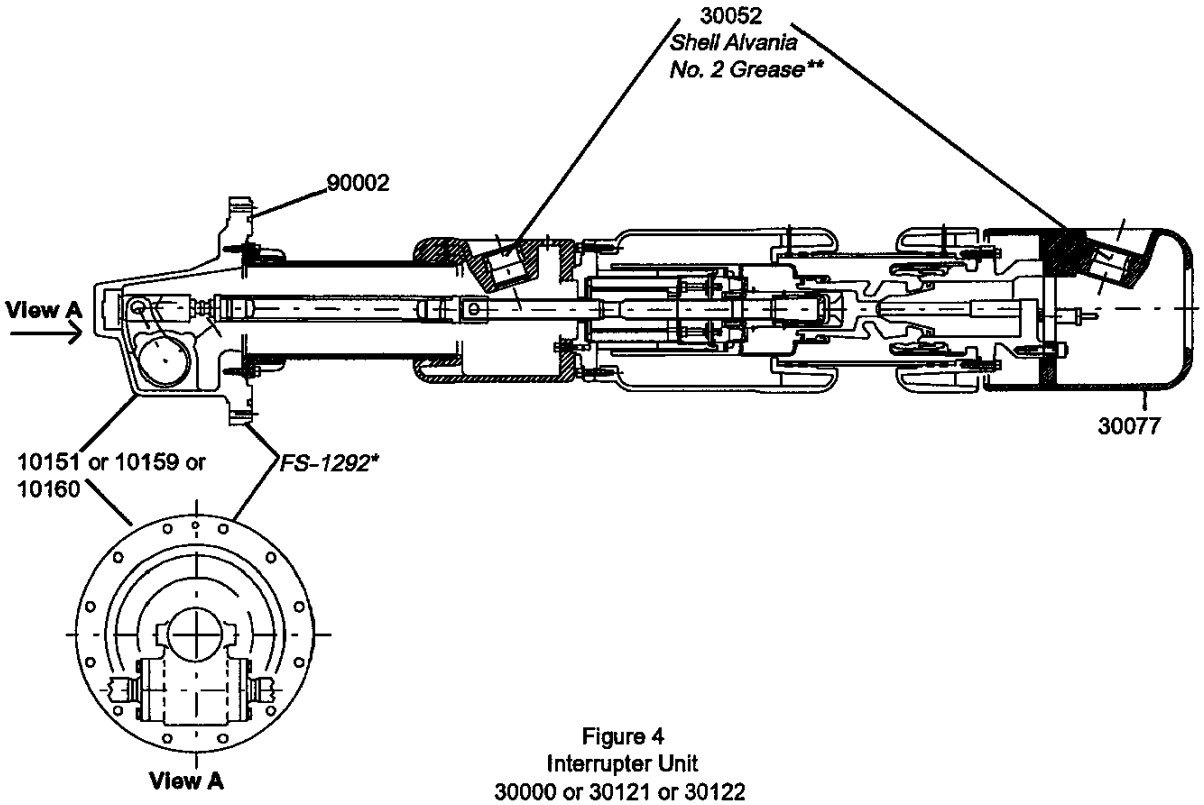


Figure 4
Interrupter Unit
30000 or 30121 or 30122

10151	Bellcrank Assembly (Center)
10159	Bellcrank Assembly (Left)
10160	Bellcrank Assembly (Right)
30000	Interrupter Unit (Center)
30052	Plug-In Connection
30077	Rear Exhaust Shield
30121	Interrupter Unit (Left)
30122	Interrupter Unit (Right)
90002	O-Ring, Tank End

*Apply Dow Corning FS-1292 grease to all flange surfaces outside of the O-ring groove to prevent corrosion.
**Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

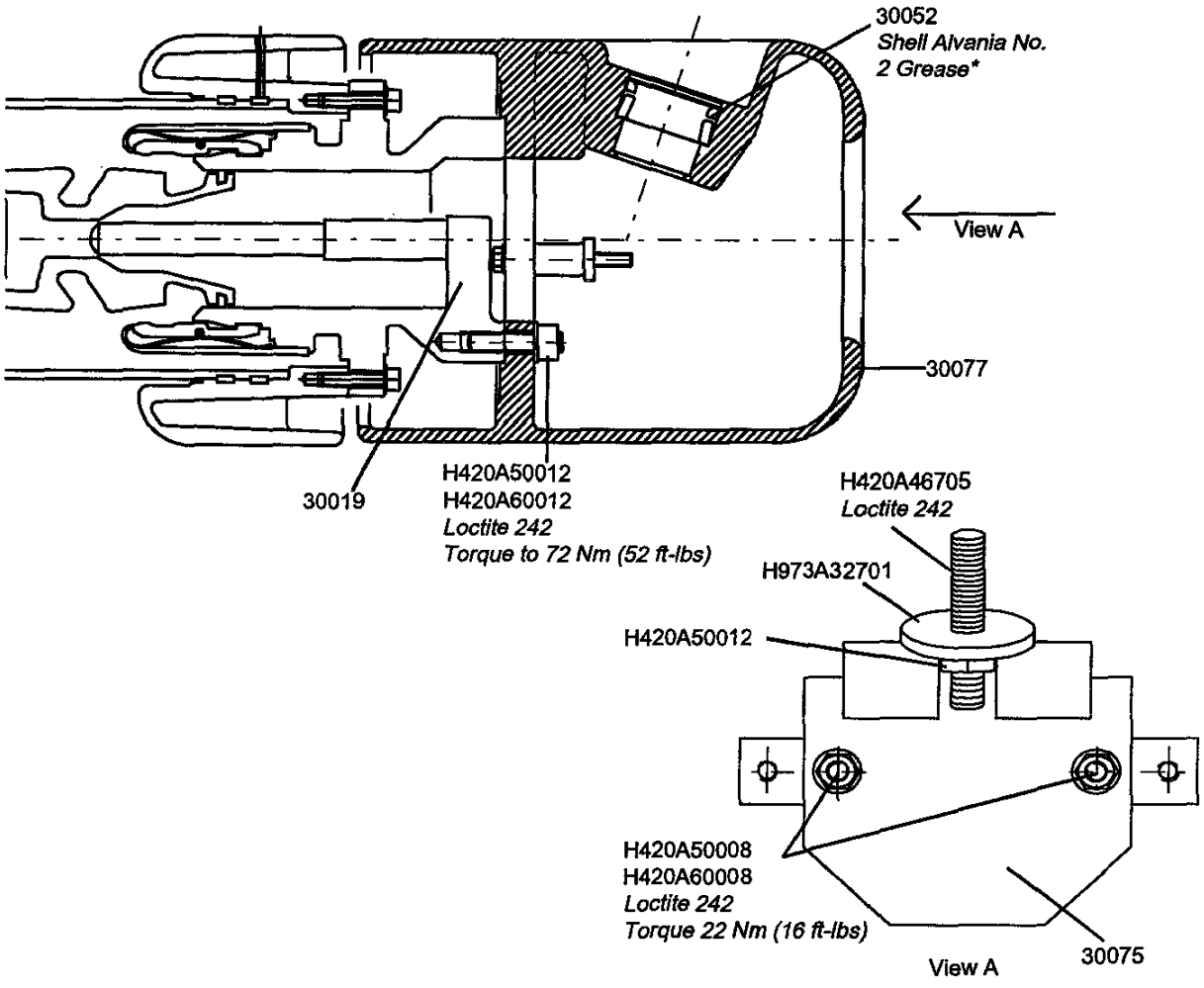


Figure 5
Rear of Interrupter Unit

30019	Stationary Contact Assembly
30052	Plug-In Connection
30075	Deflector
30077	Rear Exhaust Shield
H420A46705	Stud, M12 x 65 mm
H420A50008	Nut, M8
H420A50012	Nut, M12
H420A60008	Flat Washer, M8
H420A60012	Flat Washer, M12
H973A32701	Washer

*Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

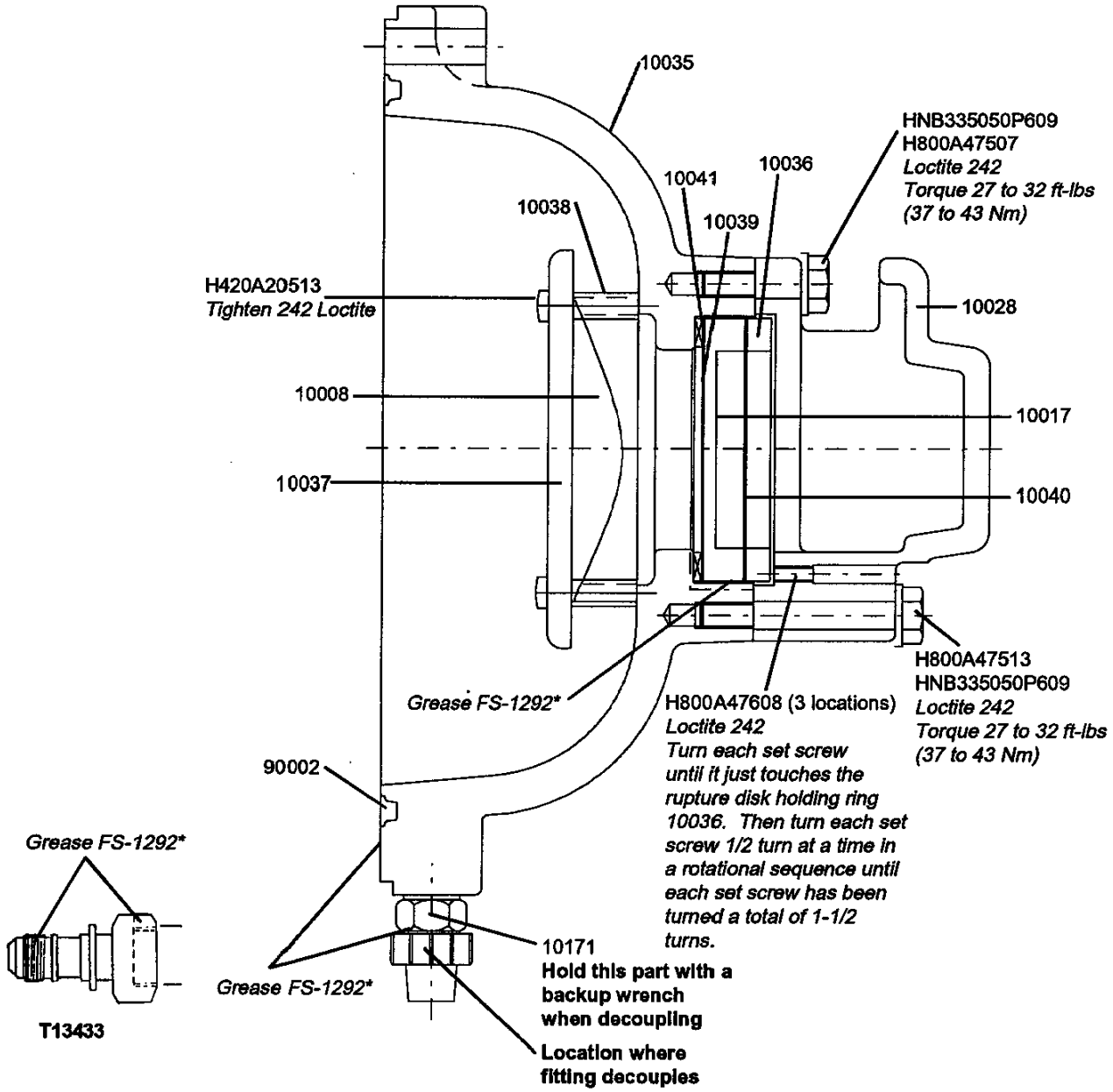


Figure 6
Rear Tank Cover Assembly 10032

10008	Desiccant Bag	10041	Pressure Gasket
10017	Rupture Disk	10171	DILO Quick Disconnect Fitting
10028	Rupture Disk Protective Cover	90002	O-Ring, Tank End
10035	Rear Tank Cover Flange	H420A20513	Phillips Head Bolt, M6 x 45
10036	Rupture Disk Holding Ring	H800A47507	Bolt, 3/8-16 x 1-1/2-inch (1)
10037	Cover	H800A47513	Bolt, 3/8-16 x 3-inch (5)
10038	Spacers	H800A47608	Set Screw 1/4-20 x 1-inch
10039	Solid Gasket	HNB335050P609	Washer, M10
10040	Gasket (1/32-inch)	T13433	DILO Quick Disconnect Tool

*Apply Dow Corning FS-1292 grease to all flange surfaces outside of the O-ring groove to prevent corrosion. Apply Dow Corning FS-1292 to lubricate the threads of the DILO quick disconnect fitting 10171.

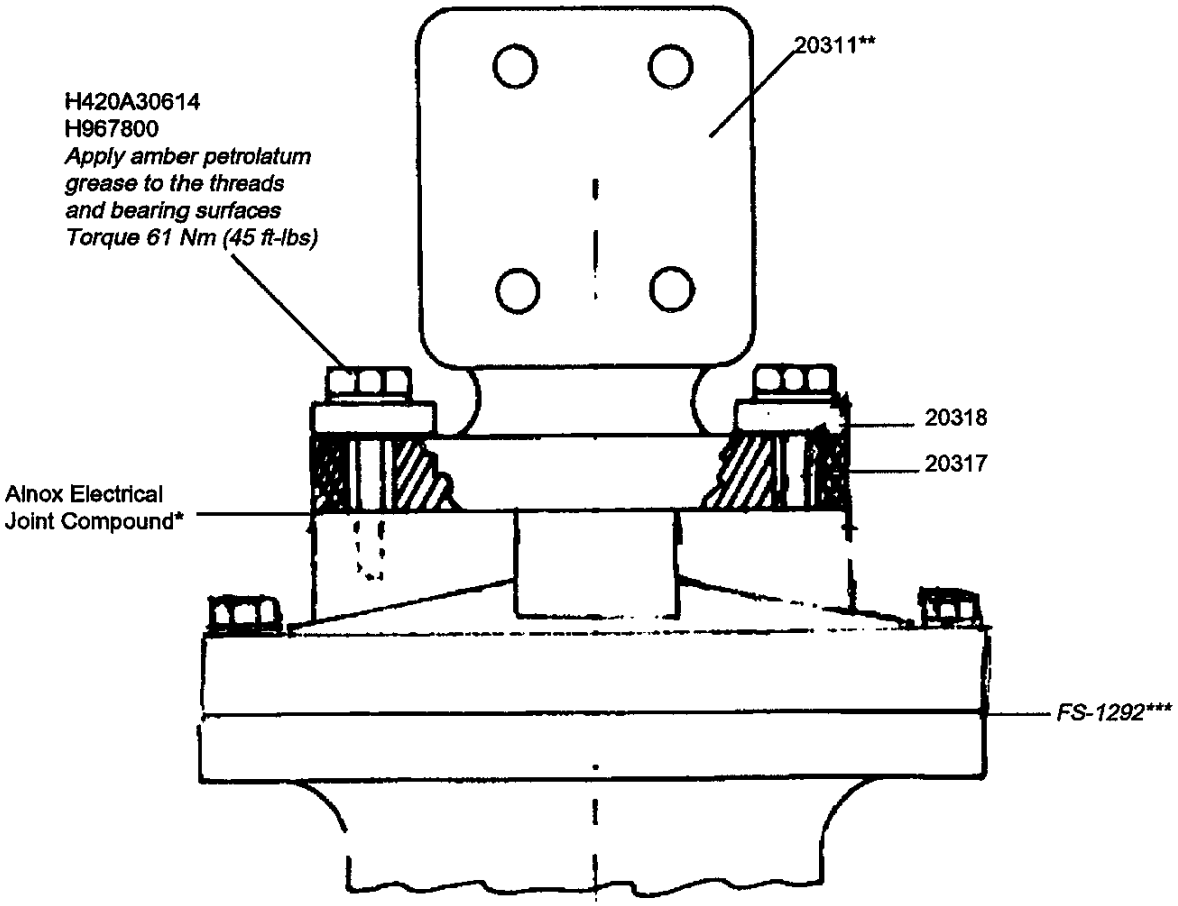


Figure 7
Terminal Pad 20311

20311	Terminal Pad
20317	Clamping Ring
20318	V-Clamps
H420A30614	Hex Head Bolt, M12 x 50
H967800	Belleville Washer, M12

*Requires surface preparation as described in step 1 in section 3.6.

**Rotate to desired orientation.

***Apply Dow Corning FS-1292 Grease to all flange surfaces outside of the O-ring groove to prevent corrosion.

Refer to Plate 6 for more details.

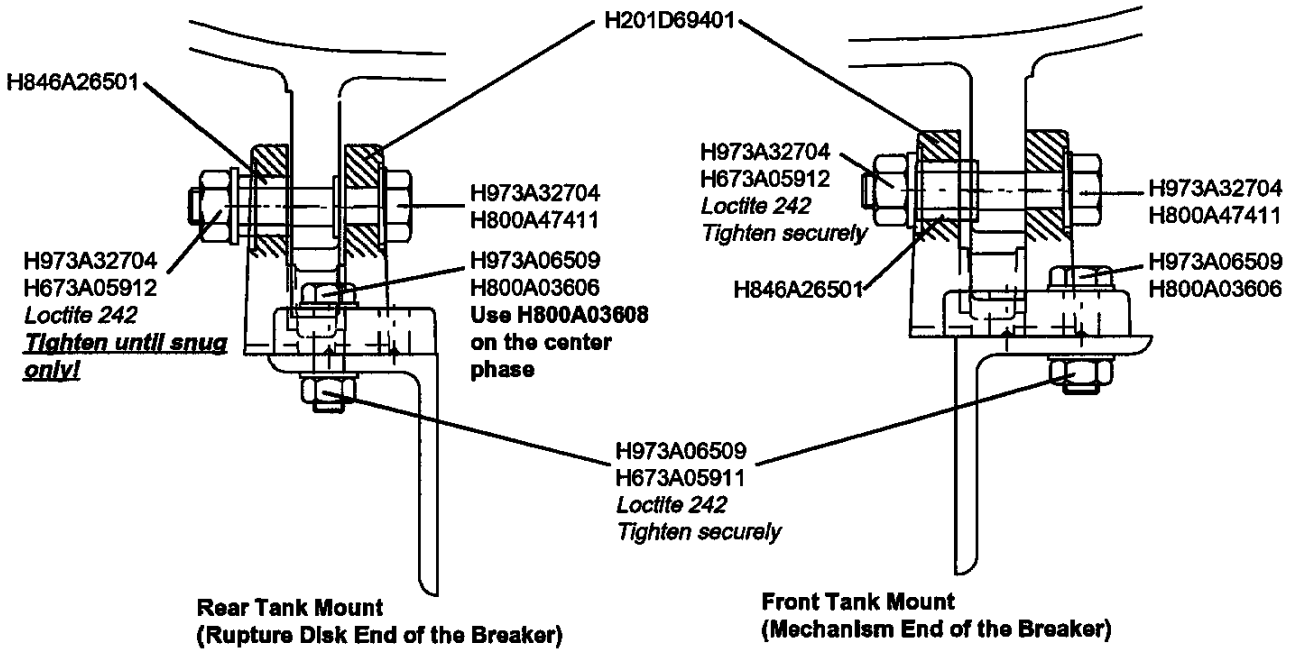


Figure 8
Tank Mounting Hardware

H201D69401	Tank Mounting Bracket
H673A05911	Nut, 5/8-11-inch
H673A05912	Nut, 3/4-10-inch
H800A03606	Bolt, 5/8-11 x 2-1/4-inch
H800A03608	Bolt, 5/8-11 x 2-3/4-inch
H800A47411	Bolt, 3/4-10 x 4-1/2-inch
H846A26501	Spacer
H973A06509	Flat Washer, 5/8-inch
H973A32704	Flat Washer

Procedure for Mounting the Pole Tank to the Structural Fame

1. Using the indicated hardware, fasten the tank mounting brackets H201D69401 (Fig. 8) at the front and rear of the structural frame as shown in Figure 8. (Note that the location of the bolts differ from front to rear.)

2. Lower the pole tank into position at the proper angle. **Loosely** (do not tighten yet) fasten the pole tank in place using bolts H800A47411, flat washers H973A32704, spacers H846A26501, and nuts H673A05912. Apply a liberal amount of Loctite 242 to the threads of bolts H800A47411.

3. Securely tighten nuts H673A05912 ***at the front tank mount first.***

4. Tighten nuts H673A05912 at the rear tank mount until they are ***snug only*** and the spacer H846A26501 is touching the tank gusset.

Notice: *Overtightening nuts H673A05912 at the rear tank mount may cause bracket H201D69401 to break.*

SF_6 Circuit Breakers

Type PM

Publication No. 218P012-01

145 PM Porcelain Entrance Bushings©

ASEA BROWN BOVERI

9 February 1993

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Notice 1

Based on our own experience, you will obtain the best possible operational reliability by following the recommendations given in these instructions. The data contained herein purports solely to describe the product, and it is not a warranty of performance or characteristics. It is with the best interests of our customers in mind that we constantly strive to improve our products and keep them abreast of advances in technology. This may lead to discrepancies between a product and these instructions.

Notice 2

Within the scope of these instructions, it is impossible to take into account every eventuality which may arise with technical equipment in service. Please consult our local salesman in the event of any irregularities, especially if not referred to herein.

Notice 3

We expressly decline liability for damages resulting from any incorrect operation or wrong handling of our equipment, even if these instructions contain no specific indication in this respect. We stress the fact that only genuine spare parts should be used for replacements.

Notice 4

This publication is a copyrighted work. Therefore, it is not permissible to disclose, reprint, copy, or reproduce any part of these instructions without express written permission from ABB.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the ABB Power T & D Company Inc. Power Circuit Breaker Division, 125 Theobold Ave., Greensburg, PA 15601, Phone No. (412) 838-5200.

Porcelain Entrance Bushings

1 Introduction

This module describes the porcelain entrance bushings and related maintenance on the 145 PM circuit breaker.

1.1 Description

The bushings are an integral part of the breaker and are specifically designed to connect to the high voltage line or bus and carry high voltage power to the interrupter while providing line-to-ground insulation. Standard porcelain bushings are designed to ANSI C37 standards. Designs with varying creepage and BIL ratings also are available.

A front and rear porcelain entrance bushing are installed at obtuse angles on top of each pole unit (Fig. 1). The bushings on the mechanism side of the breaker are referred to as the front bushings; the bushings on the rupture disk side are referred to as the rear bushings. The rear bushings are identical to the front bushings (except that a removable stud is installed at the tip of the bushing conductor for rear bushing application).

Both front and rear bushings are hollow, high strength porcelain insulators with top and bottom aluminum flanges permanently cemented onto each end. The bottom flange of the bushing bolts onto a pocket on the pole tank. A bushing conductor assembly (through rod) with a top cap welded to it attaches to the top flange of the porcelain insulator and extends through the hollow center, finally attaching to the interrupter. The bushing conductors plug into spring loaded contact rings at either end of the interrupter.

The bushings are filled with sulfur hexafluoride (SF_6) gas which acts as the insulating medium. The lower bushing end is fully open to the pole tank which allows the SF_6 gas to freely communicate between the tank and bushing. O-rings in the top cap and pocket flange directly seal against the upper and lower ground end faces of the porcelain insulator.

A grounded throat shield attaches to the tank pocket and extends into the bottom of the bushing. This shield is uniquely shaped to grade the voltage field in the air along the exterior length of the bushing as well as the internal area where the conductor enters the pole tank.

The six porcelain bushing assemblies, including the bushing conductors, are identical within any given breaker and can be interchanged if required. Because variations of bushings based on BIL and creepage exist, interchanging insulators between 145 PM breakers, should be done only after first consulting your local ABB representative or the factory in Greensburg.

A NEMA four-hole terminal pad (Fig. 3) is provided in the field assembly materials for connection at each top cap.

DANGER

Since porcelain is extremely brittle, be careful not to bump or rap the bushings against hard objects.

2 Bushing Maintenance

Bushing maintenance entails:

- General maintenance (section 2.2):
  - Cleanliness,
  - Fastener locking,
  - Checking the seals for cracks, deformities, and brittleness,
  - Flange corrosion protection,
  - Treatment of silverplating;
- Removing the bushing (section 2.3);
- Disassembling the bushing (section 2.4);
- Re-assembling the bushing (section 2.5);
- Installing the bushing (section 2.6);
- Refilling with SF_6 gas (section 2.7).

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance procedures.

2.1 Tools and Materials

The following tools and materials are required for performing maintenance on the bushings:

- Light crane;
- Two nylon slings (6-ft long, 2-inches wide);
- Two step ladders (10-ft);
- Standard wrenches and sockets;
- Come-along (winch);
- Torque wrench (10 to 150 ft-lbs);
- Halogen leak detector;
- Portable vacuum cleaner;
- Lint-free wipers;
- Denatured ethyl alcohol;
- Loctite 242;
- Alnox Electrical Joint Compound;
- Amber Petrolatum Grease;
- Shell Alvania No. 2 Grease;
- Dow Corning Fluoro Silicone FS-1292 Grease ;
- Scotch-Brite (extra fine);
- Special tools:
  - Bushing guide rods T13436 (Fig. 4),
  - Bushing conductor removal tool T13441.

2.2 General Maintenance Practices

The following sub-sections are general, recommended practices employed in the process of performing maintenance on the bushings.

2.2.1 General Cleanliness

Maintaining the cleanliness of the component surfaces in the breaker is an extremely important part of maintenance because the major insulating components in the breaker are subjected to high electrical stresses. Because cleanliness is so important, care must be taken to perform internal breaker maintenance under clean, dry conditions.

Warning

The importance of cleanliness cannot be overstressed. Introducing loose dirt, especially metallic particles, into an open pole unit (SF_6 gas compartment) can cause dielectric failure. Insulating surfaces must be protected from physical, damage (nicks and scratches) and kept clean and dry at all times.

Loose dirt (especially metallic particles) as well as residue left from sweaty hands and atmospheric moisture can lead to dielectric failure. It is best to avoid handling critical insulating components with bare hands. Instead, wear snug-fitting cloth gloves when handling insulating parts and surfaces. To ensure cleanliness, wipe insulating surfaces with lint-free wipers dampened with denatured ethyl alcohol.

Important: Never clean an insulating component with the same wiper used to clean aluminum or metal parts.

2.2.1.1 Specific Guidelines for Cleaning the Bushings

The porcelain exterior of the bushing has weather sheds designed to resist surface contamination and to maximize the wet dielectric strength of the surface. The glazed surface is easily cleaned by any method safe for station post insulators. Because cleaning techniques may be environment-specific, follow your own company policy for standard cleaning procedures.

Warning

Regardless of the cleaning method used, do not leave any filmy residue from the cleaning agent, e.g. soap film, on the bushing after cleaning.

2.2.2 Fastener Locking

Since the impact loading which the circuit breaker experiences during operation tends to loosen threaded hardware, Loctite Threadlocker 242 must be applied to all critical bolted joints.

Clean the threads in blind holes if they can be adequately dried afterwards. Apply Loctite sparingly to the outermost edges of the thread. Two small drops of Loctite are enough even for large threads.

Hardware secured with Loctite usually can be unfastened with proper wrenches. In case of difficulty, the connection can be loosened by heating the joint to 150°C (300°F). Be careful not to damage materials which are sensitive to heat, such as insulation or sealing components.

Use particular care in applying Loctite to fasteners used in assembling current carrying connections. Apply Loctite only where specified. If used improperly, Loctite can squeeze between contact areas and may cause a high resistance joint. Ensure that excess Loctite does not squeeze into contact areas.

2.2.3 Seals

Sealing rings which have been in service will be deformed from being compressed into their sealing grooves. Therefore, when disassembling components with sealing rings, replace them. Replacements are available from ABB.

Maintenance tips pertaining to seals include:

1. Do not grease or lubricate O-rings or any other seals unless specified otherwise.
2. Never clean seals with abrasives even if they are very fine.
3. Use only lukewarm, soapy water to clean the seals.
4. Use a soft, dry cloth to dry the seals.
5. Always check seals for cracks, deformities, and brittleness before they are installed. Acceptable seals are flexible and free of cracks. Do not install seals that are cracked, brittle, or deformed.

2.2.4 Flange Corrosion Protection

The grease used in sealing joints (Dow Corning FS-1292) is intended to be used as a flange corrosion protectant only. This grease is to be applied to all flange surfaces outside of the O-ring seals, or in other words, to areas where water can become entrapped between metal-to-metal joints. Pay special attention to areas around bolts where moisture is most likely to enter. Apply Dow Corning Fluoro Silicone FS-1292 Grease in all such cases.

2.2.5 Treatment of Silverplating

Silverplated contact areas can be polished *lightly* with extra fine Scotch-Brite to remove surface oxide. Do not heavily abrade the silverplated surfaces to avoid rubbing off the plating.

In situations where sliding contact joints are used, such as in the case of the plug-in type bushing conductors, the silverplated areas must be lubricated with Shell Alvania No. 2 Grease. Thoroughly rub the grease into the microscopic pores of the silverplated surface; remove all excess grease so that only a light film remains.

2.3 Removing the Bushing

When working with the bushings, follow standard precautions to prevent the brittle porcelain bodies from being chipped or otherwise damaged e.g. avoid bumping the porcelain sheds with tools, etc. In addition, avoid scratching or denting the internal bushing throat shield 20004 (Fig. 1). Refer to Plate 1.

Warning

Remove the gas and open the pole unit following the instructions in the Maintenance module of this manual before removing a bushing.

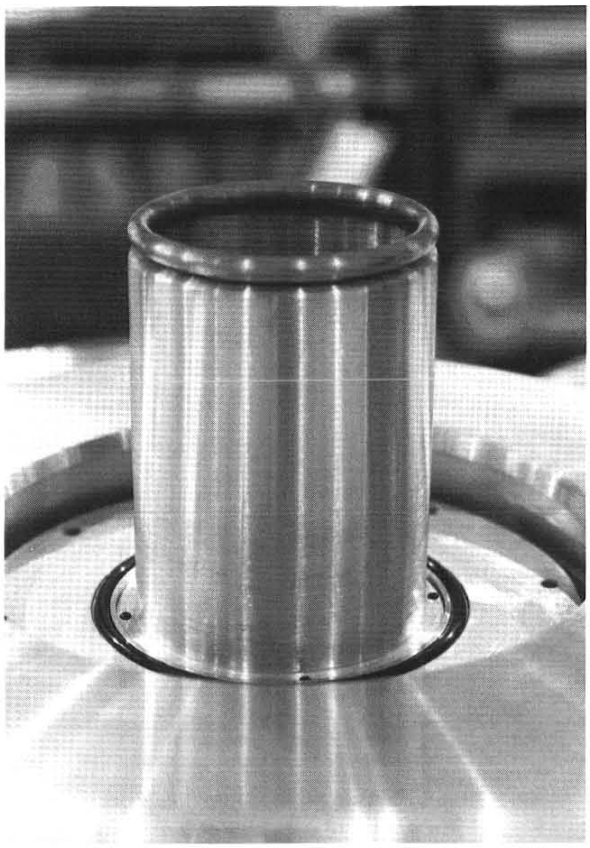


Plate 1: Throat shield

Bushing assemblies should be removed from the breaker as a complete unit with the bushing conductor in place.

Separate procedures are followed for removing the front and rear bushing assemblies. To remove the front bushing assembly 20009 (Fig. 1), refer to section 2.3.1; to remove the rear bushing assembly 20010, refer to section 2.3.2.

The standard creep porcelain entrance bushing assembly (with the bushing conductor installed) weighs approximately 123 kgs (275 lbs). Use a light crane to lift the bushing.

To lift the bushing, use the two-point lift method with one sling choked around the top of the bushing and the other sling choked below the bottom shed of the bushing. Place a come-along (winch) in line with the sling to allow the bottom of the bushing to be either raised or lowered as necessary. Refer to Plate 2.

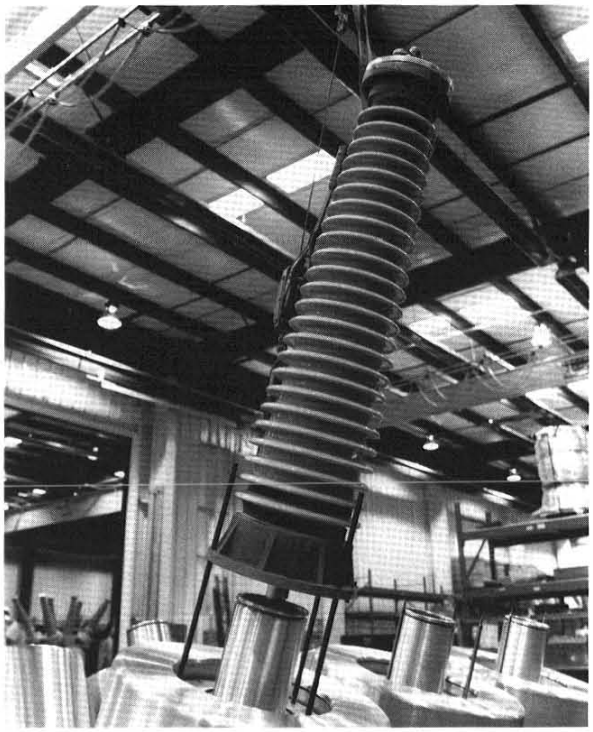


Plate 2: Two-point lift method

Warning

The internal bushing throat shields 20004 (Fig. 1 and Plate 1) must be approximately centered within the porcelain bodies. Avoid scratching or denting the throat shields. If the throat shield is noticeably off center, especially to the extent that it touches the porcelain wall, the electric field characteristics will be negatively affected and dielectric failure could result.

If a throat shield is off center or dented, discard it and replace it with a new one.

If SF_6 decomposition products are present (when the pole unit is opened) they must be removed and disposed of as soon as possible as described in the module Safe Handling Practices for SF_6 Gas. Clean the breaker parts promptly after opening the pole unit to prevent damage caused by corrosive and conductive compounds formed when SF_6 decomposition products are exposed to moisture in the air.

2.3.1 Removing the Front Bushing Assembly

To remove the front bushing assembly 20009 (on the mechanism side of the breaker) (Fig. 1):

1. Reclaim the SF_6 gas using procedures specified in the Pole Unit module of this manual.
2. Choke a sling around the top of the bushing.
3. Choke a second sling below the bottom shed of the bushing.
4. Place a come-along (winch) in line with the lower sling to allow the bottom of the bushing to be raised or lowered as necessary at the proper angle. Refer to Plate 2.
5. Using a light crane, slowly and carefully take up tension on the slings but do not put undue cantilever stress on the porcelain insulator.
6. Remove three 1/2-inch hex head bolts H800A45709 (Fig. 1) positioned 120 degrees apart around the bottom flange of the bushing assembly and install bushing guide rods T13436 (Fig. 4) in place of the bolts. Refer to Plate 3.

Notice: *The bushing guide rods are used to prevent the bushing assembly from dropping against the throat shield and damaging it when the bushing is being removed and installed. These guide rods always should be used when removing and installing a bushing.*

Plate 3: Bushing guide rods

7. Remove the remaining bolts from the bottom flange of the bushing.
8. Carefully lift the bushing assembly from the pole unit adjusting the angle of the assembly using the come-along (winch). The plug-in contact will become disengaged from the plug-in connection 30052 (Fig. 1) as the bushing is lifted from its flange.

Caution

Take precautions not to bump the porcelain insulator while lifting the bushing.

9. Proceed to disassemble and clean the bushing assembly as described in section 2.4. Cleaning should be performed as soon as possible to prevent damage caused by corrosive compounds formed when SF_6 decomposition products are exposed to atmospheric moisture.

2.3.2 Removing the Rear Bushing Assembly

To remove the rear bushing assembly 20010 (on the rupture disk side of the breaker) (Fig. 1):

1. Reclaim the SF_6 gas from the pole unit and remove the rear tank cover assembly 10032 (Fig. 1) using procedures specified in the Pole Unit module.
2. Remove the two M8 nuts H420A50008 (Fig. 5) and flat washers H420A60008 that hold the deflector 30075 in place and lift away the deflector.
3. Remove the M12 nut H420A50012 and washer H973A32701 from the stud H420A46705 that connects the bushing conductor to the rear exhaust shield 30077.
4. Choke a sling around the top of the bushing.
5. Choke a second sling below the bottom shed of the bushing.
6. Place a come-along (winch) in line with the lower sling to allow the bottom of the bushing to be raised or lowered as necessary at the proper angle. Refer to Plate 2 to view the two-point lift method.
7. Using a light crane, slowly and carefully take up tension on the slings but do not put undue cantilever stress on the porcelain insulator.
8. Remove three 1/2-inch hex head bolts H800A45709 (Fig. 1) positioned 120 degrees apart around the bottom flange of the bushing assembly and install bushing guide rods T13436 (Fig. 4) in place of the bolts. Refer to Plate 3.

Notice: *The bushing guide rods are used to prevent the bushing assembly from dropping against the throat shield and damaging it when the bushing is being removed and installed. These guide rods always should be used when removing and installing a bushing.*

9. Remove the remaining bolts from the bottom flange of the bushing.
10. Carefully lift the bushing assembly from the pole unit adjusting the angle of the assembly using the come-along (winch).

Caution

Take precautions not to bump the porcelain insulator while lifting the bushing.

11. Proceed to disassemble and clean the bushing assembly as described in section 2.4. Cleaning should be performed as soon as possible to prevent damage caused by corrosive compounds formed when SF_6 decomposition products are exposed to atmospheric moisture.

2.4 Disassembling the Bushing

Instructions for disassembling a bushing are the same for front and rear bushings.

To disassemble a porcelain bushing:

1. Lay the bushing horizontally, supported by wooden saddle blocks. Refer to Plate 4.

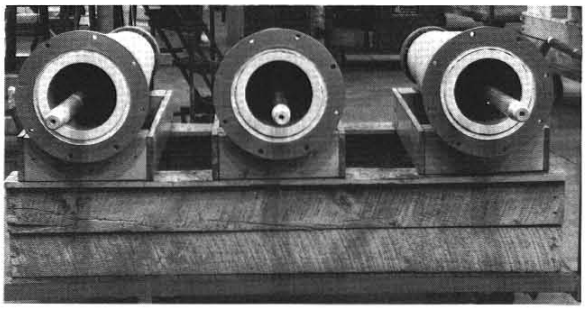


Plate 4: Bushing supported by saddle blocks

2. Place wooden blocks under the bushing conductor at the top cap and at the plug-in contact end to support the bushing conductor when the 1/2-inch hex head bolts H800A45708 (Fig. 2) on the top flange are removed.

Notice: *The bushing conductor must be supported when the bolts are removed to prevent the bushing conductor from falling and striking the porcelain insulator.*

3. Remove the 1/2-inch hex head bolts H800A45708 at the top flange.
4. With a person at each end, carefully remove the bushing conductor 20001 from the porcelain insulator.
5. Remove all SF_6 decomposition products using a vacuum cleaner. Wipe the bushing with lint-free wipers dampened with denatured ethyl alcohol. (Refer to the module Safe Handling Practices for SF_6 Gas for details on disposing of decomposition products.)

Important: *Never clean an insulating component with the same wiper used to clean aluminum or metal parts.*

6. Remove any nicks or scratches on the bushing conductor using Scotch-Brite or emory cloth. Wipe the bushing conductor with clean lint-free wipers dampened with denatured ethyl alcohol.

2.5 Re-Assembling the Bushing

Instructions for re-assembling a bushing are the same for front and rear bushings.

To re-assemble a porcelain bushing:

1. Remove the old O-ring 90001 (Fig. 2) from the top cap of the bushing conductor; clean the flange area and the O-ring groove with a lint-free wiper dampened with denatured ethyl alcohol.
2. Install a new O-ring 90001 over the bushing conductor and press it firmly into the groove in the top cap. Apply Dow Corning FS-1292 Grease to all flange areas outside of the O-ring groove to prevent corrosion of the flange.
3. Check that the internal surfaces of the insulator 20002 are wiped clean and free of debris.
4. Carefully re-install the bushing conductor into the insulator.
5. Apply a drop of Loctite 242 to the 1/2-inch top cap bolts H800A45708. Install the bolts with flat washers H420A64012 and torque to 45 Nm (33 ft-lbs).

To install the bushing assembly, refer to section 2.6.

2.6 Installing the Bushing

Separate procedures are followed for installing the front and rear bushing assemblies. To install the front bushing assembly 20009 (Fig. 1), refer to section 2.6.1; to install the rear bushing assembly 20010, refer to section 2.6.2.

Warning

The internal bushing throat shields 20004 (Fig. 1 or Plate 1) must be approximately centered within the porcelain bodies. Avoid scratching or denting the throat shields. If the shield is noticeably off center, especially to the extent that it touches the porcelain wall, the electric field characteristics will be negatively affected and dielectric failure could result.

If a throat shield is off center or dented, discard it and replace it with a new one.

Remove any scratches on the throat shield using Scotch-Brite. Wipe the throat shield several times using lint-free wipers dampened with denatured ethyl alcohol.

2.6.1 Installing the Front Bushing Assembly

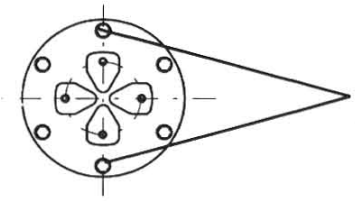
To install the front bushing assembly 20009 (Fig. 1):

1. Remove the old O-ring 90003 (Fig. 1) from the pocket flange of the pole unit; clean the flange area and the O-ring groove with a lint-free wiper dampened with denatured ethyl alcohol.
2. Firmly press a new O-ring 90003 into the groove of the pocket flange. Apply Dow Corning FS-1292 Grease to all flange areas outside of the O-ring groove to prevent corrosion. Refer to Plate 5.

Plate 5: Pocket flange

3. Remove any scratches on the throat shield 20004 (Fig. 1) using Scotch-Brite. Wipe the throat shield several times using lint-free wipers dampened with denatured ethyl alcohol.

4. Position the bushing assembly so that when it is lifted and installed, the two bolt holes in the top cap shown in the illustration below are aligned along the long axis or length of the pole unit.



These bolt holes in the top cap must be aligned along the long axis or length of the pole unit.

5. Choke a sling around the top of the bushing.
6. Choke a second sling below the bottom shed of the bushing.
7. Place a come-along (winch) in line with the lower sling with the come-along fully retracted.
8. Using a light crane, slowly and carefully lift the bushing parallel to the ground. While lifting, proceed to lower the bottom of the bushing by slacking off on the come-along (winch) until the bushing is oriented at the required angle. Refer to Plate 2 for the two-point lift method.

Caution

Take precautions not to bump the porcelain insulator 20002 (Fig. 2) while lifting the bushing.

9. Apply a light coat of Shell Alvania No. 2 Grease to the male plug-in area of the bushing conductor 20001 (Fig. 1). Thoroughly rub the grease into the pores of the silverplating with a lint-free wiper and remove all excess.
10. Install three bushing guide rods T13436 (Fig. 4) 120 degrees apart on the pocket flange of the pole tank.
11. Raise the bushing assembly above the tank pocket; adjust the angle of the bushing with the come-along (winch) and slowly lower the bushing onto the tank pocket allowing the bushing guide rods to pass through the bolt holes on the bottom flange of the bushing. Refer to Plate 6.

Important: While the bushing assembly is being lowered into place, the male plug-in contact area of the bushing conductor 20001 (Fig. 1) will engage with the female plug-in connection 30052 on the interrupter unit.

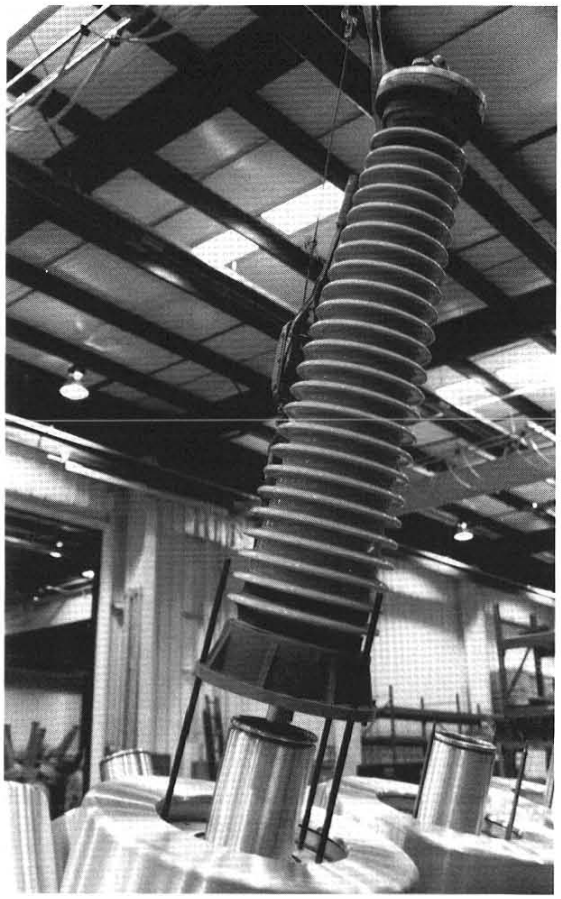


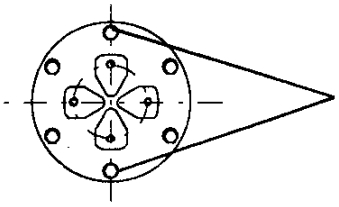
Plate 6: Lowering the bushing onto the pocket flange

12. Apply a drop of Loctite 242 to the threads of the bottom flange 1/2-inch hex head bolts H800A45709 (Fig. 1). Install the bottom flange bolts and flat washers H420A64012 (remove the bushing guide rods and replace them with the remaining bolts when all of the other bolts are in place). Torque the bolts to 60 Nm (45 ft-lbs).
13. Proceed to section 2.7 if all other maintenance work is complete.

2.6.2 Installing the Rear Bushing Assembly

To install the rear bushing assembly 20010 (Fig. 1):

1. Remove the old O-ring 90003 (Fig. 1) from the pocket flange of the pole unit; clean the flange area and the O-ring groove with a lint-free wiper dampened with denatured ethyl alcohol.
2. Firmly press a new O-ring 90003 into the groove of the pocket flange. Apply Dow Corning FS-1292 Grease to all flange areas outside of the O-ring groove to prevent corrosion. Refer to Plate 5.
3. Remove any scratches on the throat shield using Scotch-Brite. Wipe the throat shield several times using lint-free wipers dampened with denatured ethyl alcohol.
4. Position the bushing assembly so that when it is lifted and installed, the two bolt holes in the top cap shown in the illustration below are aligned along the long axis or length of the pole unit.



These bolt holes in the top cap must be aligned along the long axis or length of the pole unit.

5. Choke a sling around the top of the bushing.
6. Choke a second sling below the bottom shed of the bushing.
7. Place a come-along (winch) in line with the lower sling with the come-along fully retracted.
8. Using a light crane, slowly and carefully lift the bushing parallel to the ground. While lifting, proceed to lower the bottom of the bushing by slacking off on the come-along (winch) until the bushing is oriented at the required angle. Refer to Plate 2 for the two-point lift method.

Caution

Take precautions not to bump the porcelain insulator 20002 (Fig. 2) while lifting the bushing.

9. Apply a light coat of Shell Alvania No. 2 Grease to the male plug-in area of the bushing conductor 20001 (Fig. 1). Thoroughly rub the grease into the pores of the silverplating with a lint-free wiper and remove all excess.
10. Install three bushing guide rods T13436 (Fig. 4) 120 degrees apart on the pocket flange of the pole tank.
11. Raise the bushing assembly above the tank pocket; adjust the angle of the bushing with the come-along (winch) and slowly lower the bushing onto the tank pocket allowing the guide rods to pass through the bolt holes on the bottom flange of the bushing. Refer to Plate 6.

Important: While the bushing assembly is being lowered into place, the male plug-in contact area of the bushing conductor 20001 (Fig. 1) will engage with the female plug-in connection 30052 on the interrupter unit.

12. Apply a drop of Loctite 242 to the threads of the bottom flange 1/2-inch hex head bolts H800A45709 (Fig. 1). Install the bottom flange bolts and flat washers H420A64012 (remove the bushing guide rods and replace them with the remaining bolts when all of the other bolts are in place). Torque the bolts to 60 Nm (45 ft-lbs).
13. Install the M12 nut H420A50012 (Fig. 5) and washer H973A32701 that connect the bushing conductor 20001 to the rear exhaust shield 30077. Apply Loctite 242 and tighten the nut until it is **snug only** (hand-tighten plus 1/4 turn).

Caution

Do not overtighten nut H420A50012. This nut is intended only to support the interrupter. If the nut is overtightened, undue cantilever stress will be applied to the interrupter support tube which could cause mechanical failure of the tube. The nut is locked into position by the deflector 30075 (Fig. 5) and cannot turn loose.

14. Install the deflector using the two M8 nuts H420A50008 and washers H420A60008. Apply Loctite 242 and torque to 22 Nm (16 ft-lbs).
15. Proceed to section 2.7 if all other maintenance work is complete.

2.7 Gas Refilling

After all maintenance work has been completed, refer to the Pole Unit module for instructions to perform the following:

1. Ensure that the pole unit tank is internally clean and free of debris, metal particles, etc.
2. Replace the desiccant bag 10008 (Fig. 1).
3. Re-install the rear tank cover assembly 10032.
4. Immediately perform a vacuum procedure to remove ambient air and moisture.
5. Refill the breaker with SF_6 gas.
6. Leak check all seals with a halogen leak detector.

3 Installing the Bushing Top Terminal
Plate 7

Each 145 PM circuit breaker is provided with six four-hole NEMA terminal pads 20311 (Fig. 3) as part of the field assembly materials. To install the terminal pad to the top cap of the bushing conductor 20001 (Fig. 1):

1. Coat mating surfaces between the terminal pad 20311 (Fig. 3) and top cap of the bushing with Alnox Electrical Joint Compound (found in the service kit). Abrade both contact surfaces with a wire brush to remove dirt and oxides. Completely wipe off the Alnox with a clean, lint-free wiper and immediately apply a new coat of Alnox to both mating surfaces to prevent oxidation.

2. Position the terminal pad on the top cap of the bushing.

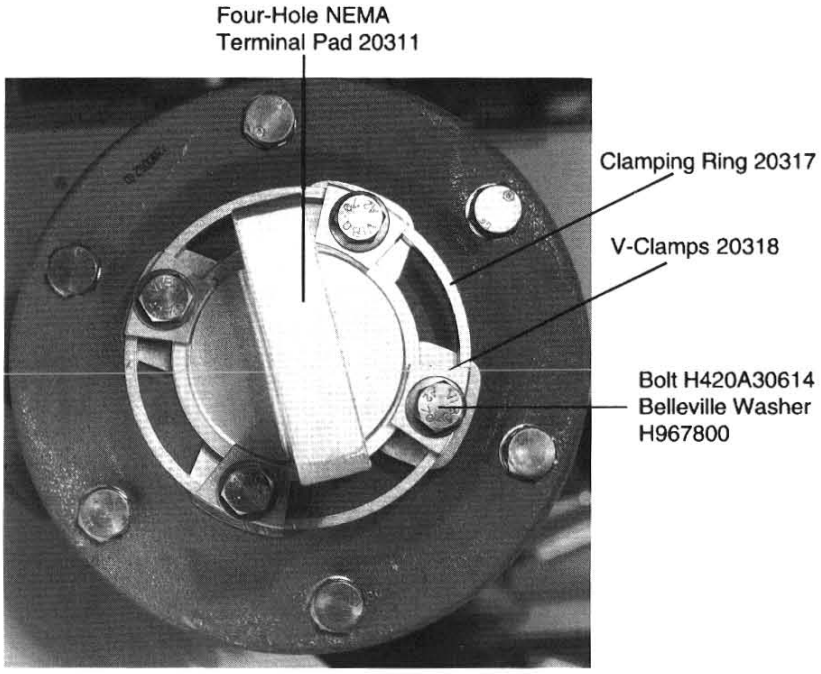


Plate 7: Installing the bushing top terminal

3. Place a clamping ring 20317 (Fig. 3) over the terminal with the drip slots at the bottom of the clamping ring.

4. Place four V-clamps 20318 between the clamping ring and terminal pad and over the holes in the top cap of the bushing.

5. Place a belleville washer H967800 on each of the four M12 hex head bolts H420A30614. Apply Amber Petrolatum Grease to the bearing surfaces and the threads of each bolt. Place a bolt through each V-clamp, and screw the bolts into the four holes of the top cap of the bushing.

6. Turn the terminal pad to the desired orientation (the terminal can be turned 360 degrees) and torque the bolts to 61 Nm (45 ft-lbs).

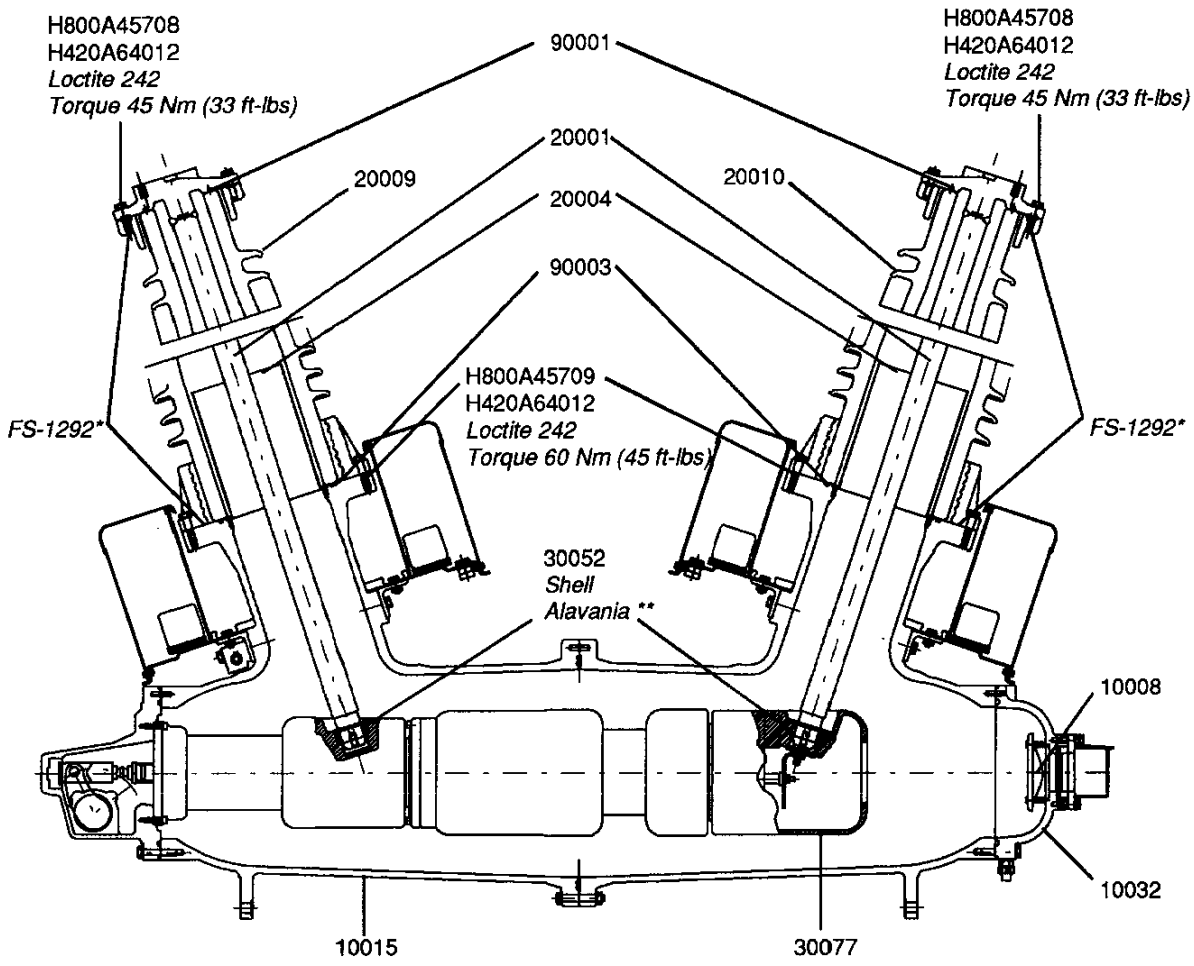


Figure 1
Center Pole Unit Assembly 10048

10008	Desiccant Bag
10015	Pole Tank
10032	Rear Tank Cover Assembly
20001	Bushing Conductor
20004	Throat Shield
20009	Front Bushing Assembly
20010	Rear Bushing Assembly
30052	Plug-In Connection
30077	Rear Exhaust Shield
90001	O-Ring (Top Flange)
90003	O-Ring, (Bottom Flange)
H420A64012	Flat Washer, M12
H800A45708	Hex Head Bolt, 1/2-13 x 1-1/2 inch
H800A45709	Hex Head Bolt, 1/2-13 x 2 inch

*Apply Dow Corning FS-1292 grease to all flange surfaces outside of the O-ring groove to prevent corrosion.

**Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

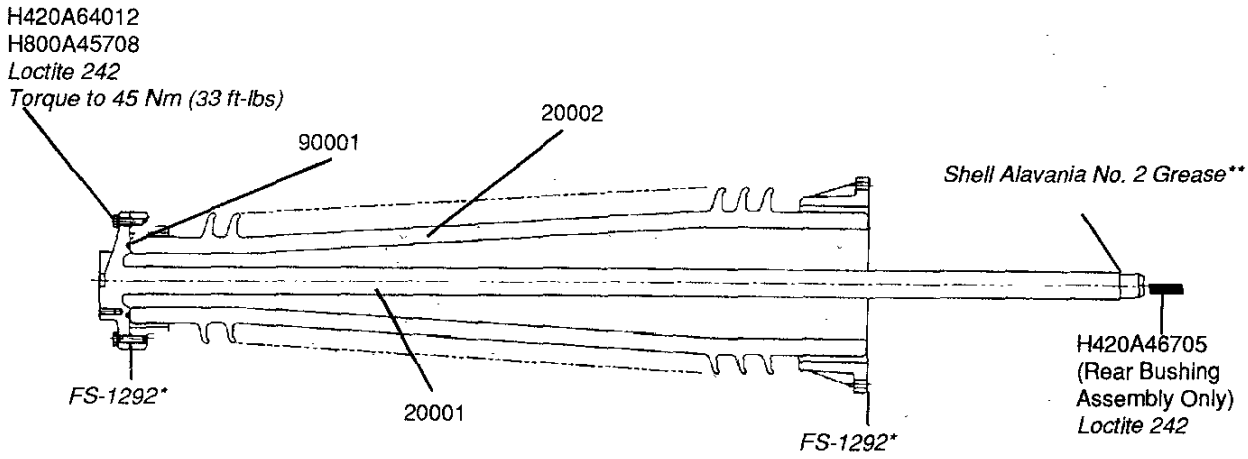


Figure 2
Entrance Bushing Assembly
Front Bushing Assembly 20009
Rear Bushing Assembly 20010 (includes stud)

20001	Bushing Conductor
20002	Insulator
90001	O-Ring, Top Flange
H420A46705	Threaded Stud, M12 x 65
H420A64012	Flat Washer, M12
H800A45708	Hex Head Bolt, 1/2-13 x 1-1/2 inch

*Apply Dow Corning FS-1292 grease to all flange surfaces outside of the O-ring groove to prevent corrosion.

**Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

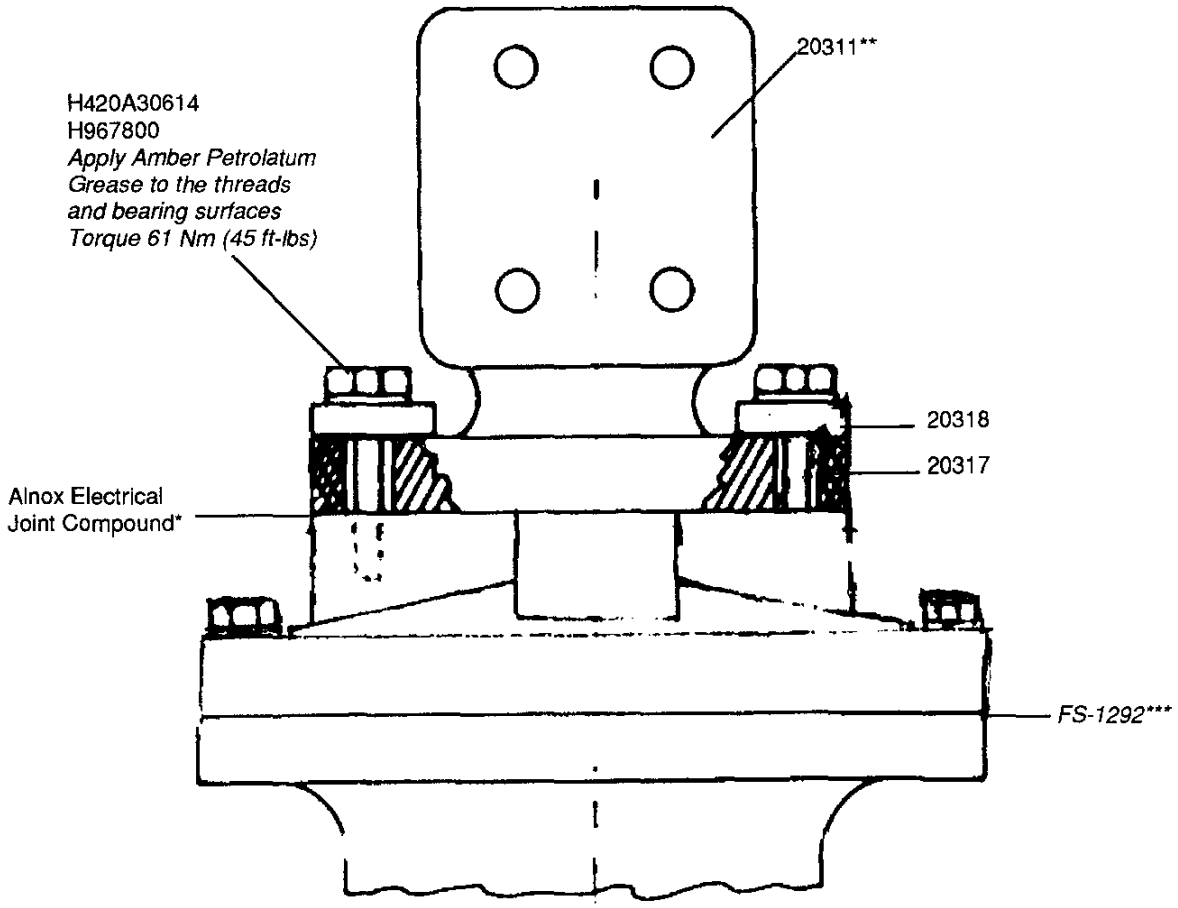


Figure 3
Terminal Pad 20311

20311	Terminal Pad
20317	Clamping Ring
20318	V-Clamps
H420A30614	Hex Head Bolt, M12 x 50
H967800	Belleville Washer, M12

*Requires surface preparation as described in section 3 of this module.

**Rotate to desired orientation.

***Apply Dow Corning FS-1292 Grease to all flange surfaces outside of the O-ring groove to prevent corrosion.

Refer to Plate 7 for more details.

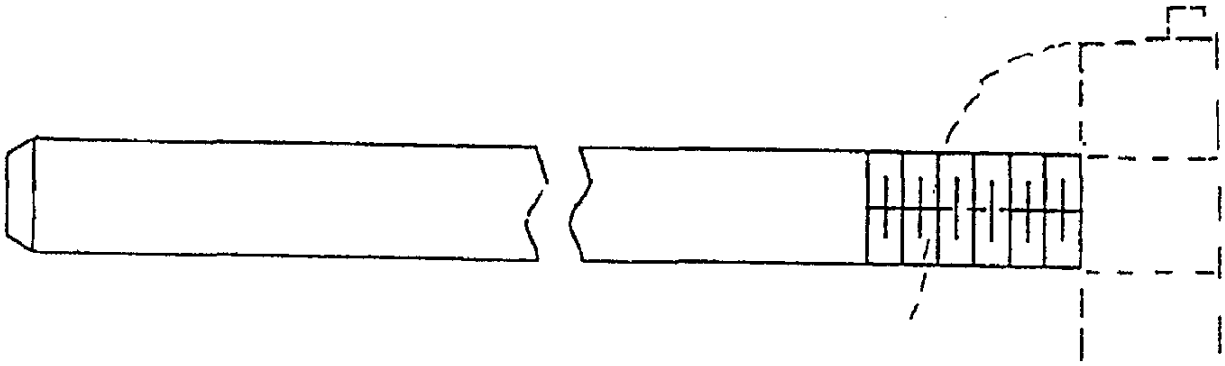


Figure 4
Bushing Guide Rod T13436

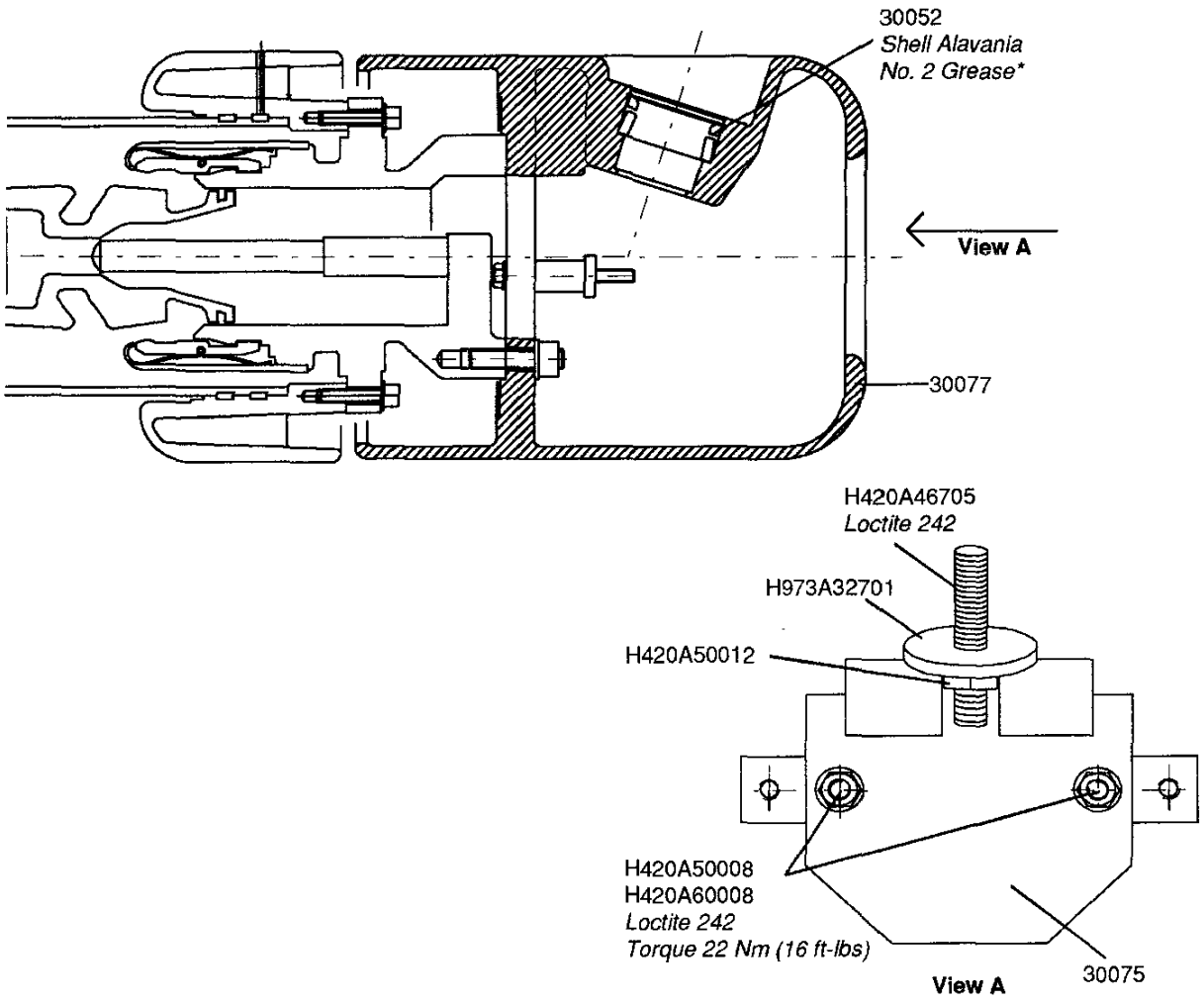


Figure 5
Rear of Interrupter Unit

30052	Plug-In Connection
30075	Deflector
30077	Rear Exhaust Shield
H420A46705	Stud, M12 x 65 mm
H420A50008	Nut, M8
H420A50012	Nut, M12
H420A60008	Flat Washer, M8
H973A32701	Washer

*Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

SF_6 Circuit Breakers

Type PM

Publication No. 948P006-01

145 PM Current Transformers©

ASEA BROWN BOVERI

10 February 1993

Contents

Figures

Notice 1

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Current Transformers

1 Introduction

Instructions in this module apply to removing and re-installing the bushing-type current transformers (CTs) and their protective covers.

1.1 Description

Each phase can be equipped with many combinations of bushing-type CTs or linear couplers. The CTs are housed in a weatherproof aluminum protective cover located at the base of the entrance bushings. CT secondary leads are installed in conduits extending from each CT housing and terminating onto shorting type terminal blocks in the control cabinet. Refer to Plate 1.

The CTs are provided as per customer specifications. Multi-ratio relaying class CTs are applied most commonly. However, single-ratio metering class CTs and linear couplers are available if requested. A nameplate on the inside of the cabinet door indicates the location, accuracy, and ratio of the current transformers.

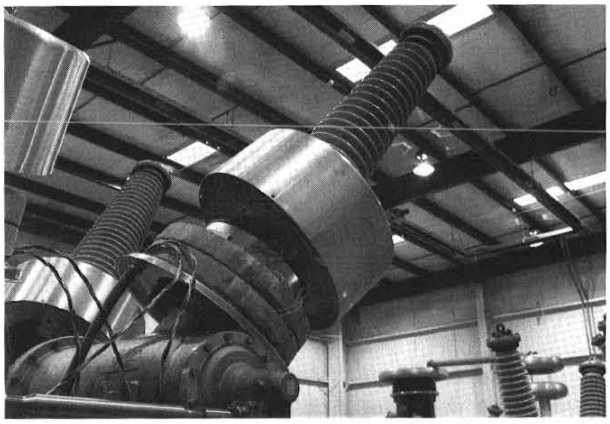

Plate 1: Bushing-type current transformers

2 CT Maintenance

CT maintenance involves the following procedures:

- Removing the CT protective cover (refer to section 2.1);
- Removing the CT(s) (refer to section 2.2);
- Installing the CT(s) (refer to section 2.3);
- Re-installing the CT protective cover (refer to section 2.4).

Important: The CT protective cover, as well as the CTs, can be lifted over the entrance bushing without removing the bushing.

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance procedures.

Each current transformer secondary must be connected to a relaying or metering burden or be short circuited at all times.

Warning

The system pressure should be lowered to a slight positive pressure of approximately 5 psig (34.5 kPaG) when removing or replacing the CT protective cover or CTs. Be careful not to bump the bushing while removing the CTs. Bumping a pressurized bushing could result in cracking the porcelain and causing it to rupture.

Caution

Do not stand on the CT protective cover, otherwise you could crush the cover or damage the seal around the lip of the bottom support.

2.1 Removing the CT Protective Cover

The CT protective cover 70001 (Fig. 1) is removed whenever a CT 70000 needs to be added, replaced, or removed.

To remove the CT protective cover:

1. Remove the bolts H800A08105, nuts H673A09102, and flat washers H420A64008 at the bottom of the CT protective cover.
2. Carefully lift the protective cover over the top of the bushing; avoid damaging the porcelain glaze or sheds.

2.2 Removing the CT(s)

Before removing the CT(s), remove the CT protective cover. Refer to section 2.1.

To remove the CT(s):

1. After lowering the SF_6 gas pressure to a slight positive pressure of approximately 5 psig (34.5 kPaG), disconnect the CT leads.
2. Using a light crane, carefully lift the CT over the top of the bushing; avoid damaging the porcelain glaze or sheds.

2.3 Installing the CT(s)

Prior to installing the CT(s), the SF_6 gas pressure must be lowered to a slight positive pressure of approximately 5 psig (34.5 kPaG).

To install a CT:

1. Using a light crane, carefully lower the CT over the top of the bushing; avoid damaging the porcelain glaze or sheds.
2. While lowering the CT in place, install the appropriate number of pressboard spacers (Fig. 1) between the CTs to attain the following approximate gap clearances:
   - 1/2 inch on the inner diameter of the CT;
   - 1/8 inch to 1/4 inch between CTs;
   - 3/8 inch to 1/2 inch between the bottom CT and the support.

Caution

Pressboard spacers must be installed to ensure that the CTs are isolated from the CT protective cover 70001 and bottom support 70003 (Fig. 1).

3. Connect the secondary leads to the shorting terminal blocks.
4. Re-install the CT protective cover. Refer to section 2.4.

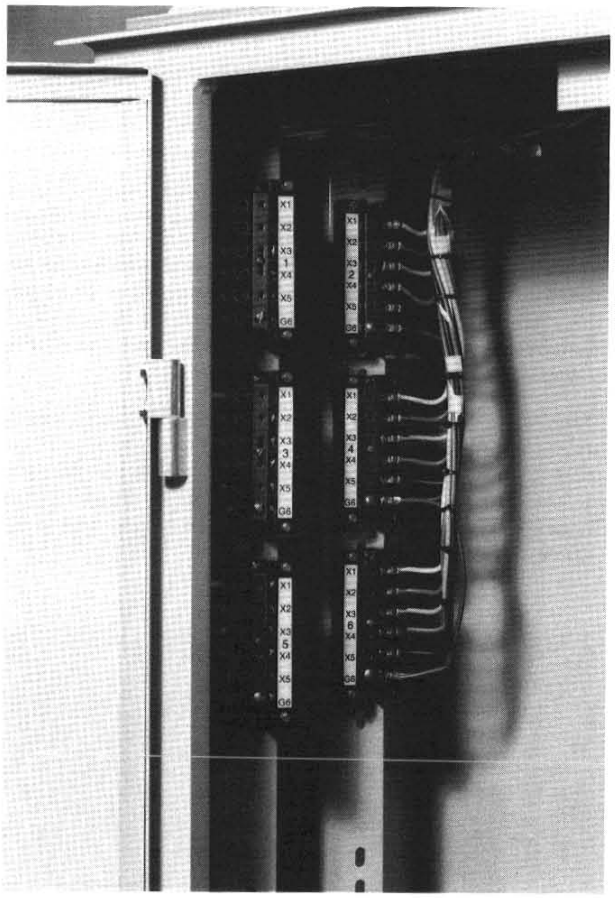

Plate 2: Shorting terminal blocks

2.4 Re-Installing the CT Protective Cover

Caution

When re-installing the CT protective cover 70001 (Fig. 1), be careful not to damage the insulating seal 70002 around the lip of the bottom support 70003. This seal serves both as a weather seal and an insulating barrier. Without this insulating barrier, the CT protective cover would form a continuous conducting loop around the CTs, thereby shorting them and jeopardizing CT accuracy.

To reinstall the CT protective cover:

1. Carefully place the CT protective cover over the top of the de-pressurized bushing; avoid bumping the bushing. The CT protective cover should seat itself evenly on the insulating seal without excessive force.
2. Re-install the bolts at the bottom of the CT protective cover to fasten the cover to the support.

Warning

Fill the breaker with SF_6 gas if it had been de-pressurized as recommended. Refer to the Maintenance module.

3 Wiring

The CT wiring is depicted on the last sheet of the wiring diagram package in the Customer Data module. This diagram includes the connections of any special test switches or plugs that may have been installed on the breaker for testing and monitoring of the CTs. The CT ratios and accuracies, as well as their relative position in relation to the breaker main contacts are also included.

3.1 CT Curves

For CT curves, refer to the Customer Data module.

4 Replacement Parts

The actual ABB part numbers for the CTs which are equipped with the breaker are located on a Current Transformer Location Nameplate (Fig. 2). The nameplates are located inside the door of the main control cabinet. The CT curve number, the ratio, and the accuracy class are also included on this nameplate. Please identify these numbers when service or spare parts are required.

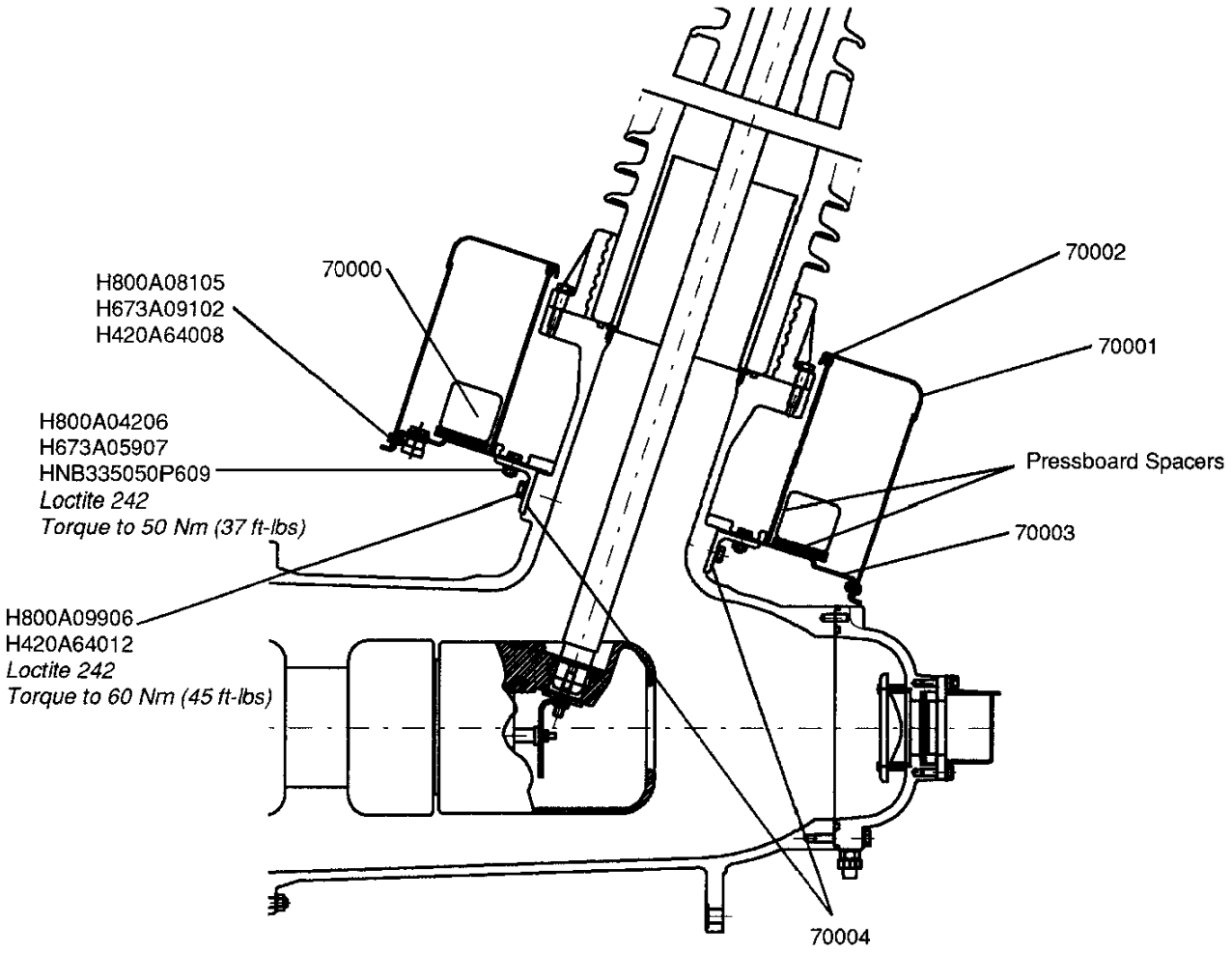

Figure 1
Current Transformer 70000

70000	Current Transformer
70001	CT Protective Cover
70002	Insulating Seal
70003	Bottom Support
70004	Mounting Bracket
H420A64008	Flat Washer (Two)
H420A64012	Flat Washer, M12
H673A05907	Nut, 3/8-16
H673A09102	Nut, 5/16
H800A04206	Hex Head Bolt, 3/8-16 x 1-inch
H800A08105	Bolt, 5/16-18
H800A09906	Bolt, 1/2-13 x 1-1/4-inch
HNB335050P609	Washer, M10

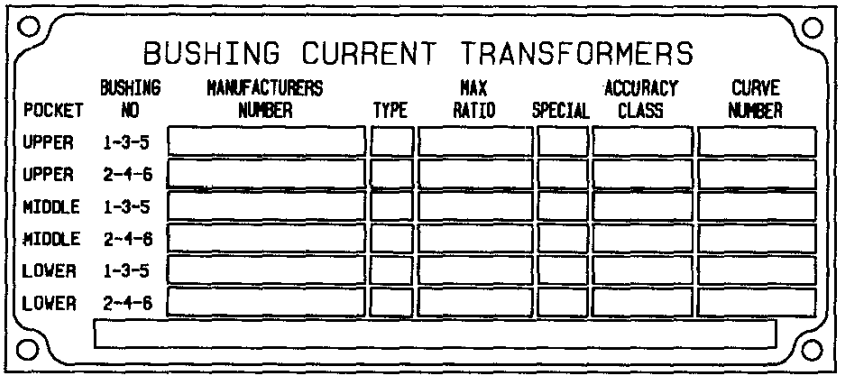

Figure 2
Current Transformer Location Nameplate

SF_6 Circuit Breakers

Type PM

Publication No. 539P009-02

145 PM Interrupters®

ASEA BROWN BOVERI

7 October 1993

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Figures & Checklists

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Interrupters

1 Introduction

The 145 PM interrupters, their operation and maintenance (including disassembly and assembly) are described in this module.

1.1 Description

The type SW interrupter is a single pressure, single break, sulfur hexafluoride (SF_6) gas puffer-type unit capable of interrupting 40 kA terminal faults and 90 percent short-line faults at 40 kA without the addition of external line-to-ground capacitors. Each interrupter consists of a moving contact assembly and a stationary contact assembly, both which contain a main contact and an arcing contact.

Under normal conditions, the main contacts parallel the arcing contacts and carry continuous current through the breaker. During interruption, the main contacts part first. Shortly afterward, the arcing contacts part, an arc propagates between them and the current eventually is interrupted as described in section 1.2. Because the arc is interrupted at the arcing contacts, the integrity of the main current carrying contacts is preserved.

The interrupting components are suspended by an insulating support tube situated within the grounded, cylindrical tank of each pole unit. In the OPEN position, the moving and stationary contact assemblies are isolated from each other by an insulating interrupter tube. The moving contacts are driven by the bellcrank assembly, which converts the vertical motion of the operating mechanism to the horizontal motion of the interrupter contacts. An insulating pullrod connects the bellcrank assembly to the moving contacts.

1.2 Operation

The SW interrupter unit is a single pressure design, using a combination of puffer and self-blast technologies. SF_6 gas fills the pole tanks and bushings at a pressure of 87 psig (600 kPaG) at 20°C (68°F) and serves as both an insulating and arc-quenching medium. The higher pressure SF_6 gas needed for arc interruption is generated during the opening stroke of the breaker, as outlined in the proceeding sub-sections.

1.2.1 CLOSED Position

In the CLOSED position, the contacts are fully engaged and the maximum compressible volume of SF_6 gas is within the moving puffer cylinder. This gas entered the moving puffer cylinder through a one-directional check valve during the previous closing stroke. Refer to the illustration on page 2.

1.2.2 Interruption at High Currents

As the breaker begins to open, the main contacts part first, transferring the current to the arcing contacts. Shortly afterwards, the arcing contacts part and an arc begins to propagate between the arcing contacts which are enclosed within Teflon nozzles. While the current is at higher levels or, in other words, around current peak, the arc heats and pressurizes the SF_6 gas in the area surrounding the arcing contacts. This pressure build-up propels the heated SF_6 gas surrounding the arcing contacts into the constant volume self-blast chamber while the unique nozzle design directs the flow. Refer to the illustration on page 2.

By virtue of the advanced design of the SW interrupter, the hot, pressurized gas is able to be sufficiently cooled by turbulently mixing with the cool gas in the self-blast chamber. This action results in a high pressure mixture at a low temperature - a necessity to ultimately achieve interruption.

Approaching current zero, the intensity of the arc reduces. As a result, gas flow reverses driving the pressurized SF_6 gas across the arcing contacts. Owing to the excellent thermal properties of the SF_6 gas, the arc is cooled and finally extinguished at current zero.

After the arc is extinguished, the moving contacts continue to travel to the fully OPEN position. During this time, the area around the contact gap is cleansed of hot gases and decomposition products to re-establish the dielectric strength in the contact zone.

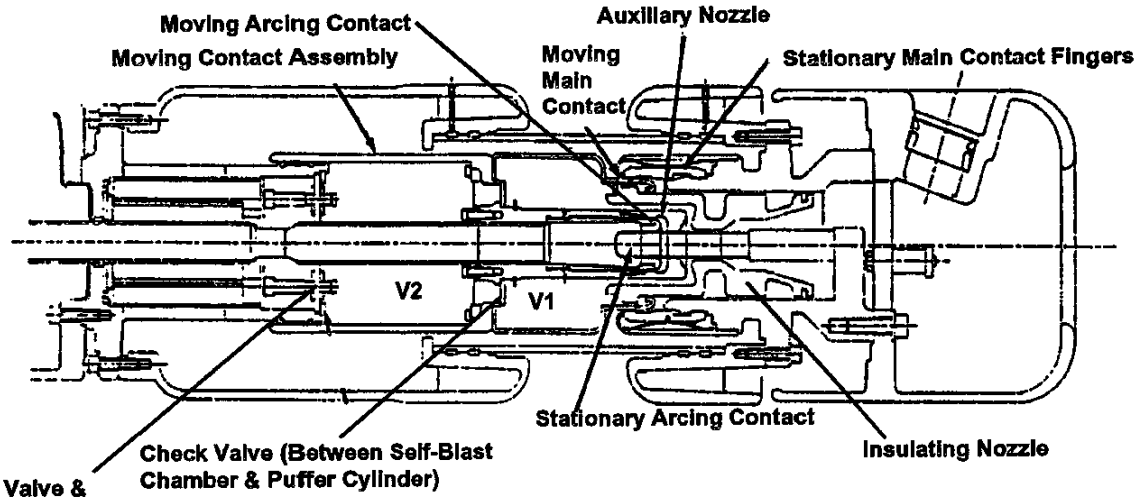
During high current interruption, the pressure build-up is high enough in the self-blast chamber to cause the one-directional check valve between the self-blast chamber and the puffer cylinder to seal off the path between the two. A relief valve built into the moving contact support provides a means for releasing the pressure build-up in the puffer cylinder at a predetermined value (lower than the pressure in the self-blast chamber during high current interruption).

To summarize the process of high current interruption, the energy required for pressurizing the SF_6 gas used to extinguish the arc is generated by the arc itself, thus the "self-blast" designation. Unlike pure puffer interrupters, the SW interrupter does not require as powerful of a mechanism because the pressure differential needed for high current interruption is generated by the arc and not by the mechanism. The maximum pressure build-up in the puffer cylinder is limited to the release pressure of the relief valve.

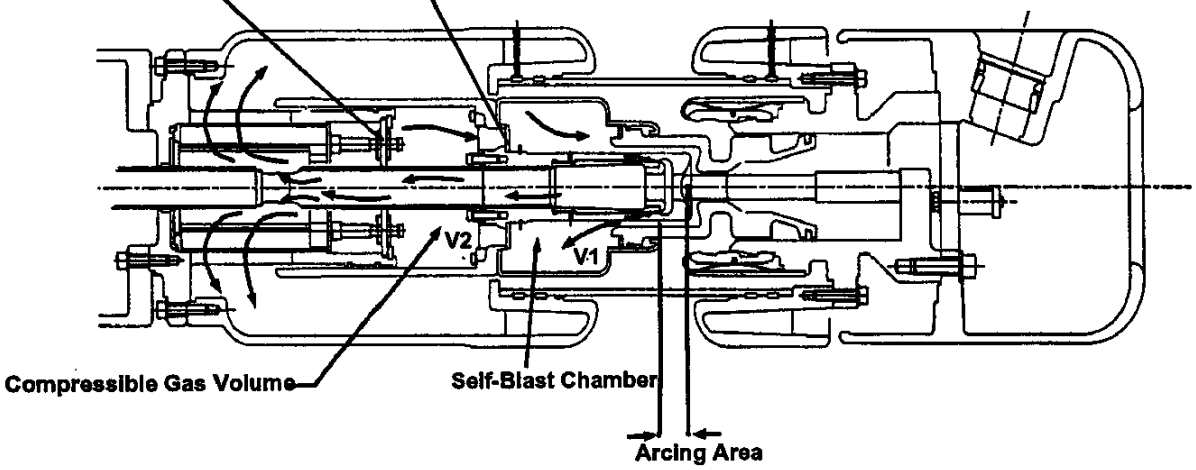
1.2.3 Interruption at Low Currents

For interruption of lower currents which cannot generate sufficient gas pressure in the self-blast chamber, a "light" puffer cylinder provides the pressure differential needed to extinguish the arc. In this case, the one-directional valve between the self-blast chamber and the puffer cylinder does not seal off because the pressure build-up in the self-blast chamber does not exceed the release value of the relief valve. Pressurized gas flows from the puffer cylinder through the self-blast chamber and into the arcing zone to extinguish the arc. This "soft interruption" process effectively quenches lower current arcs for load switching, capacitive switching, and inductive switching. The puffer cylinder provides a gentle blast which minimizes current chopping during inductive switching.

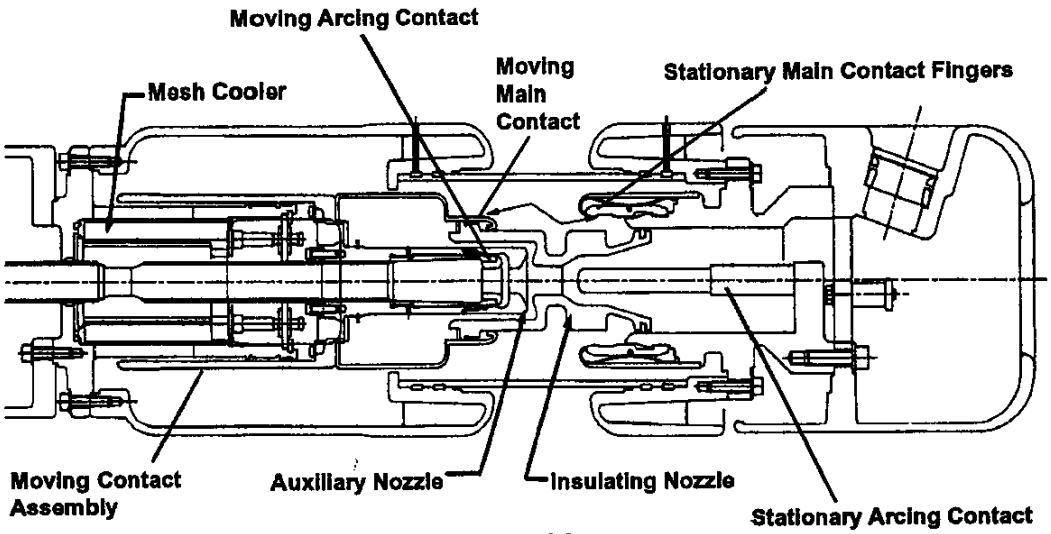
After the arc is extinguished, the moving contacts continue to travel to the fully OPEN position. During this time, the area around the contact gap is cleansed of hot gases and decomposition products to re-establish the dielectric strength in the contact zone.



Closed Position



Interruption



Open Position

1.2.4 OPEN Position

In the OPEN position, contact separation provides full rated dielectric capability and the breaker stands prepared for its next closing operation. Refer to the illustration on page 2.

1.2.5 Interrupter Closing Operation

During a closing operation, the arcing contacts make before the main contacts of the continuous current path. Due to the movement of the puffer cylinder, the puffer chamber fills with SF_6 gas through the check valve located in the moving contact support assembly.

2 Interrupter Maintenance

Interrupter maintenance is summarized in Table 1 below. Interrupter maintenance includes:

- Nozzle and contact inspection;
- Removing decomposition products;
- Replacing nozzles and contacts as needed;
- Replacing other worn parts as needed.

Refer to the flow chart in Figure 1 which shows the overview and sequence for performing interrupter maintenance procedures. A checklist at the end of this module is provided for interrupter maintenance. This checklist serves as a reference guide of all interrupter components to be replaced or inspected during major interrupter maintenance which is performed at 10 years or after the permissible number of operations listed in Table 2 on page 5.

Table 1

Maintenance Procedure Quick Reference Table

Maintenance Procedure	Place(s) to Refer to in This Manual
Complete Interrupter Unit Maintenance	Sections 2.1 to 2.6
Reclaim the SF6 Gas	Refer to the Pole Unit module.
Remove the Rear Tank Cover Assembly/Open the Pole Unit	Refer to the Pole Unit module.
Inspect the Nozzles and Contacts	Section 2.3
Remove the Interrupter Unit	Refer to the Pole Unit module.
Disassemble the Interrupter Unit	Section 2.4
Replace the Nozzles and Contacts	Sections 2.3, 2.4, and 2.5
Re-Assemble the Interrupter Unit	Section 2.5
Re-Install the Interrupter Unit	Refer to the Pole Unit module.
Replace the Desiccant	Refer to the Pole Unit module.
Re-Install the Rear Tank Cover Assembly	Refer to the Pole Unit module.
Refilling the Breaker with SF6 Gas	Refer to the Pole Unit module.

2.1 Material Required for Interrupter Maintenance

The following materials are required for interrupter maintenance:

- Flashlight;
- No-Go gauge T13406 (Fig. 2);
- Interrupter dolly T13445;
- Interrupter assembly fixture T13438 (Fig. 6);
- Inside calipers;
- Threaded rod tool T13428 (Fig. 7);
- Clip tool T13439 (Fig. 8);
- Alignment tool T13440 (Fig. 13);
- Contact finger assembly tool T13207 (Fig. 15);
- Deep socket tool T13437 (Fig. 14);
- DILO quick disconnect tool T13433;
- Denatured ethyl alcohol;
- Lint-free wipers;
- Shell Alvania No. 2 Grease;
- Dow Corning Fluoro Silicone FS-1292 Grease;
- Molycote Spray, Dow Corning 321R;
- Pro AA2 grease;
- Set of metric wrenches and sockets;
- Set of metric allen head sockets 4 mm to 10 mm size;
- 15/16-inch and 11/16-inch standard open end wrenches;
- 15/16-inch crowsfoot wrench;
- Torque wrench 10 to 150 ft-lbs;
- Clean work area with workbench.

2.2 Interrupter Maintenance Standard Practices

The following sub-sections are general, recommended practices employed in the process of performing maintenance on the interrupters.

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance procedures.

2.2.1 General Cleanliness

Maintaining the cleanliness of the component surfaces in the breaker is an extremely important part of maintenance because the major insulating components in the breaker are subjected to high electrical stresses. Because cleanliness is so important, care must be taken to perform internal breaker maintenance under clean, dry conditions.

Warning

The importance of cleanliness cannot be overstressed. Introducing loose dirt, especially metallic particles, into an open pole unit (SF_6 gas compartment) can cause dielectric failure. Insulating surfaces must be protected from physical, damage (nicks and scratches) and kept clean and dry at all times.

Loose dirt (especially metallic particles) as well as residue left from sweaty hands and atmospheric moisture can lead to dielectric failure. It is best to avoid handling critical insulating components with bare hands. Instead, wear snug-fitting cloth gloves when handling insulating parts and surfaces. To ensure cleanliness, wipe insulating surfaces with lint-free wipers dampened with denatured ethyl alcohol.

Important: Never clean an insulating component with the same wiper used to clean aluminum or metal parts.

2.2.2 Fastener Locking

Since the impact loading which the circuit breaker experiences during operation tends to loosen threaded hardware, Loctite Threadlocker must be applied to all critical bolted joints. Four types of Loctite are used for specific applications: 222, 242, 262, and 271.

Clean the threads in blind holes if they can be adequately dried afterwards. Apply Loctite sparingly to the outermost edges of the thread. Two small drops of Loctite are enough even for large threads.

Hardware secured with Loctite usually can be unfastened with proper wrenches. In case of difficulty, the connection can be loosened by heating the joint to 150°C (300°F). Be careful not to damage materials which are sensitive to heat, such as insulation or sealing components.

Use particular care in applying Loctite to fasteners used in assembling current carrying connections. Apply Loctite only where specified. If used improperly, Loctite can squeeze between contact areas and may cause a high resistance joint. Ensure that excess Loctite does not squeeze into contact areas.

2.2.3 Treatment of Silverplating

Silverplated contact areas can be polished *lightly* with Scotch-Brite to remove surface oxide. Do not heavily abrade the silverplated surfaces to avoid rubbing off the plating.

In situations where sliding contact joints are used, such as in the case of the plug-in type bushing conductors or main breaker contacts, the silverplated areas must be lubricated with Shell Alavania No. 2 Grease. Thoroughly rub the grease into the microscopic pores of the silverplated surface; remove all excess grease so that only a light film remains.

2.3 Nozzle and Contact Inspection

Contacts are designed to withstand a great number of load switching operations without maintenance as well as a fewer number of operations as the interrupting current increases. Table 2 lists the recommended maximum number of operations that can be performed at various current levels before nozzle and contact inspection are required.

Table 2
Operations/Maintenance Table

Switching Current KA	Recommended Number of Operations
Up to 3	2000
5	400
10	100
20	25
30	10
40	10

After reaching any of the limits listed in Table 2 or after 10 years (whichever occurs first), inspect the nozzles and contacts using the procedures and replacement criteria as described in section 2.3.1.

Important: Contacts in the 145 PM circuit breaker can be inspected without completely removing the interrupter unit. However, should the nozzles and contacts require replacement or if SF_6 decomposition products are present which cannot be completely vacuumed away with the interrupter in place, the entire interrupter unit will have to be removed, disassembled, and cleaned completely.

Warning

If SF_6 decomposition products are present (when the pole unit is opened) they must be removed and disposed of as soon as possible as described in the module, Safe Handling Practices for SF_6 Gas. Clean the breaker parts, especially the insulating components, promptly after opening the pole unit to prevent damage and possible failure caused by corrosive and conductive compounds formed when decomposition products are exposed to moisture in the air.

2.3.1 Nozzle and Contact Replacement Criteria

Criteria for determining when to replace the nozzles and arcing contacts is based upon the condition of the insulating and auxiliary nozzles. The No-Go gauge T13406 (Fig. 2) is used to determine if the nozzles are acceptable.

The No-Go gauge has a hub at the center and two gauge ends - the smaller end is used to check the diameter of the auxiliary nozzle throat; the larger end is used to check the diameter of the insulating nozzle throat. Refer to the illustrations on pages 7 and 8. For a nozzle to be acceptable, the No-Go gauge must not penetrate the throat of the respective nozzle. If the hub touches the end of the insulating nozzle, this indicates that the gauge has penetrated a nozzle.

If any nozzle is unacceptable, the arcing contacts (moving and stationary) as well as the nozzles (auxiliary and insulating) will need to be replaced.

Because burning is primarily limited to the arcing contacts, the main contacts are less likely to be worn beyond use. However, if the main contacts experience a lot of operations, the silverplating on these contacts may become worn due to friction. If a copper tint is visible through the silverplating, the main contacts need to be replaced.

2.3.2 Inspecting the Nozzles and Contacts

Contact inspection involves:

- Checking the insulating and auxiliary nozzles with a No-Go gauge T13406 (Fig. 2);
- Determining the condition of the main contacts;
- Determining the need for internal cleaning based on the presence of SF_6 decomposition products.

Before performing this inspection, the following must be done:

- Reclaim SF_6 gas from the breaker;
- Open the pole unit.

Refer to the Pole Unit module for instructions to reclaim SF_6 gas and open the pole unit.

After opening the pole unit and performing initial cleaning procedures, continue with contact inspection as follows:

1. Remove the two M8 nuts H420A50008 (Fig. 3) and washers H420A60008 mounting the deflector 30075.
2. Remove the M12 nut H420A50012 fastening the rear exhaust shield 30077 to the bottom of the bushing conductor.
3. Disconnect the high voltage connections to the entrance bushings of the pole unit (at the four-hole NEMA terminal pad).
4. Remove the four-hole NEMA terminal pads from the bushing top caps (front and rear) so that the bushing conductor removal tool T13441 (Fig. 17) can be attached.

5. Remove the six 1/2-inch hex head bolts H800A45708 (Fig. 18) and washers H420A64012 from the bushing top flange.

6. Pull each plug-in bushing conductor 20001 (front and rear) from their respective plug-in connections 30052 (Fig. 4) using the bushing conductor removal tool T13441 (Fig. 17) as detailed in the steps below. The bushing conductor removal tool is a puller used to withdraw the plug-in bushing conductor from its female connection on the interrupter. The tool is made up of a T-bracket, studs, horseshoe washers, and a jacking screw. To pull each bushing conductor from its plug-in connection:

   a. Screw the three studs of the bushing conductor removal tool into the bushing top flange 120 degrees apart (into the vacant holes from bolts removed in step 5).

   b. Bolt the jacking screw onto the top cap of the bushing using the bolts provided with the tool. (The jacking screw replaces the four-hole NEMA terminal pad.)

   c. Place a horseshoe washer (provided with the tool) in the slot of each stud to support the T-bracket on the studs above the bushing cap. Secure the T-bracket to the studs using the provided nuts and flat washers.

   d. Jack the bushing conductor from its plug-in connection by turning a nut onto the jacking screw. The bushing conductor will need to be raised approximately 2 inches until the conductor is disengaged.

   e. Once the bushing conductor is free from its plug-in connection, remove the T-bracket, horseshoe washers, and the jacking screw.

   f. Carefully lift the bushing conductor by hand while supporting it at its lower end. Lift the bushing conductor above the slots in the studs and re-install the horseshoe washers to allow the assembly to rest on the horseshoe washers.

   g. Screw the three nuts provided with the tool back onto the studs to firmly fix the retracted bushing conductor in place.

   h. Cover the open top of the bushing with a plastic bag to prevent debris from entering the bushing.

7. Remove the rear exhaust shield 30077 (Figs. 3 and 4) of the interrupter unit by unscrewing the three M12 nuts H420A50012 which mount the shield.

8. Remove the M8 socket head bolts H420A04611 (Fig. 4) which mount the stationary contact assembly 30019; pull the stationary contact assembly from the interrupter and lift it out of the rear of the pole tank. Refer to Plate 2 on page 10.

9. Inspect the auxiliary nozzle 30004 (Fig. 10) using the specially designed No-Go gauge T13406 (Fig. 2) by passing the smaller end of the No-Go gauge through the throat of the insulating nozzle until it reaches the auxiliary nozzle. The No-Go gauge has a hub at the center. If the hub touches the end of the insulating nozzle, this indicates that the gauge has penetrated the throat of the auxiliary nozzle and that the nozzle is eroded unacceptably. Refer to the illustration on page 8.

Important: *When the nozzles are nearly new, the smaller end of the gauge may not pass through the throat of the insulating nozzle preventing access to the auxiliary nozzle. If this is the case, the auxiliary nozzle is acceptable.*

10. Inspect the insulating nozzle 30005 (Fig. 10) using the larger end of the No-Go gauge. If the hub touches the end of the insulating nozzle, this indicates that the gauge has penetrated the throat of the insulating nozzle and that the nozzle is eroded unacceptably. Refer to the illustration on page 7.

11. If any nozzle is unacceptable, the arcing contacts (moving and stationary) as well as the nozzles (auxiliary and insulating) will need to be replaced.

Important: *Although the nozzles may have passed this inspection and have some usable life left, there may be wear that warrants replacement - especially if the contacts are blackened and significant amounts of decomposition products are present. Since the breaker is already opened and the interrupter unit will need to be removed to clean out the decomposition products, ABB recommends, for convenience, that you replace the nozzles and contacts at this time.*

12. Examine the main moving contact/self-blast chamber 30116 (Fig. 10) and the stationary contact fingers 30026 (Fig. 5). If a copper tint is visible through the silverplating, the main contacts need to be replaced.

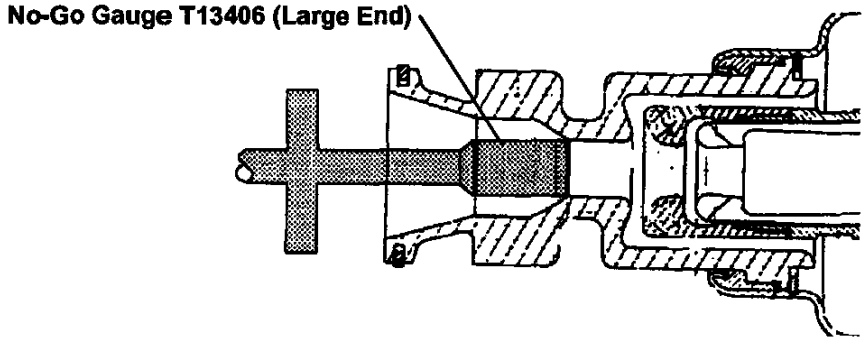
13. If any nozzles and contacts are not acceptable, remove the interrupter assembly as described in the Pole Unit module and then, disassemble the interrupter (refer to section 2.4 in this module); then replace the contacts and nozzles (refer to section 2.5 in this module).

Notice: *Always replace nozzles and contacts in complete sets. For example, the stationary arcing contacts should not be replaced without also replacing the moving arcing contacts and nozzles.*

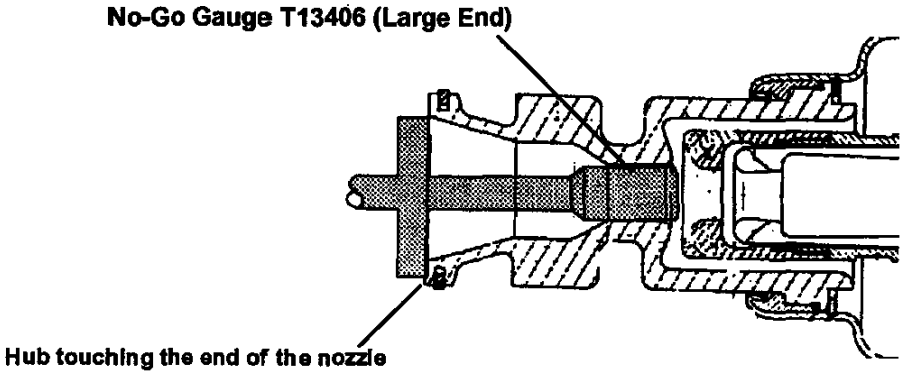
If the nozzles and contacts are acceptable, proceed to section 2.3.2.1.

No-Go Gauge Test of Insulating Nozzle

Cross-Sectional View



Acceptable Insulating Nozzle

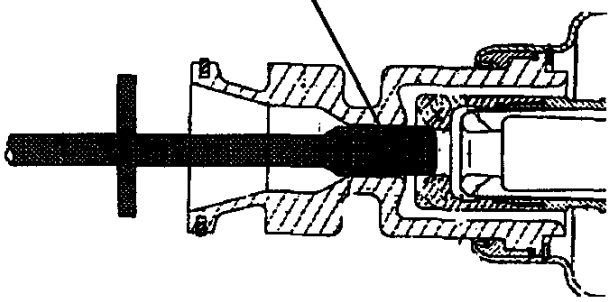


Unacceptable Insulating Nozzle

No-Go Gauge Test of Auxiliary Nozzle

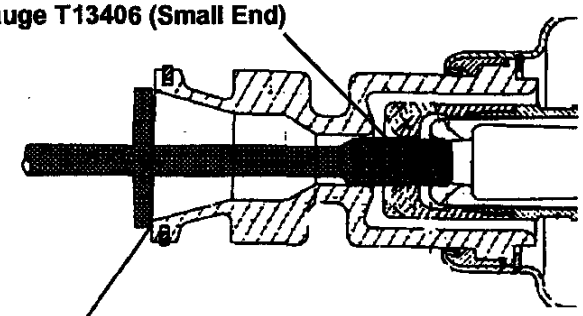
Cross-Sectional View

No-Go Gauge T13406 (Small End)



Acceptable Auxiliary Nozzle

No-Go Gauge T13406 (Small End)



Unacceptable Auxiliary Nozzle

Hub touching the end of the nozzle

2.3.2.1 Re-Assembly after Contact Inspection

To re-assemble and close the pole unit:

1. Perform the slow close procedure described in the Interphase Linkage module to move all three moving contact assemblies of the interrupter units into the CLOSED position.

Notice: *Before re-installing any of the stationary contact assemblies, the moving contact assemblies of the interrupter units must be in the fully CLOSED position to ensure proper contact alignment when the stationary contact assemblies are re-installed. Perform the slow close procedure as described in the Interphase Linkage module to position the moving contact assemblies of the interrupter units in the fully CLOSED position.*

2. Thoroughly clean all components with lint-free wipers dampened with denatured ethyl alcohol; grease the main contact silverplated surfaces with Shell Alvania No. 2 Grease.

Notice: *SF_6 decomposition products must be removed completely. This may involve removing the interrupter unit. Refer to the Pole Unit module.*

3. Lift the stationary contact assembly 30019 (Figs. 4 and 5) into the rear of the interrupter unit and **firmly** push it into position so that it fully engages the moving contact assembly (to ensure contact alignment). Be sure that the stud H783A31803 (Fig. 3) located closest to the base of the boss that supports the stationary arcing contact 30020 (Fig. 5) is aligned opposite the plug-in connections 30052 (Fig. 3) for the bushing conductors.

4. Place a drop of Loctite 242 on the threads of each M8 socket head bolt H420A04611 (Fig. 4) used to mount the stationary contact assembly. Screw the M8 socket head bolts H420A04611 with washers H420A60008 into place and torque them to 22 Nm (16 ft-lbs).

5. Clean the silverplated areas on the rear exhaust shield 30077 with lint-free wipers dampened with denatured ethyl alcohol.

6. Place the rear exhaust shield into position. Apply Loctite 242 to the threads of the three studs H783A31803 (Fig. 3) and re-install the M12 nuts H420A50012 (Figs. 3 and 4) and flat washers H420A60012 until they are **hand tight only**. (These nuts will be tightened and torqued in step 19 of this procedure.)

7. Pull the old O-ring 90001 (Fig. 18) from the groove in the top cap of the bushing.

8. Cut the O-ring to remove it.

9. Drop a clean length of string through the hollow bushing and into the pole tank.

10. Tie a new O-ring to the string and use the string to pull the O-ring over the bushing conductor up to the top cap.

11. Thoroughly clean the O-ring groove with a lint-free wiper dampened with denatured ethyl alcohol.

12. Firmly press the new O-ring into the groove.

13. Apply Dow Corning FS-1292 Grease to the flange surfaces outside of the O-ring to prevent corrosion.

14. Repeat steps 7 through 13 to replace all other affected top cap O-rings.

15. Rub Shell Alvania No. 2 Grease into the microscopic pores of the silverplated tip of the bushing conductor 20001 (Fig. 18); remove all excess so that only a light film remains.

16. Carefully lower the bushing conductor allowing the plug-in connection 30052 (Figs. 3 and 4) to engage.

17. Remove the three studs of the bushing conductor removal tool T13441 (Fig. 17) and re-install the six 1/2-inch hex head bolts H800A45708 (Fig. 18) and washers H420A64012 at the bushing top flange. Apply Loctite 242 to threads of each bolt and torque to 45 Nm (33 ft-lbs).

18. Re-install the M12 nut H420A50012 (Fig. 3) and washer H973A32701 that connect the bushing conductor to the rear exhaust shield 30077. Apply Loctite 242 to the stud H420A46705 and turn the M12 nut H420A50012 to jack up the rear exhaust shield until it is approximately centered within the pole tank. (The nut will not need to be torqued or completely tight; a fork on the deflector 30075 will hold the nut into position.) Use inside calipers to verify that the exhaust shield is approximately centered in the pole tank.

19. Torque the M12 nuts H420A50012 (Figs. 3 and 4) and flat washers H420A60012 (which fasten the rear exhaust shield 30077 to the stationary contact assembly 30019; refer to step 6) to 72 Nm (52 ft-lbs).

20. Re-install the two M8 nuts H420A50008 (Fig. 3) and washers H420A60008 mounting the deflector 30075. Apply Loctite 242 and torque to 22 Nm (16 ft-lbs).

21. Refer to the Pole Unit module to proceed as follows:
    - Install a new desiccant bag.
    - Re-install the rear tank cover assembly to close the pole unit.
    - After the pole unit has been closed, immediately evacuate the pole unit and fill with SF_6 gas.
    - Re-install the NEMA four-hole terminal pads at the bushing top cap.

2.4 Disassembling the Interrupter Unit

After removing the interrupter unit 30000, 30121, or 30122 (Fig. 4) as described in the Pole Unit module, disassemble the interrupter unit in a clean, dry work area as follows:

1. Remove any SF_6 decomposition products immediately as described in the module Safe Handling Practices for SF_6 Gas. Refer to Plate 1.

Important: While disassembling the interrupter, wipe away any SF_6 decomposition products (if present) with a lint-free wiper dampened with denatured ethyl alcohol.

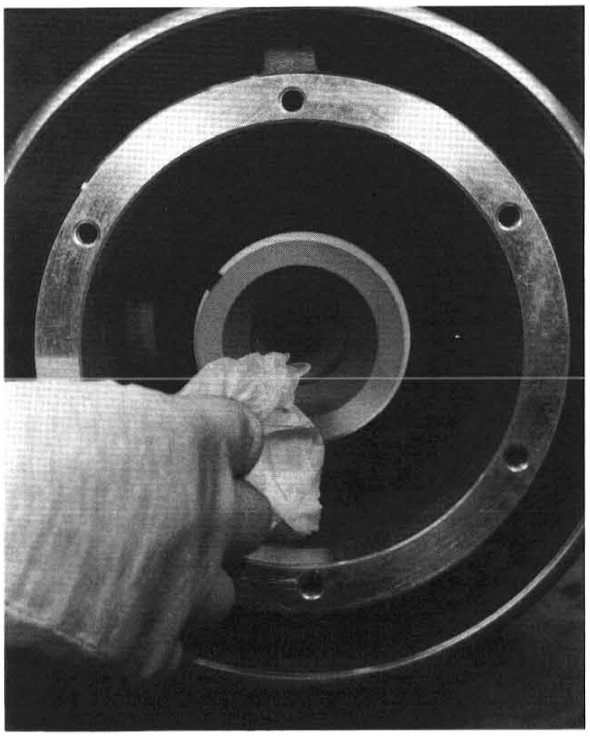


Plate 1: Removing SF_6 decomposition products

2. Remove the stationary contact assembly 30019 (Figs. 4 and 5) by unscrewing the M8 socket head bolts H420A04611 (Fig. 4). Refer to Plate 2.

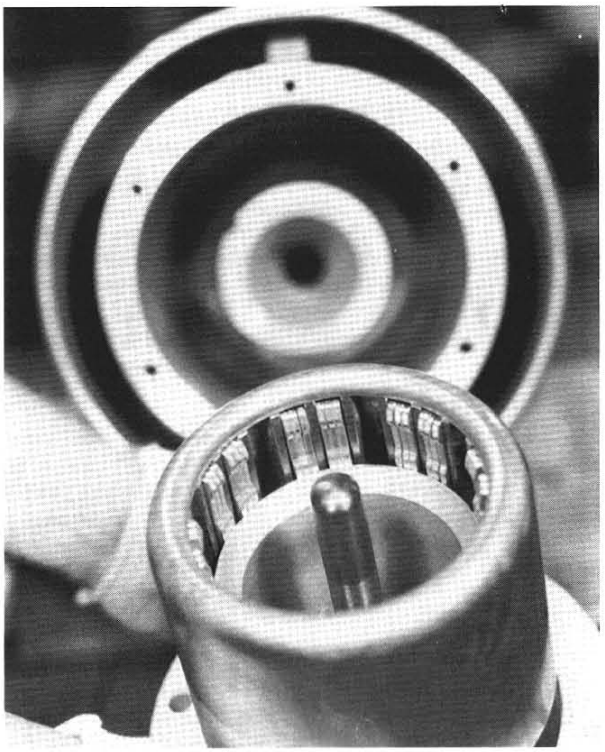


Plate 2: Removing the stationary contact assembly

3. Lift and turn the interrupter unit into a vertical position and lower it onto the interrupter assembly fixture T13438 (Fig. 6).

4. Rotate the interrupter until it drops 1/4-inch and locks on the interrupter assembly fixture.

5. Remove the M8 socket head bolts H420A04611 (Fig. 4) holding the bellcrank assembly 10151, 10159, or 10160 to the support tube 30051.

6. Use the threaded rod tools (two) T13428 (Fig. 7) and clip tools (two) T13439 (Fig. 8) to raise and support the bellcrank assembly above the interrupter. Refer to Plate 3. To do so, insert the threaded rod tools (with the groove in the rod turned down) through the interrupter support tube bolt holes and hand tighten the rod tools into the bellcrank bolt holes. Lift the bellcrank approximately 4 inches or high enough to insert the clip tools into the grooves on the rod tools. The bellcrank is now suspended, allowing access to the pullrod coupling 30106 (Fig. 4).

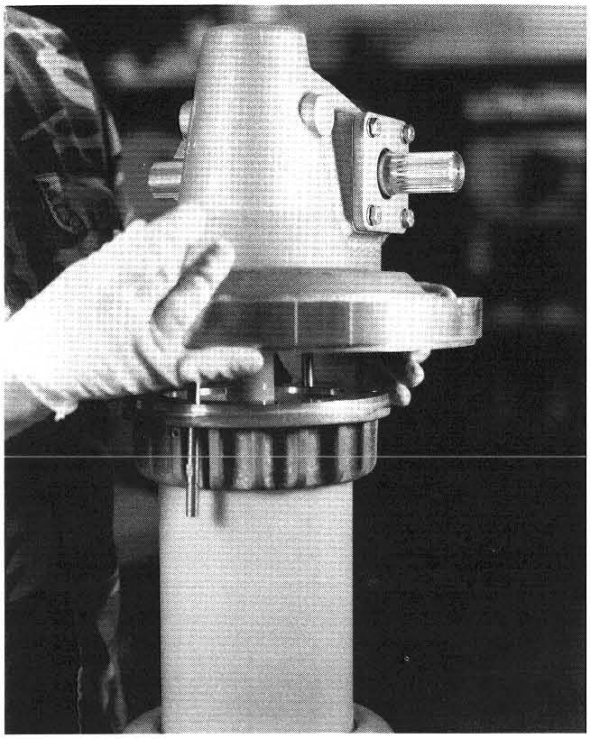


Plate 3: Threaded rod tool

7. With a set of inside calipers, measure the length of the pullrod coupling 30106 (Fig. 4) between the bellcrank arm and operating pullrod 30032 for reference on reassembly. Refer to Plate 4.

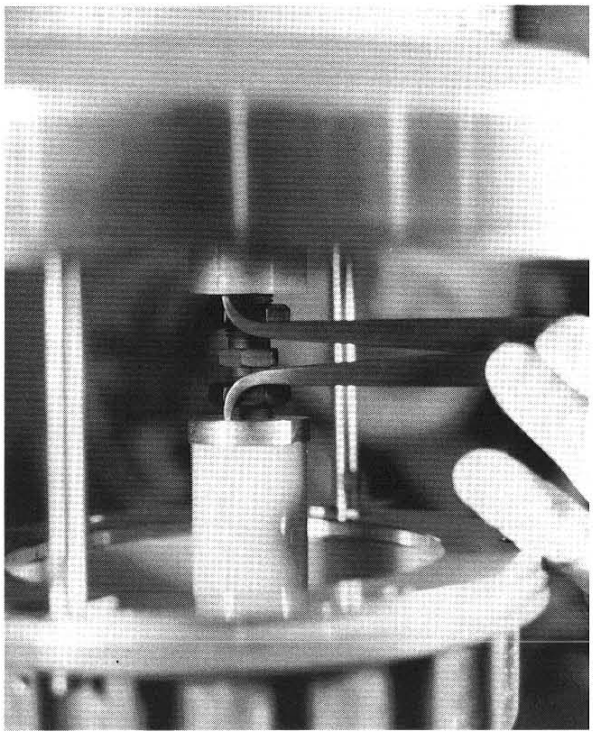


Plate 4: Measuring the length of the pullrod coupling with inside calipers

8. Loosen the M16 jam nuts H420A54116 (right hand) (Fig. 4) and H420A54156 (left hand) securing the pullrod coupling 30106. (An 11/16-inch open-end wrench and a 15/16-inch open-end wrench are needed.)

9. Remove the pullrod coupling 30106 (Fig. 4). Refer to Plate 5.

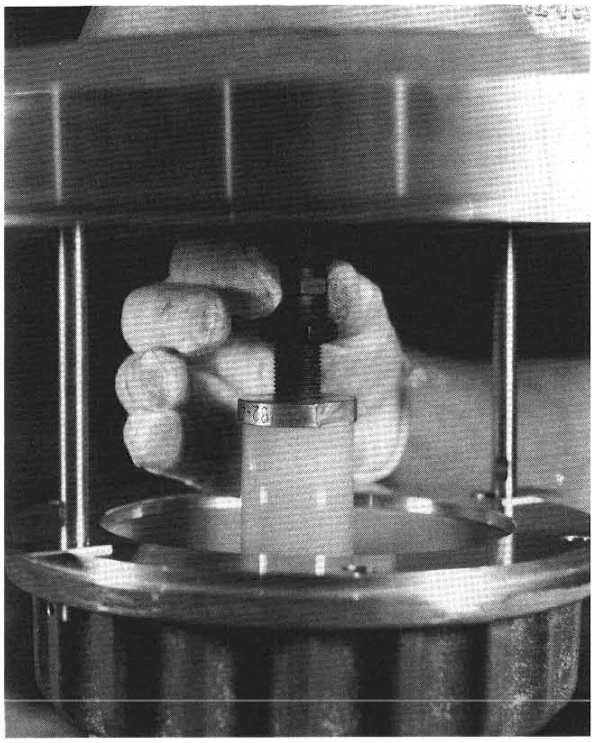


Plate 5: Removing the pullrod coupling

10. Once the pullrod coupling has been removed, lift the bellcrank away from the interrupter unit.

11. Using a socket wrench with a long extension, remove the M8 socket head bolts H420A04611 (Fig. 4) holding the support tube 30051 to the moving contact support assembly 30012. Lift away the support tube. Refer to Plate 6.

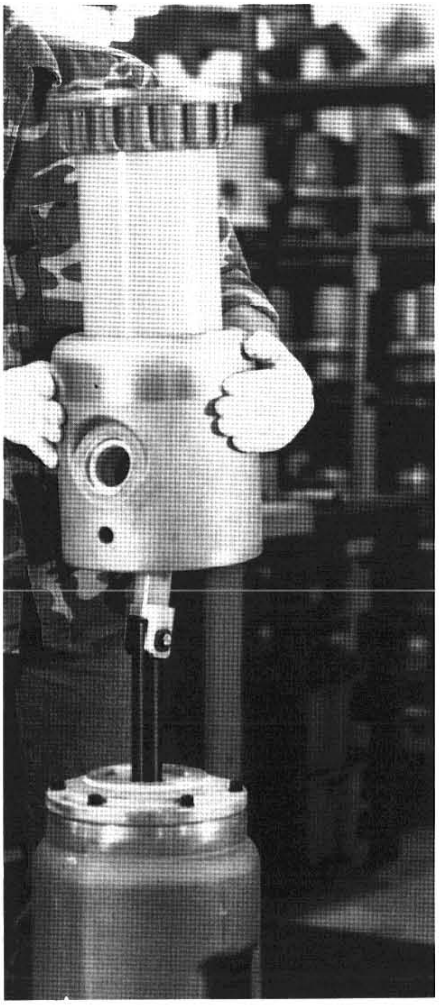


Plate 6: Lifting away the support tube

12. Remove the M8 hex head bolt H420A30406 (Fig. 4) and flat washer H420A60108 which hold the pullrod wrist pin 30105 in place and slide away the wrist pin to free the operating pullrod 30032. Refer to Plate 7.

13. Remove the M8 socket head bolts H420A04611 (Fig. 4) holding the moving contact support assembly 30012 to the interrupter tube 30030.

14. Slide the moving contact support assembly 30012 from the puffer cylinder 30007 (Fig. 10). Refer to Plate 8.

Plate 7: Removing the wrist pin of the operating pullrod

Plate 8: Withdrawing the moving contact support assembly

15. Lift the moving contact assembly 30001 (Fig. 4) out of the interrupter tube. Refer to Plate 9.

Plate 9: Lifting the moving contact assembly out of the interrupter tube

At this point, the interrupter is disassembled into its sub-assemblies. Refer to section 2.5 to replace the nozzles and contacts and re-assemble the interrupter unit.

2.5 Replacing Nozzles and Contacts and Re-Assembling the Interrupter Unit

Replacing the nozzles and contacts and re-assembling the interrupter unit 30000, 30121, or 30122 (Fig. 4) includes the following procedures:

- Rebuilding the moving contact assembly 30001 (Fig. 10) (section 2.5.1);
- Rebuilding the moving contact support assembly 30012 (Fig. 9) (section 2.5.2);
- Rebuilding the stationary contact assembly 30019 (Fig. 5) (section 2.5.3);
- Re-assembling the interrupter unit (section 2.5.4).

The following items should be replaced with new parts when re-assembling the interrupter unit:

- Moving arcing contact 30006 (Fig. 10);
- Auxiliary nozzle assembly 30117 (Fig. 10);
- Insulating nozzle 30005 (Fig. 10);
- Main moving contact/self-blast chamber 30116 (Fig. 10);
- Mesh cooler 30107 (Fig. 9);
- Multi-lam contact 30014 (Fig. 9);
- Inner guide bearing 30103 (Fig. 9);
- Outer guide bearing 30104 (Fig. 9);
- Stationary arcing contact 30020 (Fig. 5);
- Stationary main contact fingers 30026 (Fig. 5).

2.5.1 Rebuilding the Moving Contact Assembly

To refurbish and re-assemble the interrupter, start by rebuilding the moving contact assembly 30001 (Fig. 10). Refer to Plate 10. Section 2.5.1.1 lists the procedure for disassembling the moving contact assembly; section 2.5.1.2 lists the procedure for re-assembling the moving contact assembly.

Plate 10:Components of the moving contact assembly

2.5.1.1 Disassembling the Moving Contact Assembly

To disassemble the moving contact assembly 30001 (Fig. 10):

1. Remove the M5 socket head bolts H420A04410 (Fig. 10) holding the puffer cylinder 30007 to the main moving contact/self-blast chamber 30116 using a socket wrench and long extension. Refer to Plate 11.

Plate 11:Separating the main moving contact/self blast chamber from the puffer cylinder

2. Remove the retaining snap ring H776A34304 (Fig. 10) which secures the insulating nozzle 30005 into the main moving contact/self-blast chamber. Refer to Plate 12.

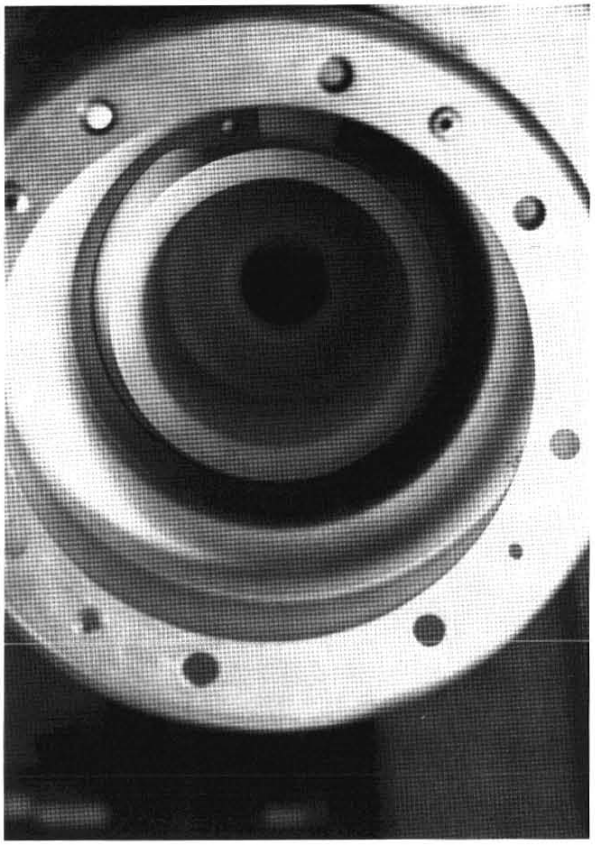


Plate 12:Retaining snap ring for the insulating nozzle

3. Remove the insulating nozzle guide ring 30119 (Fig. 10) from its groove on the insulating nozzle 30005. Refer to Plate 13.

Plate 13: Removing the insulating nozzle guide ring

4. Press the insulating nozzle out of the main moving contact/self-blast chamber 30116 (Fig. 10).

5. Unscrew the auxiliary nozzle assembly 30117 at the auxiliary nozzle adapter 30118 to release the moving arcing contact 30006. Refer to Plate 14.

Important: *If either the insulating nozzle or the auxiliary nozzle failed the No-Go test during the inspection (section 2.3.2); both nozzles and the arcing contacts must be replaced as a complete set.*

Plate 14: Unscrewing the auxiliary nozzle

6. Inspect the main contact area of the main moving contact/self-blast chamber 30116 (Fig. 10) and the inner wall of the puffer cylinder 30007. If a copper tint is visible through the silverplating of either the main contact and/or the inner wall of the puffer cylinder, the part(s) need to be replaced.

Important: *If the silverplating of the main moving contact/self-blast chamber or puffer cylinder is worn to the point that a copper tint is visible through the silverplating, the component must be replaced.*

7. If the puffer cylinder 30007 (Fig. 10) must be replaced, separate it from the exhaust tube 30002 by removing the lock nut HHATE400176P1 using the exhaust tube tool T13455 (Fig. 20). Refer to Plate 15.

Plate 15:Removing the exhaust tube lock nut

8. Remove the check plate (self-blast chamber) 30102 (Fig. 10) by releasing the retaining snap ring H776A34705. Refer to Plate 16.

Plate 16:Removing the check plate

The moving contact assembly is now disassembled and ready to be rebuilt. Complete the checklist at the end of this module before re-assembling any interrupter component.

2.5.1.2 Re-Assembling the Moving Contact Assembly

After determining the components that need to be replaced, re-assemble the moving contact assembly 30001 (Fig. 10) as follows:

1. Clean all components using lint-free wipers dampened with denatured ethyl alcohol.

*Important: Because the auxiliary nozzle 30004 (Fig. 10) and insulating nozzle 30005 are insulating components, they must be cleaned using **new** lint-free wipers that have not be used on metal components to avoid contamination.*

2. Re-install the exhaust tube 30002 into the puffer cylinder 30007. Refer to Plate 17.

Plate 17:Re-installing the exhaust tube

3. Apply Loctite 242 to the lock nut HHATE400176P1 (Fig. 10) and torque to 275 Nm (202 ft-lbs). Refer to Plate 18.

Plate 18:Lock nut

4. Re-install the check plate (self-blast chamber) 30102 (Fig. 10) by replacing the retaining snap ring H776A34705. Refer to Plate 19.

Important: It is good general practice to replace old retaining snap rings with new retaining snap rings.

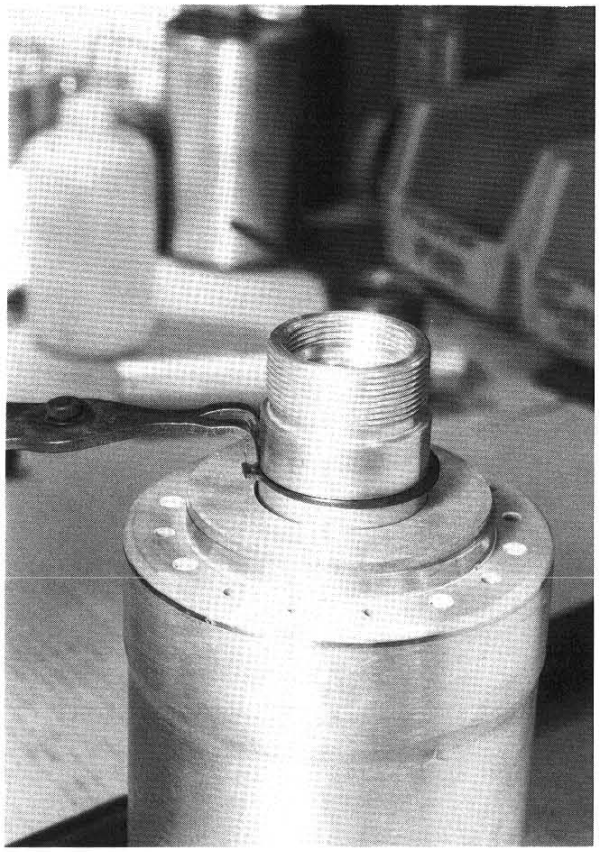


Plate 19: Re-installing the check plate

5. Unscrew the auxiliary nozzle 30004 (by hand) (Fig. 10) from the auxiliary nozzle adapter 30118. Replace the old auxiliary nozzle with a new nozzle. Firmly hand-tighten the new auxiliary nozzle in place. Refer to Plate 20.

Plate 20: Replacing the auxiliary nozzle

6. Insert a new moving arcing contact 30006 (Fig. 10) into the auxiliary nozzle assembly 30117 (which includes the auxiliary nozzle 30004 and auxiliary nozzle adapter 30118).

7. Apply Loctite 242 to the male threads of the auxiliary nozzle assembly 30117 (Fig. 10) connection and install the assembly. Torque the auxiliary nozzle assembly to 70 Nm (52 ft-lbs). Refer to Plate 21.

8. Place a new insulating nozzle O-ring 90004 (Fig. 10) into the corresponding groove on a new insulating nozzle 30005. Refer to Plate 22.

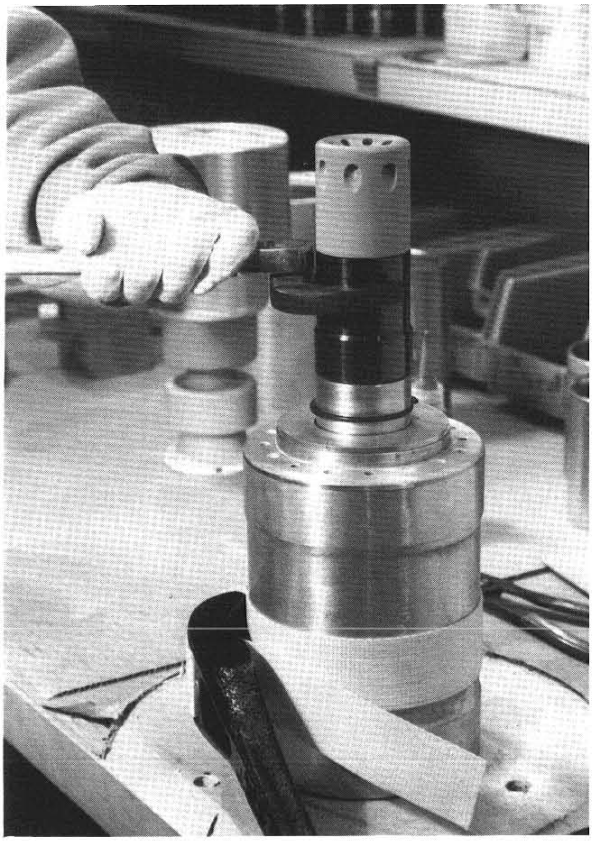


Plate 21:Re-installing the auxiliary nozzle assembly

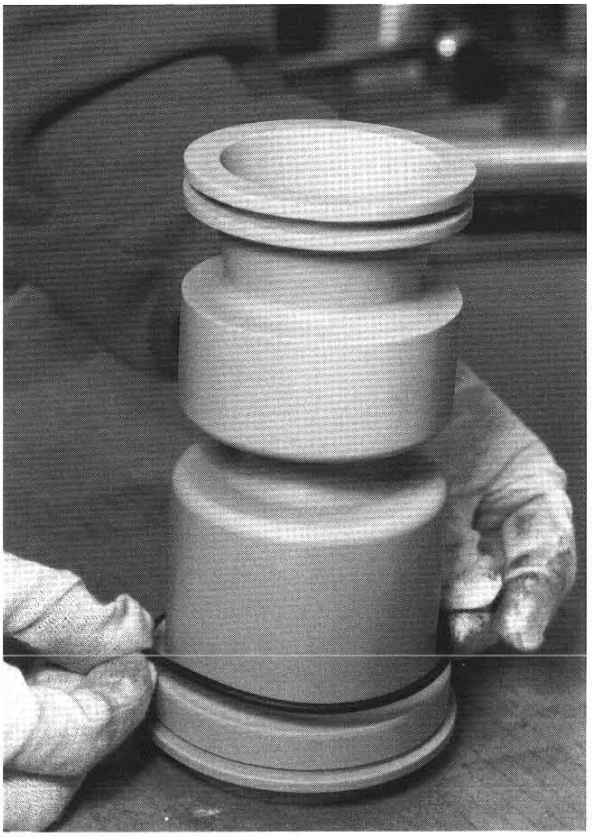


Plate 22:Installing the insulating nozzle O-ring

9. Insert the new insulating nozzle 30005 (Fig. 10) into the main moving contact/self-blast chamber 30116. Use the insulating nozzle tool T13449 to press the new insulating nozzle into place. Refer to Figure 19 and Plate 23.

Plate 23: Insulating nozzle tool

10. Secure the insulating nozzle with a new retaining snap ring H776A34304 (Fig. 10). Refer to Plate 24.

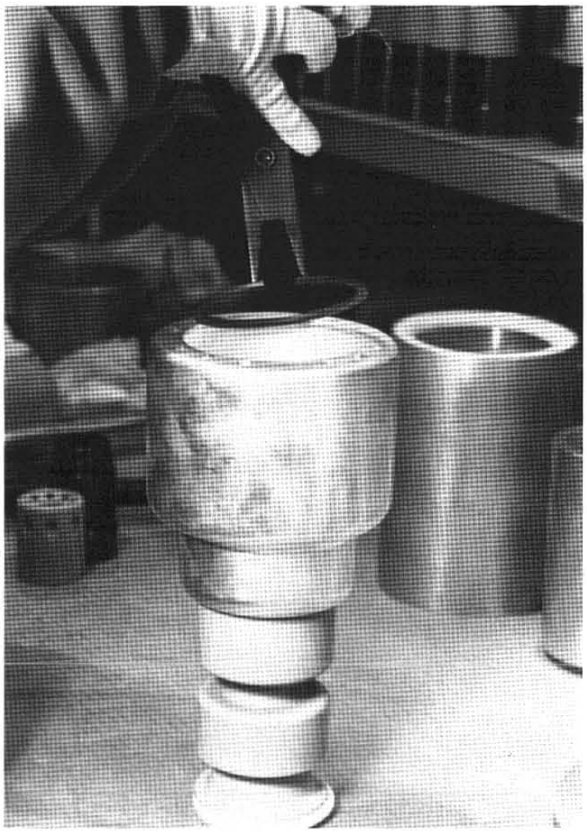


Plate 24: Re-installing the insulating nozzle retaining snap ring

11. Re-connect the main moving contact/self-blast chamber 30116 (Fig. 10) to the puffer cylinder 30007 by re-installing the M5 socket head bolts H420A04410 and flat washers H420A60005 using a socket wrench and long extension. Apply a small drop of Loctite 242 into the holes and torque to 5.5 Nm (4 ft-lbs). Refer to Plate 25.

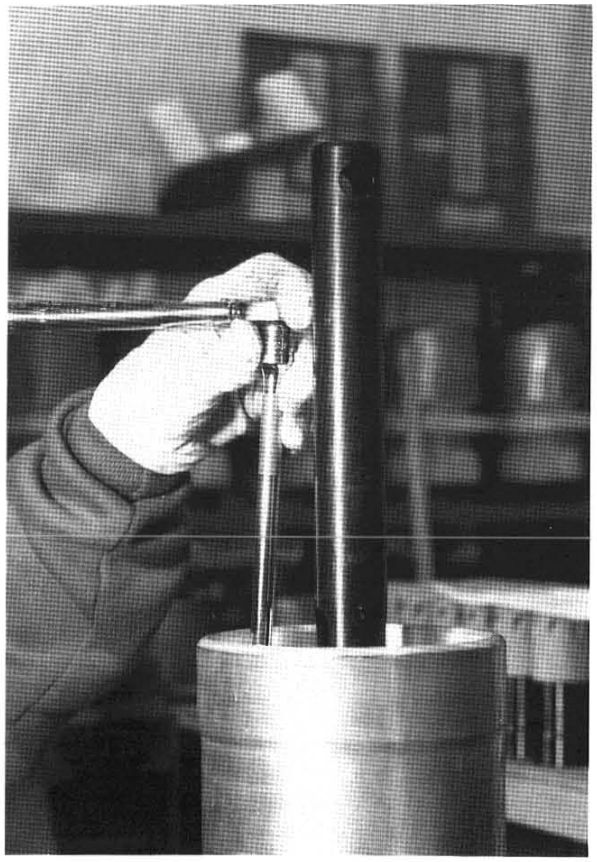


Plate 25: Re-connecting the main moving contact/self-blast chamber to the puffer cylinder

12. Place a new insulating nozzle guide ring 30119 (Fig. 10) into its groove on the insulating nozzle 30005. Refer to Plate 26.

Plate 26: Replacing the insulating nozzle guide ring

13. Thoroughly clean the moving contact assembly 30001 (Fig. 10) using denatured ethyl alcohol and lint-free wipers.

*Important: Because the auxiliary nozzle 30004 and insulating nozzle 30005 are insulating components, they must be cleaned using **new** lint-free wipers that have not be used on metal components (to avoid contamination).*

2.5.2 Rebuilding the Moving Contact Support Assembly

The mesh cooler 30107 (Fig. 9), which is mounted inside of the moving contact support assembly 30012 should be replaced during a major overhaul of an interrupter. Plate 27 shows all of the components of the moving contact support assembly.

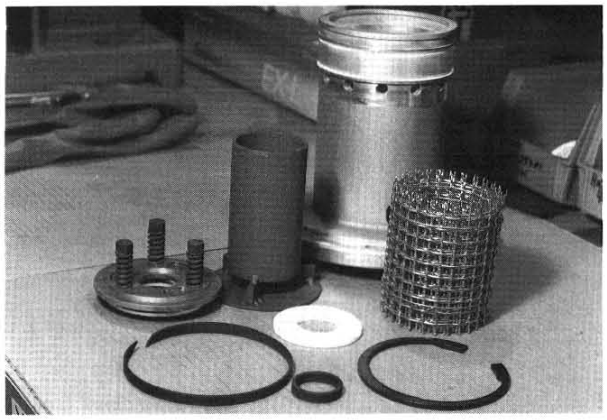


Plate 27: Components of the moving contact support assembly.

To rebuild the moving contact support assembly 30012 (Fig. 9):

1. Remove the valve plate assembly 30108 located at the nose of the moving contact support assembly 30012 by removing the retaining snap ring H776A34302. Refer to Plate 28.

Plate 28: Removing the valve plate assembly

2. Lift out the inner retainer core 30112 (Fig. 9), used mesh cooler 30107, and the Teflon disk 30120.
3. Clean all components using lint-free wipers and denatured ethyl alcohol.

4. Place a new Teflon disk 30120 (Fig. 9) into the groove at the base the assembly. Refer to Plate 29.

5. Install the new mesh cooler 30107 (Fig. 9) which will be held into a roll with wire retainers. Do not cut and remove the wires until after the mesh cooler has been slipped into place. Refer to Plate 30.

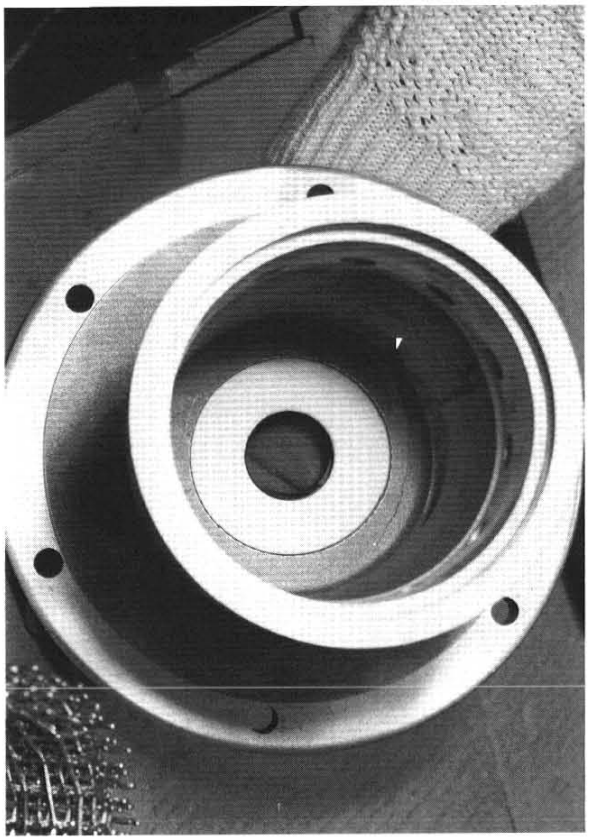


Plate 29: Teflon disk

Plate 30: Installing the mesh cooler.

6. Slide the inner retainer core 30112 (Fig. 9) back into the mesh cooler 30107. Refer to Plate 31.

Plate 31:Re-installing the inner retainer core

7. Re-install the valve plate assembly 30108 (Fig. 9) and replace the retaining snap ring H776A34302. (If any part of valve plate assembly requires replacement, replace the entire assembly 30108.) Refer to Plate 32.

Important: It is good general practice to replace old retaining snap rings with new retaining snap rings.

Plate 32:Re-installing the valve plate assembly

8. Replace the inner guide bearing 30103 (Fig. 9) at the base of the moving contact support 30018. Refer to Plate 33.

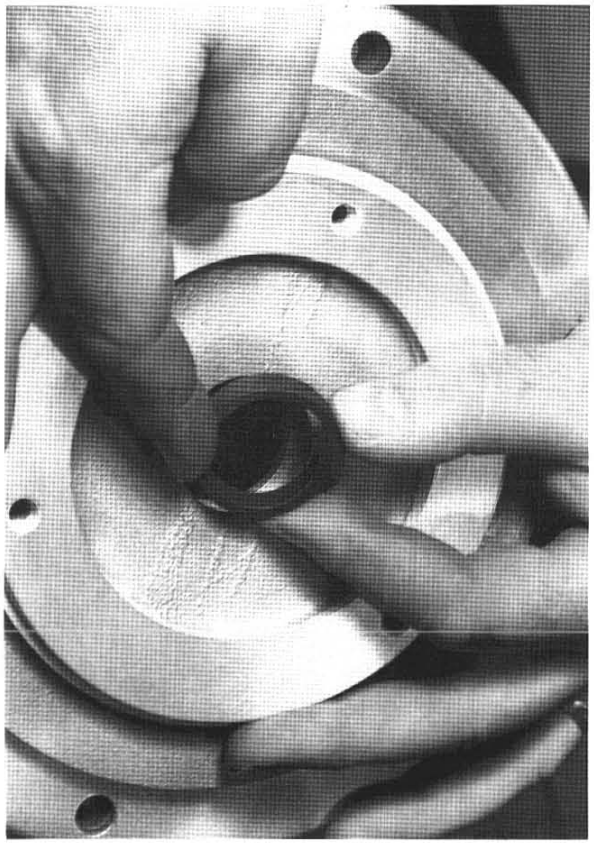


Plate 33:Replacing the inner guide bearing

9. Replace the multi-lam contact 30014 (Fig. 9) and outer guide bearing 30104 (located in the transfer area between the puffer cylinder and moving contact support assembly). Lubricate the silverplated area where the multi-lam contact is seated with a light coat of Shell Alavania No. 2 Grease and be sure to install the multi-lam contact with the teeth pointing counter-clockwise when looking at the moving contact support from above. Refer to the Plate 34.

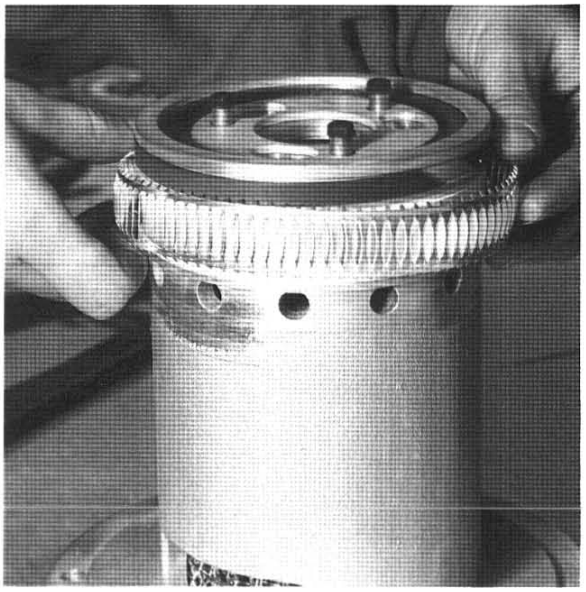


Plate 34:Replacing the outer guide bearing and multi-lam contact

2.5.3 Rebuilding the Stationary Contact Assembly

The stationary contact assembly 30019 (Fig. 5) must be refurbished and replaced before the interrupter is re-installed into the pole tank. Plate 35 shows all of the components of the stationary contact assembly.

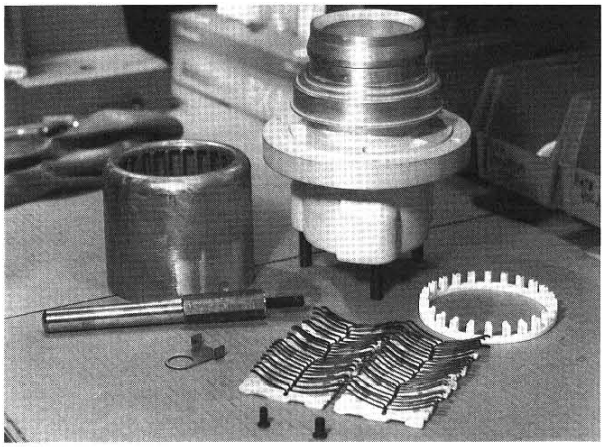


Plate 35: Components of the stationary contact assembly

To rebuild the stationary contact assembly 30019 (Fig. 5):

1. Remove the stationary arcing contact 30020 using the special deep socket tool T13437 (Fig. 14).
2. Determine if the stationary main contact fingers 30026 (Fig. 5) need to be replaced. Replacement is considered necessary if the silverplating has been worn down to the point that a copper color is visible. If the fingers do not need to be replaced, proceed to step 10.
3. If the stationary main contact fingers 30026 are to be replaced, remove the M6 socket head set screw H420A15101 that hold the contact cage 30025 to the stationary contact support 30022.
4. Pull the contact cage from the stationary contact support, allowing the contact fingers to fall free.
5. Apply a light coat of Shell Alavania No. 2 Grease to the silverplating of each contact finger. Rub the grease into the microscopic pores of the silverplating of each stationary main contact finger and wipe away excess so that only a light film remains.
6. Install the new contact fingers (48) by placing the contact cage over the contact finger assembly tool T13207 (Fig. 15) and pushing the fingers into position. Three individual fingers are needed to fill one slot in the contact cage. Fill two slots with contact fingers, then skip a slot (leaving it empty) until all contact fingers are installed. Refer to Plate 36.

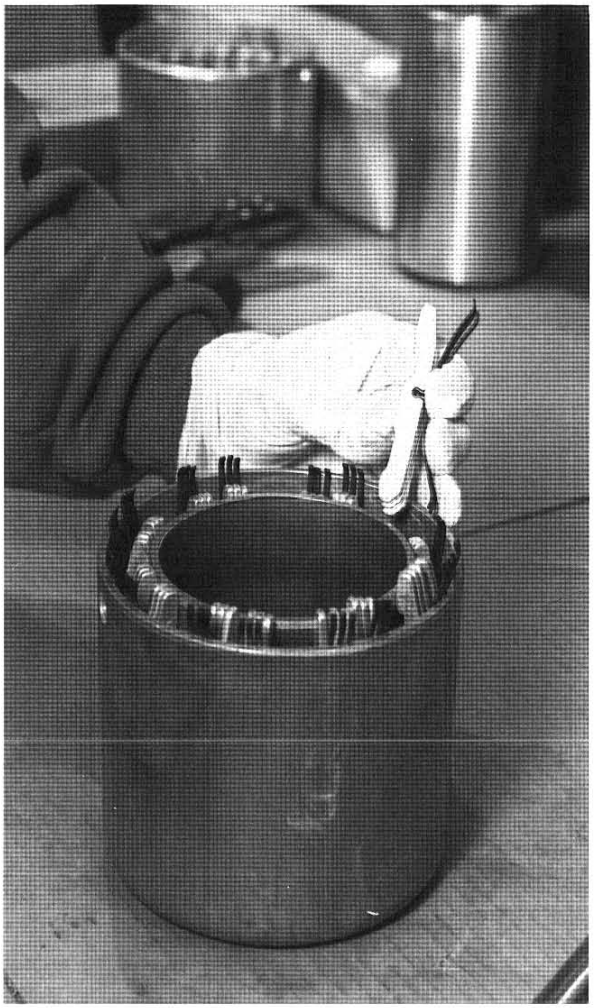


Plate 36: Installing the contact fingers in the contact cage

7. Re-install the contact spacer 30115 (Fig. 5) over the contact fingers. Refer to Plate 37.

Plate 37:Re-installing the contact spacer

8. Apply a light coat of Shell Alavania No. 2 Grease to the silverplated area of the stationary contact support 30022 (Fig. 5). Rub the grease into the microscopic pores of the silverplating and wipe away excess so that only a light film remains. Refer to Plate 38.

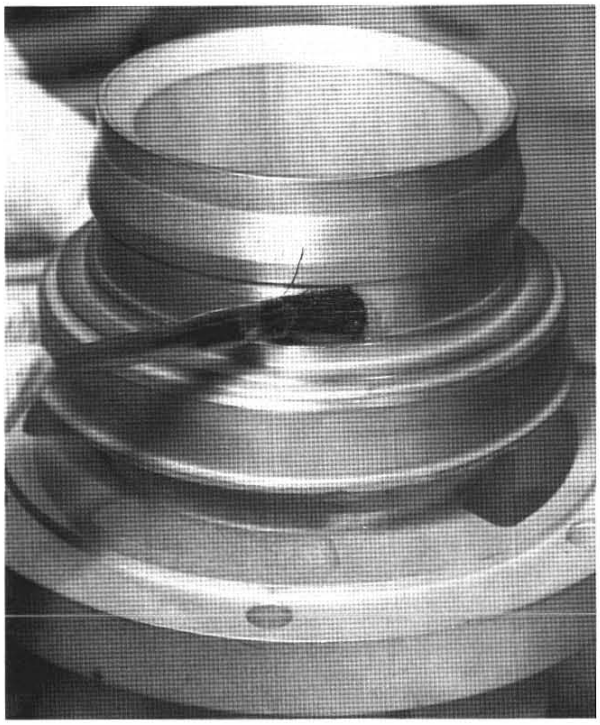


Plate 38:Applying Shell Alvania No. 2 Grease to the stationary contact support

9. Lift the contact finger assembly tool T13207 (Fig. 15), contact cage 30025 (Fig. 5) and contact fingers 30026 over the stationary contact support 30022, aligning the mounting holes. While pushing the contact cage onto the stationary contact support, allow the assembly tool to move off of the contact fingers.

10. Secure the assembly by placing a drop of Loctite 222 on each M6 socket head set screw H420A15101 (Fig. 5) and torque to 5.5 Nm (4 ft-lbs).

11. Apply Loctite 242 10 mm deep inside of the mounting hole for the stationary arcing contact 30020.

12. Be sure that the deflector clip 30123 is in place.

13. Replace the stationary arcing contact 30020 with a new one using the deep socket tool T13437 (Fig. 14). Torque the stationary arcing contact to 50 Nm (37 ft-lbs).

Important: If stud H420A15001 (Fig. 5) is not already installed in the stationary arcing contact, apply permanent Loctite 271 to the stud and install.

2.5.4 Re-Assembling the Interrupter Unit

To re-assemble the interrupter unit 30000, 30121, or 30122 (Fig. 4):

1. Apply a light coat of Shell Alvania No. 2 Grease to the inner surface of the puffer cylinder 30007 (Fig. 10). Thoroughly rub the grease into the microscopic pores of the silverplated surface; remove all excess grease so that only a light film remains. Refer to Plate 39.

Plate 39:Applying Shell Alvania No. 2 Grease to the inner surface of the puffer cylinder

2. Slide the moving contact support assembly 30012 (Figs. 4 and 9) back into the puffer cylinder 30007 (Fig. 10) of the moving contact assembly 30001 until it bottoms in the cylinder.

Important: Be careful not to pinch any of the inner and outer guide bearings 30103 and 30104 (Fig. 9) and be certain that the multi-lam contact 30014 is properly seated.

3. Carefully clean the interrupter tube 30030 (Fig. 4) with lint-free wipers dampened with denatured ethyl alcohol.

Important: Never clean an insulating component with the same wiper used to clean aluminum or metal parts.

4. Place the interrupter tube onto the interrupter assembly fixture T13438 (Fig. 6) and lock it into place. Refer to Plate 40.

Plate 40:Placing the interrupter tube on the interrupter assembly fixture

5. Apply a light coat of Shell Alvania No. 2 Grease to the main moving contact area of the moving contact assembly 30001 (Figs.4 and 10). Thoroughly rub the grease into the microscopic pores of the silverplated surface; remove all excess grease so that only a light film remains.

6. Lower the moving contact assembly into the interrupter tube while aligning the exhaust ports in the moving contact support assembly 30012 (Fig. 9) 90 degrees to the exhaust ports in the interrupter tube 30030 (Fig. 4). (Verify proper alignment by checking that the vacant space of the bolt circle pointed to in Plate 41 is turned 90 degrees to the exhaust ports in the interrupter tube.) Refer to Plate 41.

Plate 41:Re-installing the moving contact assembly

7. Bolt the moving contact assembly 30001 (Fig. 4) to the interrupter tube 30030 using M8 socket head bolts H420A04611 and washers H420A60008. Apply Loctite 242 to the threads of each bolt and torque to 22 Nm (16 ft-lbs).

8. Thoroughly clean the operating pullrod 30032 with lint-free wipers dampened with denatured ethyl alcohol.

Important: Never clean an insulating component with the same wiper used to clean aluminum or metal parts.

9. Install the operating pullrod 30032 by re-installing the wrist pin 30105.

10. Lock the wrist pin 30105 (Fig. 4) in place using the M8 hex head bolt H420A30406 and washer H420A60108. Apply Loctite 242 and torque the bolt to 22 Nm (16 ft-lbs). Refer to Plate 42.

Plate 42:Re-installing the wrist pin

11. Thoroughly clean the interrupter support tube 30051 (Fig. 4) with lint-free wipers dampened with denatured ethyl alcohol.

Important: Never clean an insulating component with the same wiper used to clean aluminum or metal parts.

12. Install the interrupter support tube 30051 (Fig. 4) by fastening it to the moving contact support assembly 30012 using M8 socket head bolts H420A04611 and washers H420A60008. Apply Loctite 242 into the holes and torque to 22 Nm (16 ft-lbs). Refer to Plate 43.

Important: *Loctite 242 for the bolts must be applied to the holes so that it will not squeeze into this current carrying joint.*

Plate 43:Re-installing the interrupter support tube

13. Push the operating pullrod down to be certain that the moving contact assembly 30001 (Fig. 4) is bottomed out on the interrupter assembly fixture.

14. Measure dimension A as shown in Plate 44 and Fig. 11 in mm. Dimension A typically is 41.5 $\pm$ 1.0 mm.

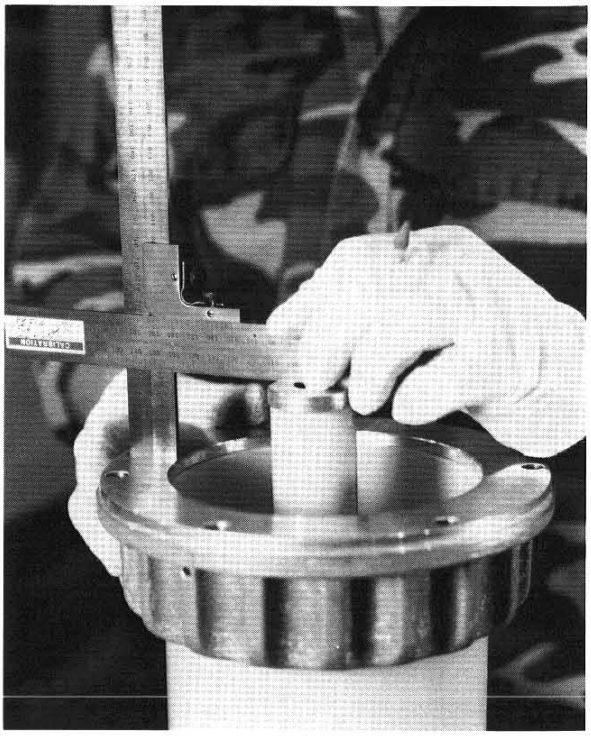


Plate 44:Measuring dimension A

15. Measure dimension B as shown in Plate 45 and Fig. 12 in mm. Dimension B typically is 95 ± 1.0 mm.

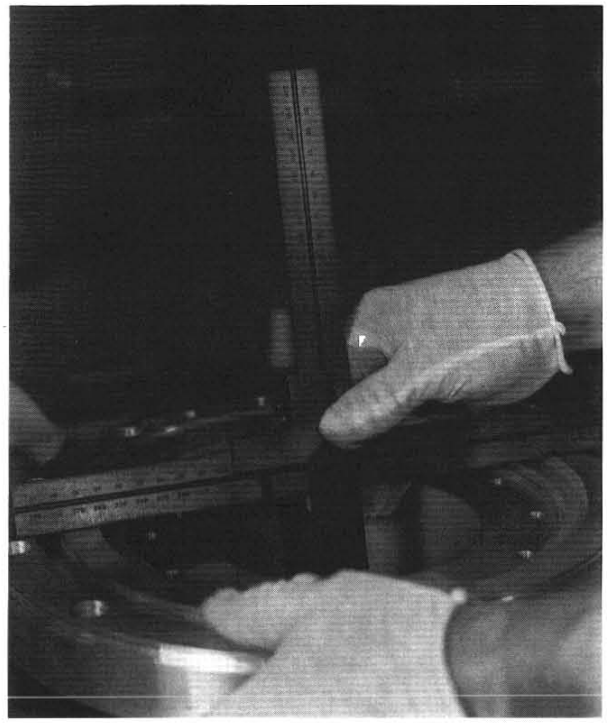


Plate 45: Measuring dimension B

16. To determine the needed length of the pullrod coupling 30106 (Fig. 4) between the operating pullrod and bellcrank arm, use the following formula:

    E = Dim. B - Dim. A - 15 mm

    Where **E** = length of the pullrod coupling in mm

    Dimension E typically is 38.5 ± 2.0 mm.

Important: *The calculated length of the pullrod coupling should be very close to the length measured with inside calipers on disassembly, step 7 in section 2.4 of this module.*

Proceed to section 2.5.4.1 for final assembly instructions.

2.5.4.1 Final Assembly for Left, Center, and Right Interrupter Units

Final assembly for an interrupter unit depends upon whether the unit is to be used for left, center, or right pole unit applications. For *left* pole applications, the bellcrank must be oriented so that the plug-in contacts are turned 30 degrees counter-clockwise from the top of the bellcrank. For *center* pole applications, the plug-in contacts should be aligned with the top of the bellcrank. For *right* pole applications, the plug-in contacts should be turned 30 degrees clockwise from the top of the bellcrank. Refer to Figure 4.

To ensure proper alignment:

1. Install the threaded rod tools T13428 (Fig. 7) as follows:

    a. For *left* pole applications, install the threaded rod tools in the holes of the bellcrank housing shown in Plate 46.

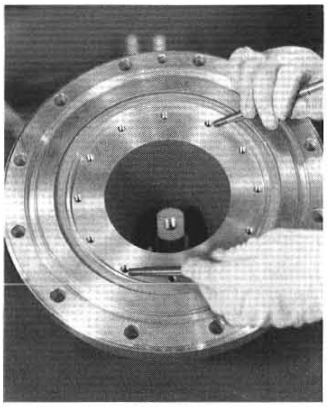


Plate 46: Installing the rod tools for a left pole unit

    b. For *center* pole applications, install the threaded rod tools in the holes of the bellcrank housing shown in Plate 47.

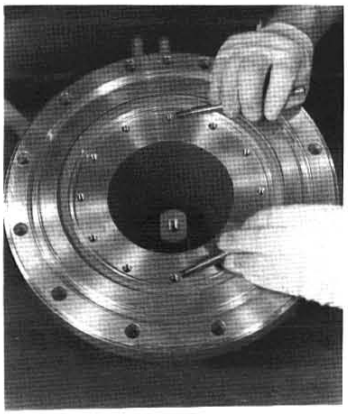


Plate 47: Installing the rod tools for a center pole unit

c. For *right* pole applications, install the rod tools in the holes of the bellcrank housing shown in Plate 48.

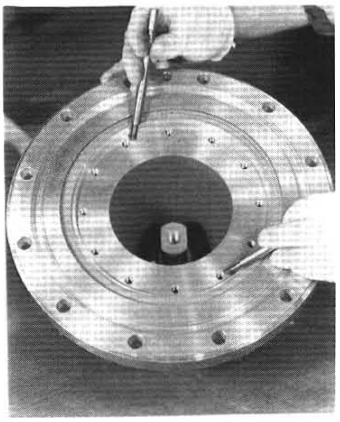


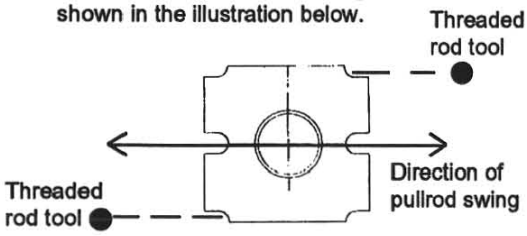
Plate 48: Installing the rod tools for a right pole unit

2. Position the bellcrank assembly over the interrupter unit, aligning the upper rod tool with the plug-in contact.

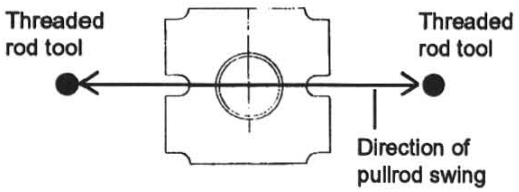
3. Install the clip tools T13439 (Fig. 8) to hold the bellcrank assembly above the interrupter unit.

4. Check alignment of the operating pullrod using the special alignment tool T13440 (Fig. 13). Refer to Plate 49. Rotate the moving contact assembly 30001 (Fig. 4) clockwise using a wrench until the appropriate slots in the special tool align with the rod tools at both extremes of the pull rod's swing. The moving contact assembly must be turned clockwise to prevent damaging the multi-lam contact 30014 (Fig. 9). Refer to Plate 50.

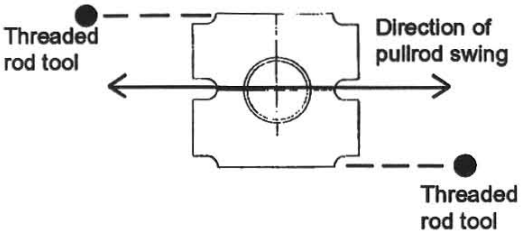
   a. For *left* pole applications, align the two slots as shown in the illustration below.



   b. For *center* pole applications, align the two slots as shown in the illustration below.



   c. For *right* pole applications, align the two slots as shown in the illustration below.



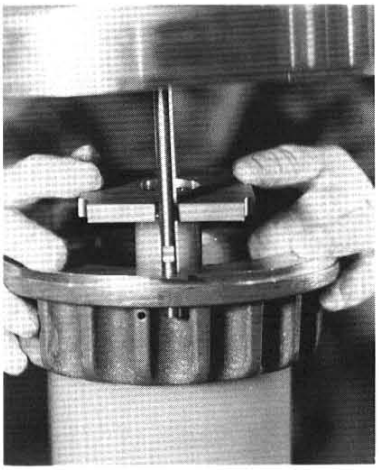


Plate 49: Aligning the center pole pullrod

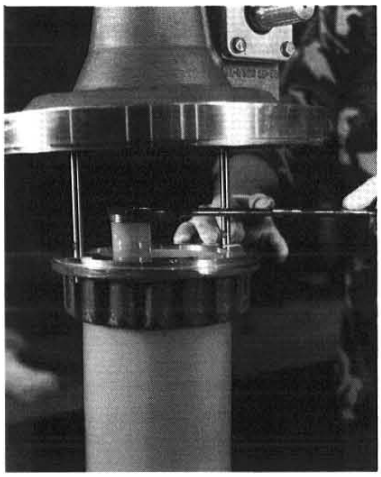


Plate 50: Turning the moving contact assembly clockwise

5. When the operating pullrod is aligned, apply Loctite 242 on the threads of the pullrod coupling 30106 (Fig. 4) and install it to the calculated length. Refer to Plate 51.

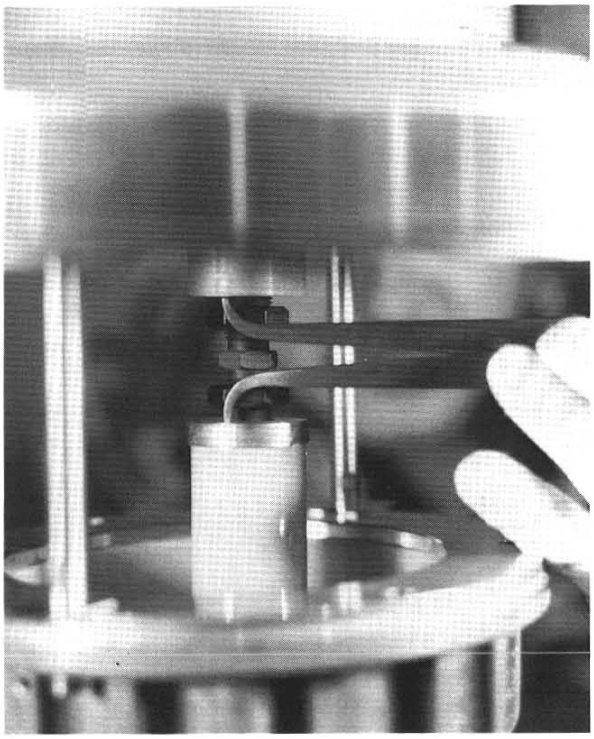


Plate 51:Setting the length of the pullrod coupling

6. Secure the pullrod coupling with M16 jam nuts H420A54116 RH (Fig. 4) and H420A54156 LH. Torque each jam nut to 50 Nm (38 ft-lbs).

Important: *While tightening the jam nuts, be sure to use a back-up wrench to prevent the operating pullrod from moving out of alignment.*

7. Remove the clip tools T13439 (Fig. 8) and allow the bellcrank assembly to lower onto the interrupter unit.

8. Re-attach the bellcrank to the interrupter support tube 30051 (Fig. 4) using M8 socket head bolts H420A04611 and washers H420A60008. Apply Loctite 242 to each of the bolts and torque to 22 Nm (16 ft-lbs). (Remove the threaded rod tools during this step.)

9. Lift the interrupter from the interrupter assembly fixture.

10. To re-install the stationary contact assembly 30019 (Fig. 4):

a. Rotate the bellcrank shaft to place the moving contact assembly into the fully CLOSED position using the manual open/close tool T13451 (shown in the Interphase Linkage module).

Notice: *When re-installing the stationary contact assembly, the moving contact assembly of the interrupter unit must be in the CLOSED position to ensure proper contact alignment.*

b. Lift the stationary contact assembly 30019 (Figs. 4 and 5) into the rear of the interrupter unit and **firmly** push it into position so that it fully engages the moving contact assembly (to ensure contact alignment). Be sure that the stud H783A31803 (Fig. 3) located closest to the base of the boss that supports the stationary arcing contact 30020 (Fig. 5) is aligned opposite the plug-in connections 30052 (Fig. 3) for the bushing conductors.

c. Install the M8 socket head bolts H420A04611 (Fig. 4) and washers H420A60008 to secure the stationary contact assembly. Apply Loctite 242 to each of the bolts and torque to 22 Nm (16 ft-lbs). Refer to Plate 52.

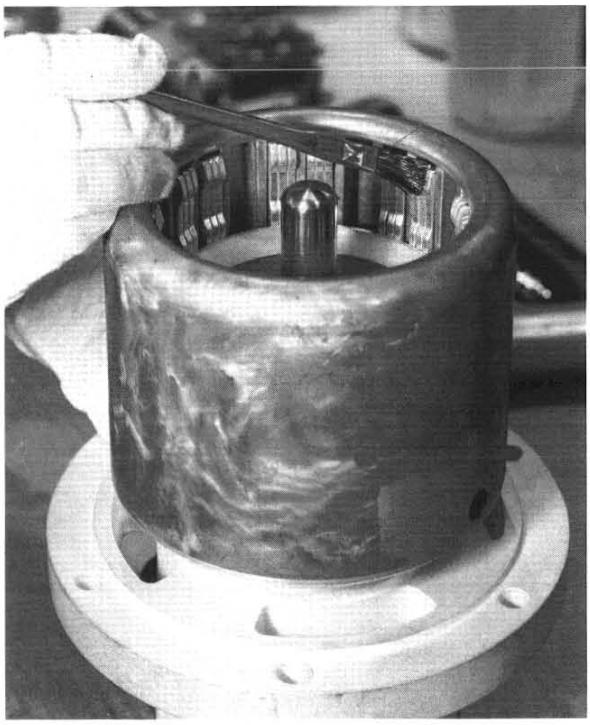


Plate 52:Stationary contact assembly

11. Re-install the rear exhaust shield 30077 (Fig. 4) using M12 nuts H420A50012 and washers H420A60012. Hand-tighten the nuts. (Final tightening will be done when the interrupter unit is re-installed in the pole tank.)

12. Refer to the Pole Unit module to proceed as follows:

    - Re-install the interrupter unit.
    - Install a new desiccant bag.
    - Re-install the rear tank cover assembly to close the pole unit.
    - After the pole unit has been closed, immediately evacuate the pole unit and fill it with SF_6 gas.

2.6 Rebuilding the Bellcrank Assembly

Refer to Figure 16 when rebuilding the bellcrank assemblies 10151 (center), 10159 (left), and 10160 (right). Rebuilding the bellcrank assembly involves replacing the weather seals 10169, gas/vacuum lip seals 10168, and bearings 10164. The seals and bearings are contained within the shaft seal assemblies 10153. The center bellcrank assembly contains two shaft seal assemblies; the left and right bellcrank assemblies each contain one shaft seal assembly. Refer to Plate 53 for a view of bellcrank components.

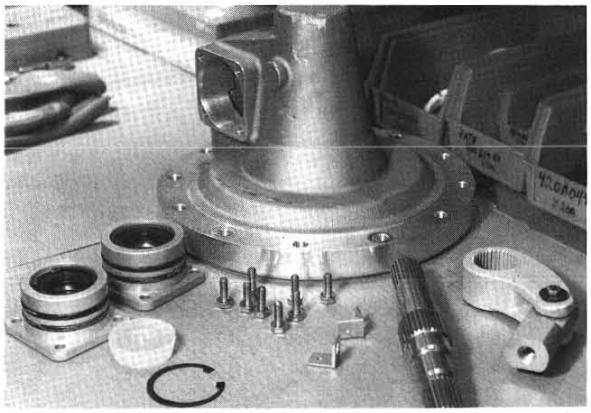


Plate 53:Bellcrank components

To replace the seals and bearings:

1. Remove the M8 hex head bolts H420A30409 (Fig. 16) and washers H420A64008 which secure the shaft seal assembly 10153 to the bellcrank housing 10152 (or 10172 or 10173).

2. Slide the shaft seal assembly from the bellcrank housing. Refer to Plate 54.

Important: *O-rings 90005 (two) tend to hold the shaft seal assembly snugly in place. It may be necessary to gently pry out the shaft seal assembly with a thin-bladed screwdriver. No sealing surfaces can be damaged by performing this procedure.*

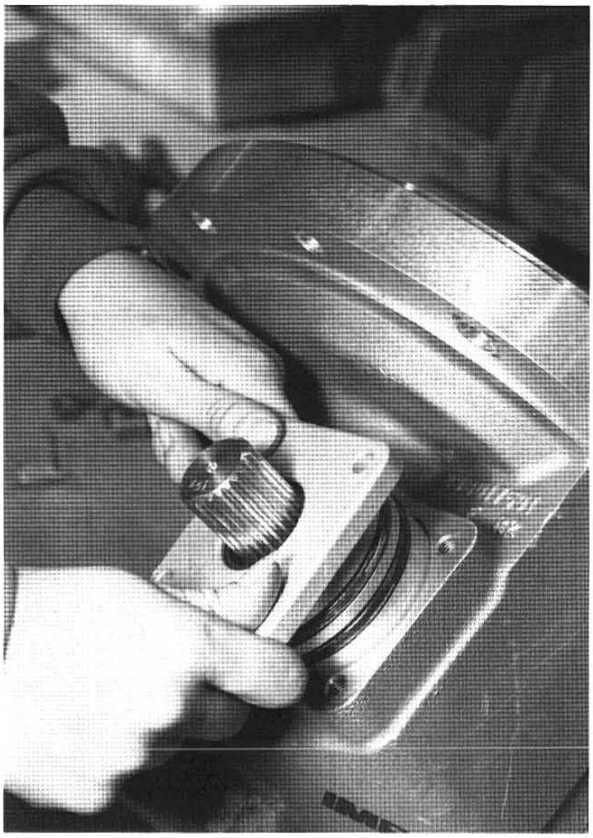


Plate 54:Shaft seal assembly

3. Remove the seal assembly snap ring H776A02215 (Fig. 16) which holds the following items within the shaft seal assembly housing:

   - Gas/Vacuum Lip Seals (two) 10168;
   - Aluminum Spacer 10170;
   - Bearing 10164;
   - Weather Seal 10169.

   Refer to Plate 55 for an exploded view of the shaft seal assembly.

   A light press may be required to push the components listed above out of the shaft seal assembly housing.

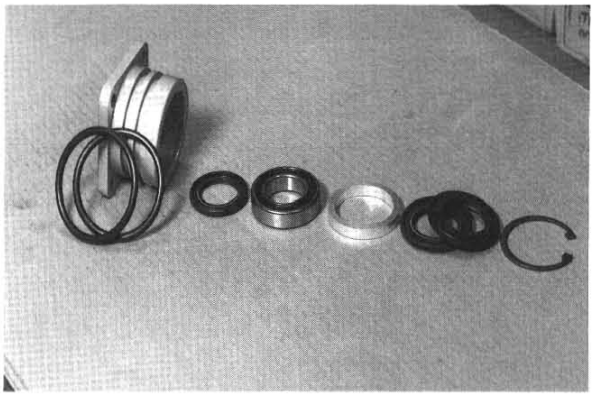


Plate 55:Shaft seal exploded view

4. Replace the seals and bearings removed in the previous step. Lightly lubricate these parts with ProAA2 grease.

5. Replace the seal assembly snap ring H776A02215 with a new snap ring.

6. Remove the old shaft seal assembly O-rings 90005 (two) and replace them with new O-rings.

7. Apply Dow Corning FS-1292 Grease to the surfaces of the shaft seal assembly and bellcrank housing which will be exposed to weather, i.e. areas outside of the sealing O-rings.

8. If the bellcrank shaft was pulled out of the internal crank 10162, it will have to be re-aligned. Align the punch mark which is located on the end of one of the splines of the bellcrank shaft with the punch mark on the internal crank. Refer to Plate 56.

Important: The line-up punch marks on the internal crank 10162 and bellcrank shaft must be aligned.

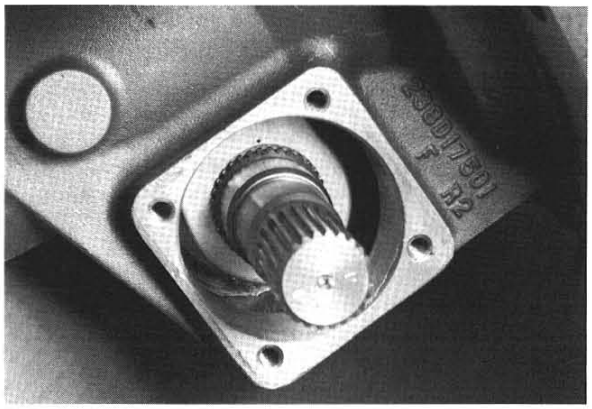


Plate 56:Aligning punch marks

9. Push the bellcrank shaft back into position.

10. Re-position the now rebuilt shaft seal assembly 10153 (Fig. 16) over the bellcrank shaft end and carefully push it into place without damaging the O-ring seals.

11. Re-install the M8 hex head bolts H420A30409 and washers H420A64008 which secure the shaft seal assembly to the bellcrank housing. Apply Loctite 242 to the threads of each bolt and torque to 24 Nm (18 ft-lbs).

12. Repeat the previous steps for any other shaft seal assemblies which need to be rebuilt.

NOTES:

Interrupter Maintenance Flow Chart

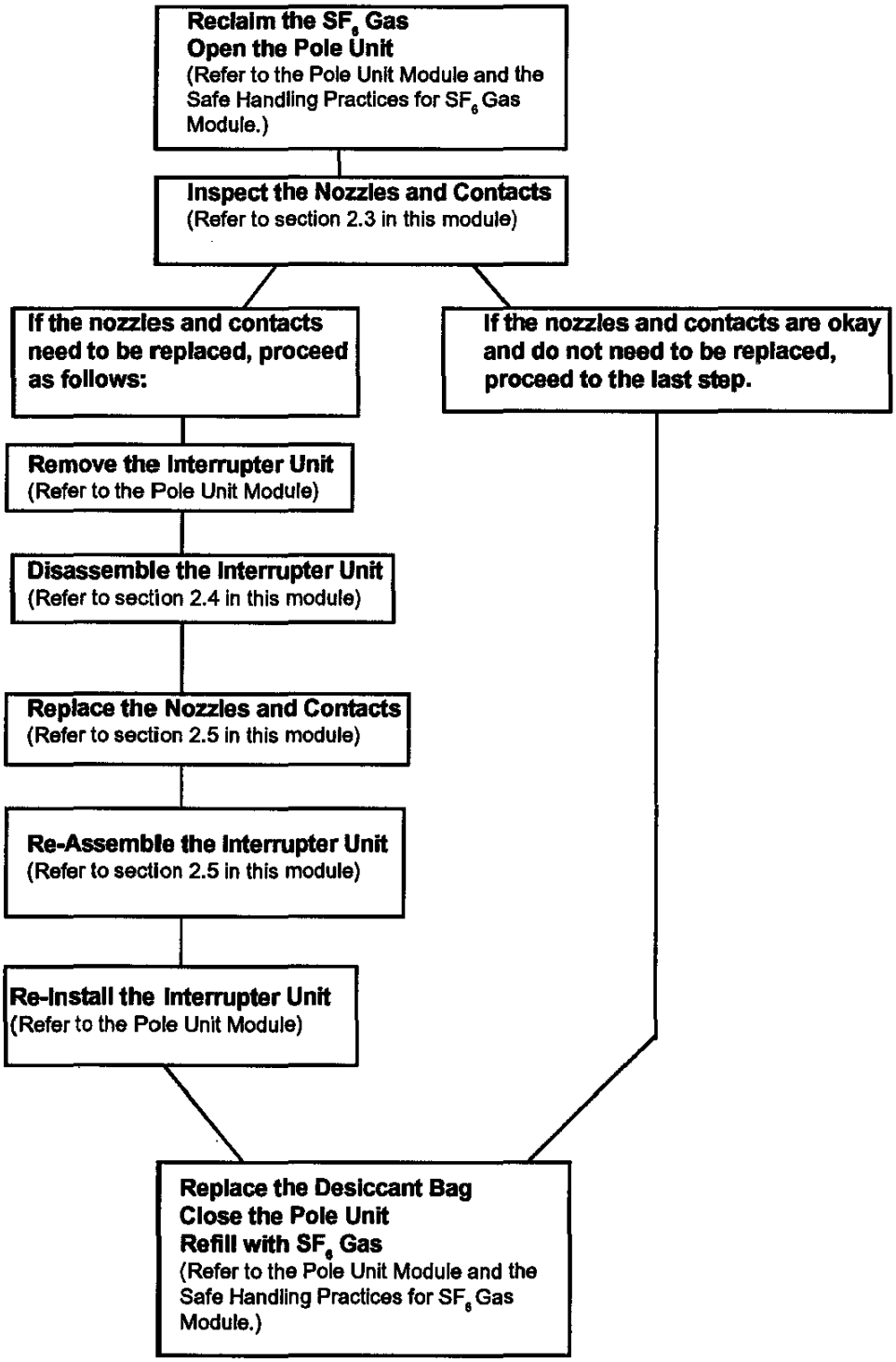


Figure 1
Interrupter Maintenance Flow Chart

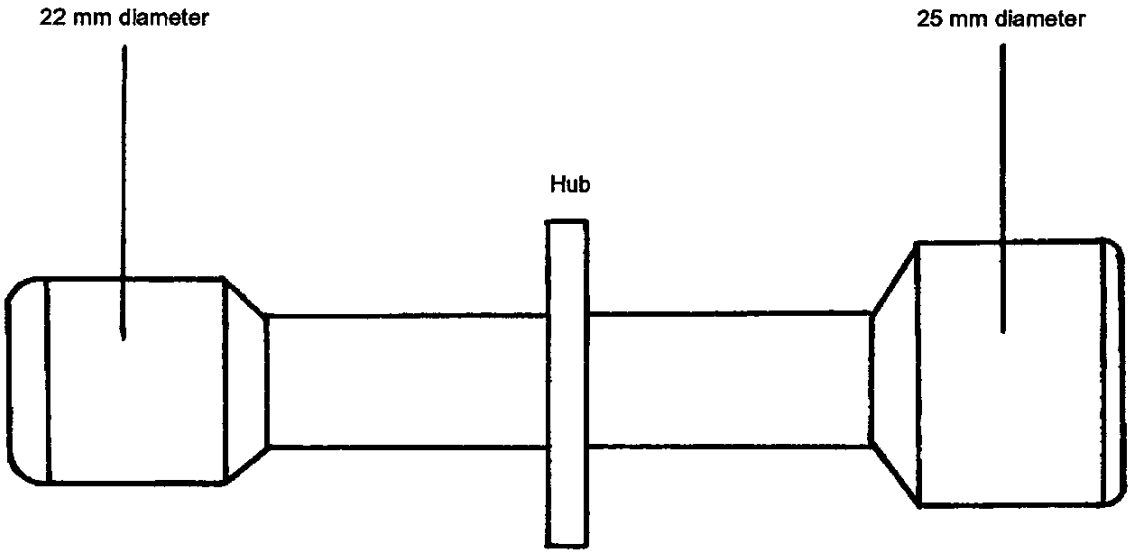


Figure 2
No-Go Gauge T13406

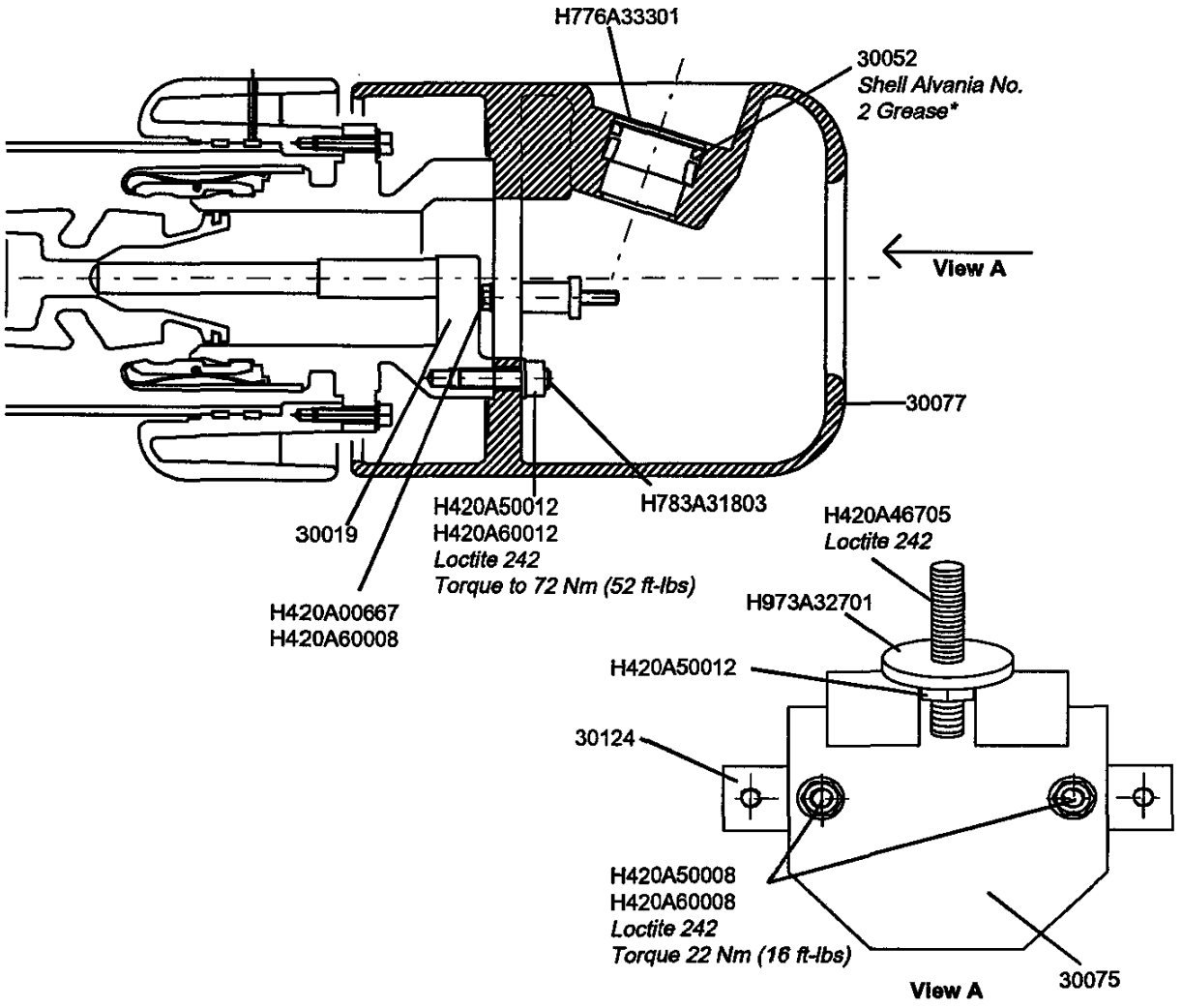


Figure 3
Rear of Interrupter Unit

30019	Stationary Contact Assembly
30052	Plug-In Connection
30075	Deflector
30077	Rear Exhaust Shield
30124	Shield Support
H420A00667	Hex Head Bolt, M8 x 65
H420A46705	Stud, M12 x 65 mm
H420A50008	Nut, M8
H420A50012	Nut, M12
H420A60008	Flat Washer, M8
H420A60012	Flat Washer, M12
H776A33301	Retaining Snap Ring
H783A31803	Stud, M12
H973A32701	Washer

*Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

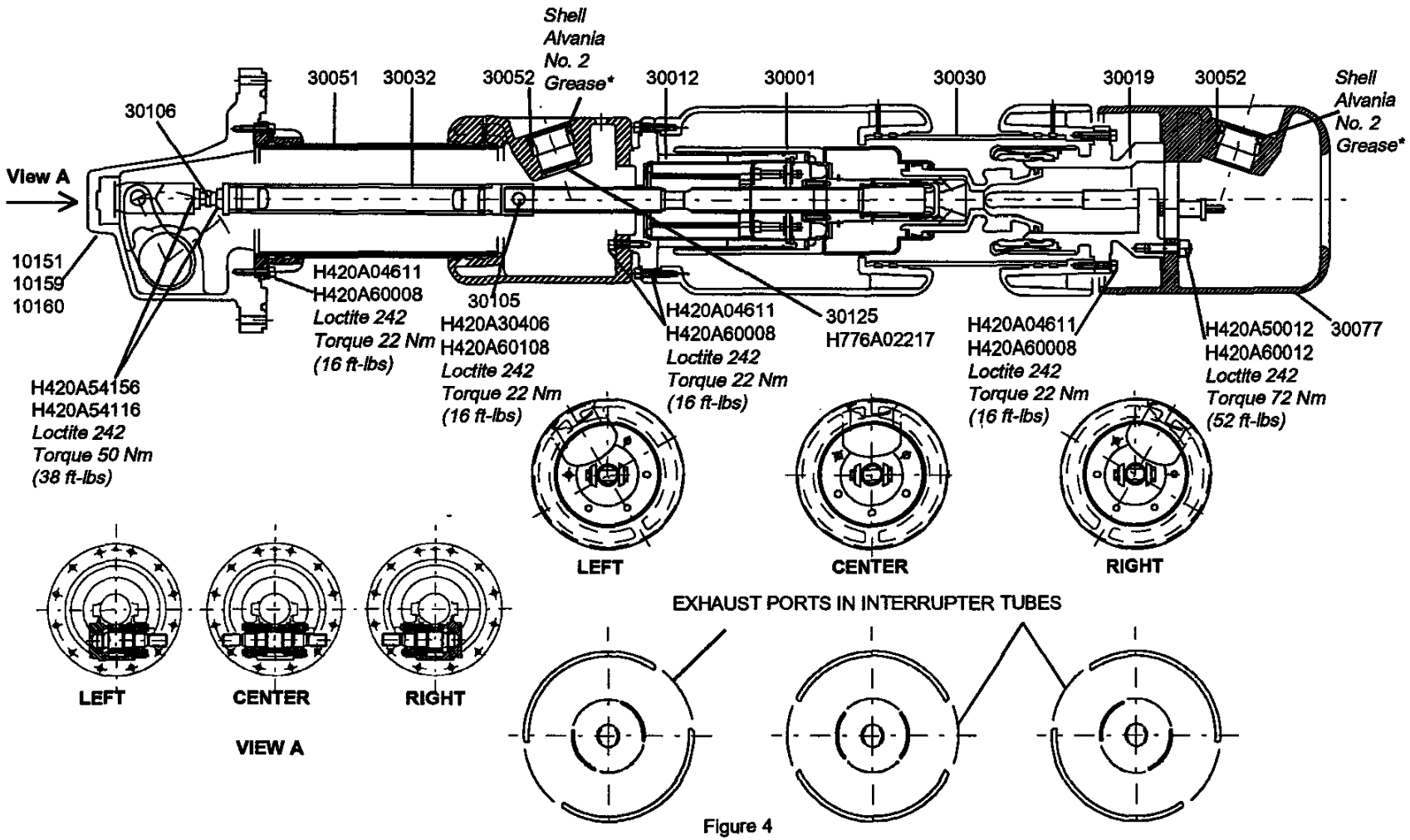


Figure 4
Interrupter Unit
30000 or 30121 or 30122

10151	Bellcrank Assembly (Center)	30051	Support Tube	H420A04611	Socket Head Bolt, M8 x 35
10159	Bellcrank Assembly (Left)	30052	Plug-In Connection	H420A30406	Hex Head Bolt, M8 x 12
10160	Bellcrank Assembly (Right)	30077	Rear Exhaust Shield	H420A50012	Nut, M12
30000	Interrupter Unit (Center)	30105	Wrist Pin	H420A54116	Jam Nut (right hand thread), M16
30001	Moving Contact Assembly	30106	Pullrod Coupling	H420A54156	Jam Nut (left hand thread), M16
30012	Moving Contact Support Assembly	30121	Interrupter Unit (Left)	H420A60008	Flat Washer, M8
30019	Stationary Contact Assembly	30122	Interrupter Unit (Right)	H420A60012	Flat Washer, M12
30030	Interrupter Tube	30125	Plate	H420A60108	Flat Washer, M8
30032	Operating Pullrod			H776A02217	Retaining Snap Ring

*Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

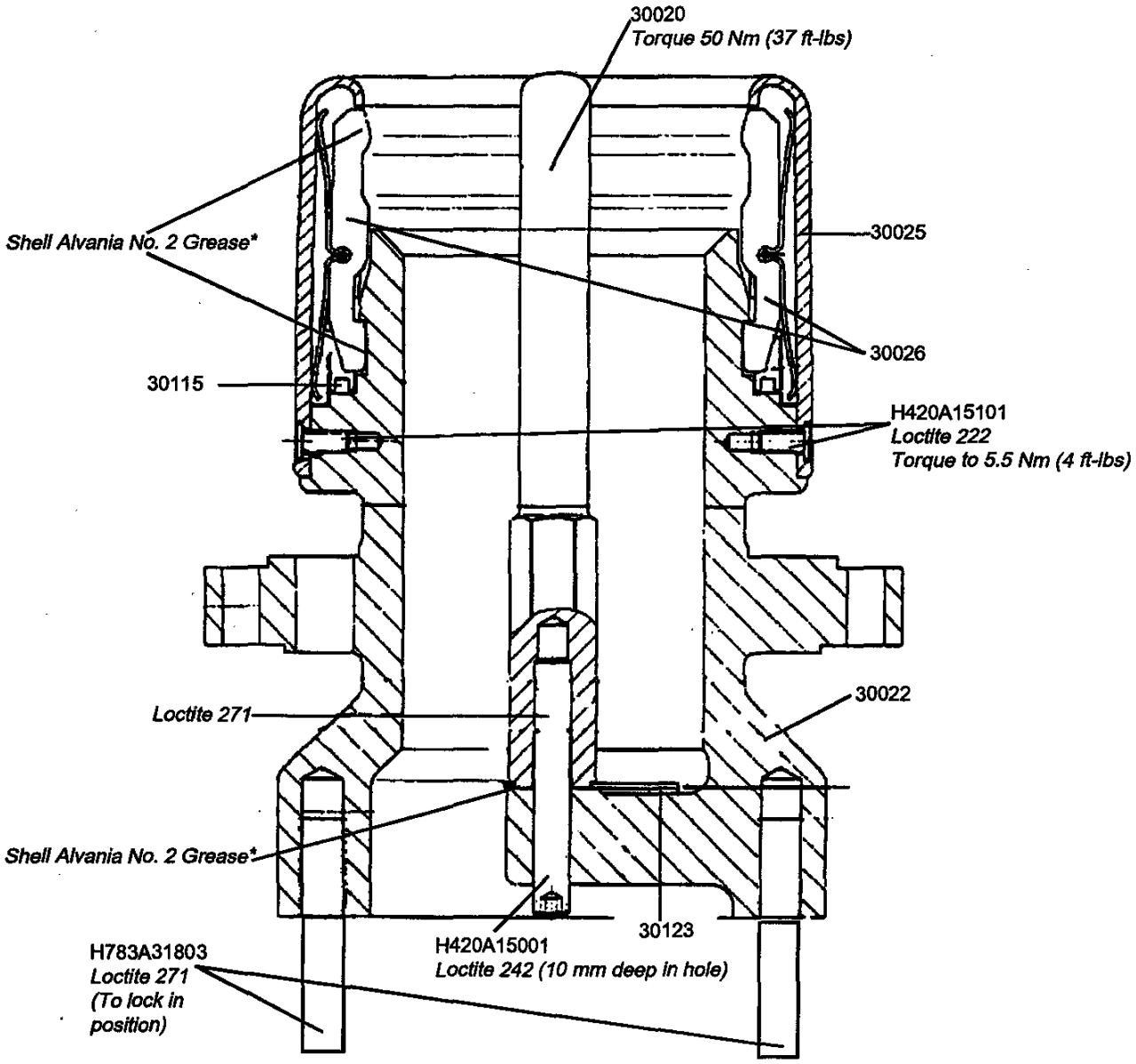


Figure 5
Stationary Contact Assembly 30019

30020	Stationary Arcing Contact
30022	Stationary Contact Support
30025	Contact Cage
30026	Contact Fingers
30115	Contact Spacer
30123	Deflector Clip
H420A15001	Stud, M10 x 70
H420A15101	Socket Head Set Screw, M6 x 12
H783A31803	Stud, M12

*Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

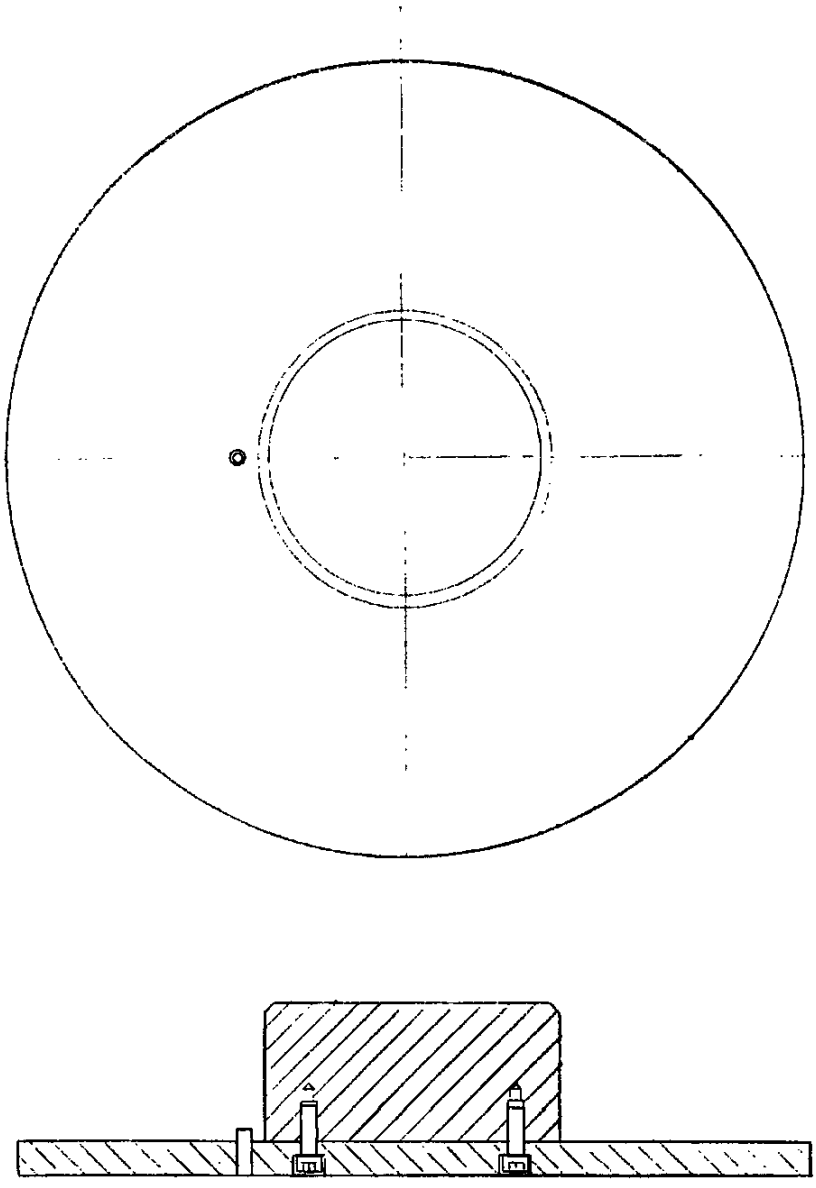


Figure 6
Interrupter Assembly Fixture T13438

Figure 7
Threaded Rod Tool T13428

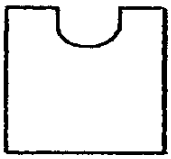


Figure 8
Clip Tool T13439

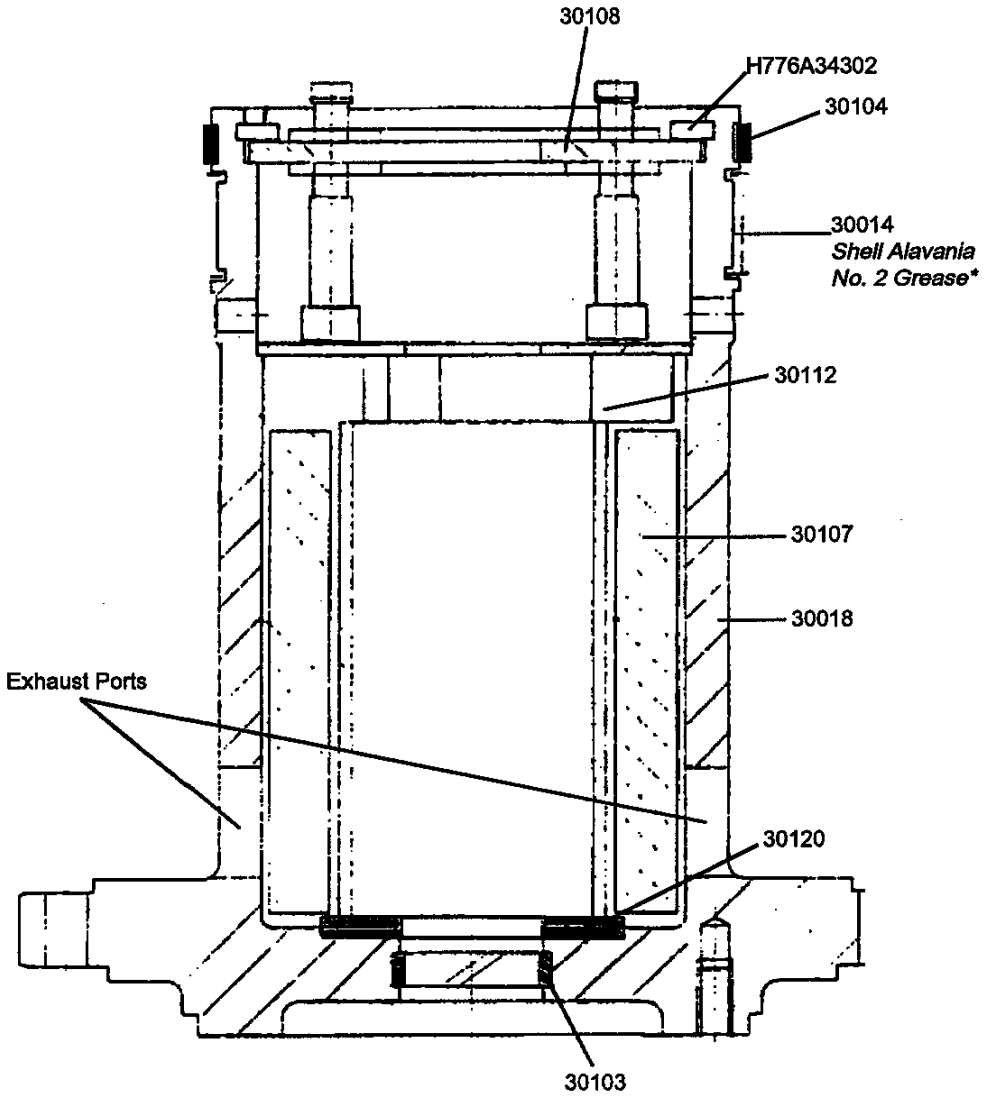


Figure 9
Moving Contact Support Assembly 30012

30014	Multi-Lam Contact	30108	Valve Plate Assembly (sold as an assembly only)
30018	Moving Contact Support		
30103	Inner Guide Bearing	30112	Innner Retainer Core
30104	Outer Guide Bearing	30120	Teflon Disk
30107	Mesh Cooler	H776A34302	Retaining Snap Ring

*Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

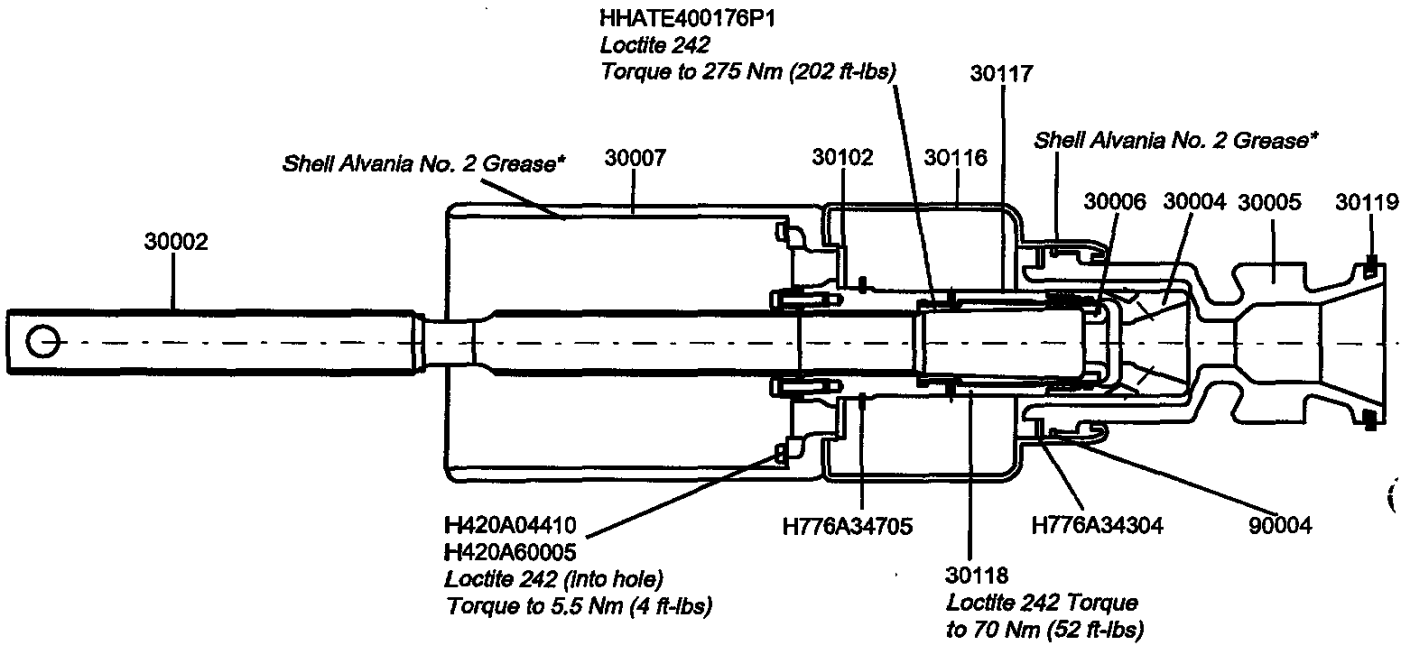


Figure 10
Moving Contact Assembly 30001

30002	Exhaust Tube
30004	Auxiliary Nozzle
30005	Insulating Nozzle
30006	Moving Arcing Contact
30007	Puffer Cylinder
30102	Check Plate (Self-Blast Chamber)
30116	Main Moving Contact/Self-Blast Chamber
30117	Auxiliary Nozzle Assembly (includes auxiliary nozzle and auxiliary nozzle adapter)
30118	Auxiliary Nozzle Adapter
30119	Insulating Nozzle Guide Ring
90004	Insulating Nozzle O-Ring
H420A04410	Socket Head Bolt, M5 x 30
H420A60005	Flat Washer, M5
H776A34304	Retaining Snap Ring
H776A34705	Retaining Snap Ring
HHATE400176P1	Lock Nut

*Rub Shell Alvania No. 2 Grease into the microscopic pores of silverplated surfaces; remove all excess so that only a light film remains.

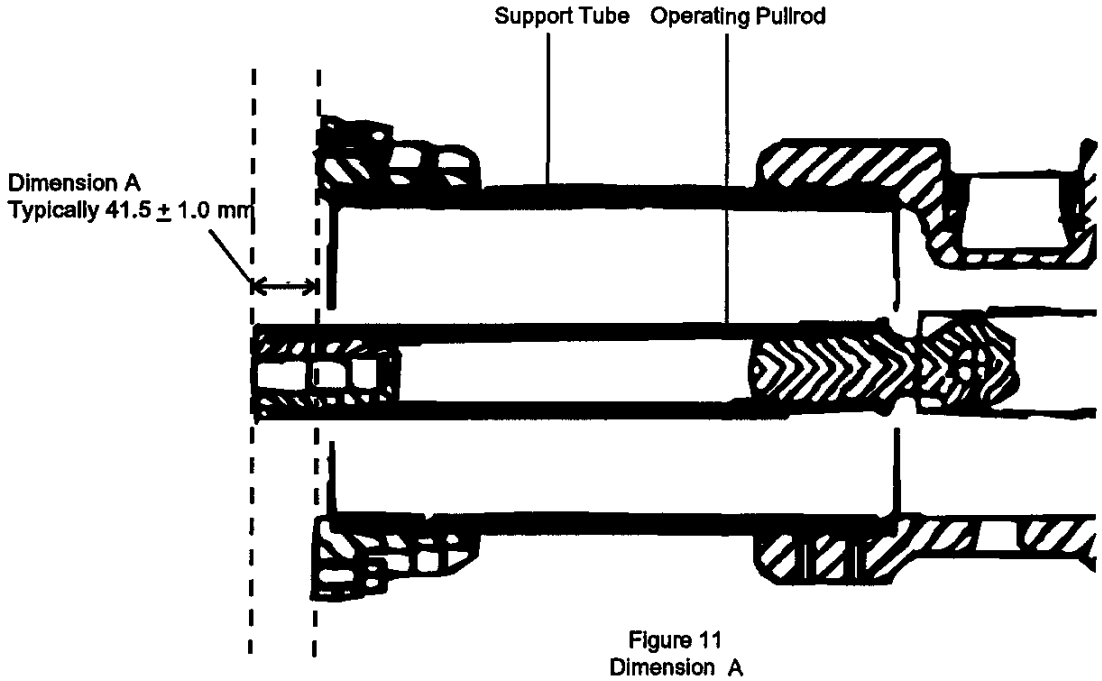


Figure 11
Dimension A

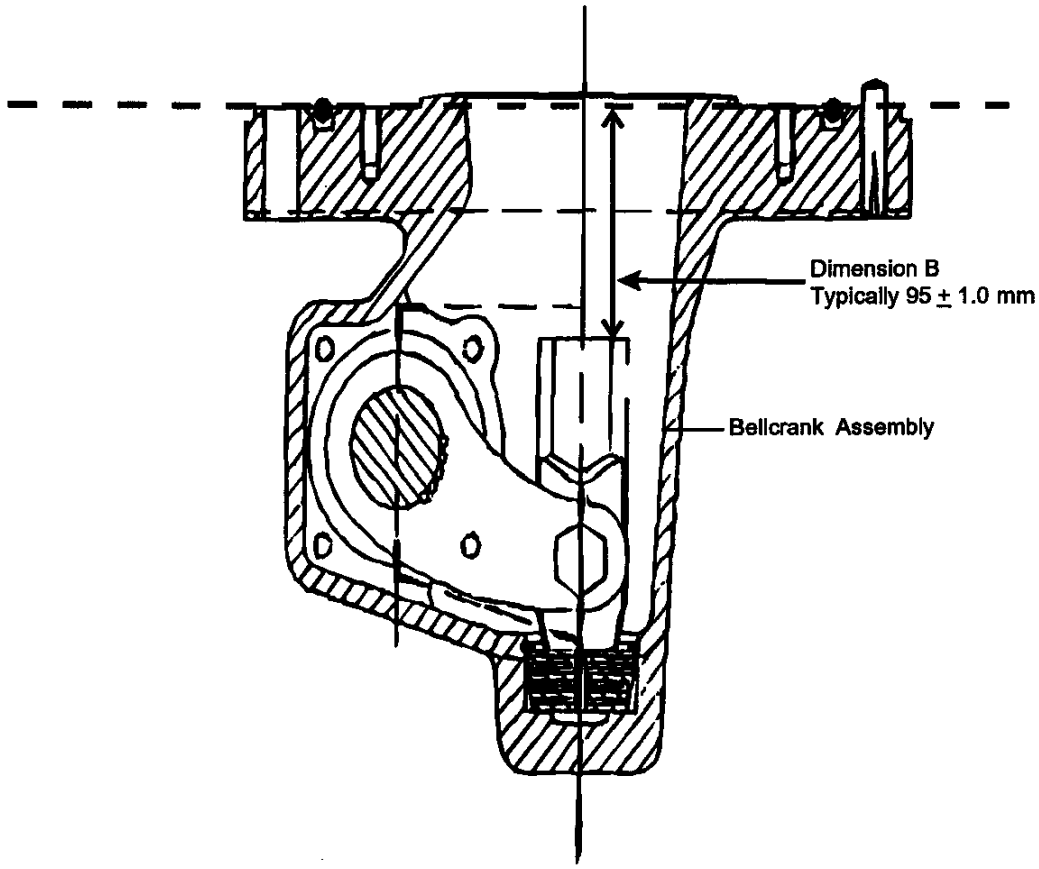


Figure 12
Dimension B

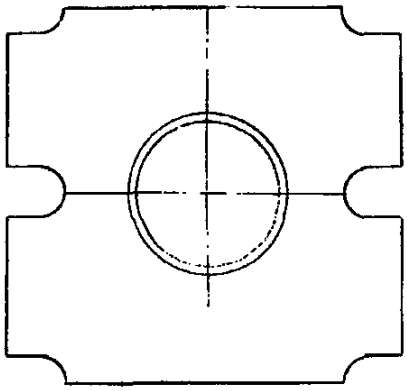


Figure 13
Alignment Tool T13440

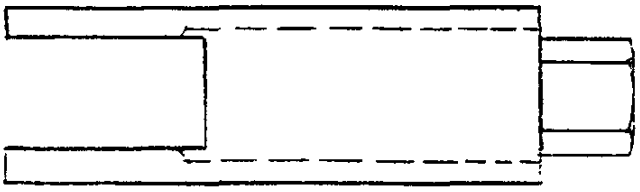


Figure 14
Deep Socket Tool T13437

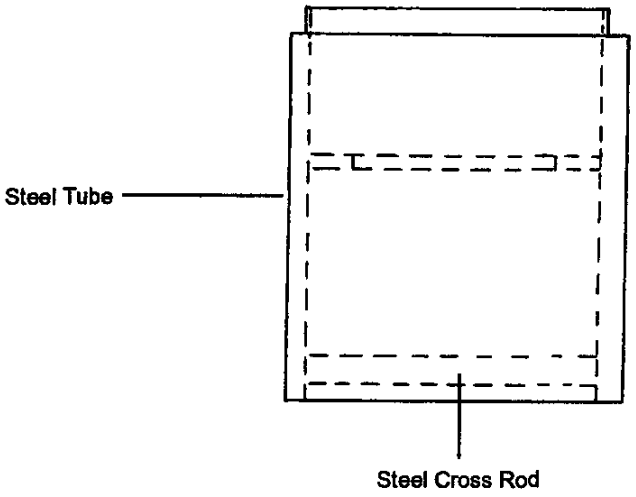


Figure 15
Contact Finger Assembly Tool T13207

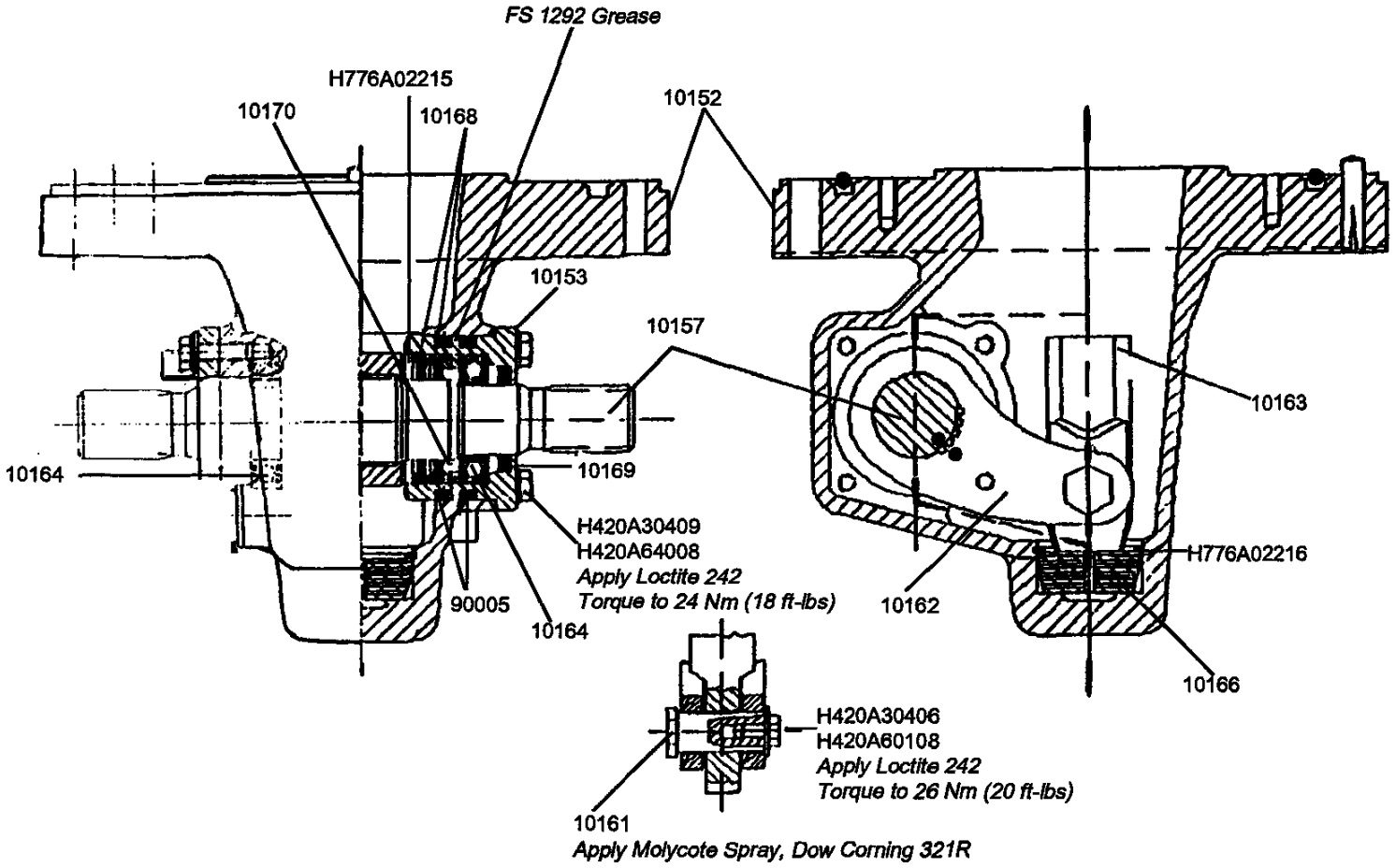


Figure 16
Rebuilding the Bellcrank
10151 (Center), 10159 (Left), and 10160 (Right)

Refer to the legend on the opposite page.

Figure 16
Rebuilding the Bellcrank

10151	Bellcrank Assembly (Center)
10152	Bellcrank Housing (Center)
10153	Shaft Seal Assembly
10156	Bellcrank Shaft (Left/Right) (not shown)
10157	Bellcrank Shaft (Center)
10159	Bellcrank Assembly (Left)
10160	Bellcrank Assembly (Right)
10161	Connecting Pin
10162	Internal Crank
10163	Connector Arm
10164	Bearing
10166	Buffer
10168	Gas/Vacuum Lip Seal
10169	Weather Seal
10170	Aluminum Spacer
10172	Bellcrank Housing (Left) (not shown)
10173	Bellcrank Housing (Right) (not shown)
90005	O-Ring (Shaft Seal Assembly)
H420A30406	Hex Head Bolt, M8 x 12
H420A30409	Hex Head Bolt, M8 x 25
H420A60108	Flat Washer, M8
H420A64008	Flat Washer, M8
H776A02215	Seal Assembly Snap Ring
H776A02216	Retaining Snap Ring

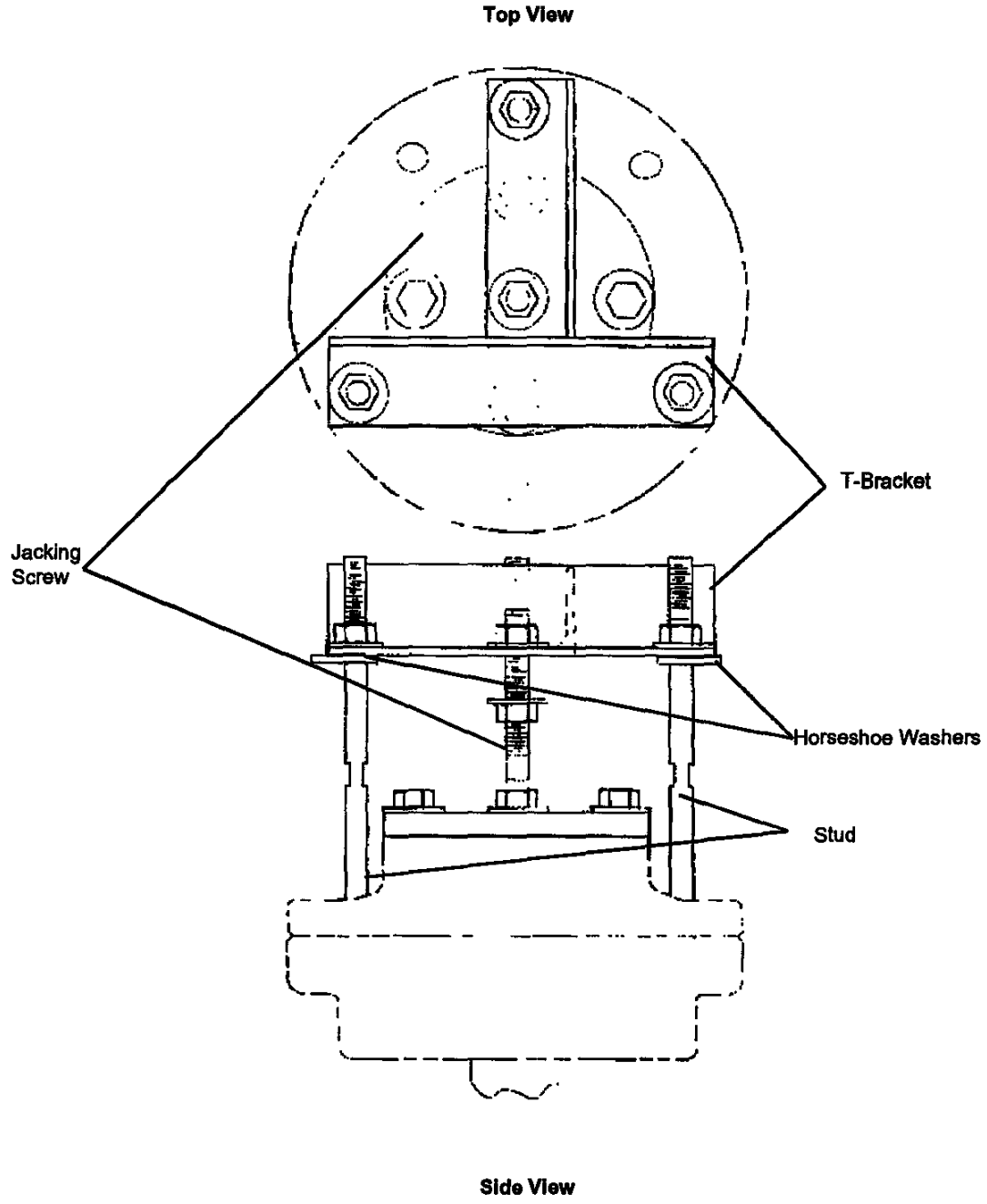


Figure 17
Bushing Conductor Removal Tool T13441

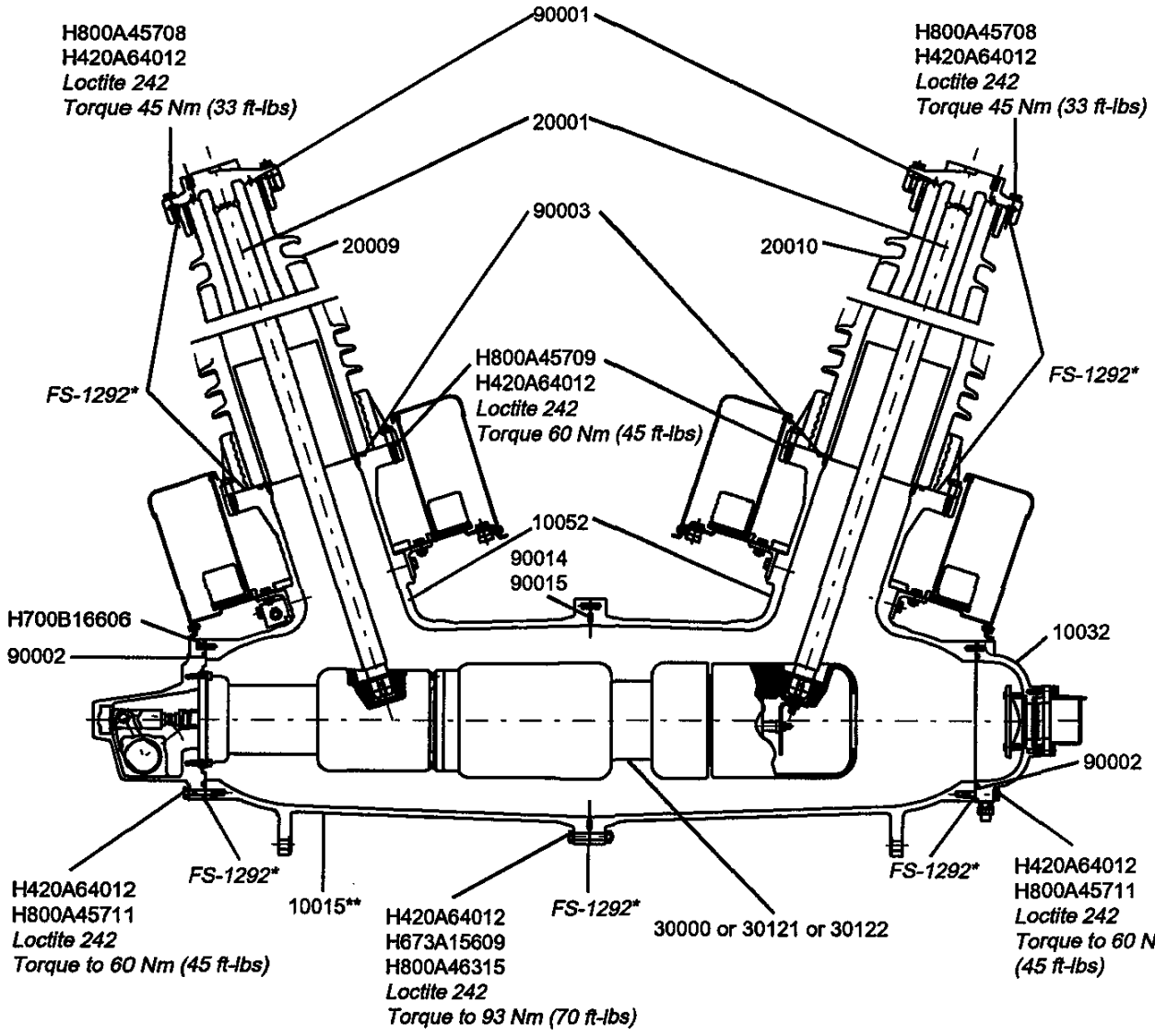


Figure 18
Pole Unit Assembly (Left, Center, or Right)
10047 or 10048 or 10049

10015	Pole Tank	90001	O-Ring, Top Flange
10032	Rear Tank Cover Assembly	90002	O-Ring, Tank End
10047	Left Pole Unit Assembly	90003	O-Ring, Bottom Flange
10048	Center Pole Unit Assembly	90014	O-Ring, Tank Center (Inner)
10049	Right Pole Unit Assembly	90015	O-Ring, Tank Center (Outer)
10052	Tank Half	H420A64012	Flat Washer, M12
20001	Bushing Conductor	H673A15609	Nut, 1/2-13
20009	Front Bushing Assembly	H700B16606	Alignment Pin
20010	Rear Bushing Assembly	H800A45708	Hex Head Bolt, 1/2-13 x 1-1/2 inch
30000	Interrupter Unit (Center)	H800A45709	Hex Head Bolt, 1/2-13 x 2 inch
30121	Interrupter Unit (Left)	H800A45711	Hex Head Bolt, 1/2-13 x 2-1/2 inch
30122	Interrupter Unit (Right)	H800A46315	Hex Head Bolt, 1/2-13 x 3-1/2 inch

*Apply Dow Corning FS-1292 grease to all flange surfaces outside of the O-ring groove to prevent corrosion.
**The pole tank 10015 is composed of two tank halves 10052.

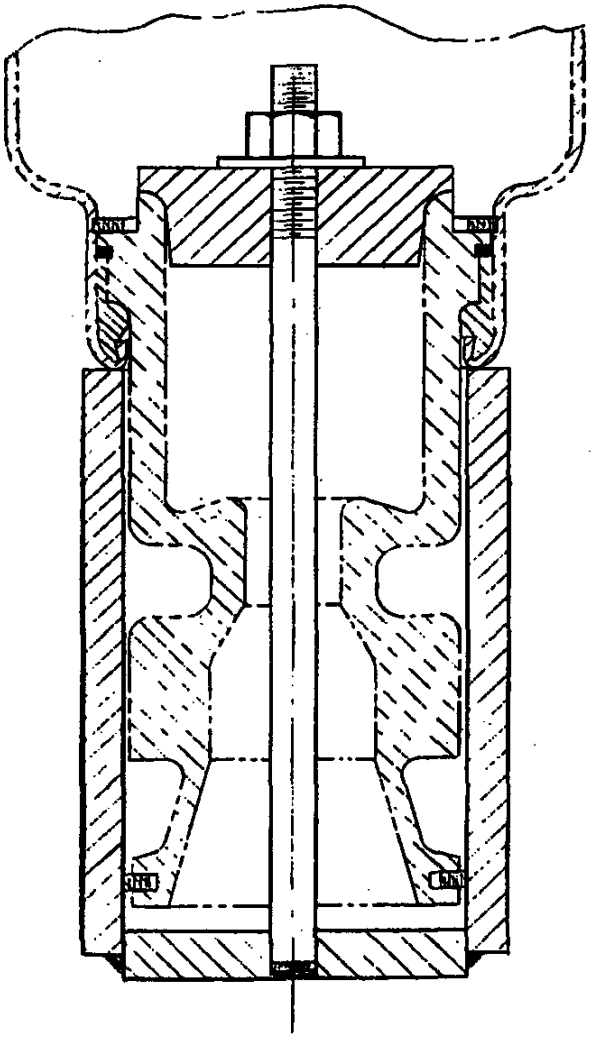


Figure 19
Insulating Nozzle Tool T13449

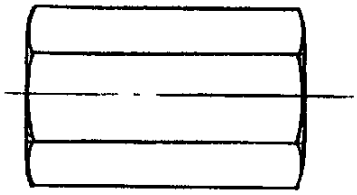


Figure 20
Exhaust Tube Tool T13455

Interrupter Major Maintenance Checklist (every 10 years or after permissible number of operations in Table 2)			
Interrupter Component	**Recommended Action**	**Condition of Component**	**Action Taken/Comments**
Stationary Contact Assembly 30019 (Fig. 5)			
Stationary Arcing Contact 30020	Replace*		
Contact Fingers 30026	Inspect**		
Contact Cage 30025	Inspect**		
Stationary Contact Support 30022	Inspect**		
Moving Contact Assembly 30001 (Fig. 10)			
Moving Arcing Contact 30006	Replace*		
Auxiliary Nozzle 30004	Replace*		
Insulating Nozzle 30005	Replace*		
Main Moving Contact/Self-Blast Chamber 30116	Inspect**		
Puffer Cylinder 30007	Inspect**		
Insulating Nozzle O-Ring 90004	Replace*		
Retaining Snap Ring H776A34304	Replace*		
Insulating Nozzle Guide Ring 30119	Replace*		
Moving Contact Support Assembly 30012 (Fig. 9)			
Mesh Cooler 30107	Replace*		
Inner Guide Bearing 30103	Replace*		
Outer Guide Bearing 30104	Replace*		
Multi-Lam Contact 30014	Replace*		
Moving Contact Support 30018	Inspect**		
Valve Plate Assembly 30108	Inspect**		
Teflon Disk 30120	Replace*		
Retaining Snap Ring H776A34302	Replace*		
*Replace the part when it reaches the permissible number of operations. If after the inspection period of 10 years, the parts are in very good condition (e.g. if there have been very few or no operations), the parts need not be replaced.			
**Inspect the part and, if necessary, replace it. Replacement is generally necessary if a silverplated area has worn to the point that a copper tint is visible through the silverplating.			

SF_6 Circuit Breakers

Type PM

Publication No. 612P005-02

145 PM Interphase Linkage®

ASEA BROWN BOVERI

6 October 1993

Contents

Figures

Notice 1

Based on our own experience, you will obtain the best possible operational reliability by following the recommendations given in these instructions. The data contained herein purports solely to describe the product, and it is not a warranty of performance or characteristics. It is with the best interests of our customers in mind that we constantly strive to improve our products and keep them abreast of advances in technology. This may lead to discrepancies between a product and these instructions.

Notice 2

Within the scope of these instructions, it is impossible to take into account every eventuality which may arise with technical equipment in service. Please consult our local salesman in the event of any irregularities, especially if not referred to herein.

Notice 3

We expressly decline liability for damages resulting from any incorrect operation or wrong handling of our equipment, even if these instructions contain no specific indication in this respect. We stress the fact that only genuine spare parts should be used for replacements.

Notice 4

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the ABB Power T & D Company Inc. Power Circuit Breaker Division, 125 Theobold Ave., Greensburg, PA 15601, Phone No. (412) 838-5200.

Interphase Linkage

1 Introduction

The 145 PM circuit breaker consists of three pole units interconnected by an interphase linkage assembly and gas manifold. The Interphase Linkage module includes all components that join the individual pole units into a single breaker unit. These components are the interphase shafts and the gas manifold.

1.1 Interphase Shafts

Two interphase shafts, left and right, tie together the three bellcrank assemblies on the 145 PM breaker (Fig. 1). The left and right interphase shafts are coupled to the mechanism pullrod through a crank at the center pole unit. The crank at the center pole converts the vertical motion of the mechanism pullrod to the rotational motion of the interphase shafts. The bellcrank assemblies then convert this rotational motion to the horizontal motion of the interrupters.

1.2 Gas Manifold

The gas manifold (Figs. 2 and 3) links the three pole units into a single gas density monitoring system. A self-sealing quick disconnect fitting at each rear tank cover assembly (Fig. 4) conveniently allows the individual pole units to be isolated from the gas manifold without losing any sulfur hexafluoride (SF_6) gas -- a great advantage when performing pole unit maintenance.

1.3 Fastener Locking

Since the impact loading which the circuit breaker experiences during operation tends to loosen threaded hardware, Loctite Threadlocker must be applied to all critical bolted joints. Four types of Loctite are used for specific applications: 222, 242, 262, and 271.

Clean the threads in blind holes if they can be adequately dried afterwards. Apply Loctite sparingly to the outermost edges of the thread. Two small drops of Loctite are enough even for large threads.

Hardware secured with Loctite usually can be unfastened with proper wrenches. In case of difficulty, the connection can be loosened by heating the joint to 150°C (300°F). Be careful not to damage materials which are sensitive to heat, such as insulation or sealing components.

Use particular care in applying Loctite to fasteners used in assembling current carrying connections. Apply Loctite only where specified. If used improperly, Loctite can squeeze between contact areas and may cause a high resistance joint. Ensure that excess Loctite does not squeeze into contact areas.

2 Isolating a Pole Unit

Certain maintenance tasks require isolating a pole unit which entails de-coupling the interphase linkages and the gas manifold. Eventually, the more critical tasks of synchronizing the interrupter contacts and re-coupling the interphase linkages arise. The following sections describe the procedures for:

- De-coupling the interphase linkages (refer to section 2.1);
- Synchronizing the interrupter contacts (refer to section 2.2);
- Re-coupling the interphase linkages (refer to section 2.3).

Important: *In addition to the common maintenance tools and materials listed in the Maintenance module, the special tools referred to herein as the slow open/close device T13444 (Fig. 5) and the manual open/close tool T13451 (Fig. 7) will be needed in this procedure.*

DANGER

Before beginning this procedure, isolate the breaker from high voltage and properly ground the breaker.

2.1 De-Coupling the Interphase Linkages

Warning

Before proceeding, verify that the operating mechanism is discharged in the OPEN position and that all control power is disabled.

De-coupling the interphase linkages involves:

- Removing the right side interphase shaft (refer to section 2.1.1);
- Removing the left side interphase shaft (refer to section 2.1.2);
- De-coupling the gas manifold (refer to section 2.1.3).

2.1.1 Removing the Right Side Interphase Shaft

To remove the right side interphase shaft 10204 (Fig. 1):

1. Remove the four M5 socket head bolts H420A31306 which hold the right side shaft cover 10203 in place.
2. Punch out the roll pins 10209 from the couplings 10205.
3. Slide the couplings 10205 onto the interphase shaft 10204 and lift off the shaft.

2.1.2 Removing the Left Side Interphase Shaft

To remove the left side interphase shaft 10204 (Fig. 1):

1. Remove the four M5 socket head bolts H420A31306 which hold the left side shaft cover 10202 in place.
2. Loosen the cover 10208 by removing the 1/4-inch bolts H800A12904.
3. Remove the M6 hex head bolt H420A31406 (Fig. 6) and washer H973A06504 which holds the crank wrist pin 10210 in place.
4. Slide out the crank wrist pin 10210 and move the mechanism pullrod assembly 10207 out of the way.
5. Remove the M8 hex head bolt H420A30467 and nut H420A58008 from the center of the crank 10206.
6. Slide the crank onto the interphase shaft 10204.
7. Punch out the roll pin 10209 (Fig. 1) from the coupling 10205. Slide the coupling onto the interphase shaft and lift the crank and shaft away.

2.1.3 De-Coupling the Gas Manifold

To de-couple the gas manifold 10213 (Figs. 2 and 3), loosen the DILO quick disconnect fitting 10171 (Fig. 3) at the rear tank cover assembly 10032 of each pole unit. No SF_6 gas will be emitted; the fitting is self-sealing. Refer to Plate 1.

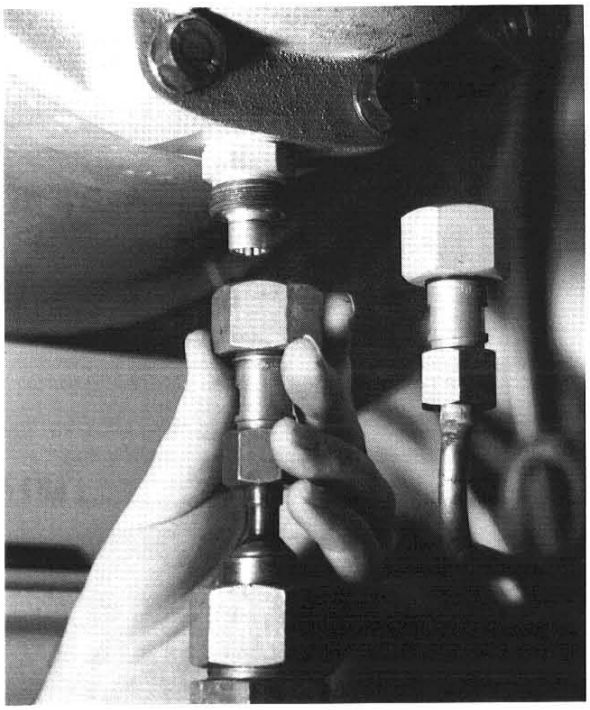


Plate 1: DILO quick disconnect fitting

2.2 Synchronizing the Interrupter Contacts

If the interrupter units have been de-coupled, they must be properly synchronized with each other before re-installing the interphase linkages. To do this, all three interrupter units must be pulled into the fully open position as described in the steps below. Only after all three interrupters are pulled into the fully open position can the interphase linkages be re-installed.

Warning

It is absolutely essential that the interrupter contacts be properly synchronized with each other as well as with the operating mechanism.

To synchronize the interrupter contacts:

1. Slide the manual open/close tool T13451 (Fig. 7) onto the splines of the bellcrank shaft 10156 (left), 10157 (center), or 10156 (right) (Fig. 1).
2. Facing the control cabinet (bellcrank end of the interrupter), with the ratchet handle T13453 (Fig. 7) on the manual open/close tool vertically upright above the bellcrank shaft, rotate the bellcrank shaft to the fully OPEN position by pulling the ratchet handle towards you until you feel the interrupter bottom out.

Caution

You must feel the interrupter bottom out when rotating the bellcrank shaft to ensure that the interrupter is in the fully OPEN position.

3. Repeat steps 1 and 2 for each bellcrank shaft.
4. Proceed to re-couple the interphase linkages. Refer to section 2.3.

2.3 Re-Coupling the Interphase Linkages

Re-coupling the interphase linkages involves:

- Re-installing the right side interphase shaft (refer to section 2.3.1);
- Re-installing the left side interphase shaft (refer to section 2.3.2);
- Re-coupling the gas manifold (refer to section 2.3.3).

Warning

Before proceeding, verify that the interrupter contacts have been synchronized as described in section 2.2 and that the operating mechanism is discharged in the OPEN position and that all control power is disabled. Open the disconnects in the control cabinet to all AC and DC power sources.

2.3.1 Re-Installing the Right Side Interphase Shaft

To re-install the right side interphase shaft 10204 (Fig. 1):

1. Slide the couplings 10205 onto the right side interphase shaft 10204 and re-install the shaft.
2. Tap the roll pins 10209 into the couplings 10205.
3. Place the right side shaft cover 10203 into position.
4. Install the four M5 socket head bolts H420A31306 and washers H961376 which hold the right side shaft cover in place. Apply Loctite 222 to secure the bolts.

2.3.2 Re-Installing the Left Side Interphase Shaft

To re-install the left side interphase shaft 10204 (Fig. 1):

1. Slide the cover 10208 over the left side interphase shaft 10204 before re-installing the shaft.
2. Slide the crank 10206 and coupling 10205 onto the left side interphase shaft.
3. Re-install the left side interphase shaft aligning the line-up dot on the crank 10206 with the line-up dot located on one of the splines of the center bellcrank shaft 10157.

Caution

The line-up dot on the crank and the line-up dot on the center bellcrank shaft must be aligned to ensure proper synchronization of the interrupters with respect to the mechanism.

4. Re-install the M8 hex head bolt H420A30467 (Fig. 6) and nut H420A58008 into the crank 10206.
5. Tap the roll pin 10209 (Fig. 1) into the coupling 10205.
6. Move the mechanism pullrod assembly 10207 into position and slide the crank wrist pin 10210 (Fig. 6) into place.

Notice: *The crank wrist pin usually can be re-installed without requiring any adjustment of the pullrod length. However, because this pin is finely machined for precision fitting, it is sometimes difficult to insert the pin. Therefore a **very slight** adjustment of the turnbuckling pullrod may be required to align the pin. To adjust the pullrod, loosen the lock nuts H420A58160 (Fig. 6) and H420A58116 and then turn the pullrod slightly (on the order of a half turn) until the pin fits. Apply Loctite 242 to the lock nuts and torque lock nut H420A58160 to 217 Nm (160 ft-lbs); torque lock nut H420A58116 to 136 Nm (100 ft-lbs). If the pin alignment is off significantly, (more than 1 mm) the interrupters may not be fully opened or properly synchronized.*

7. Re-install the M6 hex head bolt H420A31406 (Fig. 6) and washer H973A06504 which hold the crank wrist pin 10210 in place. Apply Loctite 222 to the threads of the M6 bolt and torque to 7 Nm (5 ft-lbs).
8. Re-install the cover 10208 (Fig. 1).
9. Re-install the left side shaft cover 10202 by inserting the four M5 socket head bolts H420A31306 with washers H961376.

2.3.3 Re-Coupling the Gas Manifold

To re-couple the gas manifold 10213 (Figs. 2 and 3), re-connect the DILO quick disconnect fitting 10171 (Fig. 3). No SF_6 gas will be emitted because the fitting is self-sealing.

Important: *Apply Dow Corning FS-1292 Grease to the threads of the DILO quick disconnect fitting.*

Warning

The gas manifold must be connected at all pole units to properly monitor the SF_6 gas density at all poles. If the pole unit was opened, a vacuum and refilling procedure must be performed as described in the Maintenance module.

2.4 Final Inspection

After re-installing the interphase linkages, inspect the following:

- Be sure that the gas manifold is re-connected at all phases (refer to section 2.3.3);
- Be sure that the breaker is properly filled with SF_6 gas. Refer to the Maintenance module for gas filling procedures. If the pole unit was opened, a vacuum and gas replenishing procedure must be performed as described in the Maintenance module.

3 Slow Close Operation

Perform the slow close operation anytime a stationary contact assembly is either replaced or re-installed into an interrupter unit to ensure proper contact alignment, i.e. during contact inspection.

Important: With the 145 PM circuit breaker, the mechanism cannot be jacked closed. The interrupters must be isolated from the mechanism by removing the crank wrist pin 10210 (Fig. 6).

Warning

Before proceeding, verify that the operating mechanism is discharged in the OPEN position and that all control power is disabled.

To perform a slow close operation:

1. Remove the left side shaft cover 10202 (Fig. 1) by unfastening the four M5 socket head bolts H420A31306.
2. Loosen the cover 10208 by removing the 1/4-inch bolts H800A12904.
3. Remove the M6 hex head bolt H420A31406 (Fig. 6) and washer H973A06504 which holds the crank wrist pin 10210 in place.
4. Slide out the crank wrist pin 10210 and move the mechanism pullrod assembly 10207 out of the way.
5. Strap the slow open/close device T13444 (Fig. 5) around the interphase shaft 10204 (Fig. 1). Refer to Plate 2.
6. Turn the interphase shaft by pushing the slow open/close device away from you. All three interrupter units will move to the CLOSE position simultaneously.

Plate 2: Slow open/close device

7. After completing the slow close, move the interrupters back into the OPEN position by pulling the slow open/close device towards you until you feel the interrupters bottom out.

Caution

You must feel the interrupters bottom out when rotating the interphase shaft to ensure that they are in the fully OPEN position.

8. Move the mechanism pullrod assembly 10207 (Fig. 6) into position and slide the crank wrist pin 10210 into place.

Notice: *The crank wrist pin usually can be re-installed without requiring any adjustment of the pullrod length. However, because this pin is finely machined for precision fitting, it is sometimes difficult to insert the pin. Therefore a **very slight** adjustment of the turnbuckling pullrod*

may be required to align the pin. To adjust the pullrod, loosen the lock nuts H420A58160 (Fig. 6) and H420A58116 and then turn the pullrod slightly (on the order of a half turn) until the pin fits. Apply Loctite 242 to the lock nuts and torque lock nut H420A58160 to 217 Nm (160 ft-lbs); torque lock nut H420A58116 to 136 Nm (100 ft-lbs). If the pin alignment is off significantly, (more than 1 mm) the interrupters may not be fully opened or properly synchronized.

9. Re-install the M6 hex head bolt H420A31406 (Fig. 6) and washer H973A06504 which hold the crank wrist pin 10210 in place. Apply Loctite 222 and torque to 7 Nm (5 ft-lbs).

10. Re-install the cover 10208 (Fig. 1).

11. Re-install the left side shaft cover 10202 by inserting the four M5 socket head bolts H420A31306 with washers H961376.

NOTES:

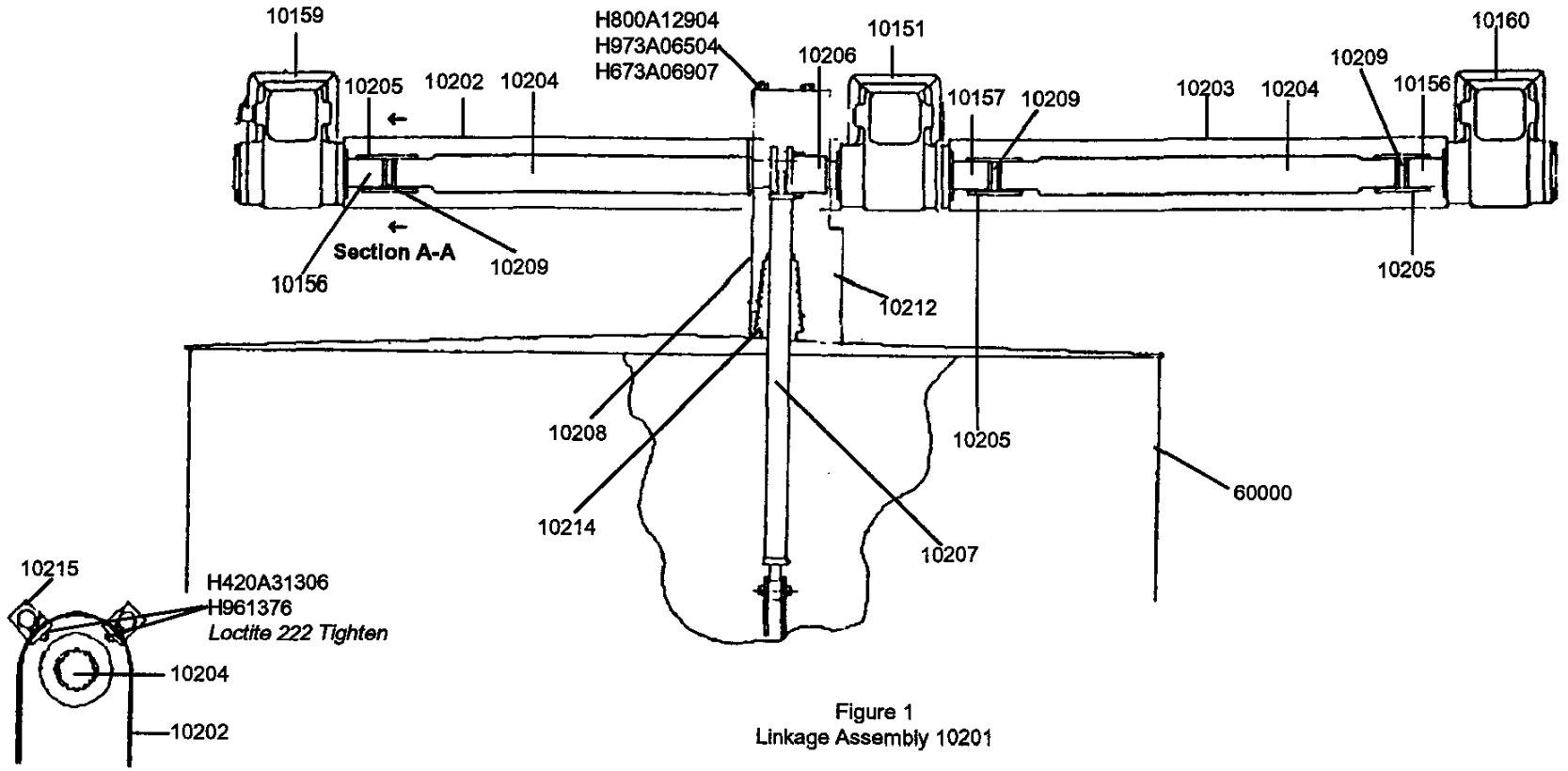
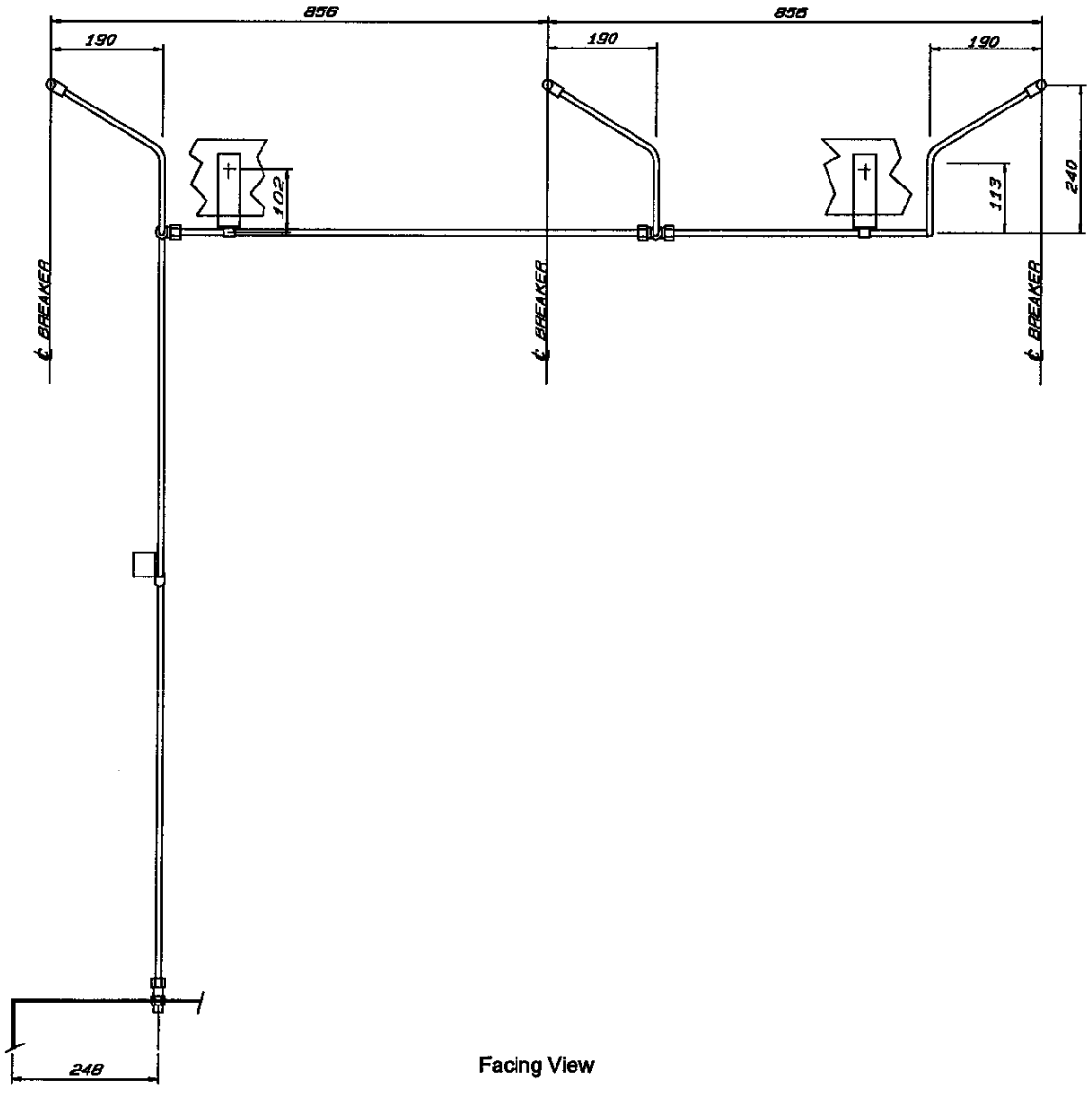


Figure 1
Linkage Assembly 10201

10151	Bellcrank Assembly (Center)	10208	Cover
10156	Bellcrank Shaft (Left/Right)	10209	Roll Pin
10157	Bellcrank Shaft (Center)	10212	Linkage Access Cover
10159	Bellcrank Assembly (Left)	10214	Rubber Boot
10160	Bellcrank Assembly (Right)	10215	Clip
10202	Left Side Shaft Cover	60000	Control Cabinet
10203	Right Side Shaft Cover	H420A31306	Socket Head Bolt, M5
10204	Interphase Shaft (Left/Right)	H673A06907	Nut Inserts, 1/4-20 inch
10205	Coupling	H800A12904	Bolt, 1/4-20 x 3/4-inch
10206	Crank	H961376	Washer
10207	Mechanism Pullrod Assembly	H973A06504	Flat Washer, 1/4-inch



Facing View

Figure 2
Gas Manifold 10213

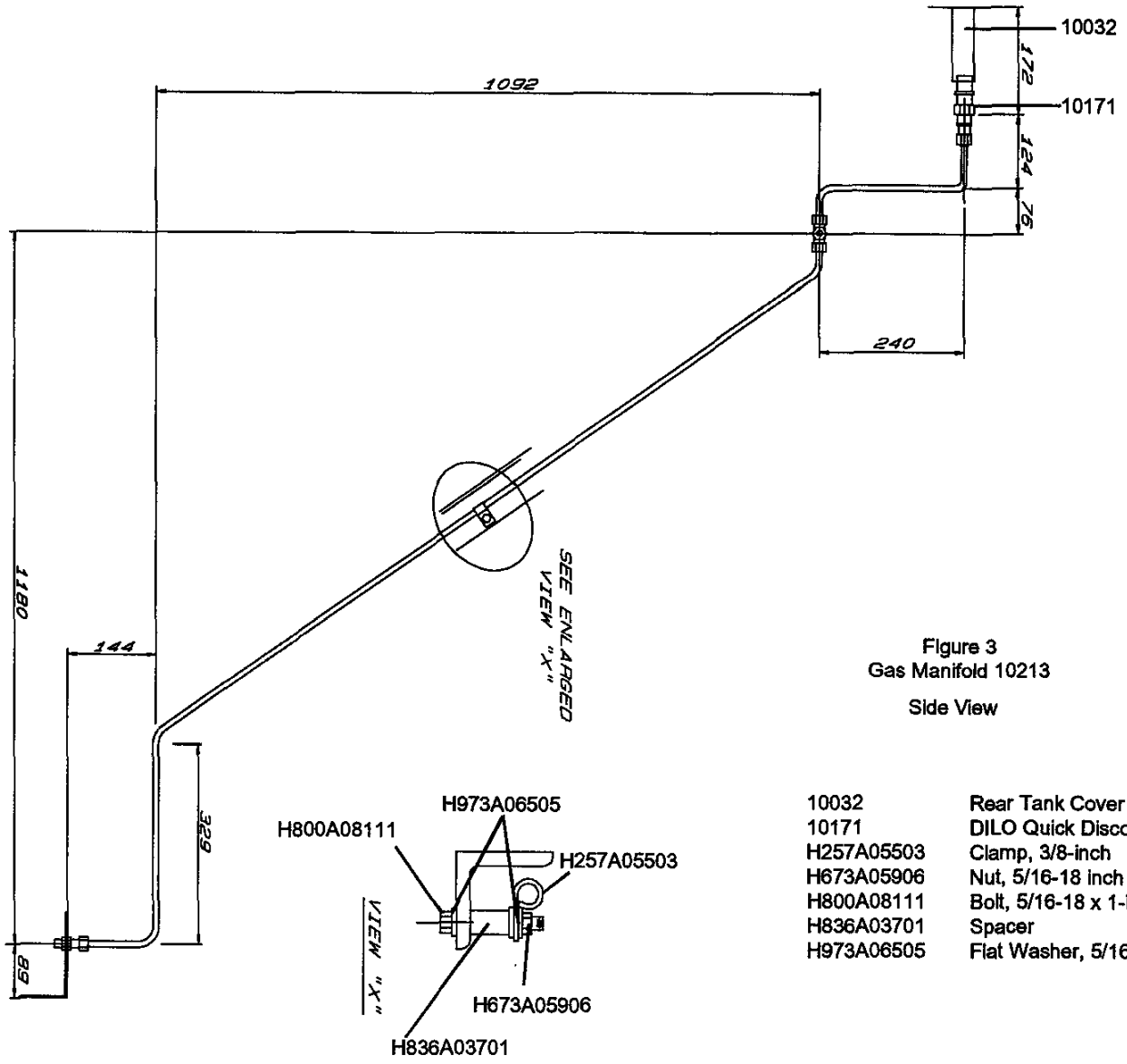


Figure 3
Gas Manifold 10213

Side View

10032	Rear Tank Cover Assembly
10171	DILO Quick Disconnect Fitting
H257A05503	Clamp, 3/8-inch
H673A05906	Nut, 5/16-18 inch
H800A08111	Bolt, 5/16-18 x 1-inch
H836A03701	Spacer
H973A06505	Flat Washer, 5/16-inch

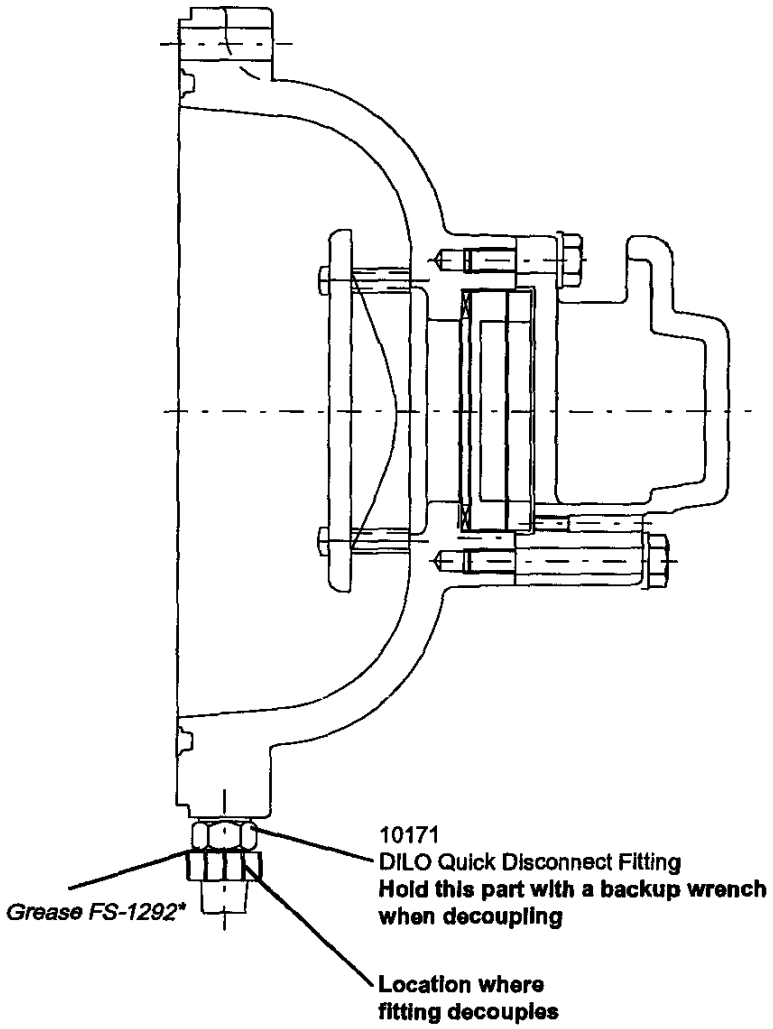


Figure 4
Rear Tank Cover Assembly 10032

*Apply Dow Corning FS-1292 to lubricate the threads of the quick disconnect fitting.

Figure 5
Slow Open/Close Device T13444

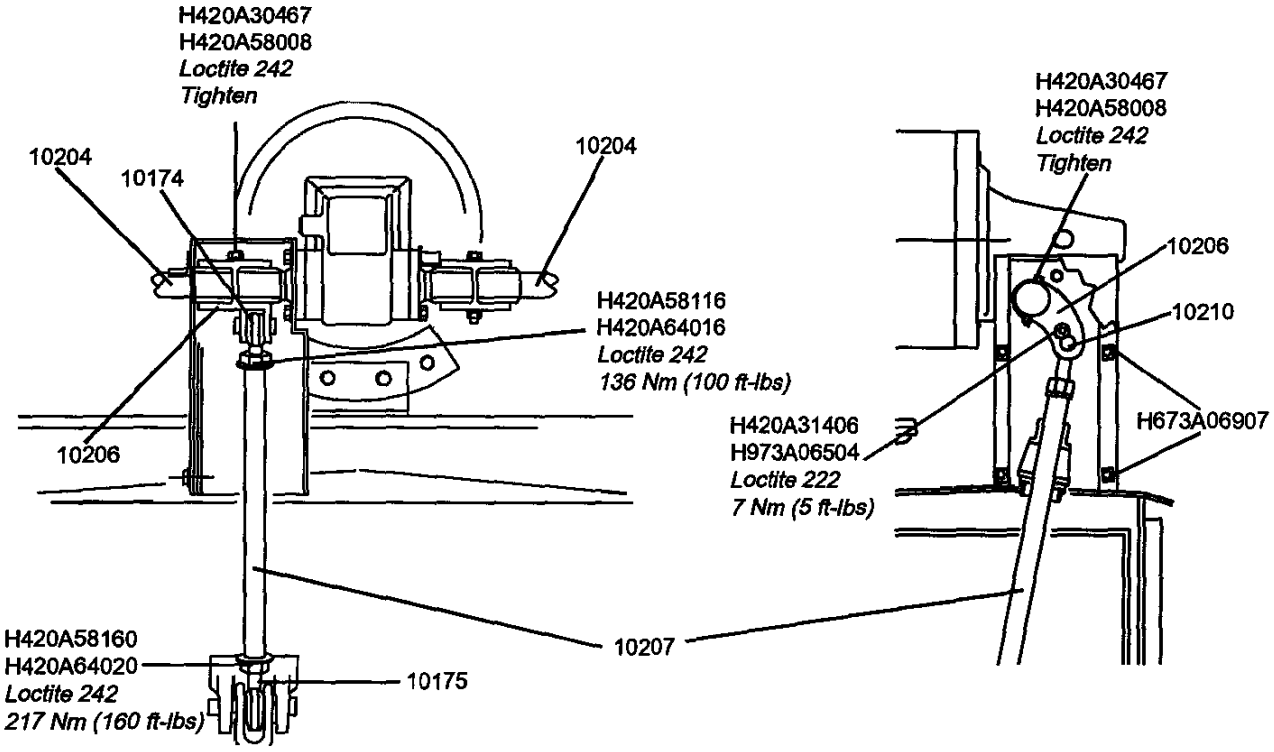


Figure 6
Crank 10206 and Mechanism Pullrod Assembly 10207

10174	Rod End, Upper
10175	Rod End, Lower
10204	Interphase Shaft (Left/Right)
10206	Crank
10207	Mechanism Pullrod Assembly
10210	Crank Wrist Pin
H420A30467	Hex Head Bolt, M8 x 65
H420A31406	Hex Head Bolt, M6 x 12
H420A58008	Nut, M8
H420A58116	Lock Nut, M16 (Right Hand)
H420A58160	Lock Nut, M20 (Left Hand)
H420A64016	Flat Washer, M16
H420A64020	Flat Washer, M20
H673A06907	Nut Insert, 1/4-20-inch
H973A06504	Flat Washer, 1/4-inch

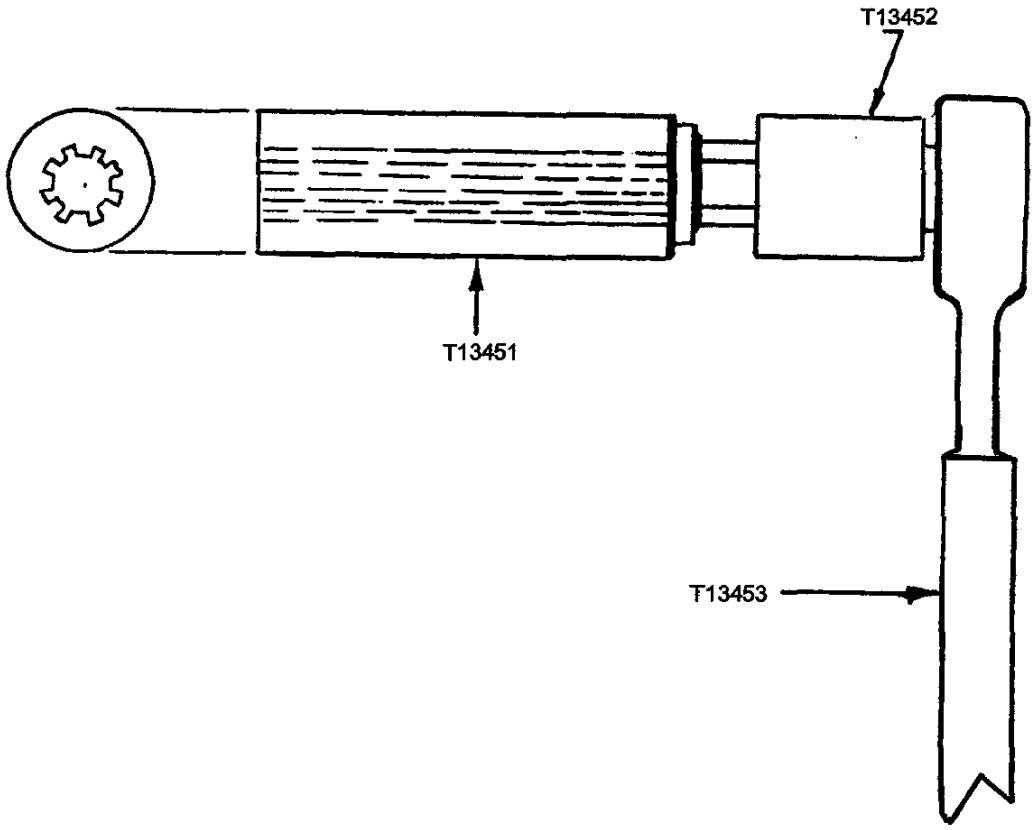


Figure 7
Manual Open/Close Tool

T13451	Manual Open/Close Tool
T13452	Socket
T13453	Ratchet Handle

SF_6 Circuit Breakers

Type PM

Publication No. 641P007-03

FSA-2 Mechanism©

ASEA BROWN BOVERI

18 February 1993

Contents

Figures & Checklists

Notice 1

Based on our own experience, you will obtain the best possible operational reliability by following the recommendations given in these instructions. The data contained herein purports solely to describe the product, and it is not a warranty of performance or characteristics. It is with the best interests of our customers in mind that we constantly strive to improve our products and keep them abreast of advances in technology. This may lead to discrepancies between a product and these instructions.

Notice 2

Within the scope of these instructions, it is impossible to take into account every eventuality which may arise with technical equipment in service. Please consult our local salesman in the event of any irregularities, especially if not referred to herein.

Notice 3

We expressly decline liability for damages resulting from any incorrect operation or wrong handling of our equipment, even if these instructions contain no specific indication in this respect. We stress the fact that only genuine spare parts should be used for replacements.

Notice 4

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the ABB Power T & D Company Inc. Power Circuit Breaker Division, 125 Theobold Ave., Greensburg, PA 15601, Phone No. (412) 838-5200.

FSA-2 Mechanism

1 Introduction

Instructions in this module apply to the type FSA-2 spring drive mechanism.

1.1 Description

The FSA-2 mechanism actuates the circuit breaker interrupters. The mechanism, housed within the control cabinet, receives operating commands from the electrical control system and translates these commands into the mechanical motion which opens or closes the circuit breaker contacts.

The FSA-2 is a pure spring-operated mechanism where the interrupters are opened and closed solely by steel coil springs. The FSA-2 mechanism stores operating energy in two sets of spring packages -- the closing springs and opening springs. The closing springs are charged under normal conditions using a charging motor and gearbox assembly, but can be manually charged if necessary. During the closing operation, the mechanism moves to the CLOSED position and simultaneously charges the opening springs using the stored energy of the closing springs. The mechanism contains enough stored energy in the CLOSED position with the closing and opening springs charged to perform an open-close-open (O-C-O) operation without re-charging. A low spring charge alarm is actuated by a limit switch should the closing springs fail to re-charge. This is the only alarm function for the FSA-2 mechanism. Refer to Section 2 for a complete description of operating principles.

The FSA-2 mechanism is available for use with all common operating voltages. Acceptable fluctuations in the system voltages are per ANSI standards. The standard circuit breaker is supplied with one trip coil. However, a second trip coil is available if specified. Either trip coil is capable of independently tripping the mechanism.

Control cabinet anti-condensation heaters H1, H2, H3, and H4 are incorporated into the FSA-2 mechanism.

The FSA-2 mechanism contains the following major components:

- Closing springs;
- Opening springs;
- Main shaft;
- Drive shaft;
- Tripping and closing latch assemblies;
- Dashpot;
- Limit switches;
- Trip and close coils;
- Charging motor and gearbox assembly;
- Anti-condensation heaters.

The functions of these components are described in section 2, "Principles of Operation."

2 Principles of Operation

This description of operating principles begins with both the closing springs and opening springs discharged. Section 2.1 describes the charging operation of the closing springs; section 2.2 describes the closing operation; section 2.3 describes the opening operation, and section 2.4 describes the duty cycle.

2.1 Charging the Closing Springs

Before a closing operation can be performed, the closing springs 53010 (Fig. 1) must be charged. Under normal operating conditions, the closing springs are charged via the charging motor and gearbox assembly 53008.

The charging motor is energized by a limit switch 53017 which is controlled by the position of the closing springs. Anytime the closing springs are in the discharged position, the limit switch is made and power (if available) is applied to the charging motor. When the closing springs move to the charged position, the limit switch opens to de-energize the charging motor.

During the charging process of the closing springs, the worm gear 53006 and the worm 53007 transfer rotational motion from the charging motor and gearbox assembly 53008 to the main shaft 53001 through the jack pawl 53023 and jack sleeve 53029. As the main shaft rotates in a clockwise direction, it causes the closing spring crank 53011 on the left side of the main shaft to rotate upward charging the closing springs.

After the main shaft is rotated clockwise slightly more than 180 degrees, the closing latch assembly 53005 engages the closing cam 53003 to hold the main shaft in the charged position. The jack pawl releases automatically. A latch reverse stop 53027 and rebound gear 53028 prevent the main shaft from reversing its direction.

A spring charge indicator 53034 (Fig. 2), visible through a view port in the control cabinet door indicates whether the closing springs are charged or discharged.

2.2 Closing Operation

After completing the charging process as described in section 2.1, the closing operation is initiated when the closing latch assembly 53005 (Fig. 1) is released by remote electrical operation of the close coil 53014. Releasing the closing latch assembly allows the closing springs 53010 to discharge, rotating the main shaft 53001 clockwise.

Simultaneously, the closing cam 53003 on the main shaft contacts the operating lever 53004 on the drive shaft 53002 causing the drive shaft to rotate in a counter-clockwise direction. The drive crank 53012 at the right end of the drive shaft rotates upward driving the mechanism pullrod assembly 10207 into the CLOSED position. At the same time, the opening springs 53019 are being charged because they also are connected to the drive crank.

At the end of this rotation, the trip cam 53020 on the drive crank engages the tripping latch assembly 53018. The tripping latch assembly holds the drive shaft in the CLOSED position with the opening springs charged and the mechanism ready to actuate an opening operation.

A hydraulic dashpot 53024 attached directly to the drive crank, dampens motion at the end of the closing stroke to reduce the speed of the mechanism before coming to the fully CLOSED position.

The position indicator 53035 (Fig. 2), visible through a view port in the control cabinet door indicates that the mechanism is in the CLOSED position.

When the closing springs discharge, the limit switch (which controls the charging motor) closes and energizes the charging motor. In 10 seconds or less after a closing operation, the closing springs will re-charge. The stop latch 53025 (Fig. 1) mechanically prevents the closing latch assembly from being released if the mechanism is already in the CLOSED position or if the closing springs are not fully charged. A limit switch also prevents electrical operation of the close coil 53014 if the closing springs are not fully charged.

In summary, during the closing operation the following occur:

- The mechanism is driven and latched into the CLOSED position;
- The opening springs are charged readying the mechanism for an OPEN operation;
- The closing springs re-charge automatically.

2.3 Opening Operation

After the opening springs have been charged during the closing operation as described in section 2.2, the mechanism is prepared to perform an opening operation. The opening operation is initiated when the tripping latch assembly 53018 (Fig. 1) is released by remote electrical operation of the trip coil 53016. Releasing the tripping latch assembly allows the opening springs 53019 to discharge pulling the drive crank 53012 and the mechanism pullrod assembly 10207 (which is connected to the drive crank) into the OPEN position. The position indicator 53035 (Fig. 2), visible through a view port in the control cabinet door, indicates that the mechanism is in the OPEN position.

The operations counter 53036 is visible in the view port. Each time the mechanism opens, the counter advances by one count.

As in the closing operation, the dashpot 53024 (Fig. 1) also dampens motion at the end of the opening stroke to reduce the speed of the mechanism before coming to the fully OPEN position.

2.4 Duty Cycle

Under normal operating conditions, the FSA-2 mechanism is in the CLOSED position with both the closing and opening springs fully charged. At this point, there is enough energy stored in the closing and opening springs to perform an open-close-open (O-C-O) operation (even if the charging motor has been disabled by a power failure, etc.) as demonstrated in the following sequence:

1. **OPEN:** The breaker can be opened using the energy in the opening springs;
2. **CLOSE:** The breaker can be closed and consequently the opening springs charged using the energy of the closing springs;
3. **OPEN:** The breaker can now be opened using the energy stored in the opening springs in the previous step.

Assuming that the charging motor is not disabled, the closing springs will re-charge within 10 seconds after a closing operation. Owing to this factor, the duty cycle is O-C-O 10 seconds CO.

3 Manual Operation

Under normal conditions, the FSA-2 mechanism operates using electrical controls. However, provisions are made for the following manual operations:

- Manually charging the closing springs (section 3.1);
- Manual closing at the mechanism (section 3.2);
- Manual opening at the mechanism (section 3.3);
- External manual tripping (section 3.4).

DANGER

Spring-operated mechanisms pose inherent hazards associated with high energy equipment having rapidly moving parts and electrical components. Only qualified personnel possessing a full understanding of this equipment should operate or service this equipment. Be careful of limbs and extremities when working around this equipment as they may become entangled in moving parts. To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance or manual operating procedures.

Manual operation of this mechanism overrides all electrical breaker operation lock-outs such as those that occur with low SF_6 gas density. Manual operation is not recommended when the high voltage circuit breaker is energized.

3.1 Manually Charging the Closing Springs

The manual spring charge tool T13443 (Fig. 4) is used to manually charge the closing springs 53010 (Fig. 1). This tool is equipped with a ratchet handle T13453 (Fig. 4) and a socket T13452. The manual spring charge tool is provided with the standard breaker tools. Refer to Plate 1.

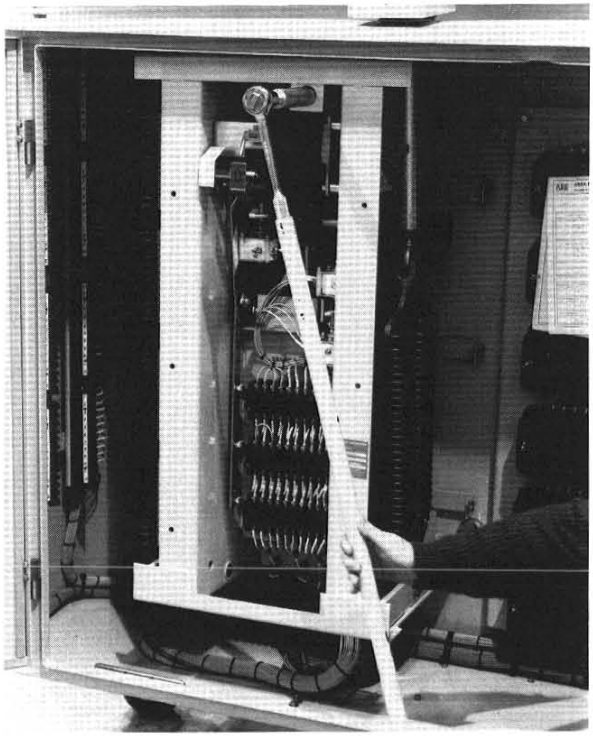


Plate 1: Manual spring charging

The manual spring charge tool allows the closing springs 53010 (Fig. 1) to be manually charged by rotating the worm gear 53006 through the bevel pinion assembly 53021 and the one-way coupling 53022. The worm gear and the worm 53007 transfer rotational motion to the main shaft 53001. As the main shaft 53001 rotates in a clockwise direction, it causes the closing spring crank 53011 on the left side of the main shaft to rotate upward charging the closing springs. After being rotated clockwise slightly more than 180 degrees, the closing latch assembly 53005 holds the main shaft in the charged position.

Approximately 30 complete rotations of the manual spring charge tool are required to charge the closing springs. The jack pawl 53023 automatically disengages.

Should the charging motor start while this special tool is being used, the one-way coupling will ratchet to prevent injuries.

Notice: *Use only the manual spring charge tool T13443 (Fig. 4) to manually charge the closing springs. There is no other way to manually charge the closing springs.*

3.2 Manual Closing at the Mechanism

To manually close the FSA-2 mechanism, the closing springs 53010 (Fig. 1) must be fully charged. To initiate closing, lift up on the closing lever 53013. Refer to Plate 2.

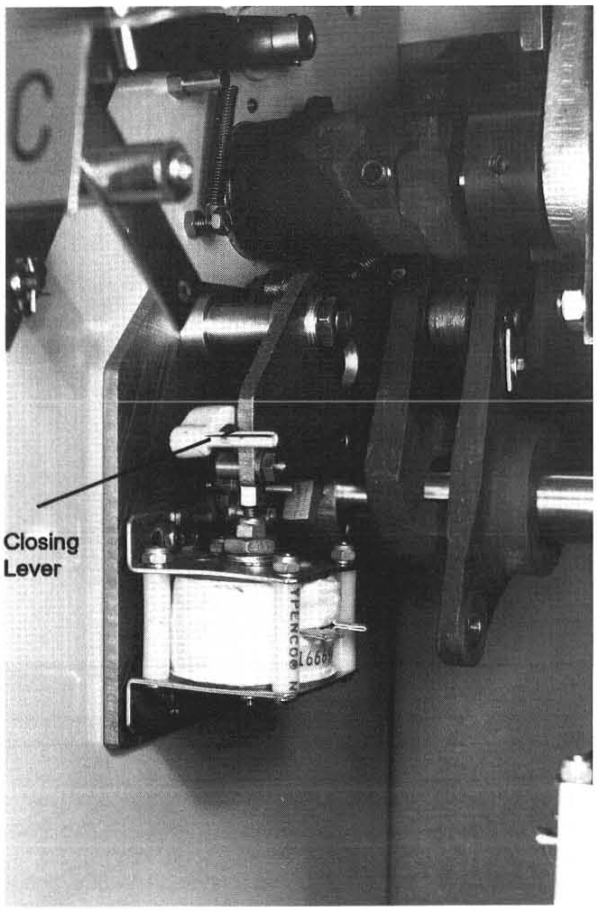


Plate 2: Manual closing

3.3 Manual Opening at the Mechanism

To manually open the FSA-2 mechanism, the opening springs 53019 (Fig. 1) must be fully charged. To initiate opening, lift up on the tripping lever 53015. Refer to Plate 3.

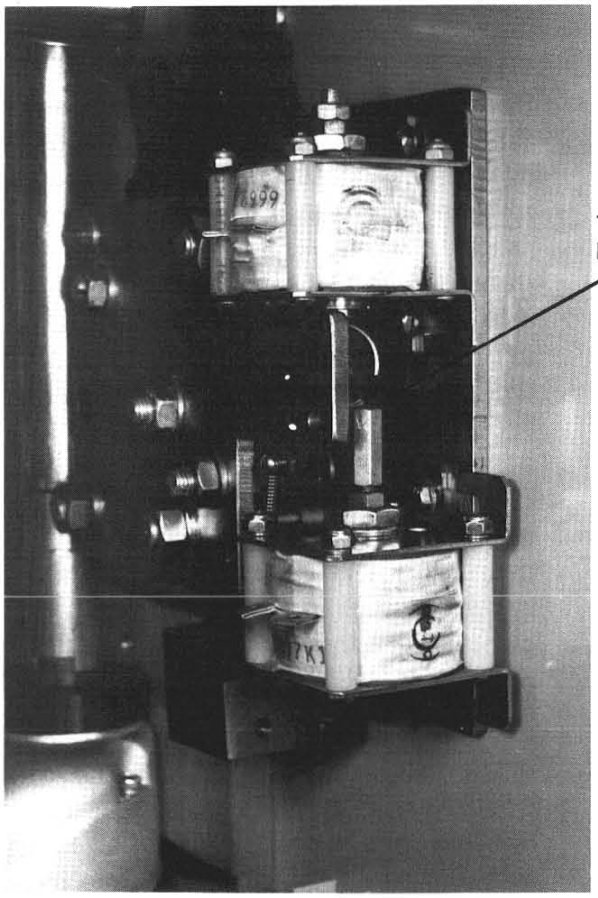


Plate 3: Manual opening

3.4 External Manual Tripping

When specified, a manual trip device 53033 (Fig. 5) is supplied with the circuit breaker. This device consists of a lever assembly connected to an actuating rod that extends through the bottom of the control cabinet for convenient external access. The rod is fitted with a knob which, when pulled, initiates manual tripping by lifting on the tripping lever 53015 (Fig. 1). A 69 switch 53043 (Fig. 5) locks out the closing circuit until the manual trip device is reset. The manual trip system is designed to accept a Kirk Key Interlock which can be supplied.

DANGER

Manual operation of this mechanism overrides all electrical breaker operation lock-outs such as those that occur with low SF_6 gas density. Manual operation is not recommended when the high voltage circuit breaker is energized.

4 Commissioning the FSA-2 Mechanism

Commissioning the FSA-2 mechanism on initial start-up includes performing the following procedures and checks:

- Applying control power to the charging motor (section 4.1.);
- Adjusting the auxiliary switches (section 4.2.);
- Adjusting the limit switches (section 4.3.);
- Checking that anti-condensation heaters are energized and functioning properly (section 4.4);
- Functional testing (section 4.5):
  - Checking the low spring charge alarm,
  - Operational tests of the mechanism;
- Completing the commissioning checklist.

Important: A commissioning checklist is provided at the back of this module. Use this checklist as a reference guide when performing the commissioning procedures in this section.

DANGER

Spring-operated mechanisms pose inherent hazards associated with high energy equipment having rapidly moving parts and electrical components. Only qualified personnel possessing a full understanding of this equipment should operate or service this equipment. Be careful of limbs and extremities when working around this equipment as they may become entangled in moving parts. To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance or manual operating procedures.

Manual operation of this mechanism overrides all electrical breaker operation lock-outs such as those that occur with low SF_6 gas density. Manual operation is not recommended when the high voltage circuit breaker is energized.

4.1 Applying Control Power to the Charging Motor

Since charging motors of differing operating voltages are available (both AC and DC), refer to the wiring diagrams in the Customer Data module to determine the type of charging motor provided. The power requirements for the charging motor also are listed on the front page of the wiring diagram.

The mechanism is shipped from the factory with the closing and opening springs discharged and the breaker in the OPEN position. When power is applied to the charging motor, the closing springs should charge in 10 seconds or less. If the motor does not charge in 10 seconds, verify that the proper operating voltage is being applied and that the supply cable is sized sufficiently to carry the necessary current based on the power requirements of the charging motor.

4.2 Adjusting the Auxiliary Switches Plate 4

The Type L2 auxiliary switches 53040 (Figs. 1 and 7) are factory set and in general do not require adjustment. The switches are driven by a linkage system connected to the drive shaft 53002 (Fig. 1) of the FSA-2 mechanism. An adjustable auxiliary switch drive arm 53044 (Fig. 7) consisting of two clevises 53051 and 53054 and a rod 53055 drive the auxiliary switch crank 53056. This crank, in turn, drives the auxiliary switches. Should adjustments to the auxiliary switches be required, make the adjustment by loosening the locknuts of the clevises and turning the rod of the adjustable drive arm. Adjust the switches as per the instructions in the Type L2 Auxiliary Switches publication.

Notice: *Although the auxiliary switches can be advanced or delayed in 22-degree increments and also can be changed from an "a" contact to a "b" contact or vice versa, they should not be re-adjusted without first consulting the factory in Greensburg.*

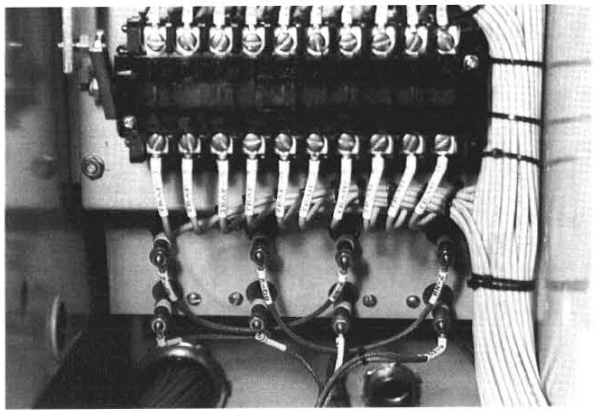


Plate 4: Auxiliary switches

4.3 Adjusting the Limit Switches Plate 5

The limit switches 53017 (LS1, LS2, LS3 and LS4) (Fig. 1) are identical. They are factory-set and are not field adjustable (a pin is used to fix the adjustment setpoint of the limit switch assembly). It is possible to replace the individual limit switches simply by unbolting the entire assembly from the frame and replacing the old switch with a new switch (section 5.10).

The limit switches provide the following functions:

- Start and stop the charging motor - (typically LS1 and LS3);
- Closing operation block for a discharged closing spring i.e. latch check switch (typically LS2);
- Low spring charge alarm (typically LS4).

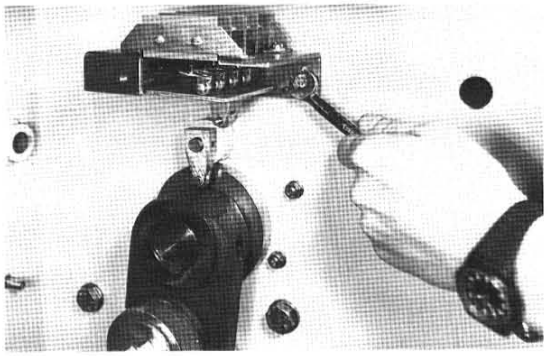


Plate 5: Limit switches

4.4 Checking the Anti-Condensation Heaters

Assure that power is supplied to the heater circuit and that the four anti-condensation heaters 60001 (Fig. 7) are functioning properly. Check the wiring diagram in the Customer Data module for the proper supply voltage. The power demand is 300W maximum. Heaters H1 and H2 operate continuously to provide 150W of heat. Heaters H3 and H4, are controlled by a thermostat to provide an additional 150W of heat when the temperature falls below the setpoint of the thermostat.

Important: *The anti-condensation heaters should be energized at all times to prevent condensation and subsequent corrosion. If the breaker is to be stored longer than one month, establish temporary power connections to energize the anti-condensation heaters.*

4.5 Functional Testing

Functional testing of the FSA-2 mechanism should be done in conjunction with breaker commissioning as specified in the Installation and Commissioning module of this manual. Mechanism checklists for commissioning checks as well as maintenance procedures are provided at the end of this module for reproduction and use in the field.

Functional testing includes:

- Checking the low spring charge alarm (section 4.5.1);
- Operational tests (section 4.5.2).

4.5.1 Checking the Low Spring Charge Alarm

The FSA-2 mechanism has one alarm function -- the low spring charge alarm (typically given by limit switch LS4) which indicates the condition of the closing springs.

The limit switch for low spring charge alarm energizes a time delay relay (set at one minute) when the closing springs are discharged. If the closing springs fail to recharge within the one minute delay, the relay picks up to provide a low spring charge alarm.

The latch check switch LS2 prevents electrical energization of the closing circuit when the closing springs are not fully charged.

The low spring charge alarm should be checked for proper operation during commissioning. Check the alarm as follows:

1. Disable the supply voltage to the charging motor but do not disable the DC control voltage to the breaker control scheme.
2. Discharge the closing springs by closing the mechanism either electrically or manually.
3. Monitor the alarm contact for the low spring charge alarm. After approximately a 1-minute delay, a low spring charge alarm should be indicated since the closing springs remain discharged.
4. After assuring that the alarm is operating properly, restore the supply voltage to the charging motor.
5. After the closing springs have re-charged, verify that the low spring charge alarm resets.

4.5.2 Operational Tests of the Mechanism

Operational testing of the mechanism is performed in conjunction with the installation and commissioning procedures described in the Installation and Commissioning module. The circuit breaker timing characteristics (contact velocity and dampening of overtravel) depend upon proper operation of the mechanism. Refer to section 5.3 (in this module) for instructions to adjust the dashpot which determines the amount of overtravel; section 5.8.1 (in this module) lists instructions for adjusting the opening and closing velocities.

Refer to the Maintenance module for procedures to measure contact velocity.

5 FSA-2 Mechanism Maintenance and Inspection

The FSA-2 mechanism is designed to perform up to 5000 Close-Open operations without requiring major maintenance or overhaul. After 5000 operations or 10 years of service, trained personnel should inspect and overhaul the mechanism. During overhaul, the mechanism will be disassembled and all components will be cleaned and inspected for damage or unusually heavy wear. Parts exhibiting heavy wear will be replaced.

To ensure proper operation, certain routine maintenance tasks are required yearly and after every 2500 Close-Open operations (or after 5 years of service -- whichever comes first). The yearly and 2500-operation maintenance requirements for the FSA-2 mechanism are detailed in respective checklists at the end of this module. The checklist pages can be reproduced for convenient use in the field.

General maintenance guidelines, which include fastener locking and lubrication, are covered in section 5.2. Specific routine maintenance tasks are described in the proceeding sections:

- Adjusting/resetting the dashpot (section 5.3);
- Rebuilding the dashpot (section 5.3.1);
- Adjusting the trip and close coils (section 5.4.1);
- Adjusting the opening and closing velocities (section 5.8.1);
- Replacing the following:
  - Trip and close coils (section 5.4),
  - Tripping latch assembly (section 5.5),
  - Closing latch assembly (section 5.6),
  - Charging motor and gearbox assembly (section 5.7.1),
  - Motor brushes (section 5.7.2),
  - Closing springs (section 5.8),
  - Opening springs (section 5.8),
  - Anti-condensation heaters (section 5.9),
  - Limit switches (section 5.10).

DANGER

Spring-operated mechanisms pose inherent hazards associated with high energy equipment having rapidly moving parts and electrical components.

Only qualified personnel possessing a full understanding of this equipment should operate or service this equipment. Be careful of limbs and extremities when working around this equipment as they may become entangled in moving parts.

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance or manual operating procedures.

Before replacing any components on the mechanism, be sure that the mechanism springs are discharged and that all control power is disconnected.

Manual operation of this mechanism overrides all electrical breaker operation lock-outs such as occur with low SF_6 gas density. Manual operation is not recommended when the high voltage circuit breaker is energized.

5.1 Materials Required for FSA-2 Mechanism Maintenance

Materials required when performing maintenance on the FSA-2 mechanism are:

- Exxon Ronex MP (Moly base grease);
- Exxon Ronex (Lithium base grease);
- Shell Diala D or ASEA 65 (inhibited) - dashpot oil;
- Molycote Spray Dow Corning No. 321;
- Loctite Primer;
- Loctite 242 (removable);
- Loctite 262 (permanent);
- Loctite 271 (permanent);
- Standard wrenches and tools.

5.2 General Maintenance Guidelines

General maintenance includes fastener locking (section 5.2.1) and lubrication (section 5.2.2).

5.2.1 Fastener Locking Instructions

Apply permanent Loctite 271 to:

- All set screws used to retain cams or lever arms.

Apply permanent Loctite 262 to:

- Fastening hardware for the closing and tripping latch assemblies;
- Lock nuts H420A52020 (Fig. 1) for the adjustment screws;
- Nuts H420A52016 (Fig. 1) for the upper pivot point of the closing springs.

Carefully clean all hardware with Loctite primer when using either permanent Loctite 262 or 271. Use Loctite Grade 242 on all other fasteners within the mechanism. Refer to Figure 3 for torque values.

Important: To remove fasteners retained with Loctite 262 or 271, heat the fastener to 302°F (150°C).

5.2.2 Lubrication

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

Refer to Table 1 for mechanism components which require lubrication on a routine basis. Also refer to Plate 6.

Important: The transfer roller 53031 (Fig. 1) pin requires a spray coat of Moly-Dow Corning No. 321; spray on bare, clean metal prior to applying a coat of Exxon Ronex Lithium base grease. This is done at the factory and need not be repeated until after 5000 operations.

Table 1		
Lubrication Schedule for FSA-2 Mechanism		
Item	**Frequency**	**Grease**
Worm 53007 (Fig. 1)	Every year	Exxon Ronex MP*
Worm Gear 53006 (Fig. 1)	Every year	Exxon Ronex MP*
Components of the Tripping Latch Assembly 53018 (Fig. 1)	2500 operations or after 5 years	Exxon Ronex**
Components of the Closing Latch Assembly 53005 (Fig. 1)	2500 operations or after 5 years	Exxon Ronex**
Closing Cam 53003 (Fig. 1)	2500 operations or after 5 years	Exxon Ronex**
Bevel Pinion Assembly 53021 (Fig. 1)	2500 operations or after 5 years	Exxon Ronex**
Bearing, FSA-2 Shafts 53067 (Fig. 1)	5000 operations or after 10 years	Exxon Ronex**
Transfer Roller 53031*** (Fig. 1)	2500 operations or after 5 years	Exxon Ronex**
*Moly base grease		
**Lithium base grease		
***After 5000 operations, requires a spray coat of Moly-Dow Corning No. 321 - spray on bare metal before applying a coat of Exxon Ronex lithium base grease		

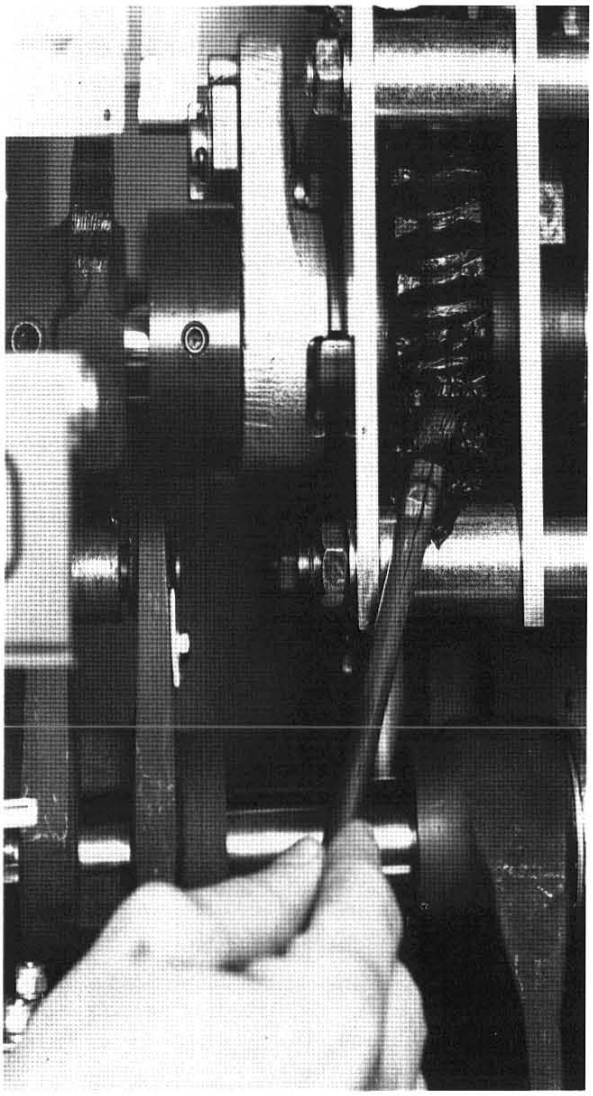


Plate 6: Lubricating the worm gear

5.3 Adjusting/Resetting the Dashpot
Plate 7

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

The dashpot 53024 (Figs. 1 and 6) is a dual-action hydraulic shock absorber which dampens the motion at the end of both the opening and closing strokes. The setting of the dashpot determines the amount of interrupter overtravel observed during circuit breaker timing. Refer to the Maintenance module of this manual for typical distance vs. time characteristics showing the allowable limits for overtravel.

To adjust or reset the dashpot (fine tune the dampening characteristics):

1. Remove the right side spring cover 53038 (Fig. 2).
2. Loosen the lock nut H673A16001 (Fig. 6) where the dashpot piston 53059 turns into the dashpot clevis 53050.
3. Turn the dashpot piston one turn at a time (moving the piston up into the clevis increases trip dampening and decreases closing dampening; moving the rod out of the clevis does the opposite).

Notice: *Dampening must be set so that the overtravel for both opening and closing falls within the ranges specified in the "Timing Tests" section of the Maintenance module.*

4. When the proper dampening characteristics are achieved, secure the lock nut H673A16001 of the dashpot piston 53059 using Loctite 242.
5. Replace the right side spring cover 53038 (Fig. 2).

For a new dashpot, a starting point of four threads remaining on the piston outside of the clevis will allow operation without damage until final adjustments are complete.

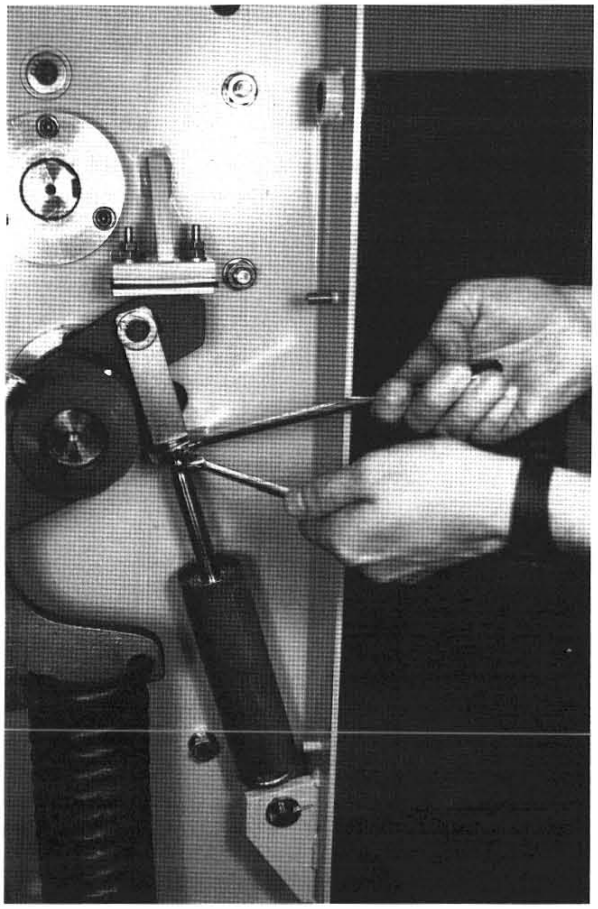


Plate 7: Adjusting the dashpot

5.3.1 Rebuilding the Dashpot

The dashpot 53024 (Fig. 6) is filled with 90 cc of hydraulic oil -- either ASEA 65 inhibited or Shell Diala D. During overhaul (after 5000 operations or after 10 years), remove this oil and replace it with a new supply of oil as described in Figure 6. The dashpot is factory-set and must be reset if disturbed. Refer to section 5.3 to reset the dashpot.

Refer to Figure 6 for instructions on changing the dashpot oil and replacing the seals.

5.4 Replacing the Trip and Close Coils Plates 8 and 9

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

Coils are factory-set and should not be disassembled. Primary trip coil 53016 and close coil 53014 (Fig. 2) are identical. A secondary trip coil 53066 is available as an option.

To remove either a trip or close coil:

1. Remove the coil mounting bolts.
2. Remove the old coil.
3. Replace it with a new coil.
4. Re-install the mounting bolts; apply Loctite 242 and tighten.
5. Proceed to section 5.4.1.

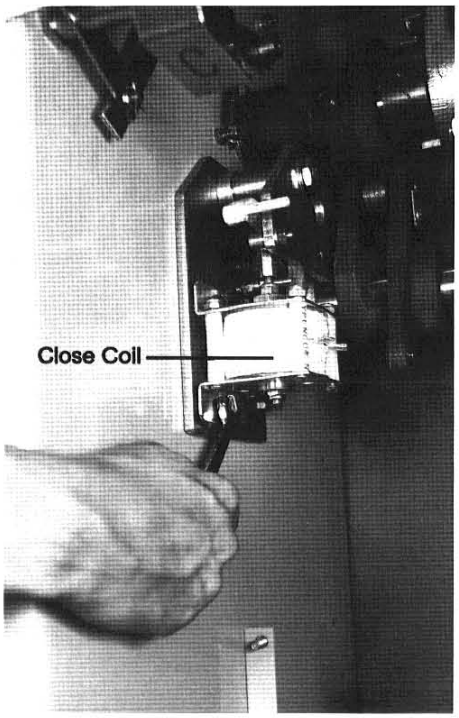


Plate 8: Replacing the close coil

5.4.1 Adjusting the Trip and Close Coils

The trip and close coils need to be adjusted when re-installing or replacing the respective trip or close coil. Refer to Figure 8 for instructions to adjust the trip and close coils.

After adjusting the coil(s), perform circuit breaker timing tests as per the instructions in the Maintenance module to verify that the timing characteristics are correct.

5.5 Replacing the Tripping Latch Assembly Plate 9

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

The tripping latch assembly 53018 (Fig. 1) is factory-set. The only maintenance required is lubrication of the component parts as described in Table 1 section 5.2.2. If a tripping latch assembly is worn, it should be replaced as an entire assembly.

To replace the tripping latch assembly:

1. Remove the trip coil 53016 (Figs 1 and 2) from the tripping latch assembly.
2. Remove the right side spring cover 53038 (Fig. 2).
3. Unfasten the three M12 nuts securing the latch assembly. It may be necessary to heat the nuts to loosen the Loctite.
4. Remove the old tripping latch assembly 53018 (Fig. 1) and replace it with a new latch assembly.
5. Re-install the three M12 nuts which secure the tripping latch assembly; apply Loctite 262 and torque to 43 ft-lbs (57 Nm).
6. Re-install the trip coil as per section 5.4.

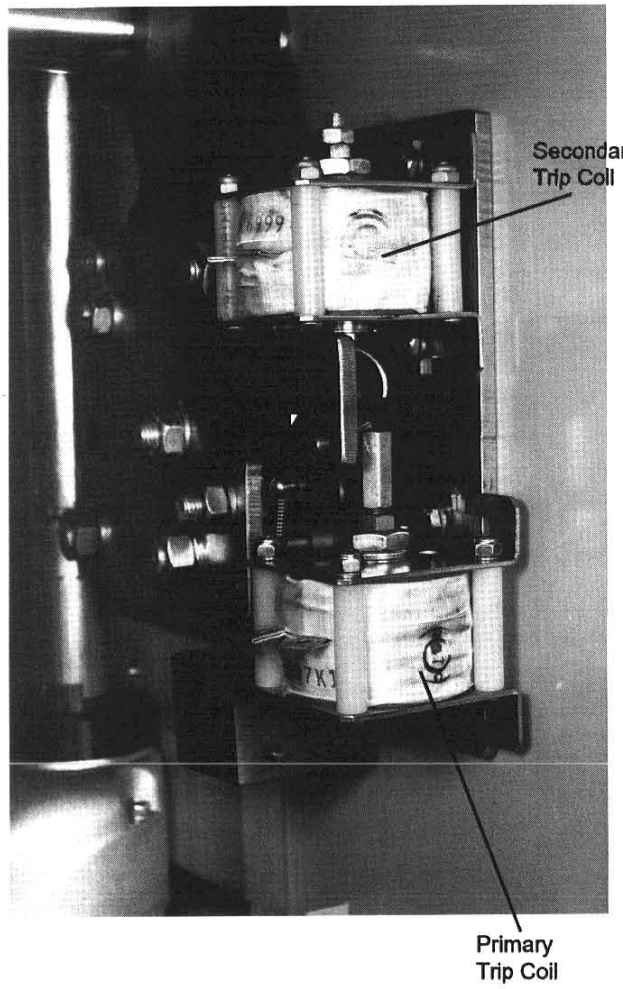


Plate 9: Replacing the tripping latch assembly

5.6 Replacing the Closing Latch Assembly Plate 10

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

The closing latch assembly 53005 (Fig. 1) is factory-set. The only maintenance required is lubrication as described in Table 1 of section 5.2.2. If a closing latch assembly is worn, it should be replaced as an entire assembly.

To replace the closing latch assembly:

1. Remove the close coil 53014 (Figs. 1 and 2) from the closing latch assembly.
2. Remove the left side spring cover 53037 (Fig. 2).
3. Unfasten the two M12 hex head bolts securing the latch assembly. It may be necessary to heat the bolts to loosen the Loctite.
4. Remove the old closing latch assembly and replace it with a new latch assembly.
5. Re-install the two M12 bolts which secure the latch assembly; apply Loctite 262 and torque to 43 ft-lbs (57 Nm).
6. Re-install the close coil as per section 5.4.

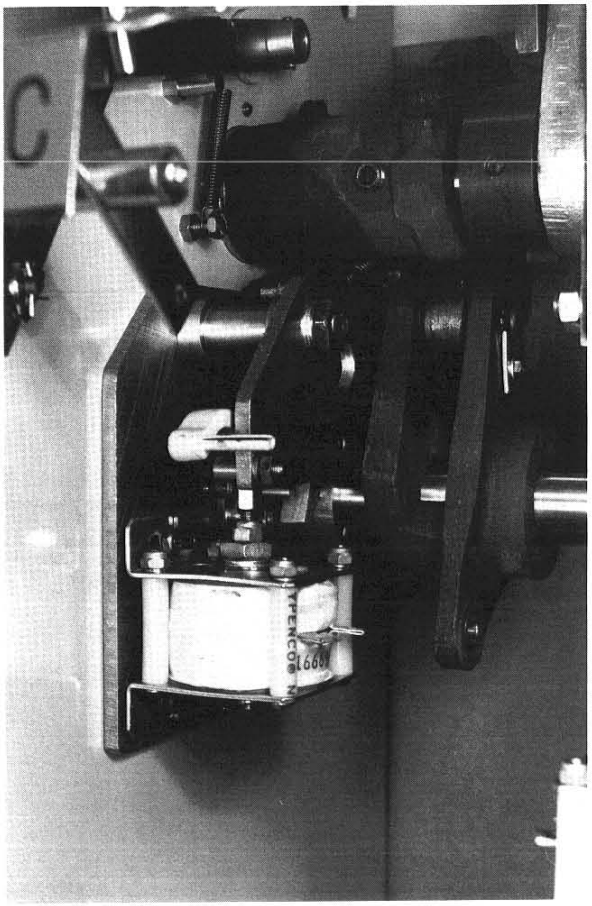


Plate 10:Replacing the closing latch assembly

5.7 Replacing the Charging Motor and Gearbox Assembly and Motor Brushes Plate 11

The charging motor and gearbox assembly 53008 (Fig. 1) is a single unit. The following procedures are covered in this section:

- Replacing the charging motor and gearbox assembly (section 5.7.1.);
- Replacing the motor brushes (section 5.7.2).

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

5.7.1 Replacing the Charging Motor and Gearbox Assembly

To repair or replace the charging motor and gearbox assembly 53008 (Fig. 1):

1. Remove the seven nuts that mount the auxiliary switch panel assembly 53039 (Fig. 7).
2. Disconnect the auxiliary switch linkage at clevis 53054 to allow the panel to swing aside.
3. Swing the panel with the auxiliary switches 53040 and wiring aside.
4. Remove the right side spring cover 53038 (Fig. 2).
5. Unscrew the two bolts holding the charging motor and gearbox assembly in place.
6. Replace the old charging motor and gearbox assembly with a new one and then re-install the unit using the two bolts removed in step 5. Apply Loctite 242 and torque to 22 ft-lbs (29 Nm).
7. Re-install the right side spring cover.
8. Re-connect the auxiliary switch linkage at clevis 53054 (Fig. 7).
9. Re-install the seven nuts to mount the auxiliary switch panel assembly 53039. Apply Loctite 242 and tighten.

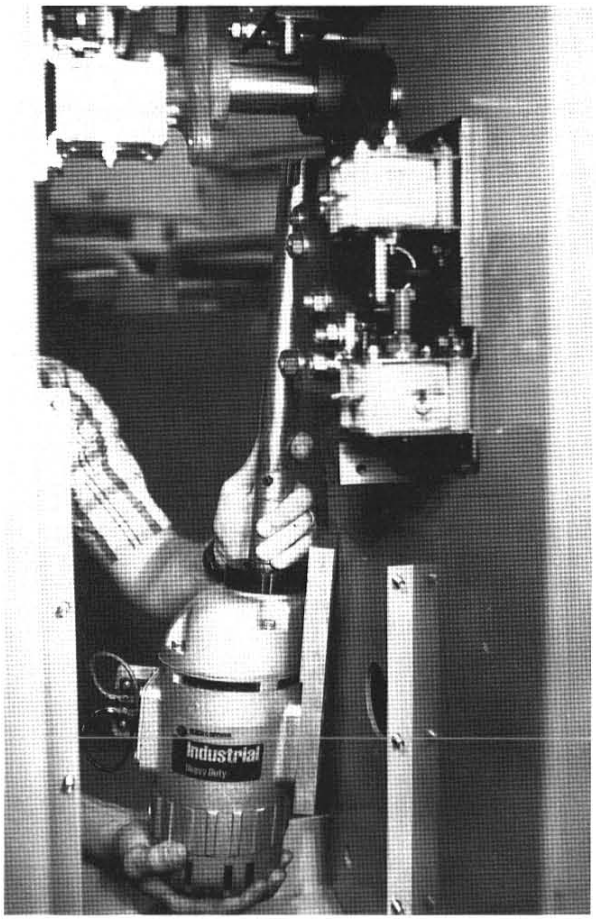


Plate 11:Replacing the charging motor and gearbox assembly

5.7.2 Replacing the Motor Brushes

To replace the motor brushes 53009 (Fig. 1):

1. Remove the seven nuts that mount the auxiliary switch panel assembly 53039 (Fig. 7).
2. Disconnect the auxiliary switch linkage at clevis 53054 to allow the panel to swing aside.
3. Swing the panel with the auxiliary switches 53040 and wiring aside.
4. Remove the brush holding caps.
5. Remove the old motor brushes 53009 (Fig. 1) and replace them with new brushes.

6. Re-install the brush holding caps.
7. Re-connect the auxiliary switch linkage at clevis 53054 (Fig. 7).
8. Re-install the seven nuts to mount the auxiliary switch panel assembly 53039. Apply Loctite 242 and tighten.

5.8 Replacing the Opening and Closing Springs Plate 12

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

Both the opening springs 53019 (Fig. 1) and closing springs 53010 can be changed without removing the mechanism from the breaker control cabinet. Prior to removing a spring assembly, be sure that the mechanism is discharged.

Both springs are factory-pre-loaded and must be relaxed before removal.

The procedure for replacing either the opening or closing springs is the same for either assembly. The springs are replaced as an entire assembly.

To remove and replace either an opening or closing spring set:

1. Remove the appropriate spring cover 53037 (left) or 53038 (right) (Fig. 2).
2. Measure the length of the pre-loaded spring at the upper and lower mounting plate before relaxing the pre-load. This measurement serves as a reference on re-assembly.
3. Loosen the M20 lock nuts H420A52020 (Fig. 1) on the adjustment screw 53030 at the bottom of the spring assembly and relax the spring set by turning the adjustment screw. It may be necessary to heat the lock nuts to loosen the Loctite.
4. Unfasten the spring package at the upper pivot point. For the closing springs, remove the two M16 nuts H420A52016. For the opening springs remove pin 53045.
5. Remove the old spring set and replace it with a new spring set. If replacing the closing springs, re-install the M16 nuts H420A52016 applying Loctite 262 and torque to 100 ft-lbs (133 Nm). If replacing the opening springs re-install pin 53045.
6. Pre-load the new spring set to the length measured in step 2 by turning the adjustment screw 53030.
7. Tighten the lock nuts H420A52020 to hold the spring set while performing circuit breaker timing tests.
8. Perform circuit breaker timing tests as instructed in the Maintenance module to determine the opening and closing velocities. Adjust the velocities by turning the adjustment screw to increase or decrease spring pre-load; 1/4-inch of additional pre-load on either spring set (opening or closing) will increase the velocity approximately 0.1 m/sec. Note that increasing the pre-load of the opening spring will decrease the closing velocity. Adjust the spring pre-load as necessary to attain closing and opening velocities that fall within the specified ranges as given in the Maintenance module for the circuit breaker.

Notice: *Changing the pre-load of the opening springs will affect the closing velocity because the closing springs charge the opening springs. A corresponding adjustment to the closing springs should be made if any adjustment has been made to the opening springs.*

9. After the opening and closing velocities are properly set, apply Loctite 262 to the lock M20 nuts H420A52020 of the adjustment screw and torque them to 144 ft-lbs (195 Nm).
10. Re-install the spring cover.

Important: *Always re-check the closing velocity after changing the opening spring pre-load. Refer to the Maintenance module for the procedure to check the closing velocity.*

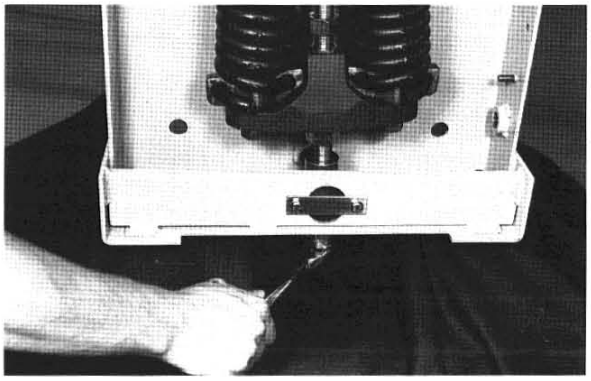


Plate 12: Replacing the opening springs

5.8.1 Adjusting the Opening and Closing Velocities

To set the opening and closing velocities:

1. Remove the spring covers 53037 (left) and 53038 (right) (Fig. 2).
2. Loosen the M20 lock nuts H420A52020 (Fig. 1) on the adjustment screw 53030. It may be necessary to heat the lock nuts to loosen the Loctite.

3. Perform circuit breaker timing tests as instructed in the Maintenance module to determine the opening and closing velocities. Adjust the velocities by turning the adjustment screw to increase or decrease spring pre-load; 1/4-inch of additional pre-load on either spring set (opening or closing) will increase the velocity approximately 0.1m/sec. Note that increasing the pre-load of the opening spring will decrease the closing velocity. Adjust the spring pre-load as necessary to attain closing and opening velocities that fall within the specified ranges as given in the Maintenance module for the circuit breaker.

Notice: *Changing the pre-load of the opening springs will affect the closing velocity because the closing springs charge the opening springs. A corresponding adjustment to the closing springs should be made if any adjustment has been made to the opening springs.*

4. After the opening and closing velocities are properly set, apply Loctite 262 to the M20 lock nuts H420A52020 (Fig. 1) of the adjustment screw 53030 and torque them to 144 ft-lbs (195 Nm).

5. Re-install the spring covers.

Important: *Always re-check the closing velocity after changing the opening spring pre-load.*

5.9 Anti-Condensation Heaters

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

Four anti-condensation heaters (H1, H2, H3, and H4) 60001 (Fig. 7) are located on the auxiliary switch panel 53039 of the FSA-2 mechanism. These heaters maintain the temperature inside the control housing high enough to prevent condensation.

Common Voltages are:

- 120 VAC - Connected for 1/2 voltage operation (1/4 wattage),
- 240 VAC - Connected for 1/2 voltage operation (1/4 wattage).

The power demand is 300W Maximum. Heaters H1 and H2 operate continuously to provide 150W of heat. Heaters H3 and H4, are controlled by thermostat 23-1 to provide an additional 150W of heat when the temperature falls below the setpoint of the thermostat.

Important: *The anti-condensation heaters should be energized at all times to prevent condensation and subsequent corrosion. If the breaker is to be stored longer than one month, establish temporary power connections to energize the anti-condensation heaters.*

To replace an anti-condensation heater 60001 (Fig. 7):

1. Remove the seven nuts that mount the axillary switch panel assembly 53039.
2. Disconnect the auxiliary switch linkage at clevis 53054 to allow the panel to swing aside.
3. Replace the old anti-condensation heater element with a new one.
4. Re-connect the auxiliary switch linkage at clevis 53054.
5. Re-install the seven nuts to mount the auxiliary switch panel assembly 53039. Apply Loctite 242 and tighten.

5.10 Replacing Limit Switches
Plate 13

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance. Be sure that the mechanism springs are discharged and that all control power is disconnected.

The limit switch assembly 53042 (Fig. 1) is actuated by the closing spring crank 53011. When the closing springs 53010 are charged, the crank engages the limit switch assembly to change the state of the limit switches 53017.

The limit switches 53017 (LS1, LS2, LS3 and LS4) are identical. They are factory-set and are not field adjustable (a pin is used to fix the adjustment setpoint of the limit switch assembly). It is possible to replace the individual limit switches simply by unbolting the entire assembly from the frame and replacing the old switch with a new switch.

The limit switches provide the following functions:

- Starting and stopping the charging motor - (typically LS1 and LS3);
- Closing operation block for a discharged closing spring i.e. latch check switch (typically LS2);
- Low spring charge alarm (typically LS4).

The limit switch for low spring charge alarm energizes a time delay relay (set at one minute) when the closing springs are discharged. If the closing springs fail to recharge within the one minute delay, the relay picks up to provide a low spring charge alarm.

The latch check switch prevents electrical energization of the closing circuit when the closing springs are not fully charged.

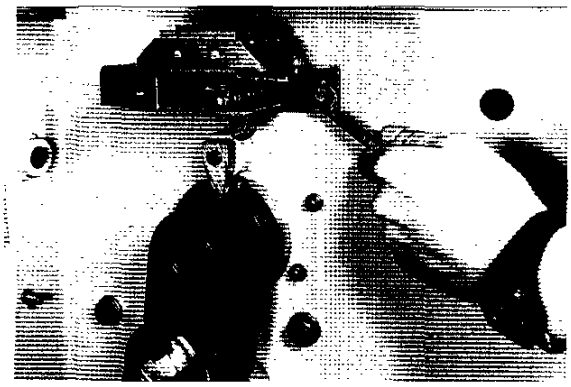


Plate 13:Replacing the limit switches

NOTES:

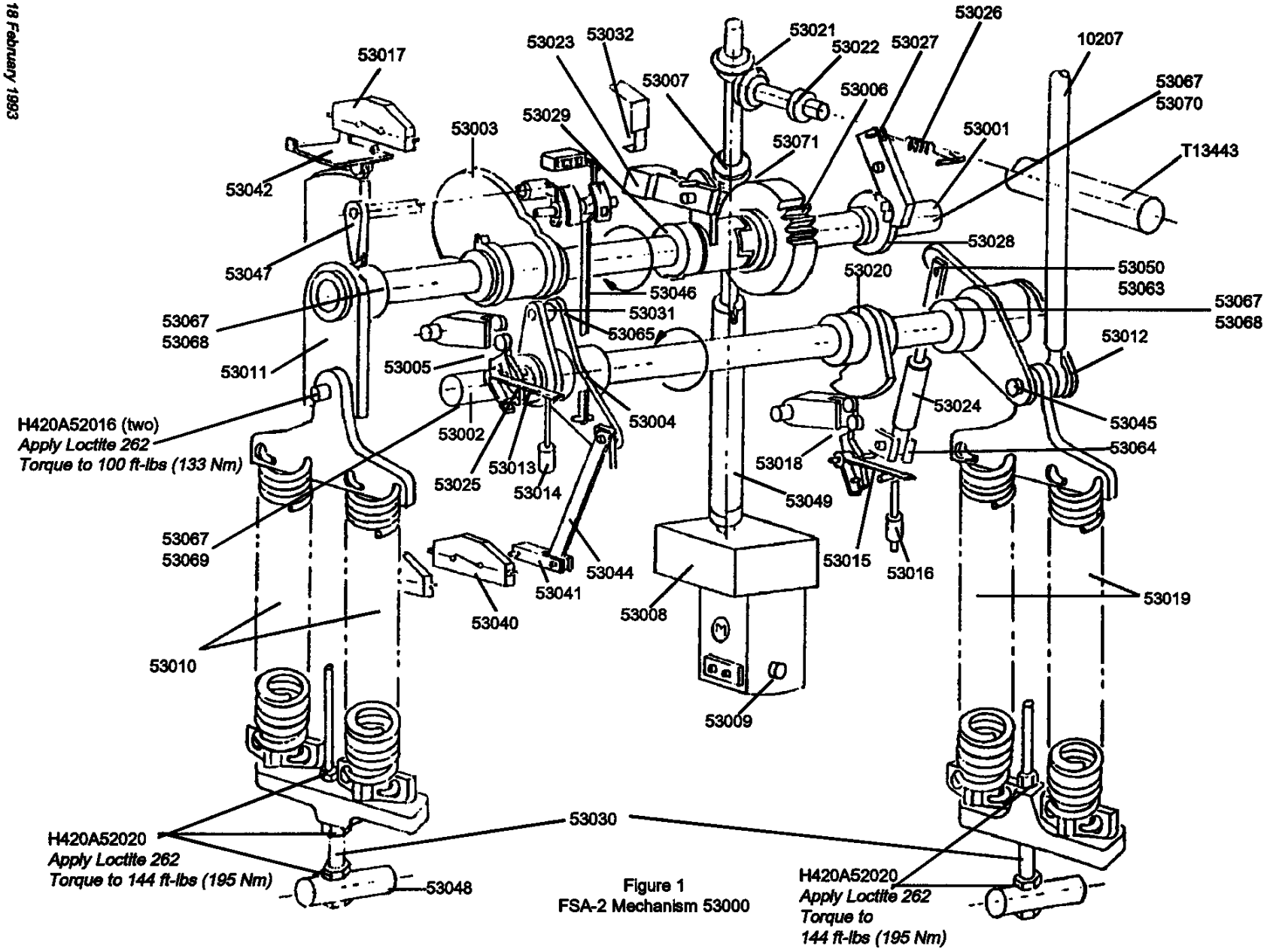


Figure 1
FSA-2 Mechanism 53000

Figure 1
FSA-2 Mechanism 53000

10207	Mechanism Pullrod Assembly
53001	Main Shaft
53002	Drive Shaft
53003	Closing Cam
53004	Operating Lever
53005	Closing Latch Assembly
53006	Worm Gear ┐ Components sold
53007	Worm ┘ as assembly 53071
53008	Charging Motor and Gearbox Assembly
53009	Motor Brushes
53010	Closing Springs
53011	Closing Spring Crank
53012	Drive Crank
53013	Closing Lever
53014	Close Coil
53015	Tripping Lever
53016	Trip Coil
53017	Limit Switch (LS1, LS2, LS3, and LS4)
53018	Tripping Latch Assembly
53019	Opening Springs
53020	Trip Cam
53021	Bevel Pinion Assembly
53022	One-Way Coupling
53023	Jack Pawl
53024	Dashpot
53025	Stop Latch
53026	Latch Reverse Stop Spring
53027	Latch Reverse Stop
53028	Rebound Gear
53029	Jack Sleeve
53030	Adjustment Screw
53031	Transfer Roller
53032	Jack Pawl Release
53040	Auxiliary Switch
53041	Auxiliary Switch Operating Lever
53042	Limit Switch Assembly
53044	Auxiliary Switch Drive Arm
53045	Pin
53046	Position Indicator Drive Arm
53047	Spring Charge Indicator Drive Arm
53048	Spring Holding Rod
53049	Charging Rod
53050	Dashpot Clevis
53063	Dashpot Pin (Upper)
53064	Dashpot Pin (Lower)
53065	Transfer Roller Pin
53067	Bearing, FSA-2 Shafts
53068	Bearing Race, Casting Ends
53069	Bearing Race, Drive Shaft Left
53070	Bearing Race, Main Shaft Right
53071	Worm and Worm Gear Assembly
H420A52016	Nut (two), M16
H420A52020	Lock Nut, M20
T13443	Manual Spring Charge Tool

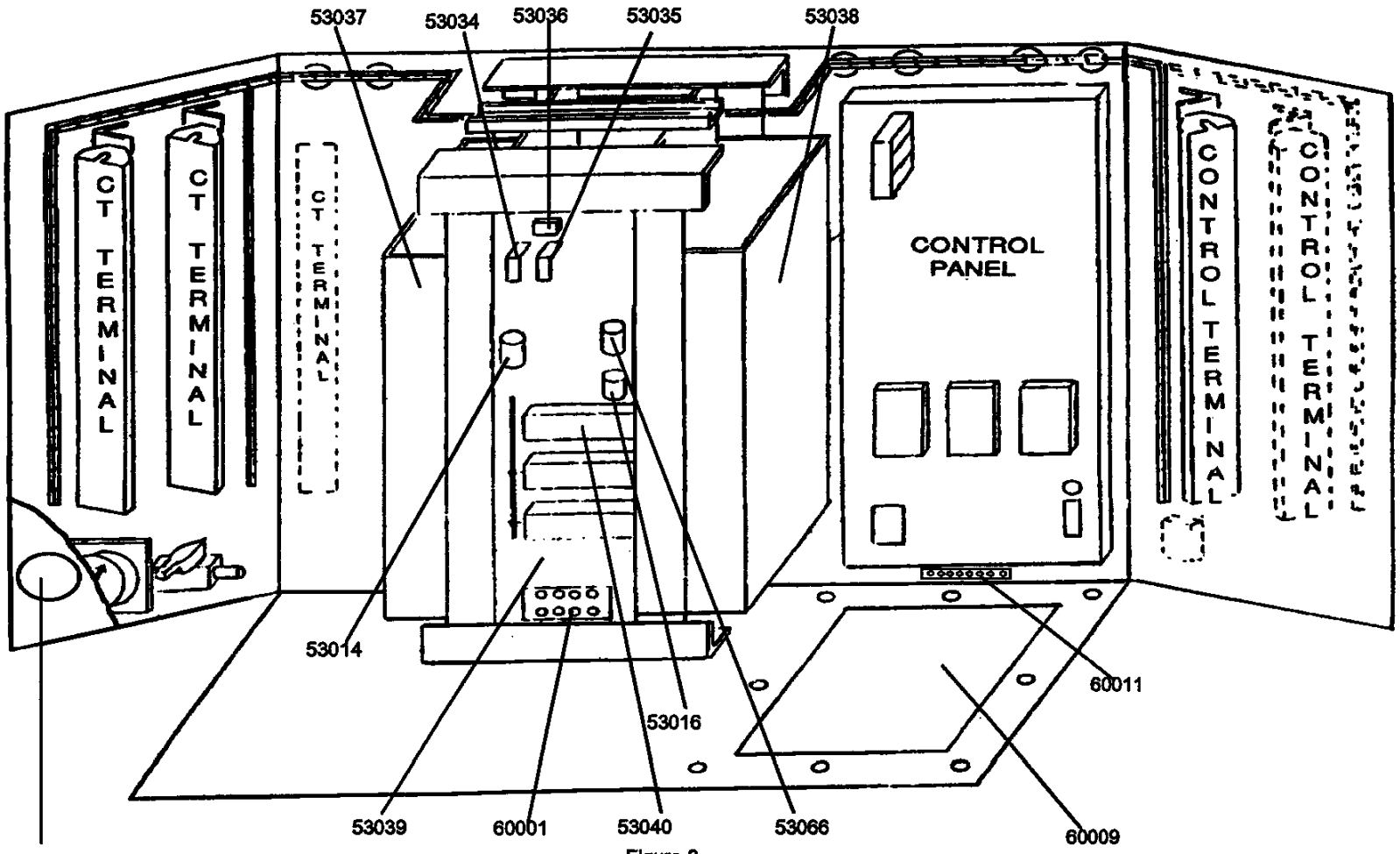


Figure 2
Control Cabinet 60000

53014	Close Coil	53039	Auxiliary Switch Panel
53016	Trip Coil	53040	Auxiliary Switch
53034	Spring Charge Indicator	53066	Secondary Trip Coil
53035	Position Indicator	60001	Anti-Condensation Heater
53036	Operations Counter	60009	Removable Plate
53037	Spring Cover (Left)	60010	View Port Window
53038	Spring Cover (Right)	60011	Control Cabinet Ground Terminal

Recommended Fastener Torque (If Not Specified)											
Metric											
		M5	M6	M8	M10	M12	M14	M16	M18	M20	
Metric Grade 5.8	ft-lbs	3	5	13	25	43	68	101	144	198	
	Nm	4	7	17	34	58	92	137	195	268	
Metric Grade 8.8	ft-lbs	5	8	20	38	66	105	156	223	306	
	Nm	6	11	27	52	89	142	212	302	414	
Metric Grade 10.9	ft-lbs	7	12	28	54	93	148	221	314	431	
	Nm	9	16	37	73	126	201	299	426	585	
{SS} GradeA2	ft-lbs	4	6	14	28	48	77	115	163	224	
	Nm	5	8	19	38	66	104	156	221	304	
U.S. Standard											
		#10	1/4	5/16	3/8	1/2	9/16	5/8	3/4	7/8	1
SAE Grade 2	ft-lbs	3	6	12	21	51	72	99	171	219	327
	Nm	4	9	17	29	69	98	134	232	297	443
SAE Grade 5	ft-lbs	4	10	19	33	78	111	153	264	338	584
	Nm	6	13	26	45	106	151	207	358	459	792
SAE Grade 8	ft-lbs	6	14	27	47	110	157	216	373	631	942
	Nm	8	19	37	63	150	213	293	505	856	1278
18-8 SS Grade 2	ft-lbs	3	7	15	25	60	85	117	202	298	479
	Nm	4	10	20	34	81	116	158	274	405	649
Note: Do not exceed grade 5.8 torques when the fastener is threaded into cast aluminum or for button head socket bolts.											

Figure 3
Torquing Table

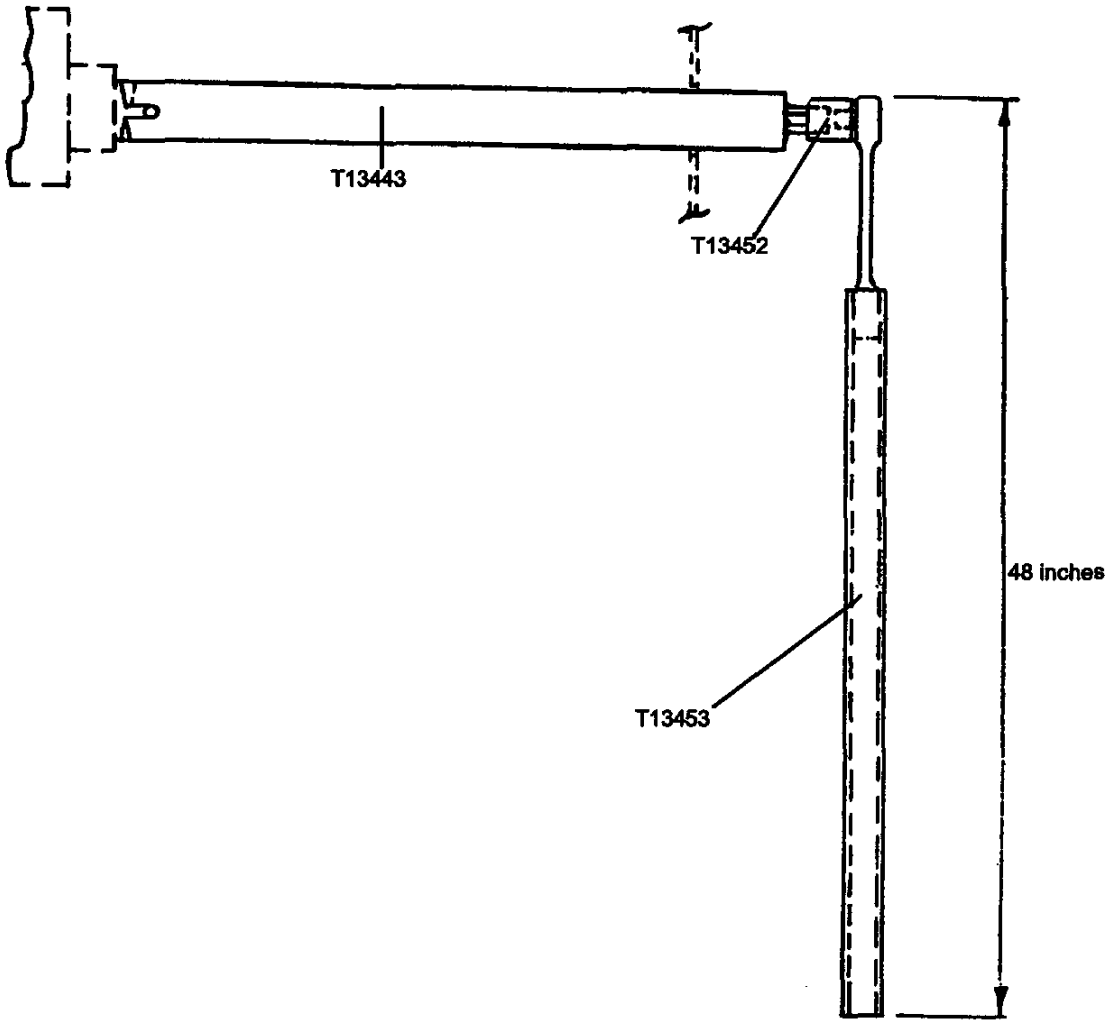


Figure 4
Manual Spring Charge Tool

T13443	Manual Spring Charge Tool
T13452	Socket
T13453	Ratchet Handle

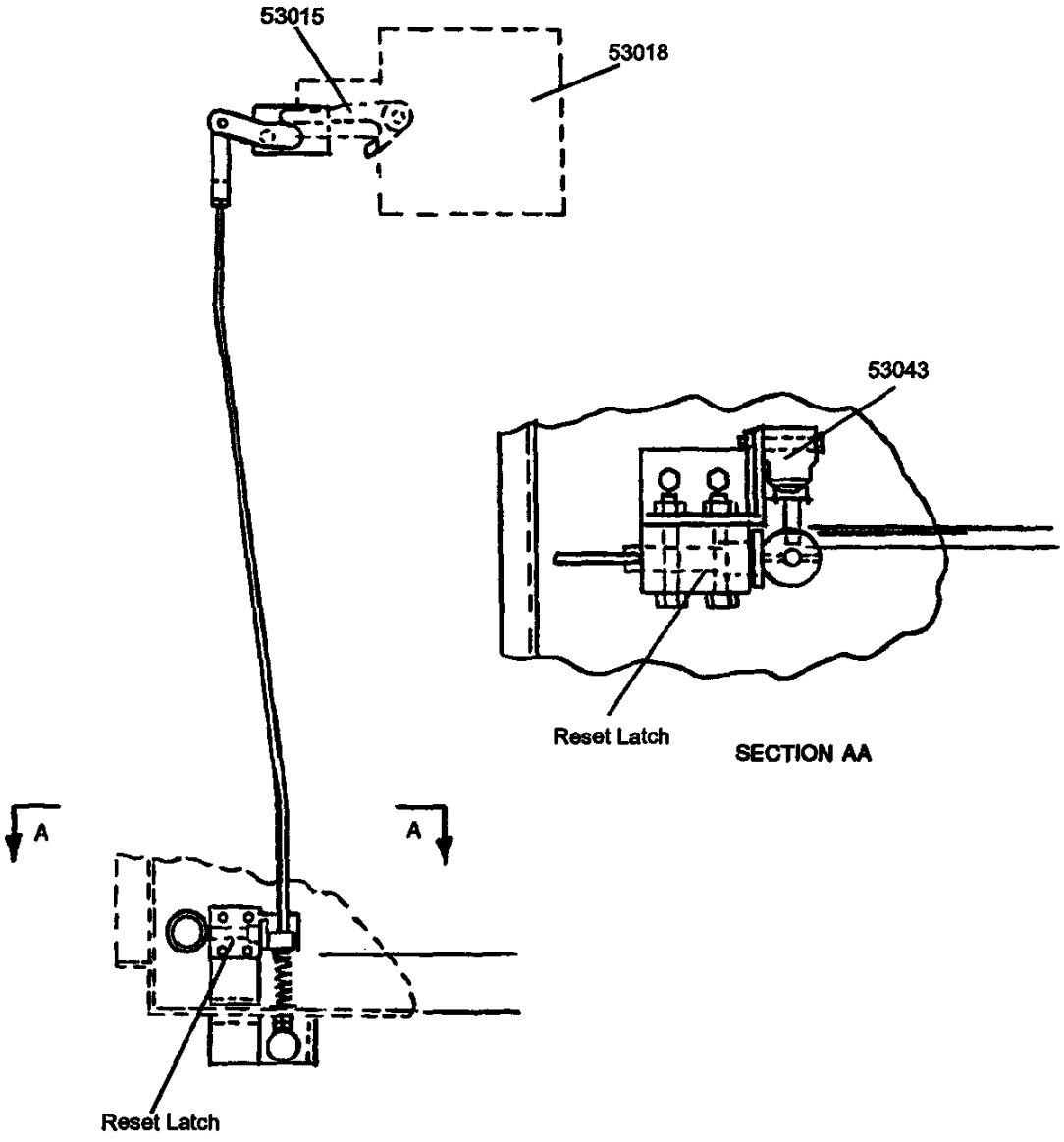


Figure 5
Manual Trip Device 53033

53015	Tripping Lever
53018	Tripping Latch Assembly
53043	69 Switch

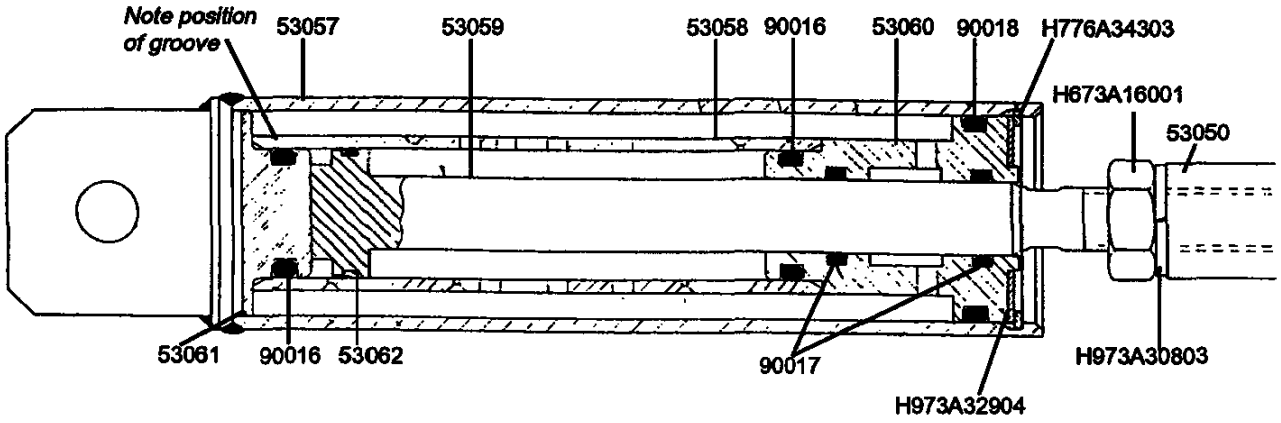


Figure 6
Dashpot (Damper) 53024

53050	Dashpot Clevis
53057	Dashpot Body
53058	Dashpot Cylinder
53059	Dashpot Piston
53060	Dashpot Cap
53061	Dashpot Plug
53062	Dashpot Piston Ring
90016	O-Ring, Dashpot Cylinder
90017	O-Ring, Dashpot Piston
90018	O-Ring, Dashpot Main
H673A16001	Lock Nut
H776A34303	Retaining Ring
H973A30803	Lock Washer
H973A32904	Washer

Removing Oil from the Dashpot/Replacing Seals

DANGER

Ensure that both the tripping and closing springs are fully discharged before removing the dashpot (damper).

To replace oil in the dashpot (damper) 53024 (Fig. 6), disconnect the dashpot from the drive crank at the dashpot clevis 53050 and at the mechanism frame. Remove the retaining ring H776A34303. Extract the dashpot piston 53059 and dashpot cap 53060 by carefully pulling the rod of the dashpot piston 53059 straight out. (The dashpot cylinder 53058 may need to be pulled out separately.)
Drain the oil from the dashpot body 53057 and the dashpot cylinder 53058. Disassemble the cylinder/piston assembly and remove the old O-ring seals 90016, 90017 and 90018. Clean all components with new dashpot oil (ASEA 65 or Shell Diala-D). Replace the O-rings and the dashpot piston rings 53062 with new parts.

Rebuilding/Refilling the Dashpot

Use oil: **ASEA 65 (inhibited) or Shell Diala-D**
89-90 cc (3.05 fluid ounces)

To re-assemble and refill the dashpot 53024 (Fig. 6), start by re-assembling the dashpot cylinder/piston assembly, which is made up of the dashpot cylinder 53058, dashpot piston 53059, dashpot cap 53060 and dashpot plug 53061. Insert the cylinder/piston assembly approximately half-way into the dashpot body 53057. Hold the cylinder/piston assembly at an angle and slowly fill the dashpot body 53057 with 89-90 cc (3.05 fluid ounces) of oil. Slowly insert the cylinder/piston assembly completely into the dashpot body 53057. Insert washer H973A32904 and install the retaining ring H776A34303. Re-install the dashpot onto the mechanism using existing hardware.

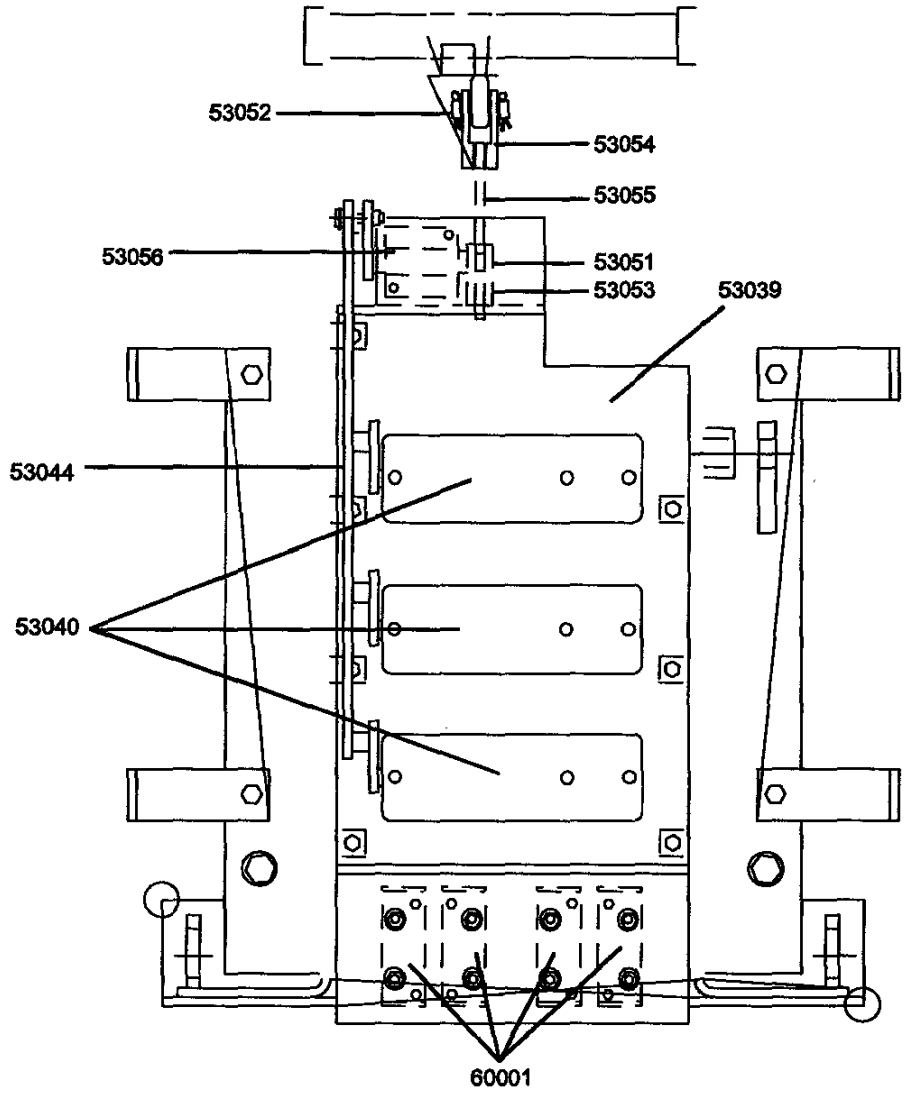


Figure 7
Auxiliary Switch Panel and Drive Linkages

53039	Auxiliary Switch Panel
53040	Auxiliary Switch
53044	Auxiliary Switch Drive Arm
53051	Clevis (Auxiliary Switch Drive - Lower)
53052	Pin (Auxiliary Switch Drive - Upper)
53053	Pin (Auxiliary Switch Drive - Lower)
53054	Clevis (Auxiliary Switch Drive - Upper)
53055	Rod
53056	Auxiliary Switch Crank
60001	Anti-Condensation Heaters (H1, H2, H3, and H4)

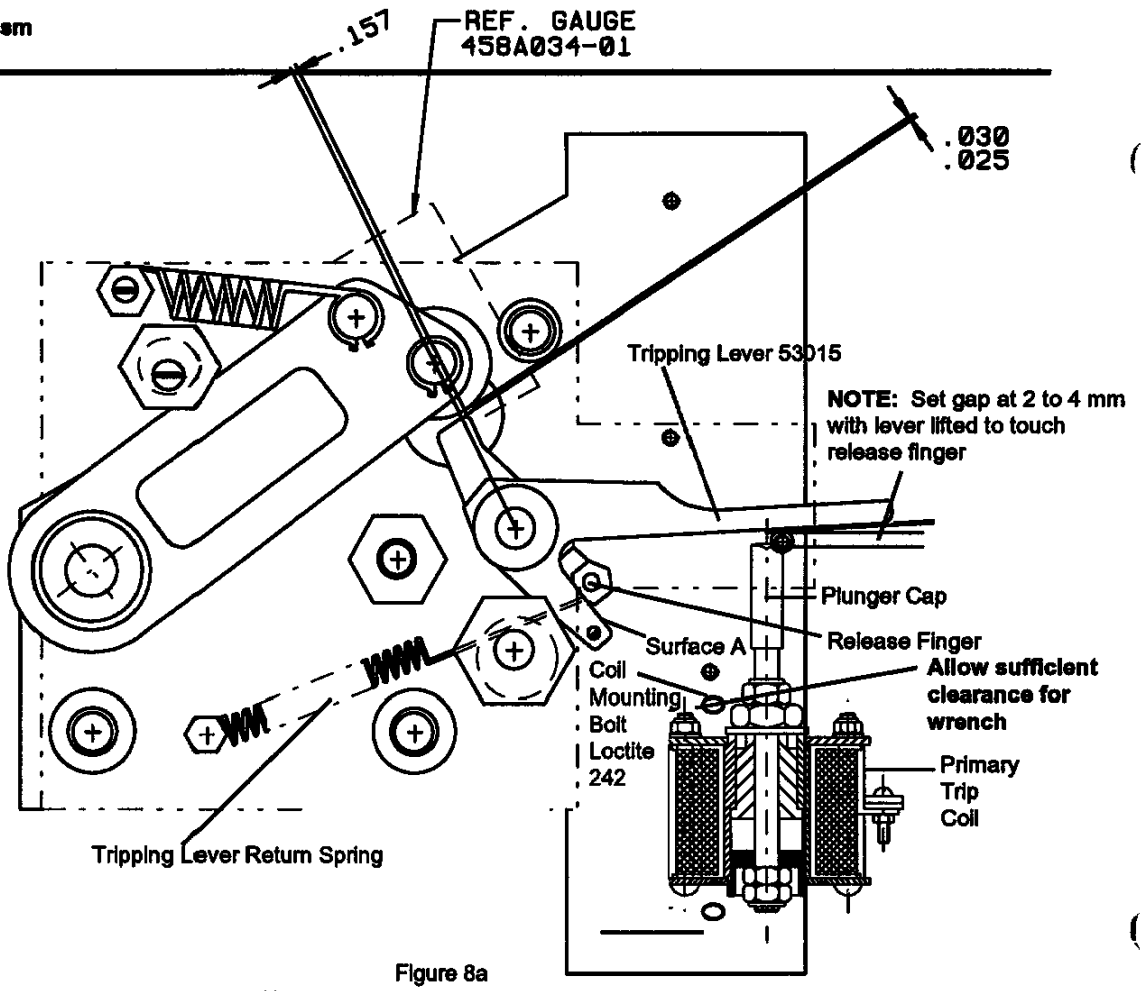


Figure 8a
Trip Coil Adjustment - 3-Cycle Latch
(USE THE DIMENSIONS SPECIFIED IN THIS PROCEDURE TO ADJUST CLOSE COILS ALSO)

DANGER

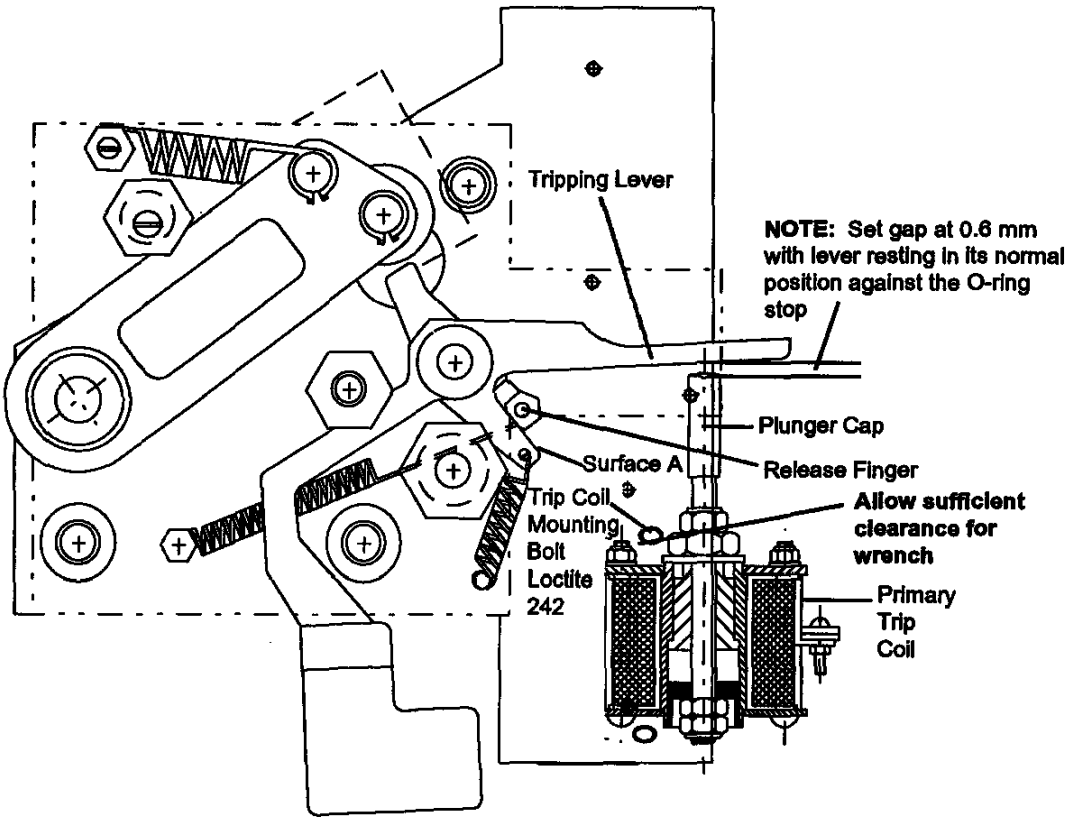
Before performing this procedure, de-energize the circuit breaker and isolate it from the high voltage system.

Important: The circuit breaker must be closed (and the closing spring charged) to measure the gap between the plunger cap (Fig. 8a) and the tripping lever 53015. However, adjusting this gap should only be done with the closing and opening springs discharged and all control and auxiliary power disconnected. (Perform all measurements and adjustments for a close coil with the closing and opening springs discharged (no need to charge any springs) and all control and auxiliary power disconnected.)

1. With the closing and opening springs discharged and all control and auxiliary power disconnected, mount the trip coil as far to the right as possible while still allowing enough room for a wrench to fit between the trip coil and trip coil mounting bolt as shown in Figure 8a.
2. Connect auxiliary power and charge the closing spring. Close the circuit breaker.
3. Very *lightly and slowly* lift the tripping lever 53015 until surface A (Fig. 8a) just makes contact with the release finger which is indicated by the tripping lever feeling harder to lift - **stop lifting the lever at this point. Do not lift it any further. If you lift it any further, the circuit breaker will trip.**

Important: The tripping lever initially moves only against the light force of the tripping lever return spring. When the tripping lever contacts the release finger, do not lift the tripping lever any further.

4. Measure the gap between the plunger cap and the tripping lever with a gauge.
5. Discharge the opening and closing springs and disable all control and auxiliary power.
6. Based on the measurement taken in step 4 of this procedure, make the necessary adjustments to obtain the 2 to 4 mm gap between the tripping lever and plunger cap by either adjusting the plunger cap or moving the coil along the slotted mounting holes.
7. Charge the closing springs, close the circuit breaker, and verify that the gap is now set for the correct dimension by repeating steps 2, 3, and 4 of this procedure. If re-adjustment is necessary repeat steps, 5 and 6 and then steps 2, 3, and 4, etc. until the gap is properly set.
8. Tighten the coil mounting bolts; (secure with Loctite 242). (The plunger cap should be locked into place using permanent Loctite 262.)



DANGER

Before performing this procedure, all control power must be disconnected and the opening and closing springs must be discharged.

Figure 8b
Trip Coil Adjustment - 5-Cycle Latch

1. Disable all control power (including the charging motor supply) and discharge the opening and closing springs.
2. Mount the trip coil as far to the right as possible while still allowing for a wrench to fit between the trip coil and trip coil mounting bolt as shown in Figure 8b.
3. With the tripping lever resting in its normal position against the O-ring stop, make the necessary adjustments to obtain the 0.6 mm gap between the tripping lever and plunger cap by either adjusting the plunger cap or moving the coil along the slotted mounting holes.
4. Tighten the coil mounting bolts; (secure with Loctite 242). (The plunger cap should be locked into place using permanent Loctite 262.)

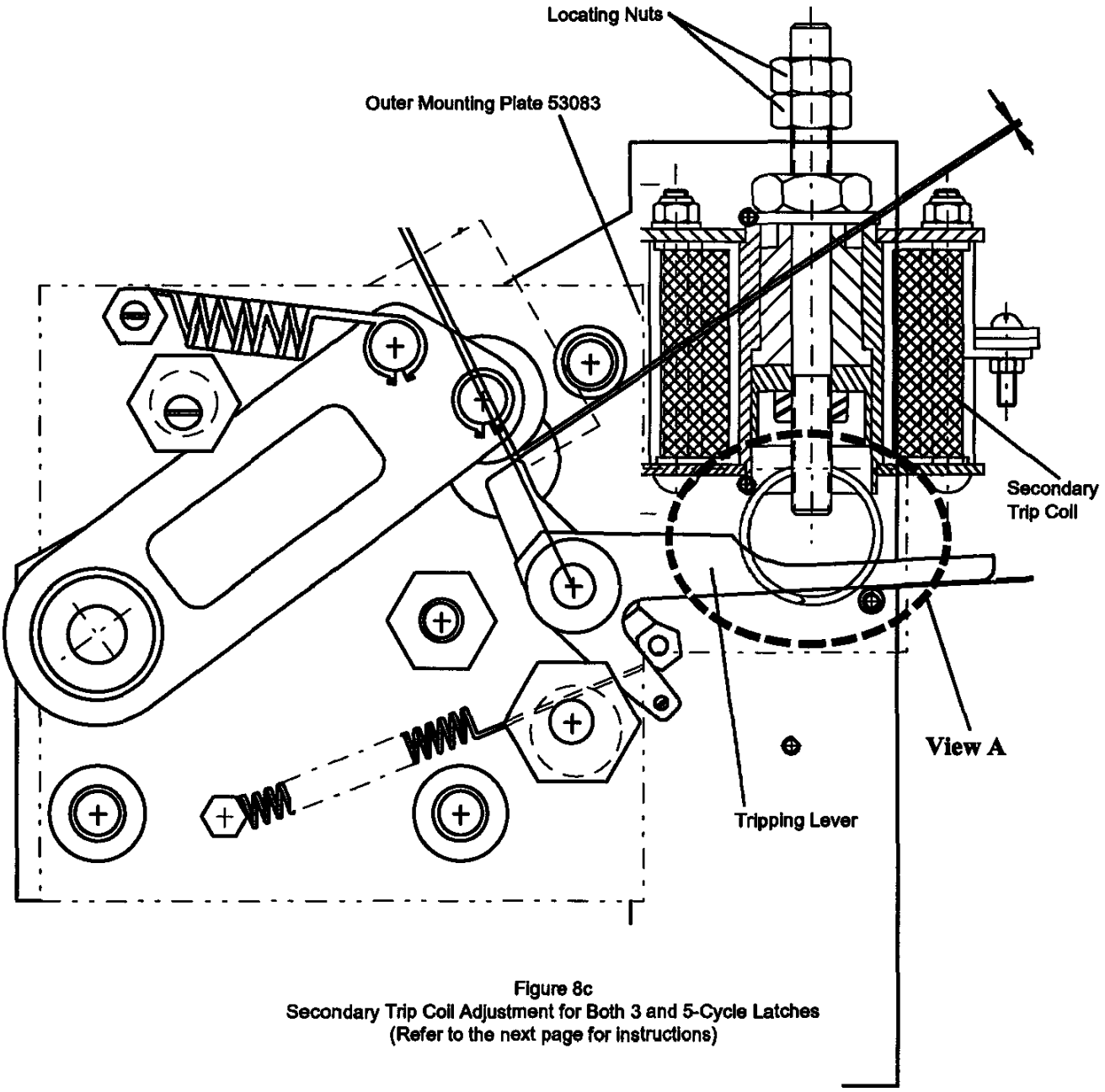
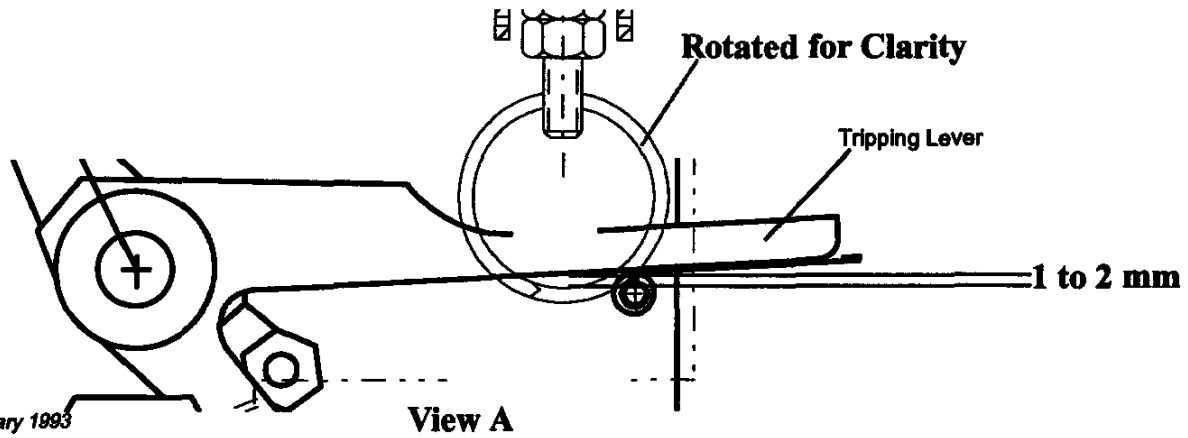


Figure 8c
Secondary Trip Coil Adjustment for Both 3 and 5-Cycle Latches
(Refer to the next page for instructions)



DANGER

Before performing this procedure, all control power must be disconnected and the opening and closing springs must be discharged.

Figure 8c
Secondary Trip Coil Adjustment for Both 3 and 5-Cycle Latches

1. Disable all control power (including the charging motor supply) and discharge the opening and closing springs.
2. Mount the secondary trip coil as far to the left as possible (until the trip coil frame touches the outer mounting plate 53083) as shown in Figure 8c.
3. Tighten the secondary trip coil mounting bolts; secure with Loctite 242.
4. Adjust the locating nuts (shown in Figure 8c) up or down to set the 1 to 2 mm gap between the tripping lever and the ring of the core assembly as shown in View A of Figure 8c.
5. Secure the locating nuts with Loctite 242 and tighten.
6. Re-verify the 1 to 2 mm gap between the tripping lever and the ring of the core assembly (adjust if necessary).

Commissioning Checklist for FSA-2 Mechanism

Date:_____

Substation:_____ Breaker ID Number: _____

Line or Bus:_____ Breaker Serial Number: _____ Mechanism Seral Number: _____

Item/Conditions to Check (Units)	Check OK or Record Data (as Required)
Rated Control Voltage (VDC)	VDC
Actual Control Voltage (VDC) (Measure and record voltage)	VDC
Rated Charging Motor Voltage (VAC or VDC)	V
Actual Charging Motor Voltage (VAC or VDC) (Measure and record voltage)	V
Apply power to the charging motor and record charging time of the closing springs	(15 seconds maximum)
Primary Trip Coil Resistance	ohms
Secondary Trip Coil Resistance (if applicable)	ohms
Close Coil Resistance	ohms
Breaker leveled and properly anchored?	
All grounding connections properly made?	
Control wiring landed?	
Breaker filled to proper operating pressure with SF6 gas (record pressure and temperature)	_____ psig _____ kPaG ____°C ____°F
Record anti-condensation heater resistance	ohms
Calculate anti-condensation heaters' wattage (specified 300 W total)	Watts
Check the low spring charge alarm	
Perform circuit breaker timing tests as per the Installation module.	
Complete the Installation and Commissioning Checklist in the Checklists module	
Record breaker operation counter after commissioning	
Commissioning checks performed by:	

FSA-2 Mechanism Maintenance Yearly Checklist

Date:_____

Substation:_____ Breaker ID Number: _____

Line or Bus:_____ Breaker Serial Number: _____ Mechanism Seral Number: _____

Item/Conditions to Check (Units)	Checked	Condition/Action Taken
Check for loose hardware		
Visually inspect the tripping latch assembly for worn or defective parts		
Visually inspect the tripping latch assembly for proper lubrication (lubricate if necessary)		
Visually inspect the closing latch assembly for worn or defective parts		
Visually inspect the closing latch assembly for proper lubrication (lubricate if necessary)		
Visually inspect the bevel pinion assembly for worn or defective parts		
Visually inspect the bevel pinion assembly for proper lubrication (lubricate if necessary)		
Visually inspect the dashpot for oil leakage; correct the leak and replace oil if necessary		
Visually inspect the worm and worm gear for worn or defective parts		
Apply additional lubrication to worm gear yearly		
Visually inspect the closing cam for wear (lubricate if necessary)		
Visually inspect the trip cam for wear (lubricate if necessary)		
Visually inspect the transfer roller for wear (lubricate if necessary)		
Record breaker operations counter		
Test performed by		

FSA-2 Mechanism Maintenance 2500 Operations (or 5-Year) Checklist

Date: _____

Substation: _____ Breaker ID Number: _____

Line or Bus: _____ Breaker Serial Number: _____ Mechanism Seral Number: _____

Item/Conditions to Check (Units)	Checked	Condition/Action Taken
Check for loose hardware		
Visually inspect the tripping latch assembly for worn or defective parts		
Clean and re-lubricate the tripping latch assembly		
Visually inspect the closing latch assembly for worn or defective parts		
Clean and re-lubricate the closing latch assembly		
Visually inspect the bevel pinion assembly for worn or defective parts		
Clean and re-lubricate the bevel pinion assembly		
Visually inspect the dashpot for oil leakage; correct the leak and replace oil if necessary (Fig. 6)		
Visually inspect the worm and worm gear for worn or defective parts		
Clean and re-lubricate the worm and worm gear		
Visually inspect the closing cam for wear		
Clean and re-lubricate the closing cam		
Visually inspect the trip cam for wear		
Clean and re-lubricate the trip cam		
Visually inspect the transfer roller for wear		
Lubricate the transfer roller		
Record breaker operations counter		
Test performed by		

FSA-2 Mechanism Maintenance 5000 Operations (or 10-Year) Checklist

Date:_____

Substation:_____ Breaker ID Number: _____

Line or Bus:_____ Breaker Serial Number: _____ Mechanism Seral Number: _____

Item/Conditions to Check (Units)	Checked	Condition/Action Taken
Check for loose hardware		
Visually inspect the tripping latch assembly for worn or defective parts		
Clean and re-lubricate the tripping latch assembly		
Visually inspect the closing latch assembly for worn or defective parts		
Clean and re-lubricate the closing latch assembly		
Visually inspect the bevel pinion assembly for worn or defective parts		
Clean and re-lubricate the bevel pinion assembly		
Rebuild the dashpot and replace the oil as described in Fig. 6		
Visually inspect the worm and worm gear for worn or defective parts		
Clean and re-lubricate the worm and worm gear		
Visually inspect the closing cam for wear		
Clean and re-lubricate the closing cam		
Visually inspect the trip cam for wear		
Clean and re-lubricate the trip cam		
Visually inspect the transfer roller for wear		
Inspect all bearings and re-lubricate (replace if necessary)		
Lubricate the transfer roller		
Record breaker operations counter		
Test performed by		

SF_6 Circuit Breakers

Type PM

145 PM Control Circuits/ SF_6 Gas Density Monitor©

Publication No. 996P004-02

ASEA BROWN BOVERI

10 February 1993

Contents

Figures

Notice 1

Based on our own experience, you will obtain the best possible operational reliability by following the recommendations given in these instructions. The data contained herein purports solely to describe the product, and it is not a warranty of performance or characteristics. It is with the best interests of our customers in mind that we constantly strive to improve our products and keep them abreast of advances in technology. This may lead to discrepancies between a product and these instructions.

Notice 2

Within the scope of these instructions, it is impossible to take into account every eventuality which may arise with technical equipment in service. Please consult our local salesman in the event of any irregularities, especially if not referred to herein.

Notice 3

We expressly decline liability for damages resulting from any incorrect operation or wrong handling of our equipment, even if these instructions contain no specific indication in this respect. We stress the fact that only genuine spare parts should be used for replacements.

Notice 4

This publication is a copyrighted work. Therefore, it is not permissible to disclose, reprint, copy, or reproduce any part of these instructions without express written permission from ABB.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the ABB Power T & D Company Inc. Power Circuit Breaker Division, 125 Theobold Ave., Greensburg, PA 15601, Phone No. (412)838-5200.

Control Circuits/ SF_6 Gas Density Monitor

1 Introduction

The instructions in this section are applicable to the control circuitry and the SF_6 gas density monitor of 145 PM circuit breakers. Section 2 covers control circuits and section 3 covers the SF_6 gas density monitor.

1.1 Description

The control circuitry is located in the breaker control cabinet (Fig. 1). The control cabinet serves the following functions:

- Houses the operating mechanism;
- Houses the auxiliary switches;
- Houses the SF_6 gas density monitor and SF_6 pressure gauge;
- Houses the CT shorting terminal blocks;
- Provides centralized controls for the circuit breaker;
- Provides a convenient place for all customer terminations;
- Contains the CLOSE and TRIP circuits, including their permissive interlocks, mechanism motor controls, and terminal blocks.

The SF_6 gas density monitor is mounted within the control cabinet and is equipped with a temperature probe and pressure switch. The temperature probe, mounted to the outside wall of the center pole tank, provides temperature input to the monitor. The monitor can compensate for outdoor temperature variations ranging from -40°C to 66°C (-40°F to 150°F) and it automatically adjusts the setpoints of the pressure switch to higher or lower pressures based on the temperature. If the SF_6 gas density drops below the acceptable level for optimum breaker operation, the monitor actuates an alarm when the pressure drops to 76 psig (524 kPaG) at 20°C (68°F) and operation lock-out at 72 psig (496 kPaG).

All devices are designed to provide trouble-free service for extended periods of time with a minimum of maintenance or service.

1.2 Wiring Diagrams

The wiring diagrams, contained in the Customer Data module of this manual, are breaker specific drawings providing all the necessary information concerning control logic, switch and relay logic, switch setpoints, and operating characteristics (voltage, current, wattage, etc.) of the control components. Figure 2 shows a generic AC wiring schematic. Figures 3 and 4 respectively show generic DC circuits with and without an X relay.

The FSA-2 spring-operated mechanism can be provided with or without an X relay in its DC control scheme. The standard is without an X relay. However, the hydraulic mechanism, Type HMB, is always provided with an X relay in its DC control scheme.

Refer to the specific wiring diagrams for the control logic for your breaker. The wiring diagram number is engraved on the operating mechanism nameplate along with the density monitor setpoints.

The wiring diagrams show the following states:

- Breaker in the OPEN position;
- All devices shown in the de-energized (shelf) state;
- Mechanism in the discharged state;
- No SF_6 gas pressure.

The first sheet of the wiring diagrams provides the following information:

- Settings for the SF_6 gas density monitor;
- Settings for the mechanism limit switches;
- Device legend;
- Electrical characteristics of relays, coils, and mechanism motors;
- Heater ratings and thermostat settings;
- Alarms and spare auxiliary switches.

Warning

The settings for the mechanism spring monitors and the SF_6 gas density monitor should never be changed from the factory recommended setpoints. Alternate settings could result in breaker failure.

The next sheet(s) in the Customer Data module show the schematics for both the AC and DC control circuits as well as the contact development for any special control switch that is required.

The subsequent sheet(s) in the Customer Data module illustrate the connection diagram showing the final factory wiring of the circuit breaker. The wires are usually marked using an opposite end destination code as shown below.

Example: B4/63CX(B1)-530

B4	Source terminal designation;
63CX	Opposite end device designation;
B1	Opposite end terminal designation;
530	Wire number as shown on the wire.

2 Control Circuits

Control circuits include both AC and DC circuitry. Refer to sections 2.2 and 2.3 respectively.

2.1 Grounding the Control Cabinet

A control cabinet ground terminal 60011 (Fig. 1) is located in the main control cabinet. A stud protruding through the back wall of the cabinet is attached to the ground terminal. This stud can be accessed from outside of the cabinet.

Notice: *The cabinet ground stud should be connected to the station ground grid.*

2.2 AC Circuits

AC circuits include:

- Charging motor (refer to section 2.2.1);
- Control cabinet heaters (refer to section 2.2.2);
- Tank heaters (refer to section 2.2.3).

Figure 2 shows a generic AC wiring schematic.

2.2.1 Charging Motor Circuit

The charging motor controls are designed to automatically maintain the stored spring energy of the mechanism. A spring limit switch closes to pick up a contactor supplying the charging motor. When the operating energy is restored to its normal level, the limit switch contact opens to turn the charging motor off. The same sequence of events holds true for either the pure spring mechanism (FSA-2) or the hydraulic mechanism (HMB). Refer to the Mechanism module of this manual for more specific details.

Notice: *The charging motors can, if specified, be operated on DC power or AC power with DC backup as options.*

2.2.2 Control Cabinet Heaters

Anti-condensation heaters 60001 (Fig. 1) are located in the control cabinet. The normal heater circuit provides for 150 Watts of heat energized continuously (H1 and H2), with another 150 Watts thermostatically controlled (H3 and H4).

Notice: *The anti-condensation heater circuit is to be energized at all times, regardless of the ambient temperature.*

These heaters are series connected for half voltage (1/4 wattage) operation on each heating element to ensure trouble-free service for many years.

2.2.3 Tank Heaters

In operating conditions where ambient temperatures below -30°C (-22°F) can occur, the breaker pole tanks must be equipped with thermostatically-controlled tank heaters to prevent the SF_6 gas from liquefying. The thermostat operates at -23°C (-10°F). A drawing detailing all components and containing all information pertinent to the tank heaters is contained in the Customer Data module.

2.3 DC Circuits

The DC control system converts remote operating signals into breaker operations. This control system also monitors the operational status of the breaker (SF_6 pressure, mechanism energy, breaker position, etc.) and automatically performs TRIP BLOCK (or AUTO TRIP) and CLOSE BLOCK functions when necessary.

Figures 3 and 4 respectively show generic DC circuits with and without an X relay.

2.3.1 CLOSE Circuit With X Relay Figure 3

The HMB mechanism is always provided with an X relay. The CLOSE circuit can be activated by a local control switch or by a remote signal, provided that the breaker is in the OPEN position with the mechanism charged and a sufficient SF_6 gas density exists (refer to section 3). When a CLOSE pulse is received by the breaker, the 52X relay picks up, seals itself in, and energizes the CLOSE coil to close the breaker. As the breaker starts to close, the 52b auxiliary contacts shunting the 52Y relay coil open, allowing the 52Y relay to pick up. Contacts of the 52Y relay drop out the 52X relay and seal in the 52Y relay by locking open the shorting path around the 52Y coil. The 52Y relay will remain energized as long as the CLOSE pulse remains present which provides the anti-pumping feature by blocking out the X relay.

During the closing operation, the CLOSE coil current is interrupted by the opening of the 52b auxiliary contacts.

2.3.2 CLOSE Circuit Without X Relay Figure 4

The closing circuit for the pure spring mechanism can be provided with or without an X relay; the standard is without the X relay.

The CLOSE circuit can be activated by a local control switch or by a remote signal, provided that the breaker is in the OPEN position with the mechanism charged and a sufficient SF_6 gas density exists (refer to section 3). As the breaker closes, a 52a auxiliary contact makes to energize the 52Y relay. A contact of the 52Y relay opens within the CLOSE coil circuit, which has been interrupted by 52b auxiliary contacts. The 52Y relay latches itself in as long as the CLOSE pulse is maintained, thus providing anti-pumping action by blocking the CLOSE circuit.

2.3.3 TRIP Circuit

The TRIP circuit can be activated by a local control switch or by remote relaying. The breaker can be tripped provided that the breaker is in the CLOSED position and that there is both sufficient SF_6 gas density (refer to section 3) and spring energy. As the breaker opens, 52a auxiliary contacts in the TRIP circuit interrupt the TRIP coil current.

3 SF_6 Gas Density Monitor

Sulfur hexafluoride (SF_6) gas serves as the insulating and arc quenching medium within the pole tanks. To perform these functions, it is essential that the proper SF_6 gas density be maintained. The SF_6 gas density is checked indirectly by monitoring pressure as a function of temperature, i.e., a given temperature **X** and pressure **Y** correspond to a certain density (assuming a constant volume).

Based on the correlation between temperature and pressure, the SF_6 gas density monitor operates as a temperature-compensated pressure switch to indirectly monitor the density of the SF_6 gas and to provide the following control functions:

- Low gas density alarm (contact 63C) at 76 psig (524 kPaG) at 20°C (68°F);
- CLOSE BLOCK and TRIP BLOCK (or AUTO TRIP) if the SF_6 gas density is at or below 72 psig (496 kPaG) at 20°C (68°F) (which is the minimum pressure necessary to maintain the full interrupting rating). These contacts (63B1 & 63B2) generally close on loss of gas density and energize the appropriate relay(s) to carry out the necessary lock-out functions (or AUTO TRIP) and provide alarm indication.

The SF_6 gas density monitor 60002 (Fig. 5) is mounted within the control cabinet and is equipped with a temperature probe and pressure switch. An SF_6 gas pressure gauge also is mounted within the control cabinet. The pressure gauge is visible through a view port window 60010 (Fig. 1) in the cabinet front wall.

The temperature probe, mounted to the outside wall of the center pole tank, provides temperature input to the monitor. A capillary tube connects the density monitor to the temperature probe; this tube exits the control cabinet through conduit and extends to the probe cover 10045 (Fig. 6) which houses the temperature probe.

The density monitor can compensate for outdoor temperature variations ranging from -40°C to 66°C (-40°F to 150°F). The monitor automatically adjusts the operating points of the pressure switch to higher or lower pressures based on temperature changes. If the SF_6 gas pressure drops below 76 psig (524 kPaG) at 20°C (68°F), the monitor actuates an alarm. If the SF_6 gas pressure drops below 72 psig (496 kPaG) at 20°C (68°F), the monitor will lock out circuit breaker operation (or AUTO TRIP and BLOCK CLOSE) and provide the appropriate alarm.

A gas manifold 10213 (Fig. 7) interconnects the pole units and connects these units to the density monitor. An isolation valve 60006 is in the gas line between the gas manifold and the density monitor 60002. By closing the isolation valve, the density monitor, pressure gauge 60003, and associated plumbing can be isolated from the rest of the gas system.

Warning

The isolation valve 60006 (Fig. 7) must remain open for proper operation of the low density SF_6 alarm and lock-out controls. A closed isolation valve could result in low gas density operation and cause breaker failure or damage.

Once the density monitor is isolated, low density alarm simulations can be performed using the sample valve 60007 (Fig. 7) at the outlet of the density monitor. This valve can be opened to release a negligible amount of SF_6 gas.

A 1/4-inch, 37-degree male flare fitting 60008 is located at the outlet of the sample valve and serves as a port for filling the breaker with gas and for gas moisture sampling.

3.1 SF_6 Gas Density Monitor Calibration

The SF_6 gas density monitor 60002 (Figs. 5 and 7) is calibrated at the factory as follows:

- The temperature probe is set at 20°C (68°F);
- Switch C (Fig. 5) is set to close at 76 psig (524 kPaG) (alarm point) with decreasing pressure;
- Switches B1 and B2 (Fig. 5) are set to close at 72 psig (496 kPaG) (breaker lock-out point) with decreasing pressure (unless alternate values are listed on the first page of the wiring diagrams in the Customer Data module).

DANGER

To prevent personal injury and damage to the equipment, before beginning any calibration or adjustment, de-energize the breaker and remove it from service.

Warning

Never change the switch settings from the factory-specified setpoints shown on the first sheet of the wiring diagrams in the Customer Data module - otherwise breaker failure could result.

To calibrate the SF_6 gas density monitor and adjust the pressure switches:

1. Refer to the SF_6 Gas Density Monitor Calibration Curve and Chart (Figs. 8 and 9) to determine the proper alarm and lock-out pressure settings for the current ambient temperature.
2. Determine the existing alarm and lock-out settings by closing the isolation valve 60006 (Fig. 7) to separate the SF_6 gas density monitor 60002 and SF_6 gas pressure gauge 60003 from the pole units.
   a. Bleed this negligible amount of gas through the sample valve 60007 until the alarm occurs.

b. Read the setting points on the pressure gauge 60003. It is strongly recommended to use an accurate, calibrated, test pressure gauge to verify the integrity of the control cabinet pressure gauge and to ensure accurate alarm and lock-out settings.

3. If the pressure spread (differential) between pressure switches is correct, with all settings either high or low by the same amount, use the main pressure adjustment nut (Fig. 5) to make the necessary changes. Use the main pressure adjustment nut to adjust all of the pressure switches at one time. Turning this nut clockwise increases the settings of all of the pressure switches by the same increment, while turning it counter-clockwise decreases all of the settings.

4. To change the pressure setting of an individual pressure switch, use the individual pressure switch adjustment nut (Fig. 5). Turning the nut clockwise increases the alarm pressure setting, while turning it counter-clockwise decreases the alarm pressure setting.

Important: *Adjusting one of the individual pressure switches will often affect the settings of the other pressure switches. Adjustments should be made in small increments and a final verification of all pressure switch settings should be performed.*

Always adjust in the order from high pressure switches to low pressure switches, i.e. start with switch C (Fig. 5) and then adjust switches B1 and B2.

5. After adjustments are complete, perform a final verification of all pressure switches.

Notice: *Never severely bend or kink the capillary tube.*

6. Be sure that the isolation valve 60006 (Fig. 7) is open.

Warning

The isolation valve must remain open for proper operation of the low density SF_6 alarm and lock-out controls. A closed isolation valve could result in low gas density operation and cause breaker failure or damage.

7. Complete the density monitor calibration section of the appropriate Maintenance Checklist in the Checklists module.

4 Miscellaneous Control Components

Miscellaneous control components include:

- Mechanism limit switches (section 4.1);
- Auxiliary switches (section 4.2);
- Operations counter (section 4.3).

4.1 Mechanism Limit Switches

The mechanism is equipped with limit switches which indicate insufficient energy level situations. Like the density monitor pressure switches, the limit switches initiate breaker alarms and lockouts. Refer to the Mechanism module of this manual for specifics.

4.2 Auxiliary Switches

The auxiliary switches furnished with this breaker are ABB Type L2 switches. For detailed instructions refer to ABB publication IB 3.6:6.7B.

The switch assembly is pre-adjusted at the factory and should not need to be readjusted.

4.3 Operations Counter

The breaker is furnished with a mechanical operations counter which is located in the control cabinet, and visible through a view port. This counter keeps track of the number of trip operations. (Optional electric operations counters can be furnished upon request and, likewise, would be located in the main control cabinet.)

5 Replacement Parts

When ordering replacement parts for any part in the control system, consult the factory. The following information is needed to ensure that the correct part is furnished:

- Breaker serial number;
- Breaker model designation;
- Wiring diagram number;
- Device name and description as stated on the wiring diagram.

NOTES:

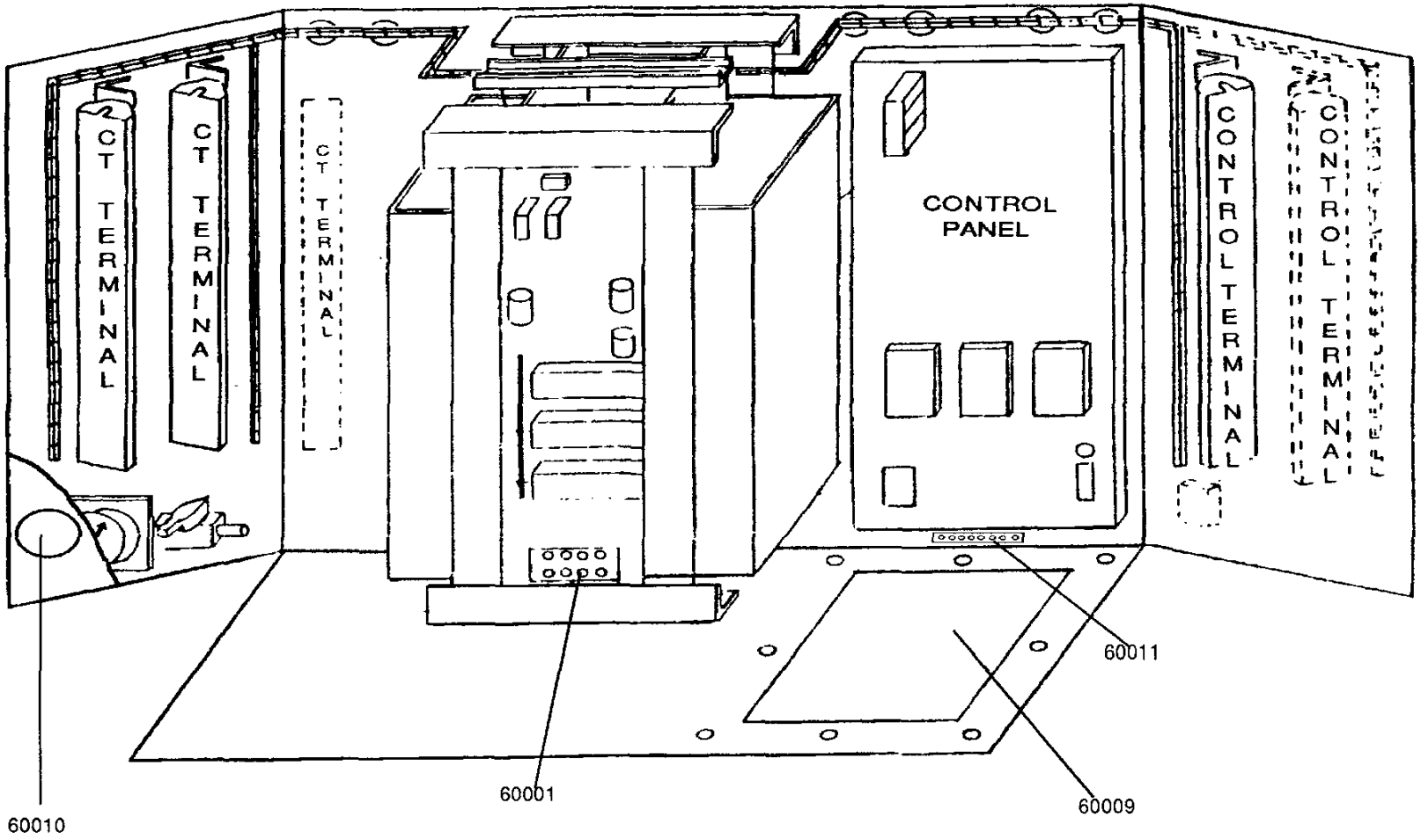
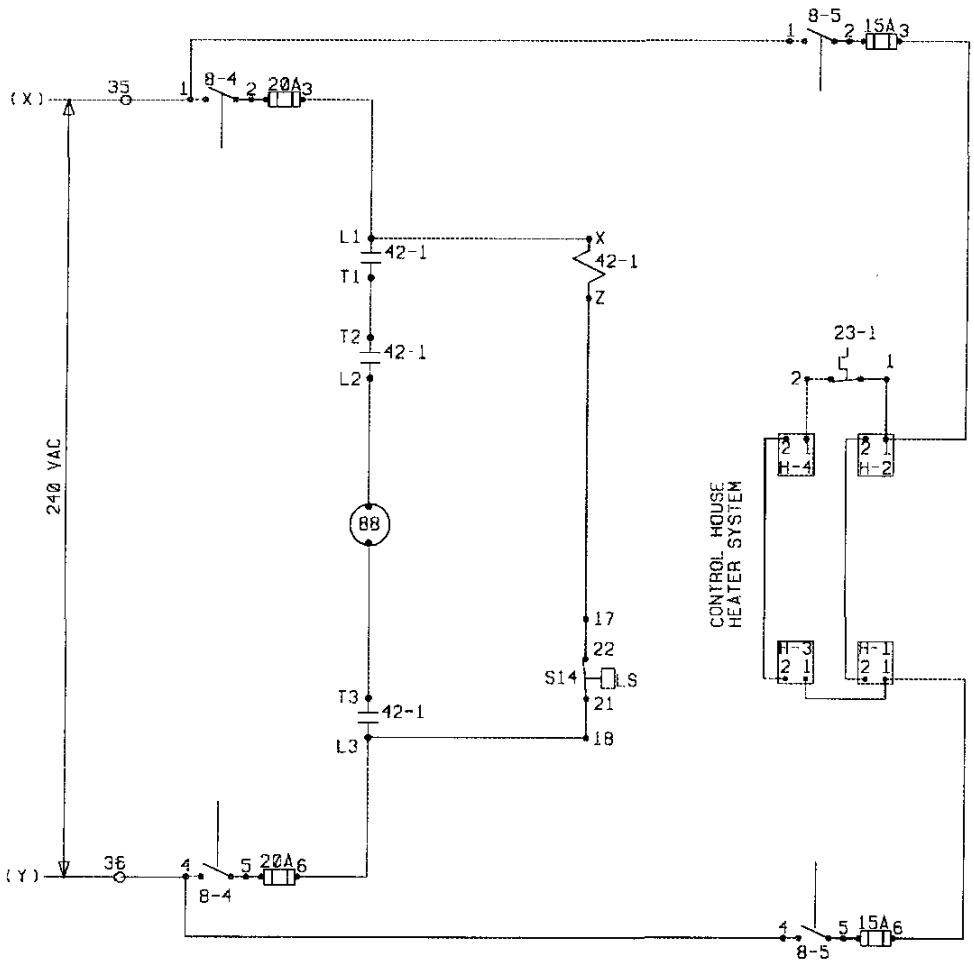


Figure 1
Control Cabinet 60000

60001	Anti-Condensation Heater
60009	Removable Plate
60010	View Port Window
60011	Control Cabinet Ground Terminal

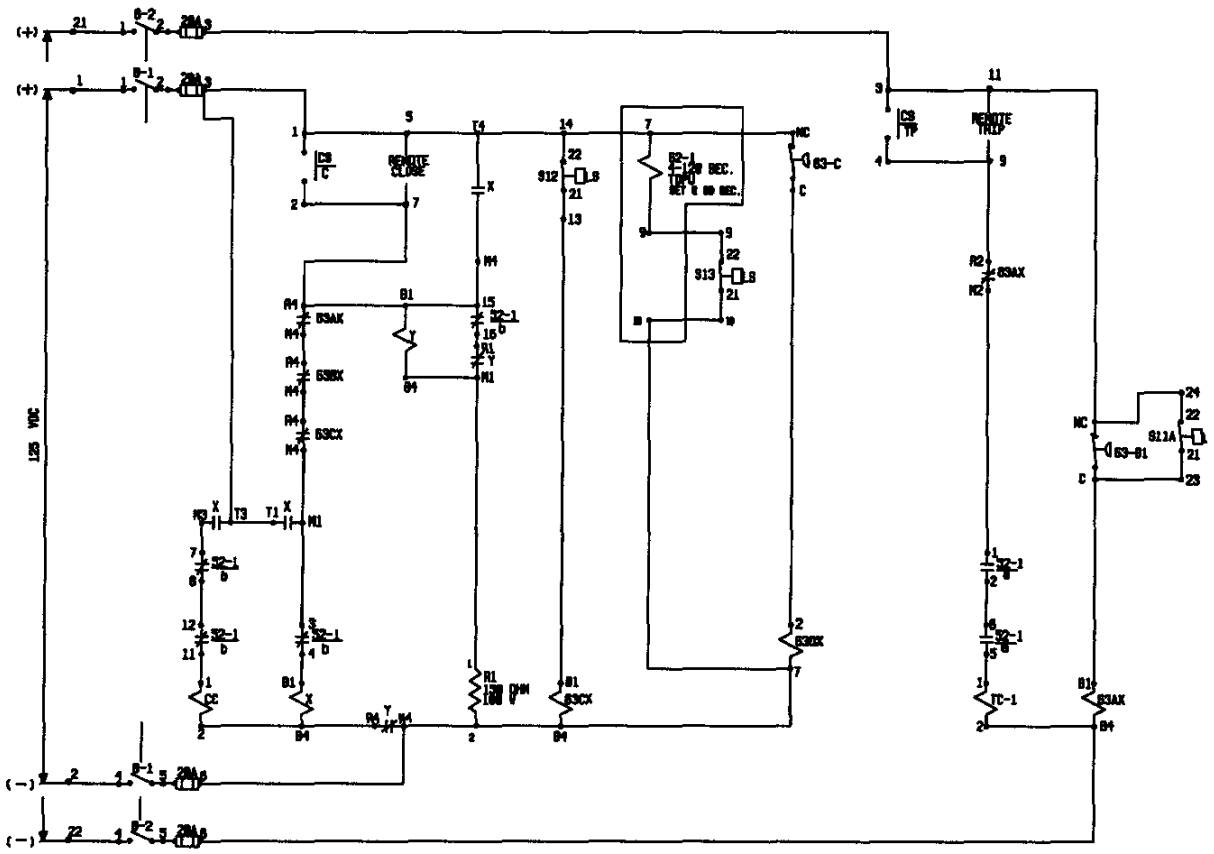


NOTE:
FOR SPECIFIC WIRING DIAGRAM, REFER TO
YOUR PARTICULAR SCHEMATIC IN THE BREAKER.

TYPICAL AC CONTROL SYSTEM

	DESCRIPTION
8-4	SPRING CHARGING MOTOR POWER SWITCH
8-5	CONTROL HOUSE HEATER POWER SWITCH, AC SUPPLY
23-1	THERMOSTAT, CONTROL HOUSE HEATERS
42-1	CONTACTOR, SPRING CHARGE MOTOR AC
S14	LIMIT SWITCH, MOTOR START-STOP
H1 TO H4	HEATERS, CONTROL HOUSING
88	MOTOR, SPRING CHARGING
TB	TERMINAL BLOCK

Figure 2
Generic AC Wiring Schematic

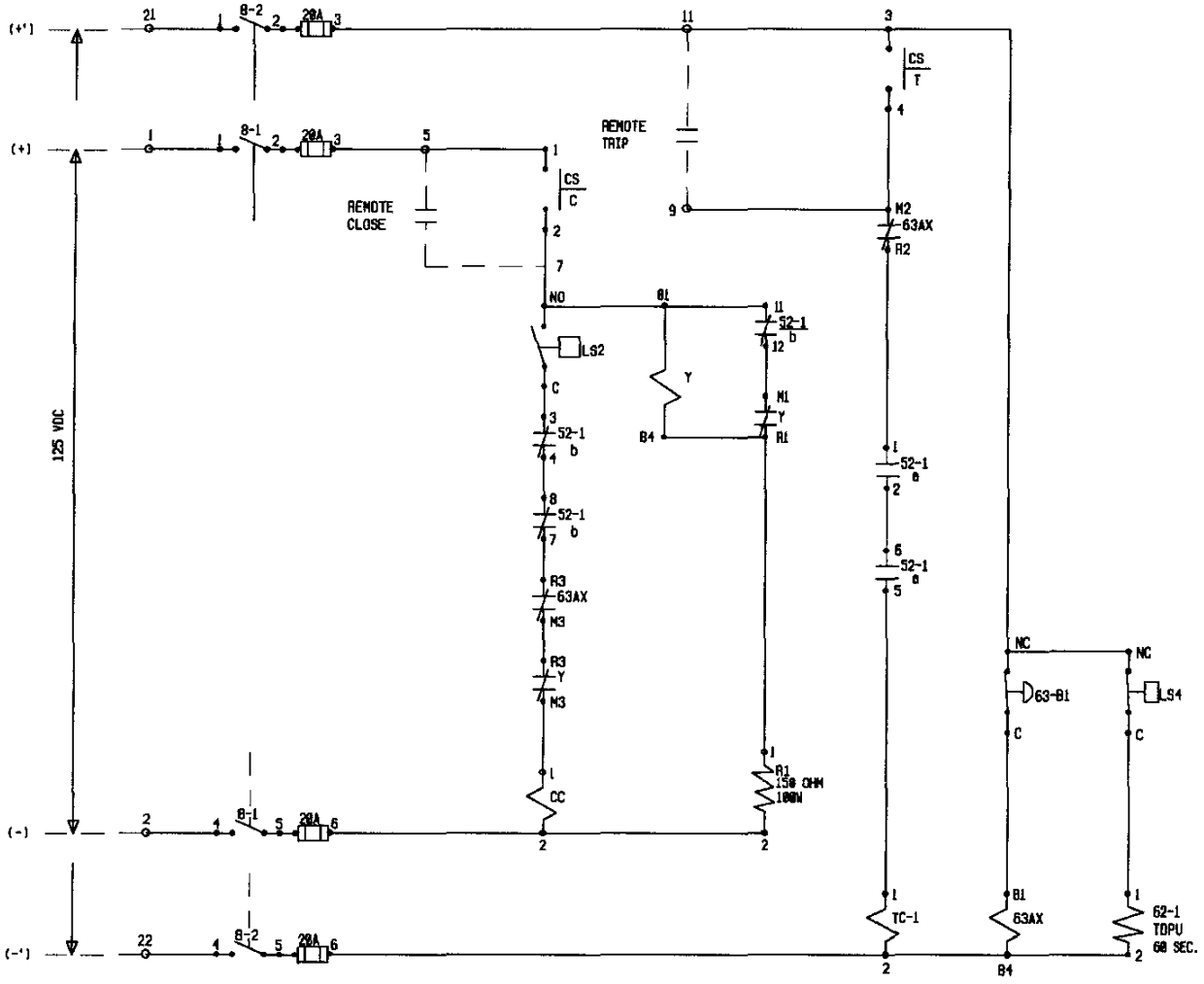


NOTE:
FOR SPECIFIC WIRING DIAGRAM, REFER TO
YOUR PARTICULAR SCHEMATIC IN THE BREAKER.

TYPICAL DC CONTROL SYSTEM

	DESCRIPTION
8-1	CONTROL POWER SWITCH, CLOSE DC SUPPLY
8-2	CONTROL POWER SWITCH, TRIP DC SUPPLY
62-1	LOW SPRING CHARGE ALARM TIMER
63	SF-6 GAS PRESSURE SWITCH
63AX	TRIP & CLOSE BLOCK AUXILIARY RELAY
63CX	CLOSE BLOCK AUXILIARY RELAY
63GX	LOW GAS PRESSURE ALARM RELAY
52	AUXILIARY SWITCH ASSEMBLY
a or b	AUXILIARY SWITCH CONTACT
C	CLOSE
CC	CLOSING COIL
CS	CONTROL SWITCH
R1	RESISTOR
S11A,S12,S13	LIMIT SWITCH, SPRING DISCHARGE
T	TRIP
TC-1	TRIP COIL
X	CLOSING RELAY
Y	ANTI-PUMP RELAY

Figure 3
Wiring Diagram: Typical DC Control System (With X Relay)

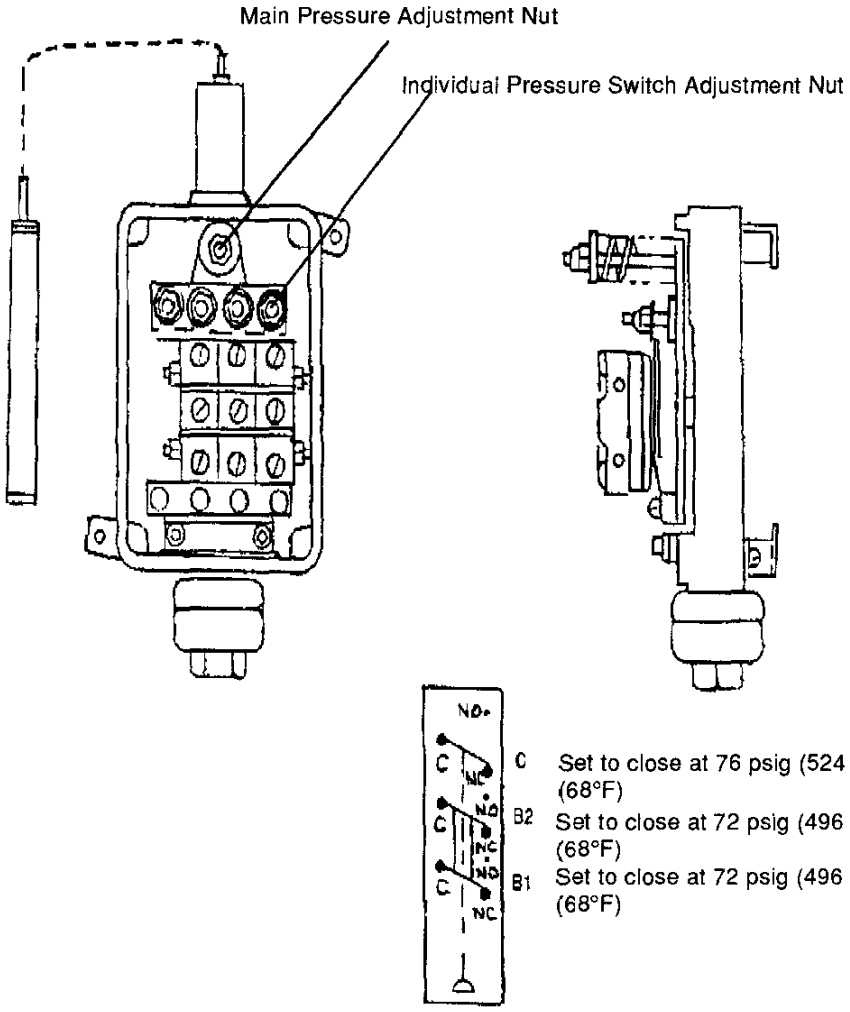


TYPICAL DC CONTROL SYSTEM

NOTE:
FOR SPECIFIC WIRING DIAGRAM, REFER TO
YOUR PARTICULAR SCHEMATIC IN THE BREAKER.

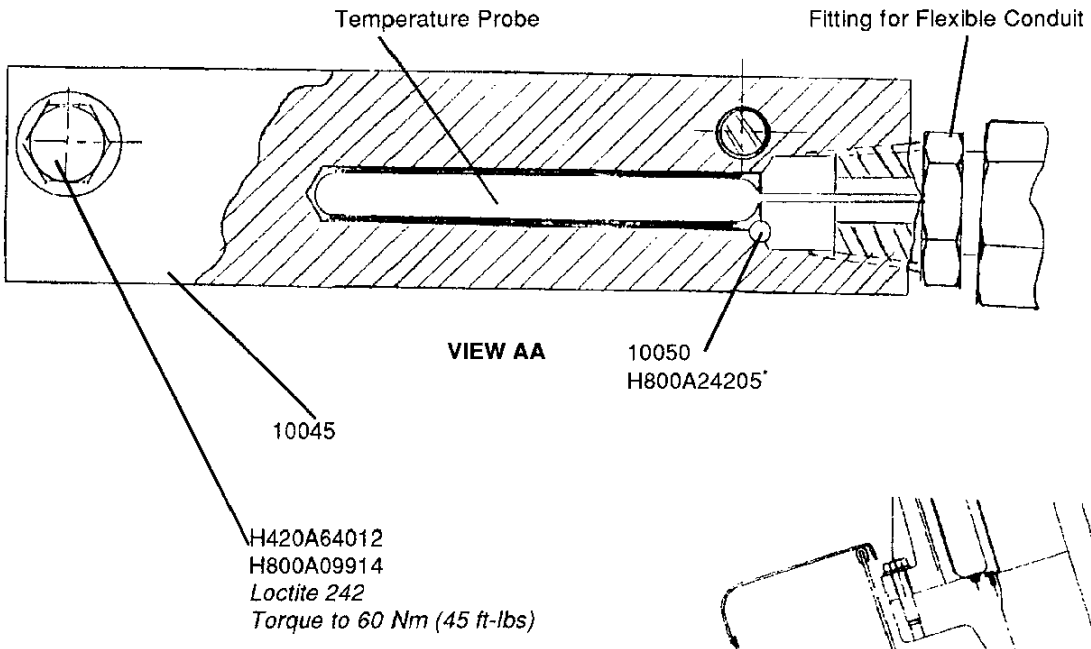
DEVICE	DESCRIPTION
8-1	CONTROL POWER SWITCH, CLOSE DC SUPPLY
8-2	CONTROL POWER SWITCH, TRIP DC SUPPLY
63	SF-6 GAS PRESSURE SWITCH--TEMP. COMPENSATED
63AX	AUTO TRIP AND CLOSE BLOCK AUX. RELAY
62-1	TIME DELAY RELAY, 60 SEC. TDPU
52-1,2	AUXILIARY SWITCH ASSEMBLY
a or b	AUXILIARY SWITCH CONTACT
C	CLOSE
CC	CLOSING COIL
CS	BREAKER CONTROL SWITCH
LS1	LIMIT SWITCH MOTOR START - STOP
LS2 & LS4	LIMIT SWITCH, SPRING DISCHARGED
R1	RESISTOR 150 OHM 100 W
T	TRIP
TC-1	TRIP COIL
Y	ANTI-PUMP RELAY

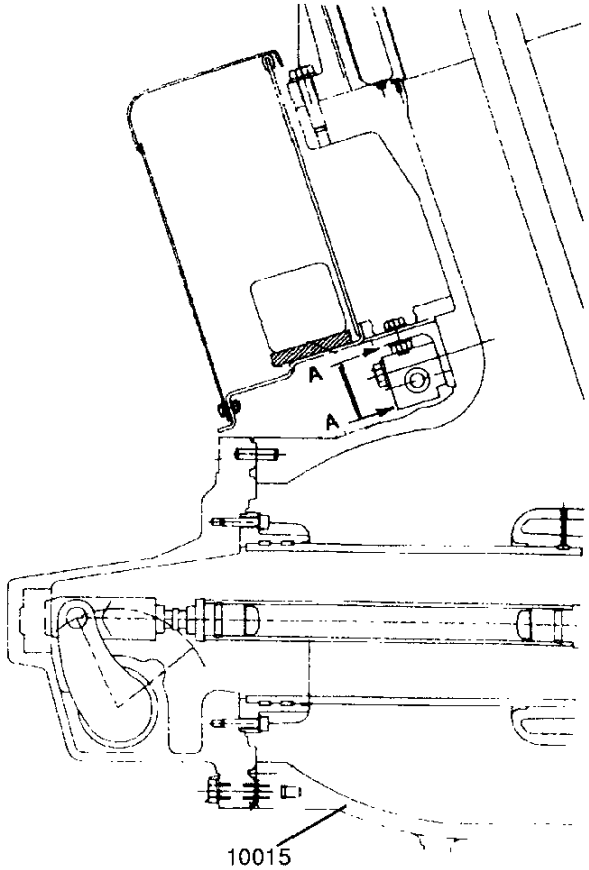
Figure 4
Wiring Diagram: Typical DC Control System (Without X Relay)



Set each switch to the pressure indicated in Figures 8 and 9.

Figure 5
SF_6 Gas Density Monitor 60002





*The probe retaining pin 10050 is held in place by screw H800A24205. When removing the probe from the probe cover 10045, remove the screw H800A24205 and slide the probe retaining pin out of the hole.

Figure 6
Temperature Probe Housing

10015	Pole Tank
10045	Probe Cover
10050	Probe Retaining Pin
H420A64012	Flat Washer, M12
H800A09914	Hex Head Bolt, 1/2-13 x 3-1/4-inch
H800A24205	Flat Head Screw, 10-32 x 1/2-inch

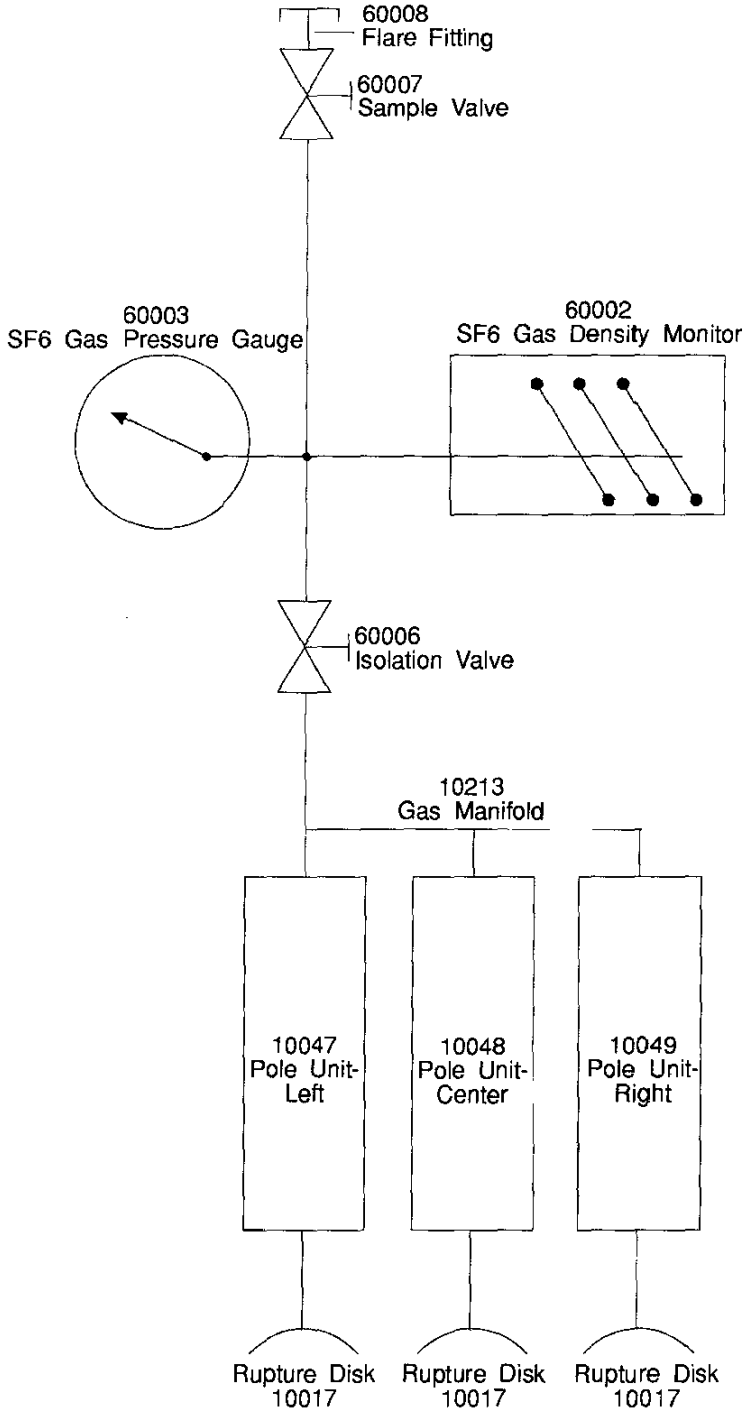
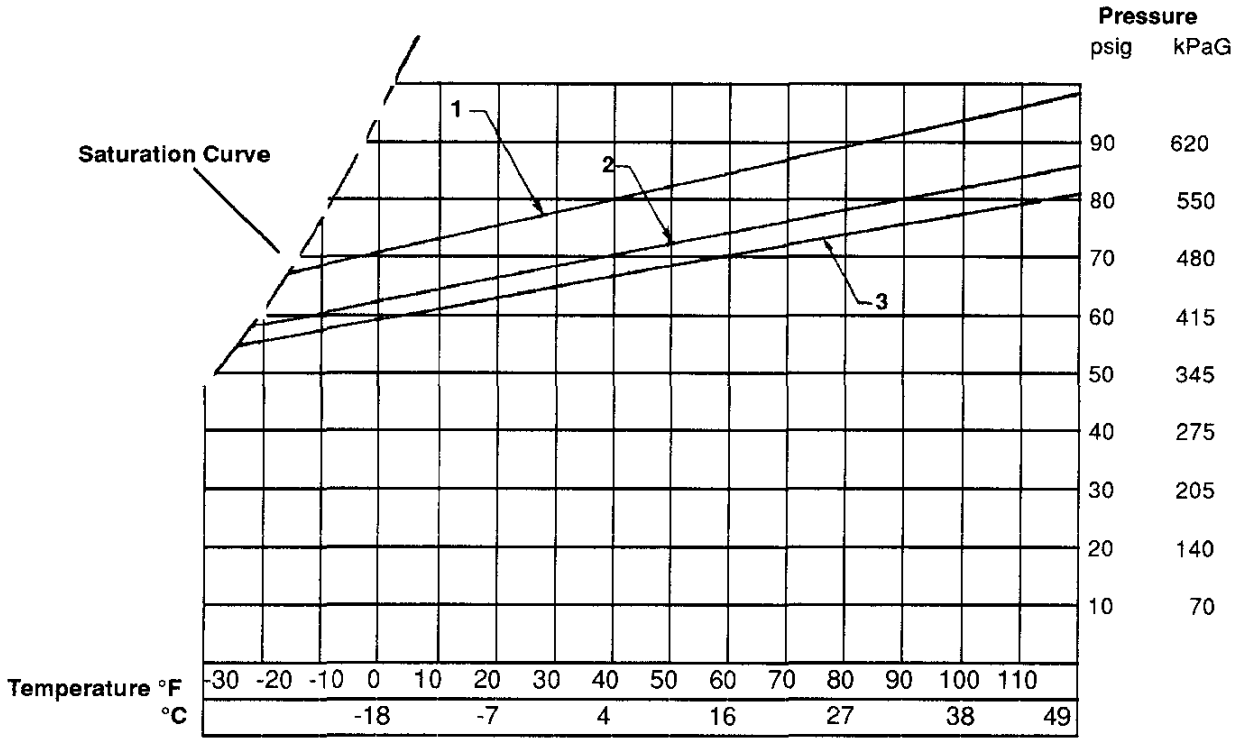


Figure 7
SF_6 Gas Schematic



1 Normal Filling Pressure psig or kPaG
2 Low Pressure Alarm (Contact 63-2C Closes)
3 Low Pressure Lock-Out (Contact 63-21B1 & 63-2B2 Close)

Figure 8
SF_6 Gas Density Monitor Calibration Curve for Pressure vs. Temperature

Important: Refer to Figure 9 for a tabular version of the characteristics above.

Tabular Version of the Pressure vs. Temperature Characteristics shown in Figure 8

Temp. F	Temp. C	*Fill psig	**Fill kPaG	*Alarm psig	**Alarm kPaG	*Lock-Out psig	**Lock-Out kPaG
-40	-40	Saturated	Saturated	Saturated	Saturated	Saturated	Saturated
-30	-34	Saturated	Saturated	Saturated	Saturated	Saturated	Saturated
-20	-29	Saturated	Saturated	58.0	399.9	54.9	378.5
-10	-23	68.8	474.4	60.0	413.7	56.9	392.3
0	-18	71.1	490.2	62.1	428.2	58.8	405.4
10	-12	73.4	506.1	64.0	441.3	60.8	419.2
20	-7	75.8	522.6	66.2	456.4	62.7	432.3
30	-1	78.2	539.2	68.1	469.5	64.7	446.1
40	4	80.5	555.0	70.2	484.0	66.6	459.2
50	10	82.8	570.9	72.3	498.5	68.5	472.3
60	16	85.2	587.4	74.3	512.3	70.4	485.4
68	20	87.0	599.8	76.0	524.0	72.0	496.4
70	21	87.6	604.0	76.4	526.8	72.3	498.5
80	27	90.0	620.5	78.5	541.2	74.2	511.6
90	32	92.3	636.4	80.5	555.0	76.2	525.4
100	38	94.7	652.9	82.7	570.2	78.2	539.2
110	43	97.1	669.5	84.8	584.7	80.1	552.3
* +/- 2 psig							
** +/- 14 kPaG							

Figure 9
SF_6 Gas Filling and Density Monitor Calibration Chart

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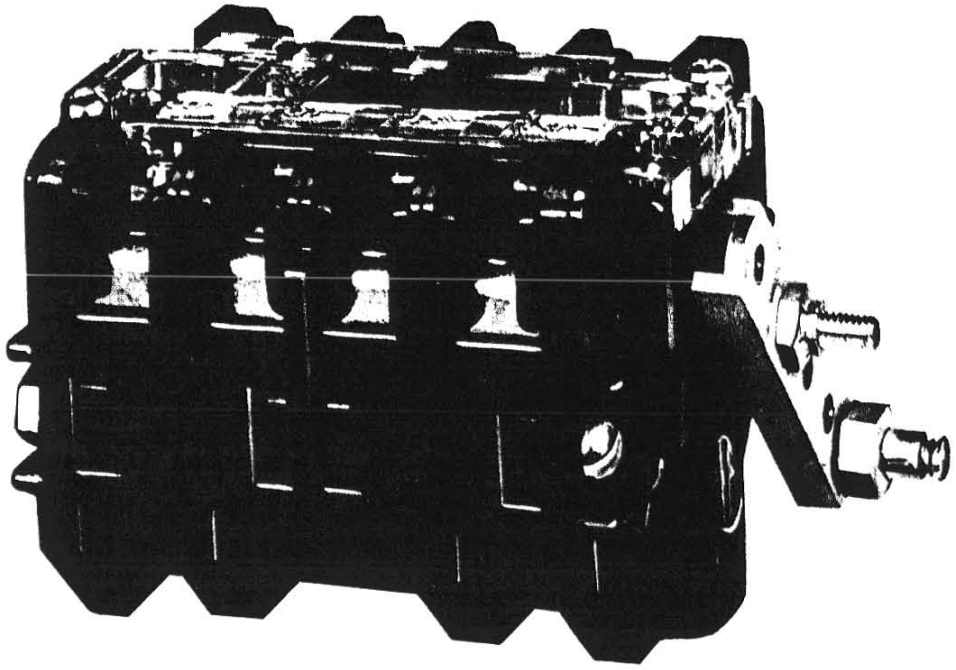
IB 3.6.6.7B

Installation/Maintenance Instructions

Switchgear Components

Type L2
Auxiliary Switches



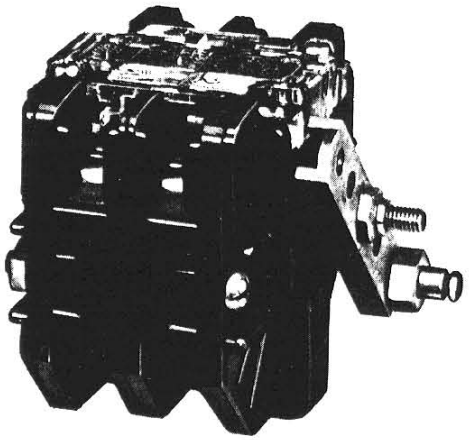


Fig. 1—Type L2 Auxiliary Switch, Two Contact

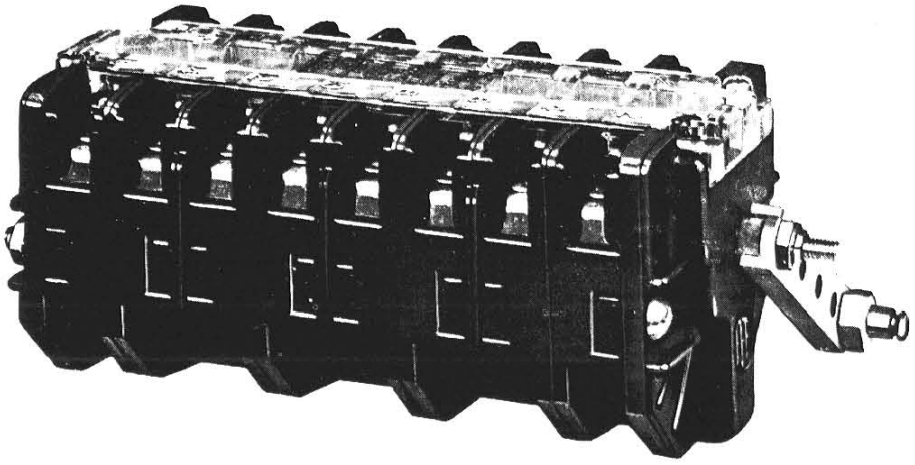


Fig. 2—Type L2 Auxiliary Switch, Eight Contact

AUXILIARY SWITCHES

TYPE L2

INTRODUCTION

The Type L2 auxiliary switch is a front-connected switch with double-break rotary contacts. The auxiliary switch can be furnished as a two, four, six, or eight contact unit.

The switch is "built-up" of a series of moldings which, when assembled, enclose the contact parts. The cover is molded of clear plastic so that it is not necessary to remove the cover to check the condition or operating sequence of the contacts.

The contacts are assembled on the shaft in any desired combination. That is, closed when the circuit breaker is closed "a"; or closed when the circuit breaker is open "b". Any contact can be removed from the shaft and rotated to change an "a" contact to a "b" contact, or a "b" contact to an "a" contact.

RATINGS

The switch contacts can carry 40 amperes continuously with limitations in interrupting as indicated in Table I. The interrupting rating for the various control voltages, listed in Table I, assume an inductance of the average trip coil.

TABLE I INTERRUPTING RATINGS

Circuit Voltage	Maximum Amperes
115 A-C	30
240 A-C	20
480 A-C	10
600 A-C	7
125 D-C	10
250 D-C	5
600 D-C	0.5

For highly inductive circuits, two contacts are sometimes placed in series.

RECEIVING AND STORAGE

RECEIVING

In general, auxiliary switches are usually mounted on a circuit breaker or other device. Auxiliary switches shipped separately for replacement purposes or for adding to existing equipment are completely assembled and packed in individual cartons. Immediately upon receipt, examine the switches for any damage sustained in transit. If injury or rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest Sales Office.

STORAGE

Individually packed switches for stock purposes or switches not for immediate installation should be left in the shipping carton and stored in a clean dry place.

DESCRIPTION

The Type L2 auxiliary switches are "built-up" of moldings which interlock and nest into each other. This assures that the moldings forming the body and cover of the switch can be assembled in only one way. The basic two contact switch consists of two end moldings, a stationary contact molding with contacts, two rotating contact moldings with contacts and retainers, two bearing moldings, cover molding, shaft, and the necessary assembly hardware.

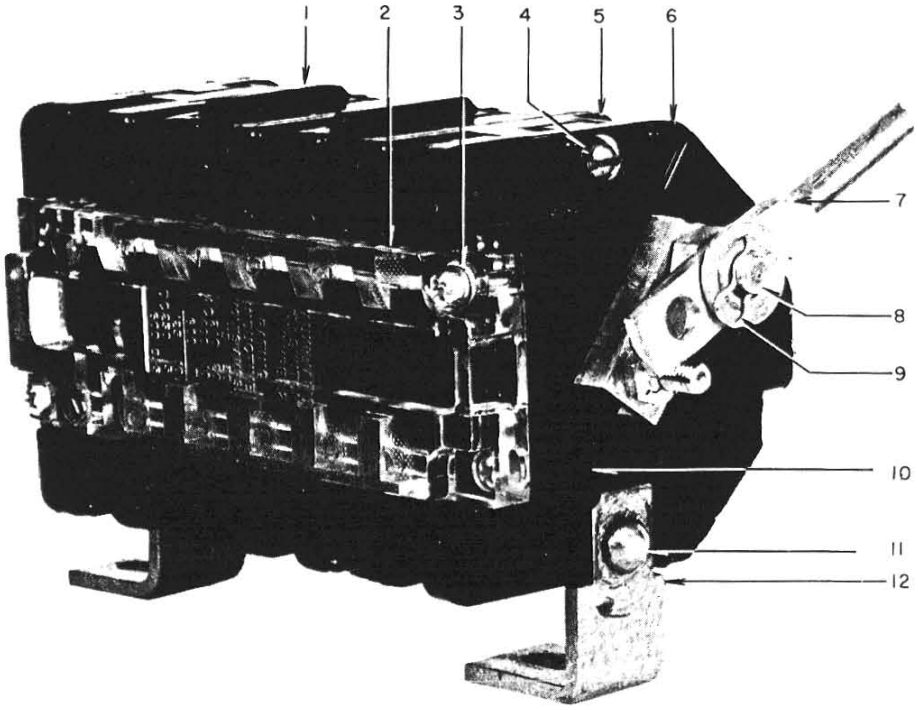
The four, six, and eight contact auxiliary switches are formed by adding an interphase molding, one stationary contact molding with contacts, two rotating contact assemblies, and a longer shaft and cover for each additional two contacts required.

CONTACTS

The stationary contacts are positioned and held in place by cavities in the stationary contact moldings. These contacts also carry the contact terminal screws.

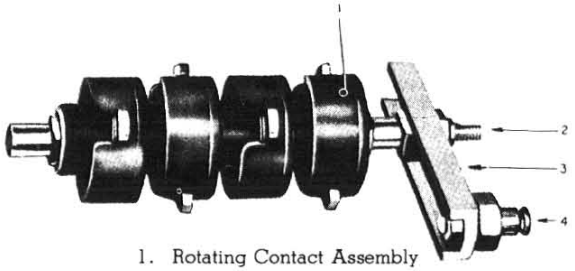
The movable contacts are positioned by a projection on the stationary contact; and the contact movement, in the open contact position, is limited by a projection on the contact molding. Each movable contact is "backed-up" by a contact spring which furnishes the necessary contact pressure. Movement of the movable contact produces contact wipe at its pivot which assures a low resistance contact with the stationary contact.

Each rotating contact is assembled on a rotating molding and held in position by a contact retainer. The complete rotating contact assembly is then positioned on a square shaft that rotates on bearings in the end moldings. The shaft opening in the contact molding is so formed that the contact molding can be placed in any one of three positions in each of the four quadrants of the shaft. If we assume that the vertical and horizontal axes forming the quadrants pass through the diagonals of the square shaft, the contact moldings can be positioned on the shaft so that the center line of the contacts is on the diagonals or at 22 degree spacings on either side of the diagonals. Standard short contacts, "a" or "b", will always have their center lines on the diagonals; while ("early make" and "late break") advanced long contacts ("a" or "b") will always have their center lines on the 22 degree spacings at either side of the diagonals.



1. Interphase Molding
2. Cover
3. Screw
4. Screw
5. Contact Molding
6. End Molding
7. Operating Link
8. Stud
9. Hair Pin Cotter
10. Bearing Molding
11. Screw
12. Mounting Feet

Fig. 3—Type L2 Auxiliary Switch, Six Contact Showing Mounting and Operating Parts



1. Rotating Contact Assembly
2. Shaft
3. Crank
4. Stud

Fig. 4—Assembly of Rotating Parts for Four-Contact Type L2 Auxiliary Switch

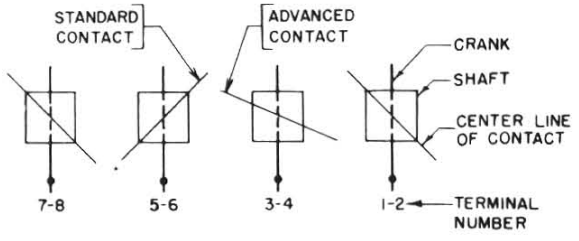


Fig. 5—Sketch Showing Center Line of Contacts Relative to Position of Shaft and Operating Crank, Viewed From End Opposite the Crank

TERMINAL IDENTIFICATION

The switch terminals are identified by means of raised numbers on the cover molding. Starting with the terminals at the crank end of the switch, the terminals on the right-hand side when facing the crank are given odd numbers beginning with one; while the contacts on the left-hand side are given even numbers beginning with two.

OPERATION

The Type L2 auxiliary switches are operated by a crank mounted on the switch shaft which is connected by an adjustable linkage to the circuit breaker. The crank and linkage are designed so that the opening and closing of the circuit breaker rotates the switch shaft 90 degrees. This rotation of the shaft opens the normally closed "b" contacts when the breaker closes and closes the normally open "a" contacts. The contact operation is reversed as the circuit breaker opens; that is, the "b" contacts close and the "a" contacts open.

MAINTENANCE

The Type L2 auxiliary switches require very little maintenance. However, it is recommended that the following be inspected every six months and whenever the circuit breaker is de-energized for inspection or maintenance. The rotating contact assembly (2, Fig. 6) should be rotated 180 degrees after every 4000 operations of the switch.

CONTACTS

A visual inspection of the contacts can be made through the clear molded cover. If the contacts show signs of burning or pitting, dis-assemble the switch and either rotate the rotating contact assembly (2, Fig. 6) 180 degrees or replace the necessary parts as described under REPAIR AND REPLACEMENT.

REPAIR AND REPLACEMENT

A minimum amount of work is required to dis-assemble the Type L2 auxiliary switches. Should it become necessary to replace contacts or other parts of the switch, proceed as described in the following sections.

Rotating Contact Assembly

To replace or change the rotating contact assemblies, proceed as follows:

1. Trip the circuit breaker and de-energize the control circuit.
2. Tag all leads with their correct terminal number and remove the leads.
3. Refer to Fig. 3 and remove hairpin cotter (9) (and spacers, if used) from crank stud (8) and remove the switch operating link (7).
4. Remove screw (11) fastening switch to mounting feet (12) and remove the complete switch. (NOTE: On switches mounted without feet, remove two self tapping screws fastening switch to mounting plate).
5. Remove two screws (3) fastening cover (2) to switch and remove cover.
6. Remove two screws fastening bearing moldings (10) to end moldings (6) and remove the bearing moldings.
7. Remove the shaft, operating crank, and rotating contacts as a complete assembly. (See Fig. 4).

CAUTION CAUTION CAUTION CAUTION

BEFORE REMOVING THE ROTATING CONTACT ASSEMBLIES FROM THE SHAFT, MAKE A SKETCH (SIMILAR TO THAT SHOWN IN FIG. 5) SHOWING THE POSITION OF THE CENTER LINE OF THE CONTACTS RELATIVE TO THE DIAGOLNALS OF THE SHAFT AND POSITION OF THE OPERATING CRANK. THIS IS IMPORTANT IF A CONTACT REMOVED AS AN "a" (OR "b") CONTACT IS TO BE REPLACED AFTER DIS-ASSEMBLY IN ITS CORRECT POSITION ON THE SHAFT AS AN "a" (OR "b") CONTACT.

The simplified sketch as shown in Fig. 5, would be typical of that made for a four contact switch having an "a" contact at terminals 1 and 2, and advanced "a" contact at terminals 3 and 4, a "b" contact at terminals 5 and 6, and an "a" contact at terminals 7 and 8. When making this sketch, hold the complete assembly, shown in Fig. 4, so that the operating crank is perpendicular to the floor and facing away from you.

8. Start with the contact assembly at the end of the shaft opposite the operating crank. Sketch the position of the contact and then remove it. Continue this procedure with each contact assembly until all the assemblies are removed from the shaft.

Replace the rotating contact assembly (1, Fig. 4) as a complete unit if either the contacts are pitted or if the contact molding is carbonized due to arcing or damaged in any way. Follow the sketch made during dis-assembly when replacing the rotating contact assemblies on the shaft. This assures correct contact sequence and switch operation.

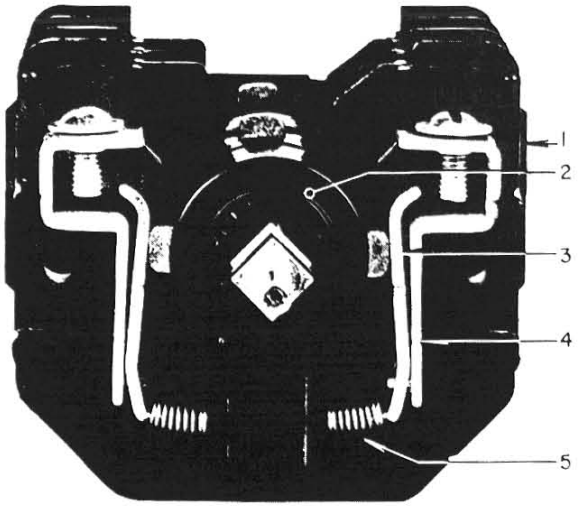
Care must be taken, when replacing the shaft, operating crank, and rotating contacts as a complete unit, to make sure the crank and switch terminals one and two are at the same end of the switch.

Re-assemble the switch parts and replace it on the circuit breaker by following the reverse of the procedure described in steps 1 to 8 above.

Movable and Stationary Contact

To replace the movable or stationary contacts, proceed as follows:

1. Proceed with and follow steps 1 to 8 as described under Rotating Contact Assembly.
2. Remove the one remaining screw (4, Fig. 3) fastening the switch moldings together. (NOTE: On switches not mounted on mounting feet, it is necessary to remove two screws).
3. Separate the end moldings (6, Fig. 3), and contact moldings (5, Fig. 3); and, if the switch has more than two contacts, the interphase moldings (1, Fig. 3).



1. Contact Molding
2. Rotating Contact Assembly
3. Movable Contact
4. Stationary Contact
5. Contact Spring

Fig. 6—Type L2 Auxiliary Switch with End Molding, Cover, and Operating Crank Removed

4. The movable contacts (3, Fig. 6), stationary contacts (4, Fig. 6), and contact springs (5, Fig. 6) are easily removed from the cavities in the contact molding, by lifting each contact assembly up and away from the molding. (NOTE: Care must be taken when removing the contacts to prevent loss of the contact spring. It is suggested that the thumb or finger be placed over the spring while the contacts are being removed).

Replace any pitted or burned contacts and examine the moldings for signs of burning or breaking. Re-assemble the parts following the reverse of the procedure described in steps 1 to 4 above.

CAUTION CAUTION CAUTION CAUTION

BEFORE REPLACING THE BEARING AND COVER MOLDINGS, CHECK AND MAKE SURE THE OPERATING CRANK AND TERMINALS ONE AND TWO WILL BE AT THE SAME END OF THE SWITCH WHEN THE ASSEMBLY IS COMPLETE.

RENEWAL PARTS

It is recommended that complete switches be carried in stock for the prompt replacement of Type L2 auxiliary switches. Additional renewal parts may be stocked to facilitate the repair of auxiliary switches after removal from the circuit breaker.

When ordering complete switches, specify the type of switch, number of contacts and contact code, type of circuit breaker on which it is to be mounted, and whether it is to be right-hand or left-hand mounted.

When ordering renewal parts, specify the type of switch, description of parts, and quantity required.

NOTES

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SF_6 Circuit Breakers

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Safe Handling Practices for SF_6 Gas©

ASEA BROWN BOVERI

15 March 1993

Contents

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Notice 2

Within the scope of these instructions, it is impossible to take into account every eventuality which may arise with technical equipment in service. Please consult our local salesman in the event of any irregularities, especially if not referred to herein.

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Safe Handling Practices for SF_6 Gas

1 Introduction

This module lists procedures required to safely perform installation, inspection, and maintenance work on sulfur hexafluoride (SF_6) gas-insulated apparatus.

In common with numerous other chemicals used everyday in industry, SF_6 gas and its decomposition products present no injury or illness problems if dealt with properly. As with other chemicals, health hazards may exist under particular conditions, if exposure or handling is careless or improper. All personnel designated to perform inspection or maintenance work on ABB SF_6-insulated apparatus should read this module and follow all of the instructions herein.

1.1 Properties of SF_6 Gas

In its pure, natural state, SF_6 gas is colorless, odorless, tasteless and possesses a low order of toxicity. The only danger in breathing pure SF_6 gas is that it displaces oxygen and can cause suffocation. SF_6 gas is chemically inert and non-flammable. The gas has a high dielectric strength and thermal properties conducive for insulating high voltage and quenching electrical arcs.

Refer to the addendum (at the end of this module) from the manufacturer for specific chemical details.

If SF_6 gas is subjected to an electric arc, heat causes the gas to decompose into potentially toxic by-products. (This gas also decomposes when exposed to other high temperature conditions such as heater filaments, smoking, welding, etc.) Fluorides of sulfur are the most toxic decomposition products and are in gaseous form. A molecular sieve (desiccant bag) containing activated alumina is provided in each pole tank. This molecular sieve eliminates most of these gaseous decomposition products. The less toxic metal fluorides are in the form of white, tan or gray powder. The amount of decomposition of the gas is a function of the intensity and duration of the arc.

Some of the SF_6 decomposition products form corrosive and conductive compounds when exposed to moisture. These compounds, which can be harmful to human beings, are also aggressive towards materials within the circuit breaker, especially insulating surfaces, if subjected to prolonged exposure. That's why it's best not to perform breaker maintenance on rainy, humid days.

By weight, SF_6 gas is approximately five times heavier than air and tends to diffuse towards the pull of gravity and pools in low places. As a result of this pooling, the gas displaces oxygen and can cause suffocation without warning if the oxygen content of air is reduced from the normal 20 percent to less than 13 percent.

In the presence of moist air, noxious decomposition products have a characteristic odor of rotten eggs.

DANGER

Since SF_6 gas displaces oxygen, avoid inhaling SF_6 gas. Oxygen deficiency can cause nausea and drowsiness. Prolonged exposure to this gas in a confined space can cause serious breathing difficulty and suffocation.

Avoid skin or eye contact with the decomposition products because they can cause skin rashes, eye irritation, and chemical burns.

In the presence of moist air, noxious decomposition products have a characteristic odor of rotten eggs. Avoid inhaling these by-products because, unprotected prolonged exposure can injure the respiratory tract. Wear the prescribed protective gear indicated in sections 1.2.1 and 3.

1.2 Equipment Used to Handle SF_6 Decomposition Products

The following equipment is used to perform maintenance on SF_6 gas-insulated apparatus where decomposition products may be present:

- Hooded disposable coveralls - Tyvec, Durafab, or equivalent - made of paper with nylon reinforcement material;
- Non-Disposable Neoprene Gloves - 14-inch size;
- Non-Disposable Rubber Boots - 17-inch size, over-the-shoe style;
- Clean, oil-free dry air supply with a capability to provide sufficient purging and ventilating capacity;
- Full-face Comfo II respirator or equivalent with twin cartridges for organic vapors and acid gases, i.e., GMC or equivalent;
- Supplied air-line respirator - MSA pressure demand type with Ultravue face piece and web belt-mounted demand regulator, 50 ft. of air supply hose, manifold with quick-disconnect and automatic shut-off outlets, cylinder pressure regulator; must have NIOSH/MESA Approval No. TC-19C-93, or equivalent from other manufacturer;
- Respirable, compressed air supply - 300 lb, approved portable tank with air meeting Grade D, ANSI Standard Z86.1-1974 with supply hose inlet pressure between 80 to 100 psig;

- Industrial wet or dry type vacuum cleaner with non-metallic attachments, micro staphicidal filter elements (particles to 0.3 microns), two 15-inch lengths of plastic hose and coupler;
- Cleaning solvent: denatured ethyl alcohol.

1.2.1 Protective Gear

Minimum required protective gear to be worn when handling SF_6 gas-insulated apparatus are:

- Gloves;
- Full-face Comfo II respirator or equivalent with twin cartridges for organic vapors and acid gases, i.e., GMC or equivalent.

Full protective gear includes:

- Gloves;
- Hooded disposable coveralls;
- Non-Disposable Neoprene Gloves - 14-inch size;
- Non-Disposable Rubber Boots - 17-inch size, over-the-shoe style;
- Supplied air-line respirator.

2 SF_6 Gas Handling Safety Practices

Safety practices when handling SF_6 gas-insulated apparatus are:

- Perform SF_6 gas handling, filling or reclaiming outdoors;
- If procedures involving SF_6 gas insulated equipment must be done indoors, work in a well-ventilated room; make sure the ventilating equipment is operating;
- No smoking;
- No exposed heaters, flames, or arc-producing equipment should be used in the area while the gas is being handled;
- If, when handling used SF_6 gas, the odor of rotten eggs is detected, personnel not wearing respiratory equipment should promptly evacuate the area;
- Correct any gas leaks at hose or fitting connections at the breaker, on the service cart, or at the cylinder.

2.1 Storing SF_6 Gas Cylinders

Pressurized cylinders which contain SF_6 gas can be damaged or ruptured by careless handling.

Requirements for storing gas cylinders include:

- Store cylinders in a well-ventilated area;
- Secure the cylinders in a way to prevent them from falling or being knocked over.

2.1.1 Heating an SF_6 Gas Cylinder

When filling during cold ambient temperatures, the cylinder may be heated using any of the following methods to convert the liquid SF_6 in the cylinder to a gaseous state:

- An electric blanket heater;
- Immersing the gas cylinder upright in a drum partially filled with warm water so that approximately half of the cylinder is immersed. Heat the water with a portable gas or electric heater.

Warning

Never heat a gas cylinder with an open flame.

Energize heaters only when transferring the gas. When heating the cylinder, be sure that the temperature in the cylinder does not exceed 100°F (38°C).

3 Maintenance of SF_6 Gas Insulated Apparatus

After an SF_6 electrical apparatus has been in service, it should be assumed that hazardous decomposition products may be present.

Before performing any maintenance on SF_6 gas-insulated apparatus, review sections 1 and 2 of this module. Perform the initial inspection of the apparatus wearing, at a minimum, gloves and a full-face respirator. If significant amounts of solid decomposition products or noxious gases are present when opening a pole unit, wear full protective gear (as listed in section 1.2.1) and proceed as per section 3.1.

If a tent-like enclosure is used around the apparatus, use a dry air ventilation system while performing maintenance work.

If no decomposition products are found:

1. Purge the apparatus thoroughly with dry air from a suitable source.

Important: *Do not purge with damp or wet air as it can endanger the integrity of insulation materials and prolong dry-out and reconditioning time.*

It is only safe to assume that there may be hazardous gaseous products present. All personnel should stand clear of the apparatus during purging.

2. Allow purging to continue long enough to assure a minimum of at least 10 complete air changes through the total apparatus before working on the equipment. If the SF_6 gas has not been fully evacuated from the apparatus prior to purging, perform a minimum of 100 air changes.
3. Reduce the purging air supply to a low level (approximately 10 air changes per hour) to provide continuous ventilation of the apparatus while personnel are working internally in the apparatus.

3.1 Removing SF_6 Decomposition Products

If significant arc powders or noxious odors are detected upon opening a pole unit or any other apparatus:

1. Wear full protective clothing and a supplied air full-face respirator.
2. Establish a restricted safety zone around the equipment. Personnel cannot enter this zone without wearing full protective gear (defined in section 1.2.1). If performing this work outdoors, the zone may need to be extended downwind of the work site.
3. Use a vacuum cleaner equipped with filters as described in section 1.2; this vacuum cleaner should be used exclusively for removing SF_6 decomposition products.
4. Wipe up any remaining powdered decomposition products with rags using denatured ethyl alcohol.
5. Remove and dispose the molecular sieve (desiccant) within the apparatus as per section 4; keep the full protective gear on.
6. Place materials used and retrieved in clean-up operations in large plastic or metal containers. These containers serve as refuse containers.
7. Proceed with purging as per section 3 after removing all decomposition products.

4 Disposing of Decomposition Products

Dispose the decomposition products outdoors since corrosive or toxic gases may evolve from the solid arc products or from the molecular sieve (desiccant). Disposal of the SF_6 residue involves neutralizing the decomposition products.

Notice: *Wear full protective gear as per section 1.2.1 during disposal.*

To properly dispose of decomposition product residue:

1. Place materials used and retrieved in clean-up operations in large plastic or metal containers. These containers serve as refuse containers.
2. Empty the vacuum cleaner housing and the absorption filter material into the container.
3. Note or measure the volume of material in the container.
4. In a separate container (plastic pail), measure a volume of water 1.5 times that of the above refuse material. Empty the water into the refuse container pouring the water quickly at first then slowly. The water mixing with the SF_6 refuse will produce some heat and foam.
5. Measure a quantity of soda ash (sodium carbonate) or lime (calcium oxide) equal to at least one-quarter the volume of the refuse and add this neutralizing agent to the water-refuse material.
6. Add the cleaning rags, protective clothing (even though it is disposable), along with the filters from the vacuum cleaner and respirator to the neutralizing mixture in the refuse container.
7. Allow the refuse container to stand uncovered for 24 hours.
8. Afterwards test the pH of the refuse mixture.

   The mixture should be at least slightly alkaline (greater than 7). If the pH is between 7 and 10, the refuse is now rendered harmless and may be disposed of in a normal manner as per local ordinances.

   If the solution pH is less than 7, it is still acidic and harmful; add additional soda ash or lime to neutralize the refuse mixture to a pH greater than 7 but less than 10. Then dispose of the material as per local ordinances.

4.1 Removing SF_6 Gas Residue from Tools and Equipment

To clean tools and equipment which have been exposed to SF_6 decomposition products:

1. Prepare a mild (10%) lime or soda ash solution and use this as the neutralizing solution.
2. Wash any hand tools, non-disposable protective gear, and equipment employed in the clean-up operation.
3. Vacuum some of this neutralizing solution through the hose and into the vacuum cleaner to neutralize particles adhering to this equipment.
4. Rinse all washed tools and equipment thoroughly with water.
5. Wash the rubber boots and Neoprene gloves in water.

ALLIED

PRODUCT SAFETY DATA SHEET

ACCUDRI® SF_6

A. GENERAL INFORMATION

TRADE NAME (COMMON NAME)	☒ C.A.S. NO. ☐ ALLIED PRODUCT CODE #
ACCUDRI® SF_6	2551-62-4

CHEMICAL NAME AND/OR SYNONYM

Sulfur Hexafluoride Synonym: Sulfur Fluoride

FORMULA	MOLECULAR WEIGHT
SF_6	146.05

ADDRESS (No., STREET, CITY, STATE AND ZIP CODE)

ALLIED-SIGNAL INC.
ENGINEERED MATERIALS SECTOR
P.O. Box 1139R
Morristown, N.J. 07960

CONTACT	PHONE NUMBER	LAST ISSUE DATE	CURRENT ISSUE DATE
Product Safety Department	(201) 455-4157	July, 1986	May, 1987

B. FIRST AID MEASURES

EMERGENCY PHONE NUMBER: (201) 455-2000

Inhalation: Immediately remove to fresh air. If breathing has stopped, give artificial respiration, preferably mouth-to-mouth. If breathing is difficult, give oxygen provided a qualified operator is available, Call a physician.

C. HAZARDS INFORMATION

HEALTH

INHALATION

Pure SF_6 is of a low order of toxicity, but may act as an asphyxiant if oxygen is reduced to below 16%, as indicated by paleness, possible cyanosis (blue skin). See also Sections G, K.

INGESTION

N.A. (gaseous)

SKIN

No effects reported. May be irritant.

EYES

No effects reported. May be irritant.

PERMISSIBLE CONCENTRATION: AIR (SEE SECTION J)

1000 ppm or 6000 mg/m^3 (OSHA). TLV (ACGIH): same.

BIOLOGICAL

None established.

UNUSUAL CHRONIC TOXICITY

None known.

C. HAZARDS (Cont.)

FIRE AND EXPLOSION

FLASH POINT	AUTO IGNITION TEMPERATURE	FLAMMABLE LIMITS IN AIR (% BY VOL.)
N.A. °C (Not flammable or combustible) ☐ OPEN CUP ☐ CLOSED CUP	N.A. °C	LOWER – N.A. UPPER – N.A.

UNUSUAL FIRE AND EXPLOSION HAZARDS

See "Hazardous Decomposition Products, Section G".

D. PRECAUTIONS/PROCEDURES

FIRE EXTINGUISHING AGENTS RECOMMENDED

N.A.

FIRE EXTINGUISHING AGENTS TO AVOID

N.A.

SPECIAL FIRE FIGHTING PRECAUTIONS

Wear self-contained breathing apparatus approved by NIOSH. Use water spray to keep cylinders cool.

VENTILATION

Mechanical (General).

NORMAL HANDLING

Observe precautions on cylinder label. Protect cylinders from physical damage.

STORAGE

Protect cylinders from physical damage, heat, and sunlight. Store in area of low fire risk. For additional information, see Compressed Gas Association Pamphlet P-1, 1974.

SPILL OR LEAK (ALWAYS WEAR PERSONAL PROTECTIVE EQUIPMENT – SECTION E)

Evacuate unprotected personnel. Protected personnel (Section E) may shut off leak. Product will disperse itself.

SPECIAL: PRECAUTIONS/PROCEDURES/LABEL INSTRUCTIONS

SIGNAL WORD – CAUTION!

NOTE: The product has no warning properties. The gas is odorless. SF_6 exposed to electric arcs may break down into toxic byproducts. (See Section G). Avoid breathing SF_6 which has been thus exposed.

Comply with OSHA Regulations for Compressed Gas and Contaminants. Also see CGA Pamphlet P-1, 1974.

E. PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY PROTECTION

Use self-contained breathing apparatus or air-supplied respirator.

EYES AND FACE

Safety glasses.

HANDS, ARMS, AND BODY

Not generally required.

OTHER CLOTHING AND EQUIPMENT

Not generally required.

F. PHYSICAL DATA

MATERIAL IS (AT NORMAL CONDITIONS):	APPEARANCE AND ODOR —	
☐ LIQUID ☐ SOLID ☒ GAS ☐ _____	Colorless, odorless gas. Non-flammable gas label. Container: 115 lb. cylinders.	
BOILING POINT °C Sublimes@-63.9°C., 1 atmos. MELTING POINT −50.8°C. °C @ 32.5 p.s.i.a.	SPECIFIC GRAVITY (H_2O = 1) N.A. (Gas)	VAPOR DENSITY (AIR = 1) 5.1 @ 1 atm., 21.1°C.
SOLUBILITY IN WATER (% by Weight) Slight	pH N.A.	VAPOR PRESSURE (mm Hg at 20°C) ☐ (PSIG) ☐ N.A. (Gas)
EVAPORATION RATE (Butyl Acetate = 1) ☐ (Ether = 1) ☐ N.A. (Gas)	% VOLATILES BY VOLUME (At 20°C) N.A. (Gas)	

G. REACTIVITY DATA

STABILITY	CONDITIONS TO AVOID
☐ UNSTABLE ☒ STABLE	Note special precautions / procedures, Section D.

INCOMPATIBILITY (MATERIALS TO AVOID)

Hot reactive metals. Liquefied gases in contact with water can explode violently.

HAZARDOUS DECOMPOSITION PRODUCTS

Thermal and electrical arc decomposition products: GASES — fluorides of sulfur (particularly sulfuryl fluoride, a convulsant, and thionyl fluoride and thionyl tetrafluoride, pulmonary irritants). SOLIDS — metal fluorides and sulfides which can be highly toxic and irritating.

HAZARDOUS POLYMERIZATION	CONDITIONS TO AVOID
☐ MAY OCCUR ☒ WILL NOT OCCUR	N.A.

H. HAZARDOUS INGREDIENTS (Mixtures Only) N.A.

MATERIAL OR COMPONENT/C.A.S. #	WT. %	HAZARD DATA (SEE SECT. J)
N.A.		

I. ENVIRONMENTAL

DEGRADABILITY/AQUATIC TOXICITY

N.A. (Inorganic)

OCTANOL/WATER PARTITION COEFFICIENT: N.D.

EPA HAZARDOUS SUBSTANCE? (CLEAN WATER ACT SECT. 311) ☐ YES ☒ NO — IF SO, REPORTABLE QUANTITY: N.A. # — 40 CFR 116-117

WASTE DISPOSAL METHODS (DISPOSER MUST COMPLY WITH FEDERAL, STATE AND LOCAL DISPOSAL OR DISCHARGE LAWS)

Disposal of sulfur hexafluoride may be subject to environmental regulations. Users of this product should review their operation in terms of applicable federal, state, and local laws, and consult with appropriate regulatory agencies before discharge or disposal of this material.

RCRA STATUS OF UNUSED MATERIAL IF DISCARDED: Not a "hazardous waste". — HAZARDOUS WASTE NUMBER: (IF APPLICABLE), N.A. — 40 CFR 261

J. REFERENCES

PERMISSIBLE CONCENTRATION REFERENCES

ACGIH: "Threshold Limit Values . . .", 1985 / 1986.
OSHA: 29 CFR 1910.1000, "Z List".

REGULATORY STANDARDS

D.O.T. CLASSIFICATION: Nonflammable gas — 49 CFR 173

I.D. No.: UN1080

None additional cited.

GENERAL

(a) Lester, D. and Greenburg, L.A., "The Toxicology of Sulfur Hexafluoride", Arch. Ind. Hyg. 2:348,1950.
(b) ACGIH: Documentation of the Threshold Limit Values and Biological Exposure Indices, 5th. Ed., 1986, American Conference of Governmental Industrial Hygienists.

K. ADDITIONAL INFORMATION

SECTION C – HEALTH – continued
Each lot is tested for toxic effects before shipment. A certificate is furnished on request.

PSDS FILE NO. 1037

SF_6 Circuit Breakers

Type PM

Publication No. 526P209-02

145 PM Maintenance©

ASEA BROWN BOVERI

12 October 1993

Contents

Figures

Notice 1

Based on our own experience, you will obtain the best possible operational reliability by following the recommendations given in these instructions. The data contained herein purports solely to describe the product, and it is not a warranty of performance or characteristics. It is with the best interests of our customers in mind that we constantly strive to improve our products and keep them abreast of advances in technology. This may lead to discrepancies between a product and these instructions.

Notice 2

Within the scope of these instructions, it is impossible to take into account every eventuality which may arise with technical equipment in service. Please consult our local salesman in the event of any irregularities, especially if not referred to herein.

Notice 3

We expressly decline liability for damages resulting from any incorrect operation or wrong handling of our equipment, even if these instructions contain no specific indication in this respect. We stress the fact that only genuine spare parts should be used for replacements.

Notice 4

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the ABB Power T & D Company Inc. Power Circuit Breaker Division, 125 Theobold Ave., Greensburg, PA 15601, Phone No. (412) 838-5200.

Maintenance

1 Introduction

Procedures, materials, and equipment required for general maintenance and testing of the 145 PM circuit breakers are described in this module.

Specific maintenance procedures performed on main components of the 145 PM circuit breakers are listed in Maintenance sections in respective component modules.

1.1 General Maintenance Guidelines

The following sub-sections are general, recommended practices employed in the process of performing maintenance.

DANGER

To prevent injury or equipment damage, the breaker must be removed from service, isolated, and grounded before performing any maintenance procedures.

1.1.1 General Cleanliness

Maintaining the cleanliness of the component surfaces in the breaker is an extremely important part of maintenance because the major insulating components in the breaker are subjected to high electrical stresses.

Because cleanliness is so important, care must be taken to perform internal breaker maintenance under clean, dry conditions.

Warning

The importance of cleanliness cannot be overstressed. Introducing loose dirt, especially metallic particles, into an open pole unit (SF_6 gas compartment) can cause dielectric failure. Insulating surfaces must be protected from physical, damage (nicks and scratches) and kept clean and dry at all times.

Loose dirt (especially metallic particles) as well as residue left from sweaty hands and atmospheric moisture can lead to dielectric failure. It is best to avoid handling critical insulating components with bare hands. Instead, wear snug-fitting cloth gloves when handling insulating parts and surfaces. To ensure cleanliness, wipe insulating surfaces with lint-free wipers dampened with denatured ethyl alcohol.

Important: Never clean an insulating component with the same wiper used to clean aluminum or metal parts.

1.1.2 Lubrication

Circuit breakers must be lubricated only where required and with specified lubrication.

1.1.3 Fastener Locking

Since the impact loading which the circuit breaker experiences during operation tends to loosen threaded hardware, Loctite Threadlocker must be applied to all critical bolted joints. Four types of Loctite are used for specific applications: 222, 242, 262, and 271. Table 1 specifies the recommended torque and type of Loctite to be applied to all fasteners in the breaker except where specified otherwise.

Clean the threads in blind holes if they can be adequately dried afterwards. Apply Loctite sparingly to the outermost edges of the thread. Two small drops of Loctite are enough even for large threads.

Hardware secured with Loctite usually can be unfastened with proper wrenches. In case of difficulty, the connection can be loosened by heating the joint to 150°C (300°F). Be careful not to damage materials which are sensitive to heat, such as insulation or sealing components.

Use particular care in applying Loctite to fasteners used in assembling current carrying connections. Apply Loctite only where specified. If used improperly, Loctite can squeeze between contact areas and may cause a high resistance joint. Ensure that excess Loctite does not squeeze into contact areas.

1.1.4 Seals

Sealing rings which have been in service will be deformed from being compressed into their sealing grooves. Therefore, when disassembling components with sealing rings, replace them. Replacements are available from ABB.

Maintenance tips pertaining to seals include:

1. Do not grease or lubricate O-rings or any other seals unless specified otherwise.
2. Never clean seals with abrasives even if they are very fine.
3. Use only lukewarm, soapy water to clean the seals.
4. Use a soft, dry cloth to dry the seals.
5. Always check seals for cracks, deformities, and brittleness before they are installed. Acceptable seals are flexible and free of cracks. Do not install seals that are cracked, brittle, or deformed.

1.1.5 Flange Corrosion Protection

The grease used in sealing joints (Dow Corning FS-1292) is intended to be used as a flange corrosion protectant only. This grease is to be applied to all flange surfaces outside of the O-ring seals, or in other words, to areas where water can become entrapped between metal-to-metal joints. Pay special attention to areas around bolts where moisture is most likely to enter. Apply Dow Corning Fluoro Silicone FS-1292 Grease in all such cases.

1.1.6 Treatment of Silverplating

Silverplated contact areas can be polished *lightly* with Scotch-Brite to remove surface oxide. Do not heavily abrade the silverplated surfaces to avoid rubbing off the plating.

In situations where sliding contact joints are used, such as in the case of the plug-in type bushing conductors or main breaker contacts, the silverplated areas must be lubricated with Shell Alvania No. 2 Grease. Thoroughly rub the grease into the microscopic pores of the silverplated surface; remove all excess grease so that only a light film remains.

Table 1

Recommended Fastener Torque (If Not Specified)

		M5	M6	M8	M10	M12	M14	M16	M18	M20	
Metric											
Metric Grade 5.8	ft-lbs	3	5	13	25	43	68	101	144	198	
	Nm	4	7	17	34	58	92	137	195	268	
Metric Grade 8.8	ft-lbs	5	8	20	38	66	105	156	223	306	
	Nm	6	11	27	52	89	142	212	302	414	
Metric Grade 10.9	ft-lbs	7	12	28	54	93	148	221	314	431	
	Nm	9	16	37	73	126	201	299	426	585	
{SS} GradeA2	ft-lbs	4	6	14	28	48	77	115	163	224	
	Nm	5	8	19	38	66	104	156	221	304	
U.S. Standard											
		#10	1/4	5/16	3/8	1/2	9/16	5/8	3/4	7/8	1
SAE Grade 2	ft-lbs	3	6	12	21	51	72	99	171	219	327
	Nm	4	9	17	29	69	98	134	232	297	443
SAE Grade 5	ft-lbs	4	10	19	33	78	111	153	264	338	584
	Nm	6	13	26	45	106	151	207	358	459	792
SAE Grade 8	ft-lbs	6	14	27	47	110	157	216	373	631	942
	Nm	8	19	37	63	150	213	293	505	856	1278
18-8 SS Grade 2	ft-lbs	3	7	15	25	60	85	117	202	298	479
	Nm	4	10	20	34	81	116	158	274	405	649

Note: Do not exceed grade 5.8 torques when the fastener is threaded into cast aluminum or for button head socket bolts.

Note: Use Loctite 222 through 1/4-inch (M6) and Loctite 242 above 1/4-inch (M6). Keep Loctite off silverplated surfaces.

2 Maintenance Frequency

Table 2 provides a list of maintenance checkpoints and suggested inspection frequency for general breaker maintenance. Specific maintenance procedures for components such as the mechanism and interrupters are found in their respective modules.

Refer to the Checklists module for checklist sheets to follow when performing monthly, yearly, and 5-year maintenance inspections. Make copies of these original checklists to serve as helpful references and sign-off sheets when performing maintenance. Checklists for interrupters and mechanism maintenance are in their respective modules.

Table 2

Maintenance Table

	Inspection Intervals			
Item/Condition	**Monthly**	**Yearly**	**5-Year**	**Major#**
All Sealing Rings Affected During Major Maintenance	-	-	-	A
SF6 Gas Pressure	C	C	C	C
SF6 Gas Density Monitor Settings	-	C	C	C
Moisture Content of the SF6 Gas	-	C	C	C
Leak Test Fittings and All Gas Sealing Connections	-	C	C	C
Circuit Breaker Timing	-	-	C	C
Contact Resistance (Micro-Ohms)	-	-	C	C
Anti-Condensation Heaters	-	C	C	C
Bushing Hardware	-	C	C	C
Tank Mounting Hardware	-	C	C	C
Rupture Disk Cover & Hardware	-	C	C	C
Bellcrank Housing & Hardware	-	C	C	C

At 10 years

A - Replace. Replace the part when it reaches the permissible number of operations. If, after the inspection period of 10 years, the parts are in very good condition (e.g., if there have been very few or no operations), the parts need not be replaced.

C- Check. Carry out a comparison of the nominal and actual values (settings and readings). Check hardware for tightness.

3 Standard Testing

The following standard tests are performed as part of maintenance:

- Pole resistance measurement (refer to section 3.1);
- Moisture measurement of the SF_6 gas in the breaker (refer to section 3.2);
- Leak checking (refer to section 3.3);
- Operational and timing tests (refer to section 3.4);
- SF_6 gas density monitor calibration (refer to section 3.5).

3.1 Pole Resistance Measurement

Using a 100 A micro-ohmmeter (or millivolt drop meter), perform a contact resistance (or milliVolt drop) measurement on each pole of the breaker. The maximum resistance from bushing terminal to bushing terminal should not exceed 150 micro-ohms.

3.2 Moisture Measurement of the SF_6 Gas

Use a moisture analyzer (hygrometer) to measure the moisture content of the SF_6 gas in the breaker. Refer to section 3.2.1.

Important: *An adequate moisture content reading can be taken 1 hour after filling the circuit breaker with gas. However, if time permits, allow 24 hours or more for the gas system to stabilize before taking a moisture content reading. The additional time for stabilization will ensure a more accurate reading.*

The maximum moisture level permitted in the SF_6 gas is:

200 ppmV (by volume) at 68°F (20°C)

The maximum moisture content to be expected from an SF_6 gas cylinder is:

SF_6 Dew Point of -50°F (-45°C)

Caution

Should the moisture content of the SF_6 gas exceed 200 ppmV on filling, the SF_6 gas must be reclaimed and recycled through a drying filter. Before refilling, the circuit breaker must be evacuated to eliminate moisture using the procedure in section 4.3.3 for replenishing gas to a pole unit that has been opened.

3.2.1 Measuring the Moisture

To ensure reliable moisture measurements, pay particular attention to cleanliness and prescribed procedure, particularly as it applies to preventing moisture from contaminating the moisture analyzer (hygrometer) and its connections. It is important that the recommendations of the analyzer supplier be followed carefully.

The gas is sampled through the 1/4-inch 37-degree male flare fitting 60008 (Fig. 12) located at the outlet of the sample valve 60007. Use only stainless steel tubing to connect the instrument. Cap the tubing immediately after taking the sample to keep moisture out.

3.3 Leak Checking

After the breaker has been opened or if an SF_6 leak is suspected, check the following threaded, O-ring, and gasket connections with a hand held halogen leak detector:

- Tube connections and fittings to the pressure gauge;
- SF_6 gas density monitor;
- SF_6 gas plumbing;
- Rupture disk;
- Bushing flanges;
- Rear tank cover assembly;
- Bellcrank housing;
- Interphase shaft seals with the breaker opened and closed.

3.4 Operational and Timing Tests

Before placing the breaker into service, perform operational and timing tests. Refer to section 3.4.1 for information pertaining to operational tests; refer to section 3.4.2 for details about circuit breaker timing tests.

3.4.1 Operational Tests

The control relays, protection devices, and schemes must be fully checked by operational tests to ensure that the breaker is ready for service. Because the control schemes are usually designed as per customer specifications, operational tests vary depending upon the particular control scheme. Refer to the breaker control schematic to determine the necessary operational tests to be performed.

Generally, operational tests include the following steps:

1. Assure that the circuit breaker will open and close electrically at both the local control switches and at the remote control switches. If a local/remote or maintenance test switch is used, verify that it is functioning properly.
2. Check the alarm and operation lock-out functions for proper actuation. The 145 PM breaker has two parameters which are monitored: SF_6 gas density and operating energy of the mechanism. To calibrate the SF_6 gas density monitor refer to section 3.5 of this module. To verify the operating energy of the mechanism, refer to the "Commissioning" section of the Mechanism module.
3. Verify that the anti-pumping circuitry (Y relay or X-Y relay scheme) is operating properly as per your particular control scheme.
4. Test any optional devices i.e., undervoltage relays, reclose time delay relays, etc.

3.4.2 Timing Tests

Timing tests are performed to verify that the circuit breaker contacts are opening and closing at acceptable velocities and within time limits that meet the design parameters of the circuit breaker and the high voltage system. Timing tests include:

- Measuring contact closing and opening times (section 3.4.2.1);
- Measuring contact velocity (section 3.4.2.2).

A full set of timing tests, including contact velocity measurements, are performed at the factory prior to shipping the breaker. Upon installation, contact timing tests as described in section 3.4.2.1 should be performed to verify closing and opening times. Contact velocity measurements are not required on installation, but should be performed during the 5-year scheduled maintenance.

A wide variety of circuit breaker analyzers (timing equipment) are available to perform these tests. The two most common types of circuit breaker analyzers are oscillographic analyzers using light-sensitive chart paper and the more advanced digital timers. Either oscillographic or digital devices are acceptable, however, the digital devices are more accurate and tend to be easier to use. Circuit breaker analyzers are normally supplied with all test leads, motion transducers, and timing channels necessary to perform timing tests.

The actual procedures for using the analyzers vary by manufacturer. However, all circuit breaker analyzers provide the following:

- Timing channels which monitor the closing and opening of the main contact;
- Channels which monitor trip and close coil currents;
- Motion channels which monitor contact movement via motion transducers;
- Event charts showing distance (vertical units) vs. time (horizontal units).

Perform all timing tests with the gas system pressurized to 87 psig (600 kPaG) at 20°C (68°F) and with the mechanism fully charged.

Refer to Table 3 for timing specifications. Figures 2, 3, and 4 show typical oscillographic measurements of timing parameters; Figures 5 and 6 show typical oscillographic motion characteristics (distance vs. time) for breaker opening and closing.

Table 3
145 PM Timing Specifications

Opening Time	30 ms maximum
Opening Velocity for FSA-2 Spring Mechanism	3.8 to 4.2 m/s
	12.4 to 13.8 ft/s
Opening Velocity for HMB Hydraulic Mechanism (40 kA interrupting rating)	4.6 to 5.0 m/s
	15.0 to 16.4 ft/s
Opening Velocity for HMB Hydraulic Mechanism (50/63 kA interrupting rating)	4.3 to 4.8 m/s
	14.1 to 15.7 ft/s
Inter-Pole Spread Opening	2 ms maximum
Closing Time	50 to 65 ms
Closing Velocity for FSA-2 Spring Mechanism	2.5 to 2.8 m/s
	8.2 to 9.2 ft/s
Closing Velocity for HMB Hydraulic Mechanism (40 kA interrupting rating)	2.5 to 2.9 m/s
	8.2 to 9.5 ft/s
Closing Velocity for HMB Hydraulic Mechanism (50/63 kA interrupting rating)	2.1 to 2.5 m/s
	6.9 to 8.2 ft/s
Inter-Pole Spread Closing	2 ms maximum
Close-Open Time for FSA-2 Spring Mechanism	25 to 50 ms
Close-Open Time for HMB Hydraulic Mechanism (40 through 63 kA interrupting rating)	20 to 38 ms
Reclose Time	20 cycles minimum

3.4.2.1 Contact Closing and Opening Times

Contact closing and opening times must be within the specified limits shown in Table 3 to assure that the circuit breaker is functioning properly. As part of maintenance, tests should be performed to verify the following:

Closing time (contact make) - time interval elapsed between energization of the close coil and the last arcing contact to make on closing (Fig. 3); units are in milliseconds (ms) or cycles (Hz).

Opening time (contact part) - time interval elapsed between energization of the trip coil and the last arcing contact to break on opening (Fig. 2); units are in milliseconds (ms) or cycles (Hz).

Close-Open time (trip-free time) - time interval elapsed between the last arcing contact to make on closing and the last arcing contact to break on opening (Fig. 4); units are in milliseconds (ms) or cycles (Hz).

Reclose time (open-close) - time interval elapsed between the energization of the trip circuit for an open operation and the making of the arcing contacts on the subsequent close operation; units are most commonly in cycles (Hz).

Inter-pole spread on closing - time interval between the first arcing contact to make and the last arcing contact to make on closing (Fig. 3); units are most commonly in milliseconds (ms).

Inter-pole spread on opening - time interval between the first arcing contact to break and the last arcing contact to break on opening (Fig. 2); units are most commonly in milliseconds (ms).

Caution

The *reclosing* time of a circuit breaker is defined as the time interval between energization of the trip circuit for an open operation and the making of the primary arcing contacts of the interrupter on the subsequent close operation.

The *rated reclosing* time of a circuit breaker is defined by ANSI Standards to be a minimum of 20 cycles. In practice, this time delay allows for deionization of fault current paths and to restore the arcing region of the breaker to its full interrupting performance level. The 145 PM breaker has been tested for this capability with the required time delay intentionally introduced by control circuits external to the breaker. For testing purposes, while the breaker is isolated from the system, the 145 PM breaker is fully capable of instantaneous reclose operations (no time delay), without sustaining mechanical damage. The instantaneous reclose time may be approximately 7 cycles. However, unless specified by contract documents, timing devices to achieve the required minimum 20-cycle delay are not provided as part of the local control circuit for the breaker. Prior to placing the breaker into service, ensure that the required time delay be part of the complete control circuit for the breaker.

ABB requires a minimum 20-cycle reclosing time.

3.4.2.2 Contact Velocity

Maintaining contact velocity within the specified limits shown in Table 3 is necessary to assure that the circuit breaker is functioning properly. Contact velocity (meters/second or feet/second) on breaker opening or closing is factory set prior to shipment. Since the contact velocity is dependent upon mechanism settings (e.g. spring pre-charge, etc.) which are unlikely to change in the relatively short time between shipment and installation, taking motion characteristics to determine contact velocity is optional during initial installation and commissioning. However, these measurements should be performed during the 5-year maintenance procedures and at major maintenance (10 years).

Contact velocity is deduced from motion characteristics of distance vs. time. Figures 5 and 6 show typical distance vs. time characteristics. To obtain motion characteristics, a motion transducer must be attached to the circuit breaker. The travel recorder kit T13435, installed as per Figures 7 and 8, will be needed to apply the motion transducer.

Once distance vs. time characteristics are obtained, contact velocity can be calculated. Contact velocity is defined as the average velocity between the two given speed measuring points as shown in Figures 5 and 6, i.e, the slope of the line drawn between these two points.

Important: *The speed measuring points for the FSA-2 spring mechanism are at 30 and 70 mm from the fully open position. The speed measuring points for the HMB hydraulic mechanism are at 40 and 70 mm from the fully open position.*

The distance traveled (on the vertical axis) between the two speed measuring points is always 40 mm (i.e. 70 mm - 30 mm = 40 mm) (Figs. 5 and 6) for FSA-2 spring mechanisms and 30 mm (i.e. 70 mm - 40 mm = 30 mm) for HMB hydraulic mechanisms. To calculate the contact velocity, the time taken to travel the distance between the two speed measuring points must be determined from the horizontal (time) axis. Contact velocity is calculated using the following formula:

$$\text{Contact Velocity} = \frac{\text{Distance } (mm)}{\text{Time } (ms)}$$

The value calculated from this formula for contact velocity will be in m/sec.

Important: *If contact velocity or the amount of overtravel is not within the specified limits as shown in Figures 5 and 6, refer to the Mechanism module for instructions on adjusting the mechanism.*

3.5 SF_6 Gas Density Monitor Calibration

The SF_6 gas density monitor 60002 (Figs. 1 and 11) is calibrated at the factory as follows:

- The temperature probe is set at 20°C (68°F);
- Switch C (Fig. 11) is set to close at 76 psig (524 kPaG) (alarm point) with decreasing pressure;
- Switches B1 and B2 (Fig. 11) are set to close at 72 psig (496 kPaG) (breaker lock-out point) with decreasing pressure (unless alternate values are listed on the first page of the wiring diagrams in the Customer Data module).

DANGER

To prevent personal injury and damage to the equipment, before beginning any calibration or adjustment, de-energize the breaker and remove it from service.

Warning

Never change the switch settings from the factory-specified setpoints shown on the first sheet of the wiring diagrams in the Customer Data module - otherwise breaker failure could result.

To calibrate the SF_6 gas density monitor and adjust the pressure switches:

1. Refer to the SF_6 Gas Density Monitor Calibration Curve and Chart (Figs. 9 and 10) to determine the proper alarm and lock-out pressure settings for the current ambient temperature.
2. Determine the existing alarm and lock-out settings by closing the isolation valve 60006 (Fig. 1) to separate the SF_6 gas density monitor 60002 and SF_6 gas pressure gauge 60003 from the pole units.
   a. Bleed this negligible amount of gas through the sample valve 60007 until the alarm occurs.
   b. Read the setting points on the pressure gauge 60003. It is strongly recommended to use an accurate, calibrated, test pressure gauge to verify the integrity of the control cabinet pressure gauge and to ensure accurate alarm and lock-out settings.
3. If the pressure spread (differential) between pressure switches is correct, with all settings either high or low by the same amount, use the main pressure adjustment nut (Fig. 11) to make the necessary changes. Use the main pressure adjustment nut to adjust all of the pressure switches at one time. Turning this nut clockwise increases the settings of all of the pressure switches by the same increment, while turning it counter-clockwise decreases all of the settings.
4. To change the pressure setting of an individual pressure switch, use the individual pressure switch adjustment nut (Fig. 11). Turning the nut clockwise increases the alarm pressure setting, while turning it counter-clockwise decreases the alarm pressure setting.

Important: Adjusting one of the individual pressure switches will often affect the settings of the other pressure switches. Adjustments should be made in small increments and a final verification of all pressure switch settings should be performed.

Always adjust in the order from high pressure switches to low pressure switches, i.e., start with switch C (Fig. 11) and then adjust switches B1 and B2.

5. After adjustments are complete, perform a final verification of all pressure switches.

Notice: Never severely bend or kink the capillary tube.

6. Be sure that the isolation valve 60006 (Fig. 1) is open.

Warning

The isolation valve must remain open for proper operation of the low density SF_6 alarm and lock-out controls. A closed isolation valve could result in low gas density operation and cause breaker failure or damage.

7. Complete the density monitor calibration section of the appropriate Maintenance Checklist in the Checklists module.

4 SF_6 Gas Removal and Replenishing

The properties of the sulfur hexafluoride (SF_6) gas used in the breaker must meet the specifications for sulfur hexafluoride according to ASTM D2472-71. SF_6 gas is available in standard industrial type cylinders. The adapter needed for connecting to the cylinder is a CGA #590 male left-hand thread connector. Cylinders containing a charge of either 25 lbs or 115 lbs of gas are available. The pressure in the cylinder is 300 psi at 24°C (75°F).

The circuit breaker should be filled with SF_6 gas to a pressure of 87 psig (600 kPaG) at 20°C (68°F).

Important: *When filling the breaker with SF_6 gas, compensate for temperature variation as shown in the pressure vs. temperature characteristics of Figure 9. The SF_6 Gas Filling and Density Monitor Calibration Chart in Figure 10 is a quick reference, tabular version of the characteristics in Figure 9. For example, at -1°C (30°F) the correct fill pressure would be 78.2 psig (539.2 kPaG).*

The SF_6 pressure gauge is mounted in the control cabinet and can be seen through a view port on the front wall. This gauge has an accuracy of 2 percent. It is good policy to periodically verify the calibration of this gauge using a test gauge with an accuracy of at least 1/4 percent, especially following shipment. The pressure gauge in the breaker is adjustable and can be re-calibrated.

4.1 Gas Handling Equipment

Either a gas cylinder (bottle) or a gas service unit can be used to top off a breaker as long as the breaker has already been evacuated and contains a definite positive pressure of sulfur hexafluoride (SF_6) gas. The gas service unit is the environmentally preferred and recommended equipment to be used when the breaker must be opened. Refer to section 4.1.1.

Notice: *When the breaker is shipped from the factory, it already is positively charged with SF_6 gas to approximately 5 psig (34.5 kPaG). Unless this initial charge of gas is lost because of unusual circumstances, the breaker can be simply topped off to the proper level on installation without performing a vacuum procedure.*

An in-line portable filter with a molecular sieve medium (desiccant) may be used each time the breaker is filled. The filter removes SF_6 decomposition products and moisture from the gas.

When filling the breaker from a cylinder supplied by a reputable gas manufacturer, using a filter as a precaution is not normally necessary.

4.1.1 Gas Service Unit

The gas service unit is an all-in-one, contained system which allows the SF_6 gas to be cost-efficiently and effectively reclaimed and recycled. Refer to Plate 1. The features on the gas service unit provide the following distinct advantages:

- The unit is cost-efficient because it saves money by reclaiming and storing the expensive SF_6 gas.
- The in-line filter on the unit removes moisture and arc by-product impurities from the recycled gas as it is being reclaimed.
- The unit is environmentally preferred because it eliminates the need to release the SF_6 gas into the atmosphere.
- The built-in vacuum pump on the unit removes air and moisture from the breaker and eliminates the need to have a separate vacuum pump.
- After the necessary vacuum is attained, the breaker can be refilled with gas directly from the gas service unit.

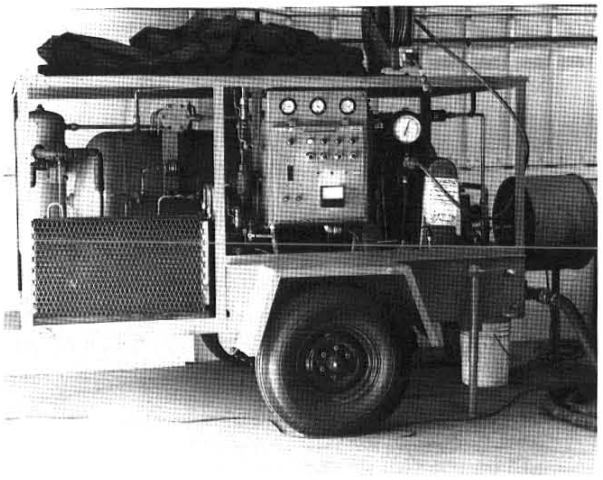


Plate 1: Gas service unit

4.2 Reclaiming SF_6 Gas from a Pole Unit

Use the procedure described in this section to reclaim SF_6 gas from a pole unit. The gas must be reclaimed any time a pole unit is to be opened.

DANGER

Remove the SF_6 gas before attempting to open the pole unit. Break the vacuum if the tank pressure is below atmospheric pressure.

Use a gas service unit to reclaim SF_6 gas from the pole unit. The gas service unit not only reclaims and stores the SF_6 gas but also, if equipped with the appropriate filters, can remove decomposition products from the gas.

Important: It is not economical or environmentally wise to exhaust the SF_6 gas to the atmosphere.

The gas service unit should be used to reclaim SF_6 gas only. Therefore, no air or other gases should ever be in the tank of the gas service unit. Check that air is purged from the unit and that the SF_6 gas already contained in the unit is of good quality (particularly in regards to gas moisture content). Use a moisture analyzer to check the moisture content of the gas in the gas service unit.

Review instructions for the gas service unit if you are not already familiar with the unit.

To reclaim SF_6 gas from a pole unit:

1. Connect the flexible hose from the gas service unit to the DILO quick disconnect tool T13433 (Fig. 13) supplied with the standard tools.
2. De-couple the pole to be serviced from the SF_6 gas manifold by loosening the self-sealing DILO quick disconnect fitting 10171 at the rear tank cover assembly 10032 (refer to Plate 2). The de-coupled fitting will seal on both sides so that no SF_6 gas can be lost from the pole units.
3. Evacuate the hose from the gas service unit to drive out air and moisture using the vacuum pump.
4. Turn off the vacuum pump.
5. Connect the DILO quick disconnect tool to the rear tank cover half of the self-sealing fitting and let the high pressure gas flow from the pole unit to the service unit. Refer to Plate 2.

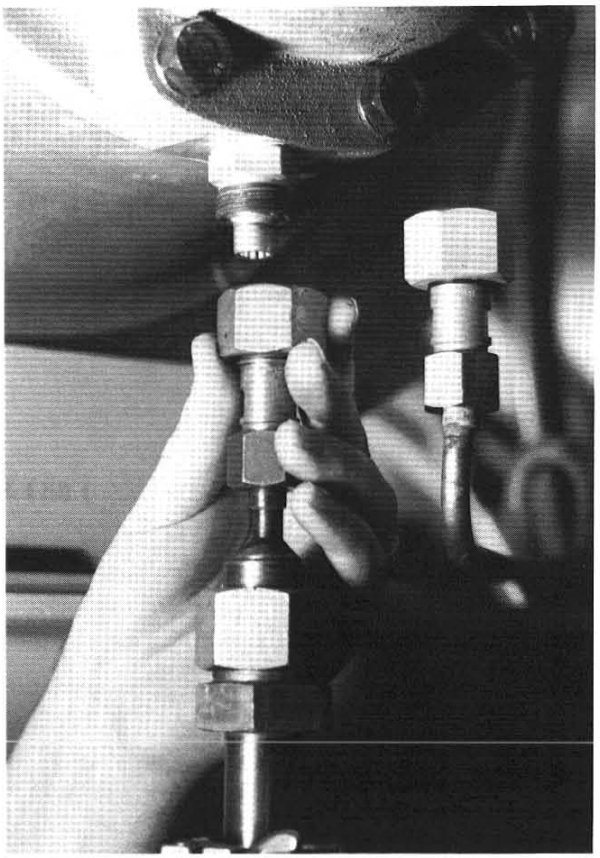


Plate 2: DILO quick disconnect tool

6. Follow the gas service unit procedures step-by-step to remove the SF_6 gas until a vacuum of about 2 mm Hg is achieved. Then close all valves on the gas service unit. Break the vacuum.
7. Repeat this procedure for each pole unit to be opened.
8. Since breaking the vacuum fills the pole unit with atmospheric air and moisture, it is strongly recommended to open the pole unit and clean the internal components of the pole tank promptly after breaking vacuum.

Warning

If decomposition products are present (when the pole unit is opened) they must be removed and disposed of as soon as possible as described in the module Safe Handling Practices for SF_6 Gas. Clean the breaker parts promptly after opening the pole unit to prevent damage caused by corrosive compounds formed when decomposition products are exposed to moisture in the air.

4.3 Filling the Circuit Breaker with SF_6 Gas

The circuit breaker should be filled with SF_6 gas to a pressure of 87 psig (600 kPaG) at 20°C (68°F).

The gas filling procedures vary in cases where the breaker has been opened and unopened.

Warning

Do not over-pressurize the circuit breaker when filling the breaker with SF_6 gas. Over-pressurization may cause the rupture disk to fail.

4.3.1 Filling an Unopened Breaker from a Gas Cylinder

Filling the breaker with SF_6 gas from a gas cylinder should only be done if the pole tanks have not been opened and a positive pressure of approximately 5 psig (34.5 kPaG) at 20°C (68°F) remains in the pole tank. Using a portable inline filter/drier is optional if filling from a gas cylinder.

Important: The gas cylinder should be vertical at all times to prevent introducing liquefied gas into the circuit breaker. Particulate matter within the gas cylinder can be carried with the liquefied gas into the breaker.

To fill the unopened breaker with gas from a gas cylinder:

1. Remove the cap from the 1/4-inch 37-degree male flare fitting 60008 at location F (Fig. 12).
2. Purge the hose and filter (if used) by allowing SF_6 gas from the cylinder to pass through the hose driving out air and moisture.
3. Shut off the gas and immediately connect the hose at location F. Refer to Plate 3.

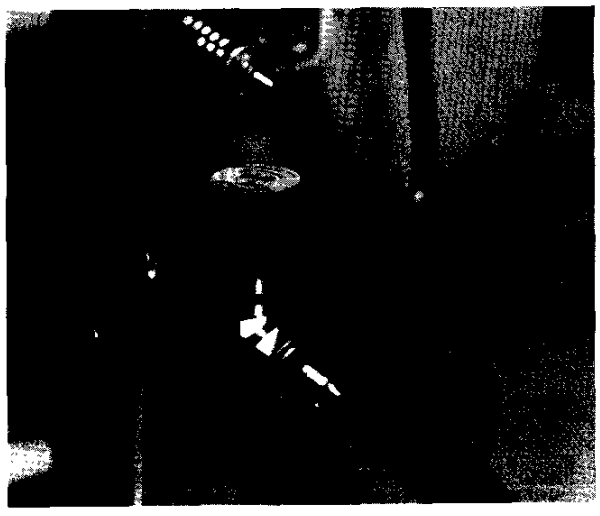


Plate 3: Connecting the fill hose

4. Open the sample valve 60007 (Fig. 12), then open the valve on the regulator at the SF_6 gas cylinder.

Warning

The gas regulator must be adjusted approximately to the final fill pressure of the breaker (87 psig (600 kPaG)) such that the SF_6 plumbing, density monitor, and gauge are not over-pressurized. Compensate for temperature variations as needed.

5. Slowly fill to the pressure for the corresponding temperature as shown in Figures 9 and 10. Approximately 65 lbs. (30 kg) of SF_6 gas by weight will be required for the breaker.

One cylinder of gas will be sufficient to fill one breaker. Usable gas may remain in the cylinder after the breaker is filled.

When filling during cold ambient temperatures, the cylinder may be heated using any of the following methods to convert the liquid SF_6 in the cylinder to a gaseous state:

- An electric blanket heater;
- Immersing the gas cylinder upright in a drum partially filled with warm water so that approximately half of the cylinder is immersed. Heat the water with a portable gas or electric heater.

Warning

Never heat a gas cylinder with an open flame.

Energize heaters only when transferring the gas. When heating the cylinder, be sure that the temperature in the cylinder does not exceed 100°F (38°C).

4.3.2 Filling an Unopened Breaker from a Gas Service Unit

Use the portable in-line filter/drier if using the gas service unit to fill the breaker with SF_6 gas. A filter with a 13x molecular sieve (desiccant) can be used.

To fill an unopened breaker with gas from a gas service unit:

1. Place the filter vertically in the line between the breaker sample valve and the SF_6 gas service unit. Gas will be forced to flow through the desiccant in the filter/drier. Care must be taken to ensure that liquid SF_6 will not enter the portable filter or breaker.

Important: The 13x molecular sieve must be replaced after passing approximately 3500 pounds of gas through the filter.

2. Purge the hose from the gas service unit by allowing the SF_6 gas to pass through the hose driving out air and moisture.
3. Turn off the gas flow and immediately connect the hose at location F (Fig. 12).
4. Open the sample valve 60007 and then open the appropriate valve on the gas service unit.

5. Slowly fill the breaker to the pressure for the corresponding temperature as shown in Figures 9 and 10. Approximately 65 lbs (30 kg) of SF_6 gas by weight will be required for the entire breaker.

4.3.3 Replenishing SF_6 Gas to a Pole Unit That Has Been Opened

After completing work inside the pole unit and immediately before closing the pole tank, install a new desiccant bag on the rear tank cover assembly and re-install the rear tank cover assembly. (Refer to the Pole Unit module of this manual for specific instructions.)

To fill a pole unit which has been opened:

1. Install the DILO quick disconnect tool T13433 (Fig. 13) to the hose of the gas service unit.
2. If it was not already done, de-couple the DILO quick disconnect fitting 10171 at the rear tank cover assembly 10032, separating the gas manifold from the single pole unit.

Important: *If the gas manifold was not decoupled from the pole units, all of the pole units will have been emptied of gas and will need to be evacuated and refilled with gas.*

3. Install the DILO quick disconnect tool from the hose to the quick disconnect coupler half on the rear tank cover assembly.
4. Pull a vacuum to below 1.0 mm Hg absolute measured with an accurate electronic vacuum gauge. Hold the vacuum for 1 hour.
5. Fill the pole tank with SF_6 gas to 87 psig (600 kPaG) at 20°C (68°F). Refer to Figures 9 and 10 for pressures at other temperatures.
6. Repeat the previous steps for all pole units which have been opened.
7. Re-connect the gas manifold when all poles have been refilled with SF_6 gas.

WARNING

The gas manifold must be connected at all pole units to properly monitor the SF_6 gas density at all pole units.

5 Equipment, Maintenance Material, and Renewal Parts

Various types of equipment, i.e., spare parts, and maintenance material are required to maintain a circuit breaker throughout its expected life.

5.1 Equipment

The equipment listed in subsequent sub-sections is used to perform maintenance.

5.1.1 Vacuum Pump

A 50 CFM vacuum pump with two stages having back flow protection is recommended. If a smaller size is available, it will be satisfactory. However, the pump-down time will take longer.

5.1.2 Vacuum Gauge

An accurate portable vacuum gauge sufficient to measure down to 0.5 mm Hg or lower must be used. Stokes Electrical Gauge, Model TB-4, or equivalent is suitable.

5.1.3 Hose Assemblies

For an expeditious vacuum, it is recommended that a short, large diameter hose (e.g., 10 feet or less by 1-1/4 inch I.D. hose) be connected between the breaker and the vacuum pump.

The suggested source for the hose assemblies is:

Aeroquip Hose
300-T S. East Ave.
Jackson, MI 49203

5.1.4 Gas Service Unit

The gas service unit should include the compressor, vacuum pump, active filters, and storage capacity of 350 to 500 lbs. of gas. Suggested sources for the gas service unit are:

DILO Company, Inc.
1936 Beckett Lake Drive
Clearwater, Florida 34623

Limco Corporation
Gravis Point Road
Glenn Cove, NY 11542

5.1.5 Portable In-Line Filter Assembly on the Gas Service Unit

An in-line portable filter connected to the gas service unit may be used each time the breaker is filled or emptied of SF_6 gas. The filter removes decomposition products and moisture from the gas, which protects the compressor and vacuum pump from damage.

The suggested source for the (molecular sieve) in-line filter is:

ABB Service Dept.
125 Theobold Avenue
Greensburg, PA 15601

5.1.5.1 Installing the Portable In-Line Filter

A filter utilizing the 13x molecular sieve (desiccant) can be used on either the gas cylinder or on the gas service unit. To install the portable in-line filter, place the filter vertically in the line between the breaker sample valve and the SF_6 gas service unit or gas cylinder. The gas will be forced to flow through the desiccant. Use care to ensure that liquefied SF_6 does not enter the portable filter or breaker.

Replace the desiccant (13x molecular sieve) after passing approximately 3500 pounds of gas through the filter. Refer to section 5.1.5.2.

5.1.5.2 Replacing Desiccant in the Portable In-Line Filter

The portable in-line filter for the gas service unit incorporates a 13x molecular sieve (desiccant) to remove moisture from the SF_6 gas. When the desiccant is spent, it needs to be replaced. (This desiccant is not to be confused with the desiccant in the rear tank cover of the pole unit.)

The key rule of thumb when replacing the desiccant is to avoid exposing the desiccant to atmospheric moisture. Therefore, it is best to perform this replacement procedure indoors if possible. If hoses are not connected to the gas service unit, always keep the flared cap in place to protect the threads and seal from the atmosphere.

To replace the desiccant in the portable in-line filter:

1. Stand the gas service unit upright and remove the pipe plug at the bottom end of unit, releasing the old desiccant. Discard the used desiccant.
2. Check the plug and clean the threads thoroughly.
3. Apply Teflon tape and Rector Seal #2 to the pipe plug and replace the plug.
4. Pour the desiccant from the shipping container directly into the filter on the gas service unit using a funnel; fill to about 1 inch from the top of the unit. Fill the unit with desiccant as quickly as possible to reduce the time which the molecular sieve and the interior of the column are exposed to the atmospheric moisture (perform indoors if possible).
5. Install the top pipe plug as soon as the filter is filled.

5.1.6 Gas Cylinder Regulator (for Size A Cylinders)

The vendor and code information for the gas cylinder single stage regulator with a delivery pressure range of 1 to 180 psig is:

Air Products and Chemicals Inc.
Code number E11-4-N515F. Connection 1/4-inch NPT

5.1.7 Leak Detector

The suggested sources for leak detectors are:

TIF Halogen Leak Detector Model 5500
Halogen Leaktector, Code 23-7023
Bacharach Instrument Inc.
625 Alpha Drive
Pittsburgh, PA 15238

Gas Leak Detector
Calgon Corporation
Route 60 Cambells Run Rd.
Pittsburgh, PA 15230

5.1.8 Moisture Analyzer

The suggested source for moisture analyzers is:

Electrolytic Moisture Analyzer
Manufacturing Engineering and Equipment
Corp. (MEECO)
250 Titus Avenue
Warrington, PA 18976

5.1.9 Timing Devices

Use any of the following devices to perform circuit breaker timing:

- Digital circuit breaker analyzer
- Oscillographic circuit breaker analyzer
- Mechanical Time Travel Recorder

5.1.10 Micro-Ohm Measurement Equipment

A Ductor or equivalent 100 amp DC micro-ohmmeter can be used to measure pole resistance.

5.2 Tools

Sections 5.2.1 and 5.2.2 provide suggested sets of tools and equipment to have available when installing or maintaining the 145 PM circuit breaker. Most of the tools listed are normally carried by a mechanic and can be substituted by any tool which will perform the same function.

5.2.1 Common Tools Supplied by User

The following tools are required for maintenance and must be supplied by the user:

- 1 Torque wrench - 10 to 150 ft-lbs;
- 1 Torque wrench - 10 to 600 ft-lbs;
- 1 Set box end and open end wrenches 5, 6, 7, 8, 9, 10, 13, 17, 19, 24, 41, 46 mm;
- 1 Set box end and open end wrenches 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, and 15/16 inch;
- 1 Socket wrench, ratchet handle;
- 1 Set of sockets 4, 5, 6, 7, 8, 9, 10, 13, 17, 19, and 24 mm;
- 1 Set of sockets 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, and 15/16 inch;
- 1 Set of Allen head sockets 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 14 mm;
- 2 Nylon slings, 2-inches wide; 6 feet long;
- 2 Step ladders;
- 1 Come along winch
- 1 Portable vacuum cleaner.

5.2.2 Special Tools

Special tools not normally available except through ABB are listed in Table 4.

Table 4
Special Tools

Index Part No.	Description	Designation A or B or C
T13207	Contact Finger Assembly Tool	B
T13406	No-Go Gauge	A
T13428	Threaded Rod Tool	B
T13433	DILO Quick Disconnect Tool	A
T13435	Travel Recorder Kit	A
T13436	Bushing Guide Rods	A
T13437	Deep Socket Tool	B
T13438	Interrupter Assembly Fixture	B
T13439	Clip Tool	B
T13440	Alignment Tool	B
T13441	Bushing Conductor Removal Tool	A
T13442	Sling	C
T13443	Manual Spring Charge Tool	A
T13444	Slow Open/Close Device	A
T13445	Interrupter Dolly	B
T13446	SF6 Gas Regulator & Hose	C
T13447	Vacuum Hose	C
T13448	Vacuum & SF6 Service Cart*	C
T13449	Insulating Nozzle Tool	B
T13451	Manual Open/Close Tool	A
T13452	Socket	A
T13453	Ratchet Handle	A
T13455	Exhaust Tube Tool	B
A - Standard Tools (provided with breaker)		
B - Optional Interrupter Maintenance		
C - Optional (purchased separately)		
*Unit cannot reclaim SF6 gas (not a gas service unit)		

5.3 Maintenance Material

The following list details the maintenance material used for the 145 PM circuit breaker.

- Sulfur Hexafluoride (SF_6):
  Manufactured as per ASTM D2472-71.
  Shipped as liquid gas in steel cylinders containing 27-35 lbs. of gas by weight.
  Each consignment is provided with a test certificate.
  Each cylinder has a serial number and date of delivery.

- Contact Grease
  ABB ED 4.1.3388
  Alvania No. 2
  Shell Oil Company;
- Cleaning Materials - Denatured Ethyl Alcohol;
- Loctite Threadlocker Nos. 222, 242, 262, & 271;
- Alnox Electrical Joint Compound (ABB ED 4.1.3318);
- Dow Corning Fluoro Silicone FS-1292 Grease (ABB ED 4.1.3322);
- Molycote Spray, Dow Corning #321 (ABB ED 4.1.3387);
- Pro AA2 Grease (available through ABB);
- Amber Petrolatum Grease;
- Scotch-Brite extra fine pads;
- Molecular Sieve (Desiccant);
- Cloth gloves;
- Lint-free wipers.

5.4 Renewal Parts

Sufficient renewal parts should be carried in stock to enable prompt replacement of worn or damaged parts. Careful planning for stock of such parts will minimize service interruptions caused by equipment breakdown and will ultimately save time and expense.

The number of renewal parts which should be maintained is dependent on conditions of operations and past experience. When continuous operation is of primary importance, more renewal parts should be stocked, the amount being dependent upon severity of service and the time required to secure replacements. It is recommended that subassemblies be stocked for use as spares.

Renewal parts may not always be identical to the original parts, since revisions may occur which improve the product. The new, improved parts, however, will be interchangeable with the original parts.

Standard hardware items are not listed, and it is suggested that these items be purchased locally to save time and expense. Where hardware is of a special nature or where standard hardware is specifically requested, it will be provided.

5.4.1. Parts Ordering Information

When ordering renewal parts, or for information concerning service or repair of parts, contact the sales office of ABB. When ordering parts, obtain the following information from the breaker nameplate and instruction book to properly identify the parts:

• Order number	see ordering documentation
• Code number of type	see identification plate
• Serial number	see identification plate
• Publication number	see cover page
• Part number	see spare parts list
• Part designation	see spare parts list
• Design	for indoor or outdoor

All parts are shipped F.O.B. point of shipment, freight prepaid and added. ABB will establish the method and routing of shipment. Standard carriers are rail or truck.

Customers may specify the method and route of shipment, but doing so obligates them for the additional expense incurred. Parts also may be sent by air or parcel post.

5.4.2 Parts Storage Instructions

Follow these instructions to preserve parts while they are in storage:

1. Carefully handle parts sealed in plastic bags; avoid ripping the bag; (plastic bags must be intact); only remove the bag when you are ready to install the part.
2. Store rubber parts in a cool, dry place; protect them from light, sun, and rain.
3. Unsuitable storage causes accelerated aging of seals. The following rules permit spare seals to be stored for several years without deterioration:
   - Maintain a storage temperature between 4°C and 21°C (40°F and 70°F).
   - Protect the storage area from water condensation or high humidity,
   - Maintain a closed atmosphere in a suitable packing to reduce the oxidizing effects of air.
   - Store the seals away from effects of ozone or equipment or machines which produce sparks or arcs.
   - Avoid contamination with fluids, oils, and fats. Avoid contact with metals (copper, iron, manganese and their alloys), rubber of other grades, and plastics.
   - Store seals (O-rings) flat with no stress, pressure, deformation, or bending.

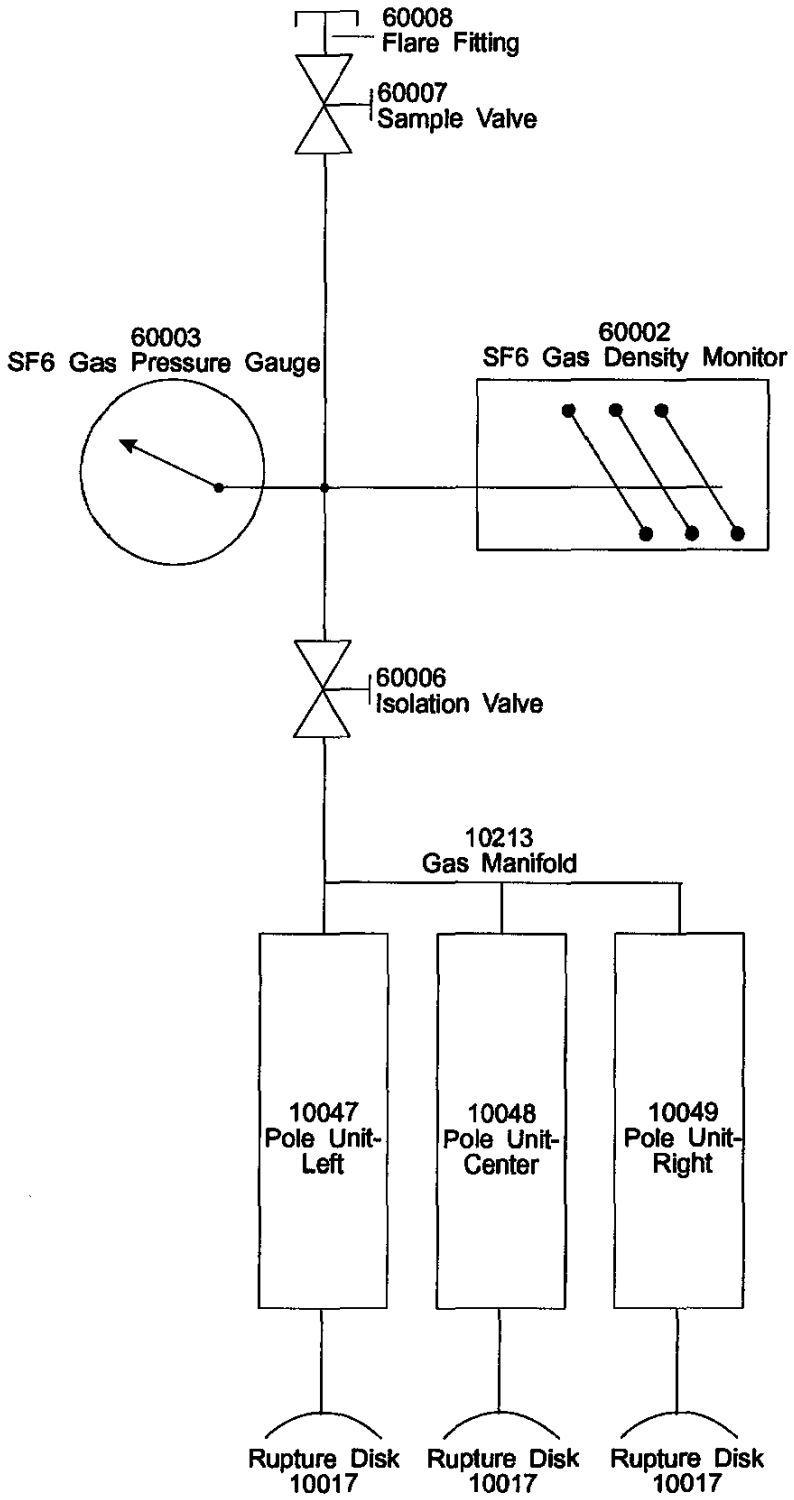
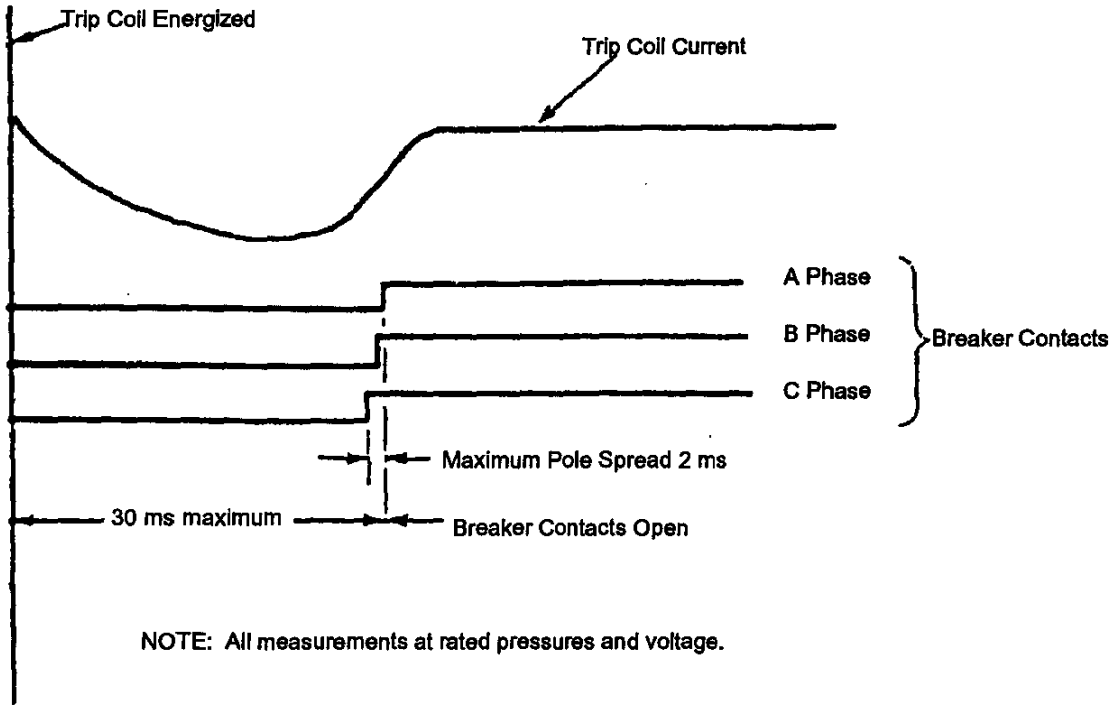
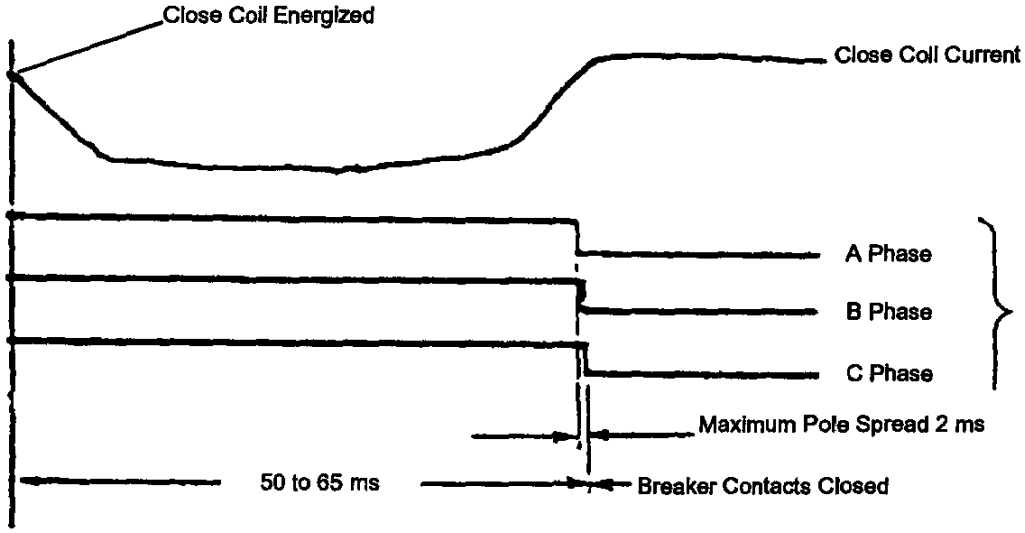


Figure 1
SF_6 Gas Schematic



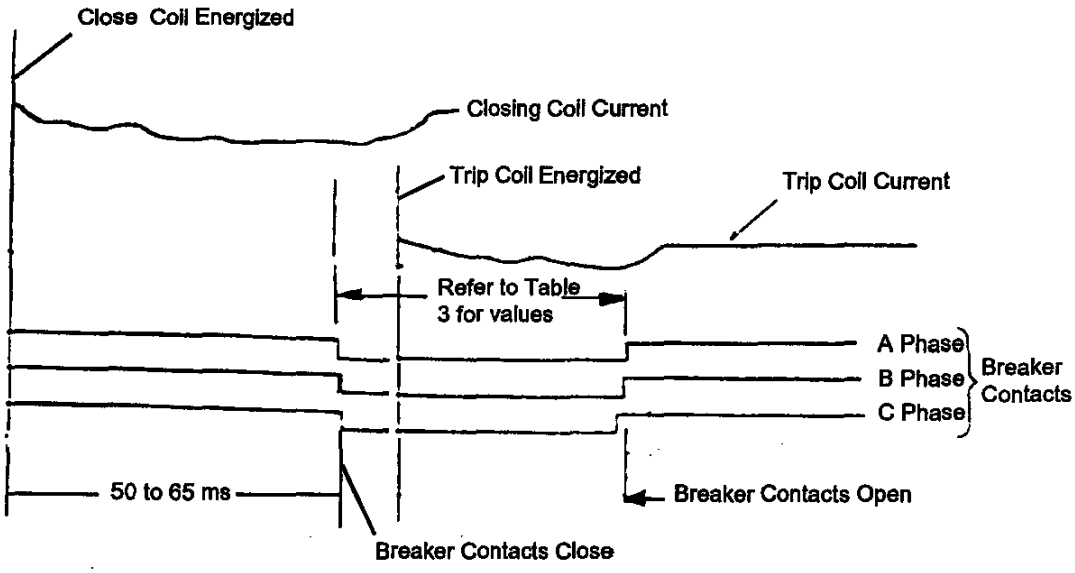
NOTE: All measurements at rated pressures and voltage.

Figure 2
OPEN Operation



NOTE: All measurements at rated pressures and voltage; does not include X-relay time.

Figure 3
CLOSE Operation



NOTE: All measurements at rated pressures and voltage.

Figure 4
CLOSE-OPEN Operation

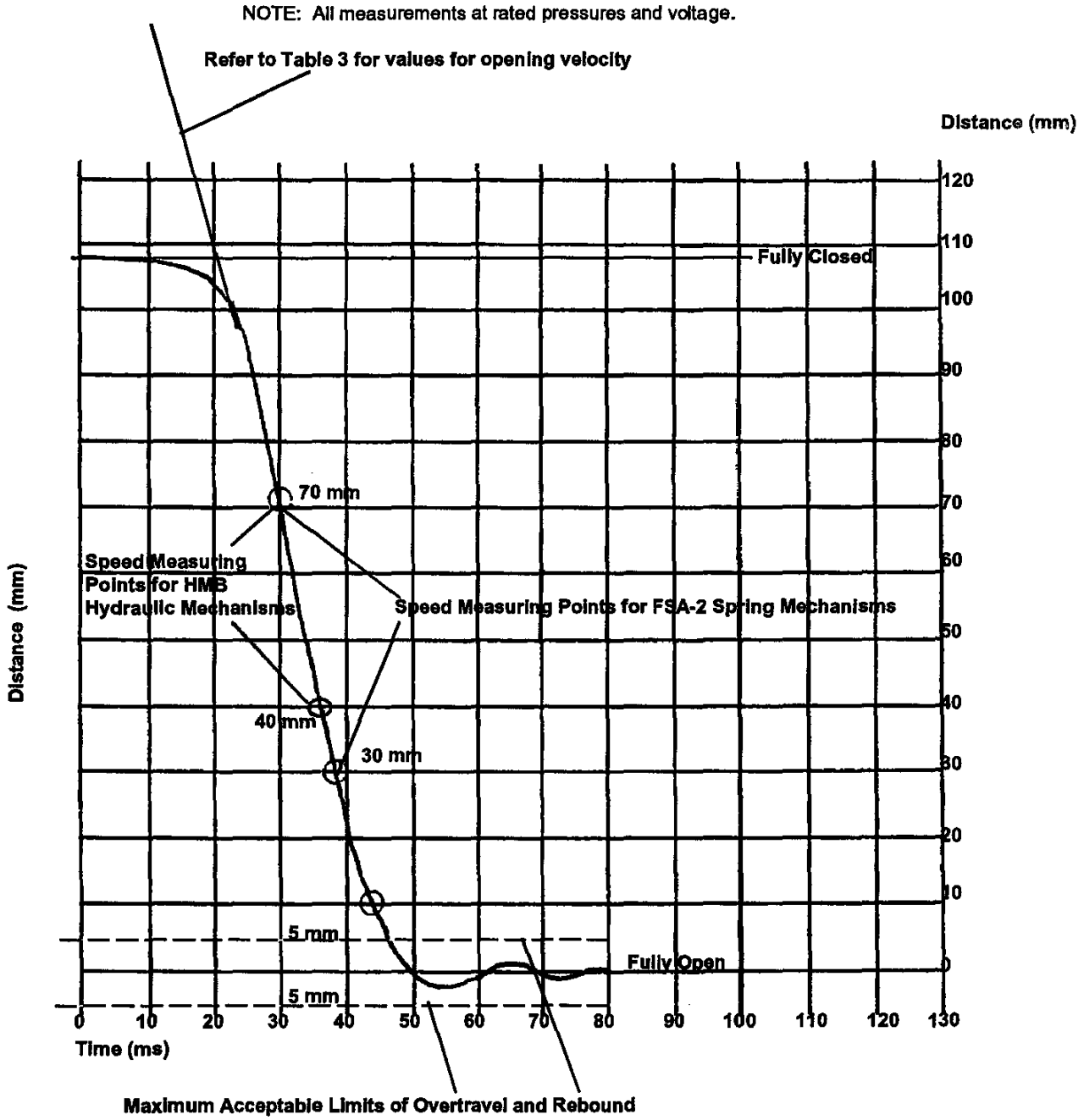
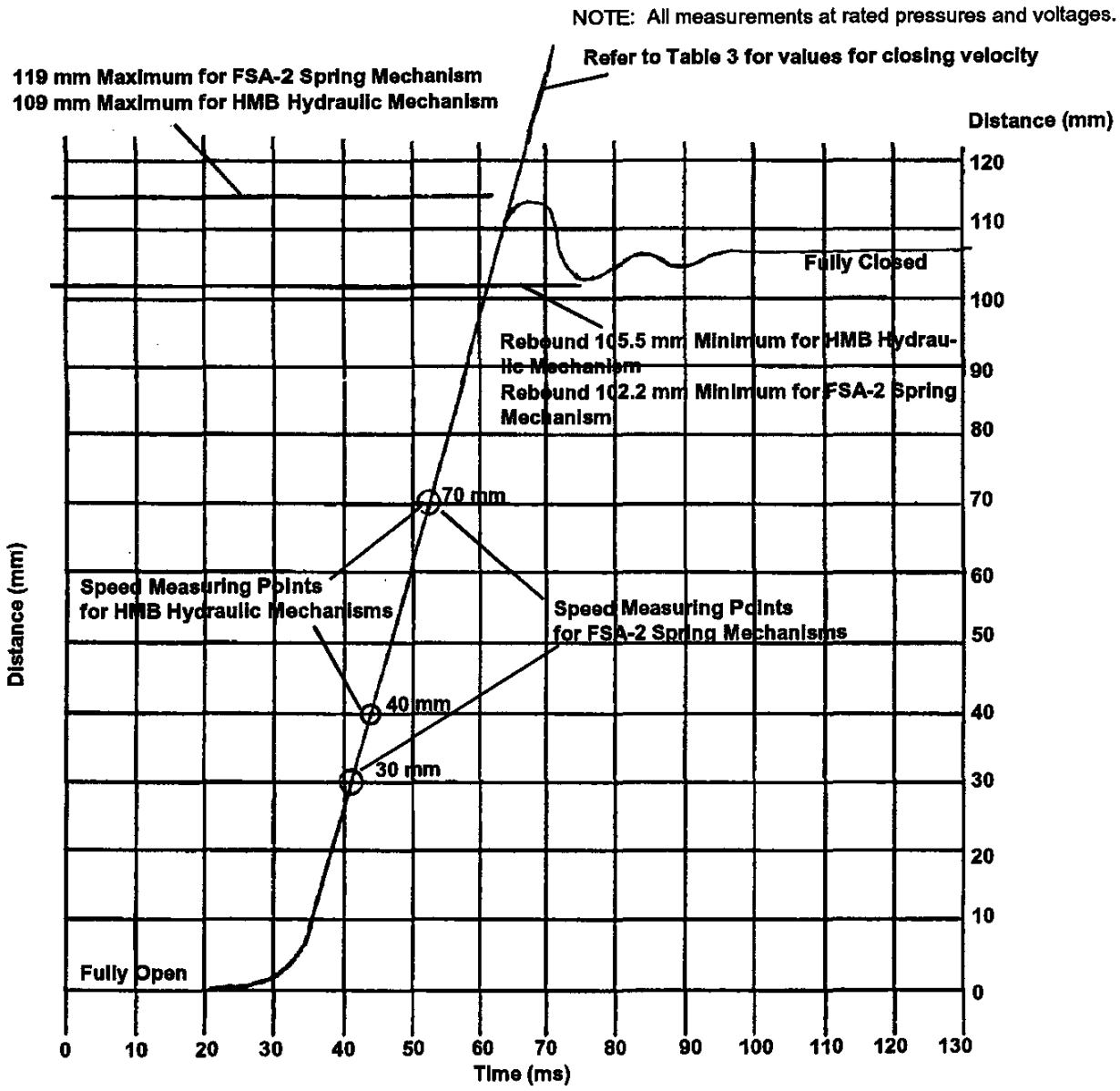


Figure 5
Typical Distance vs Time Travel Curve for the Opening Operation



Breaker Stroke: 104.1 mm Minimum for FSA-2 Spring Mechanism

105.5 mm Minimum for HMB Hydraulic Mechanism

Figure 6
Typical Distance vs. Time Travel Curve for the Closing Operation

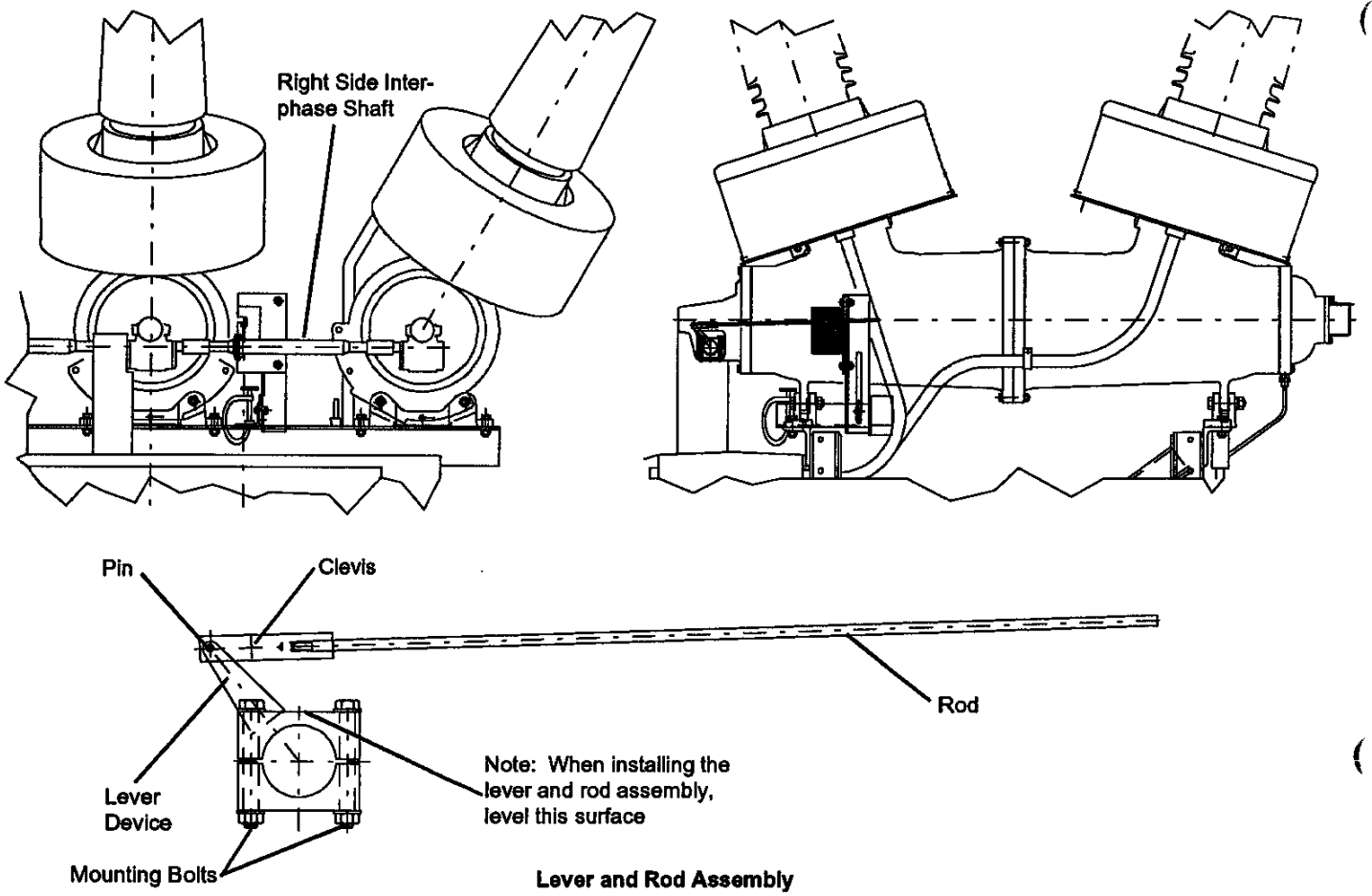


Figure 7
Travel Recorder Kit T13435

Travel Recorder Kit Mounting Instructions

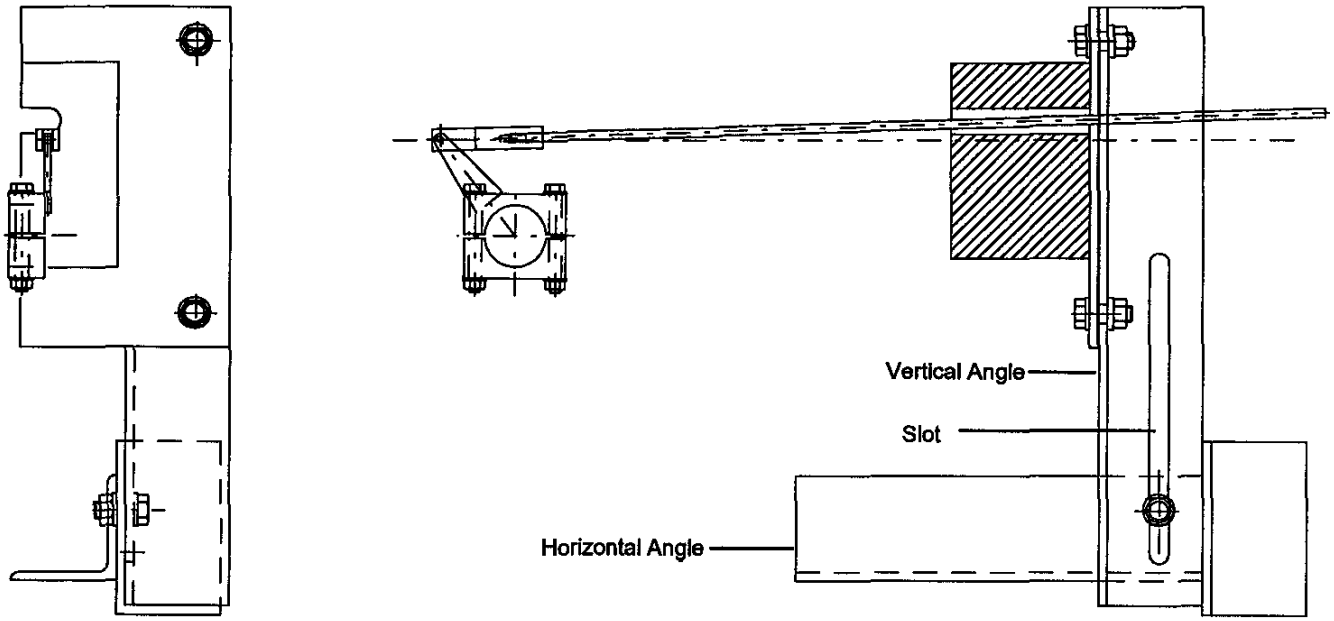
1. Open the circuit breaker and isolate it from the high voltage system. Properly ground the circuit breaker.
2. Discharge the mechanism (in the OPEN position) and disconnect all control and auxiliary power.
3. Remove the cover from the right side interphase shaft.
4. Loosely clamp the lever and rod assembly (Fig. 7) to the right side interphase shaft (at approximately the location shown in Fig. 7) using the mounting bolts provided with the kit. (The exact location where the assembly is clamped is not critical.)
5. While tightening the lever and rod assembly mounting bolts, place a level across the surface of the lever device as shown in Fig. 7 to level this surface of the lever device as closely as possible.

Important: *The travel recorder kit has been designed with enough flexibility so that it is not absolutely critical that the lever device be **exactly** leveled. Should the lever device be off level by a couple of degrees, it will not adversely affect the performance of the travel recorder kit.*

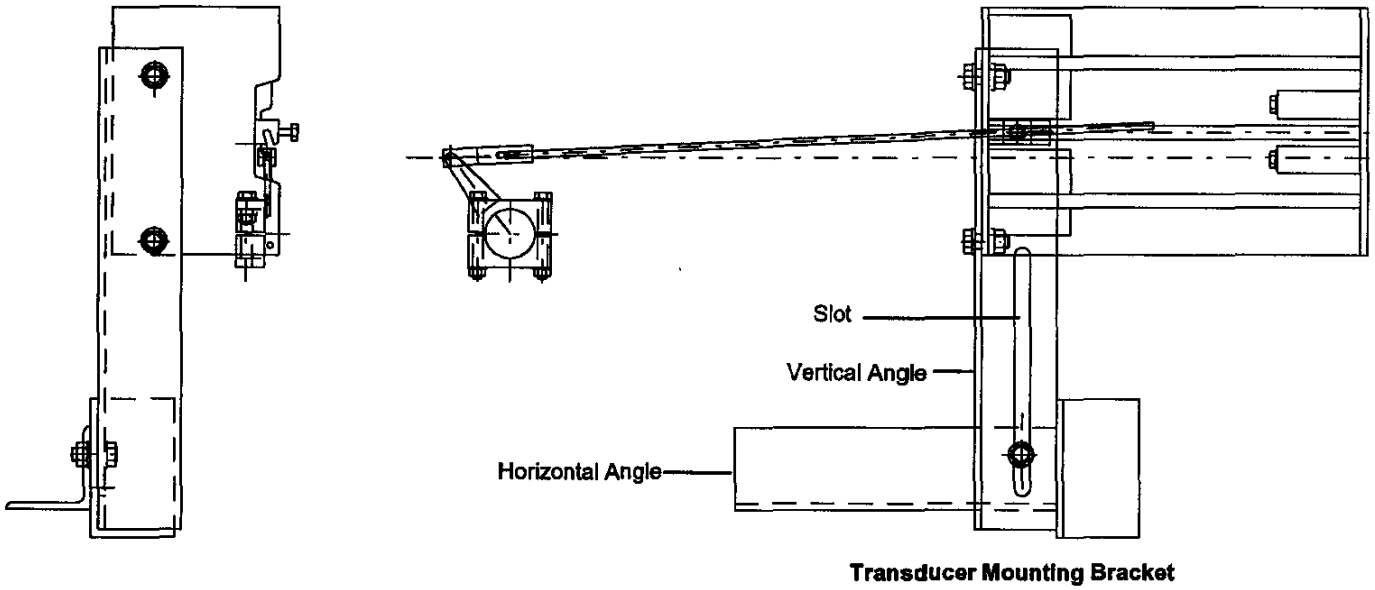
6. Assemble your transducer to the vertical angle of the transducer mounting bracket (Fig. 8) using either bolts or C-clamps. Figure 8 shows the mounting arrangement for two commonly-used transducer types.
7. Mount the transducer mounting bracket and transducer onto the horizontal member of the breaker structure (using C-clamps) as shown in Figure 7 so that the rod of the lever and rod assembly aligns with the slider or rollers, etc. of your transducer.
8. Adjust the height of the transducer by sliding the vertical angle of the transducer mounting bracket along the slot (Fig. 8) until the rod is visibly at a slight, upward angle as shown in Figure 8.

Important: *Having the rod at an exact angle is not critical.*

9. Connect the rod to the slider or rollers, etc. of your transducer.

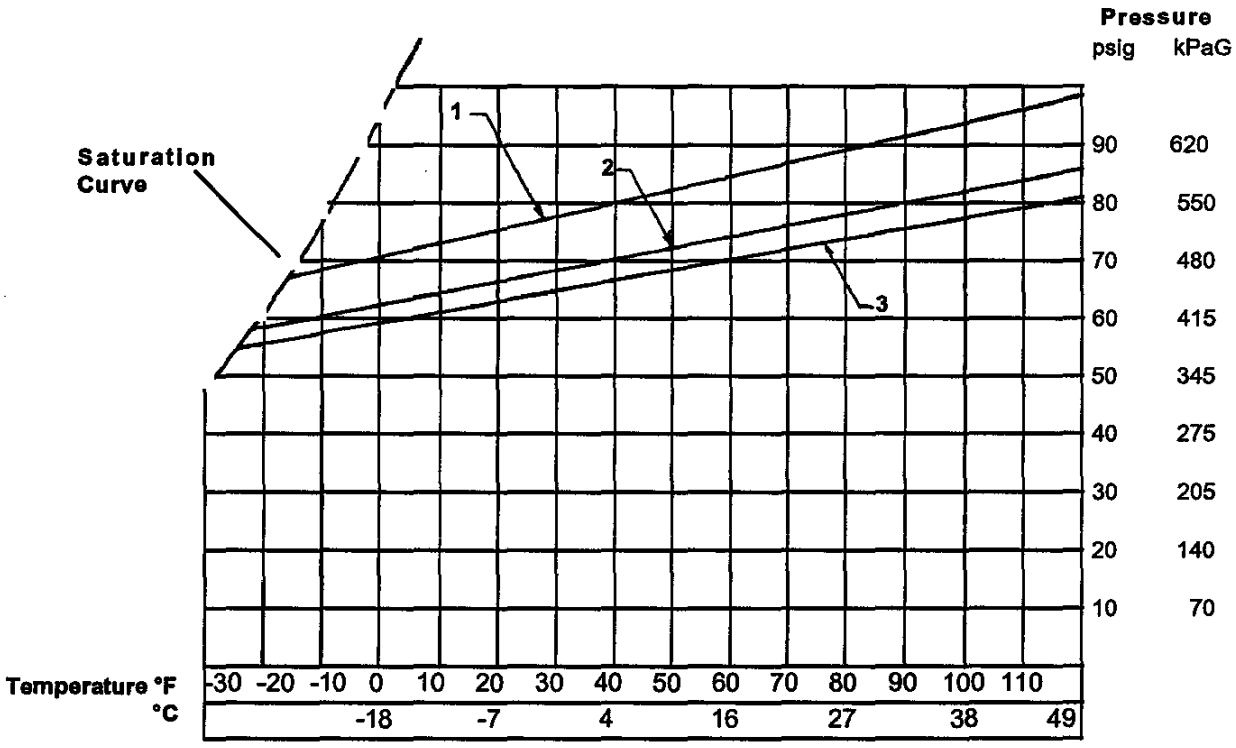


Typical Mounting Arrangement for a Doble Roller-type Transducer



Typical Mounting Arrangement for a Doble Slider/Cable Transducer

Figure 8
Details for the Travel Recorder Kit Mounting



1 Normal Filling Pressure psig or kPaG
2 Low Pressure Alarm (Contact 63-2C Closes)
3 Low Pressure Lock-Out (Contact 63-2B1 & 63-2B2 Close)

Figure 9
SF_6 Gas Density Monitor Calibration Curve for Pressure vs. Temperature

Important: Refer to Figure 10 for a tabular version of the characteristics above.

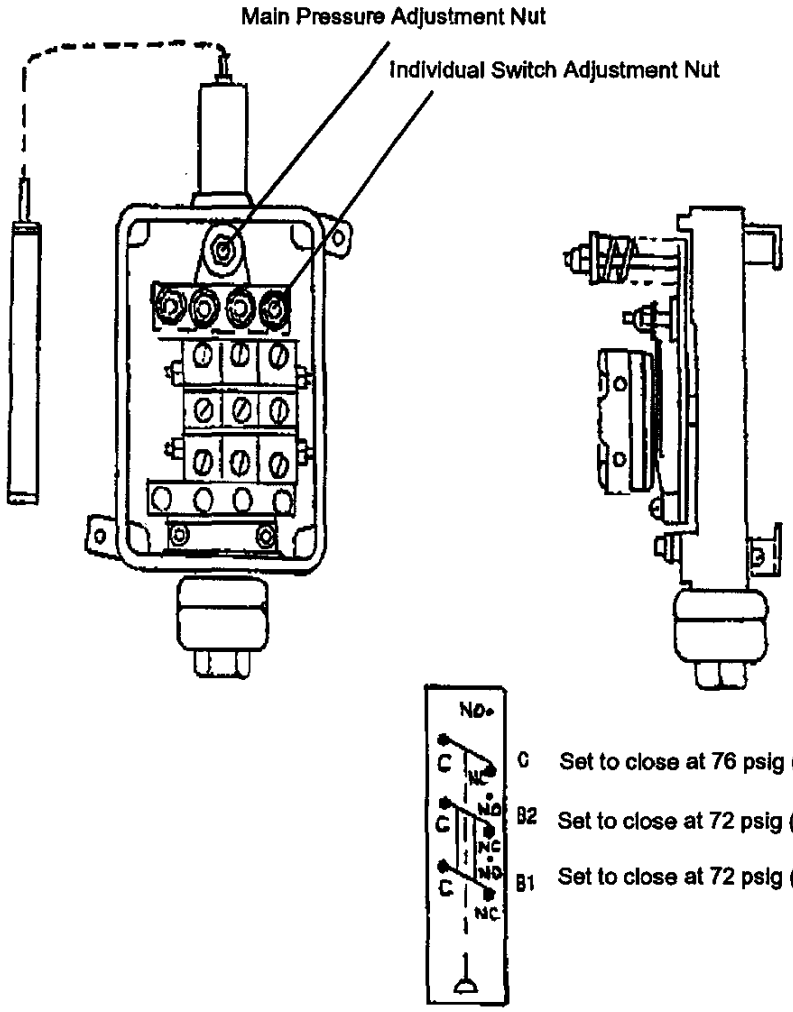
Tabular Version of the Pressure vs. Temperature Characteristics shown in Figure 9

Temp. F	Temp. C	*Fill psig	**Fill kPaG	*Alarm psig	**Alarm kPaG	*Lock-Out psig	**Lock-Out kPaG
-40	-40	Saturated	Saturated	Saturated	Saturated	Saturated	Saturated
-30	-34	Saturated	Saturated	Saturated	Saturated	Saturated	Saturated
-20	-29	Saturated	Saturated	58.0	399.9	54.9	378.5
-10	-23	68.8	474.4	60.0	413.7	56.9	392.3
0	-18	71.1	490.2	62.1	428.2	58.8	405.4
10	-12	73.4	506.1	64.0	441.3	60.8	419.2
20	-7	75.8	522.6	66.2	456.4	62.7	432.3
30	-1	78.2	539.2	68.1	469.5	64.7	446.1
40	4	80.5	555.0	70.2	484.0	66.6	459.2
50	10	82.8	570.9	72.3	498.5	68.5	472.3
60	16	85.2	587.4	74.3	512.3	70.4	485.4
68	20	87.0	599.8	76.0	524.0	72.0	496.4
70	21	87.6	604.0	76.4	526.8	72.3	498.5
80	27	90.0	620.5	78.5	541.2	74.2	511.6
90	32	92.3	636.4	80.5	555.0	76.2	525.4
100	38	94.7	652.9	82.7	570.2	78.2	539.2
110	43	97.1	669.5	84.8	584.7	80.1	552.3

* +/- 2 psig

** +/- 14 kPaG

Figure 10
SF_6 Gas Filling and Density Monitor Calibration Chart



Set each switch to the pressure indicated in Figures 9 and 10.

Figure 11
SF_6 Gas Density Monitor 60002

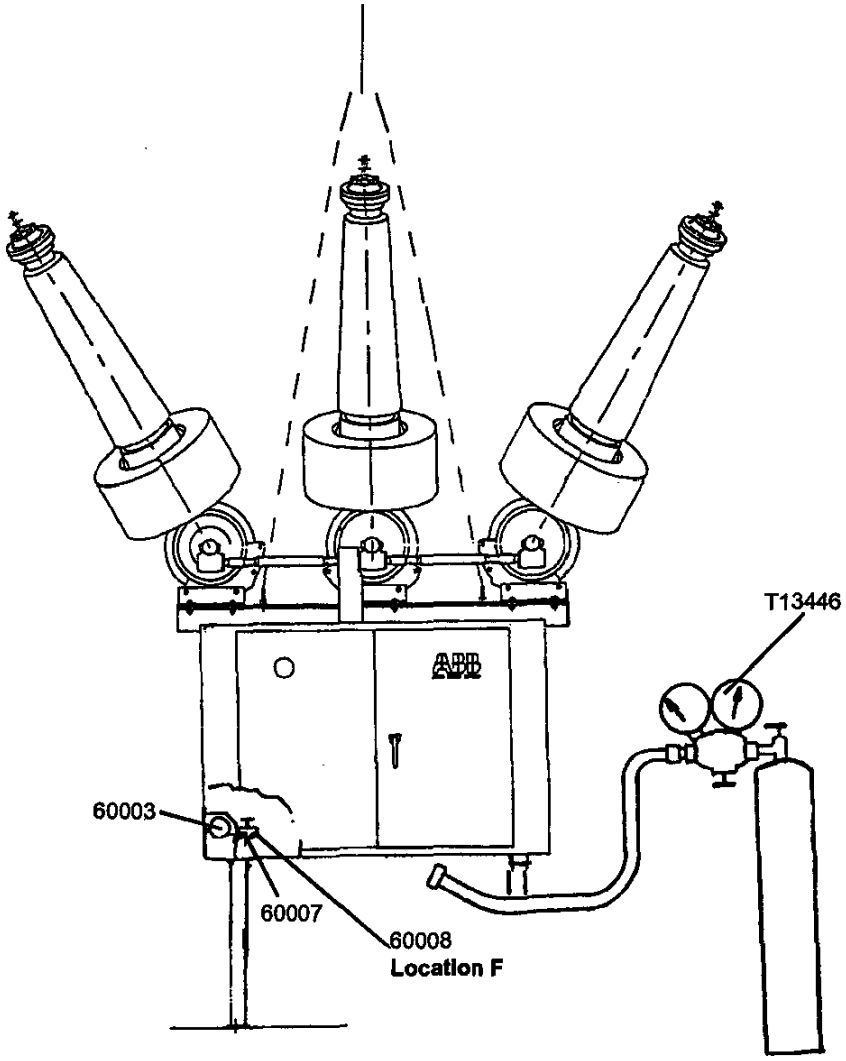


Figure 12
Gas Charging Arrangement

60003	SF_6 Gas Pressure Gauge
60007	Sample Valve
60008	Flare Fitting
T13446	SF_6 Gas Reguator and Hose

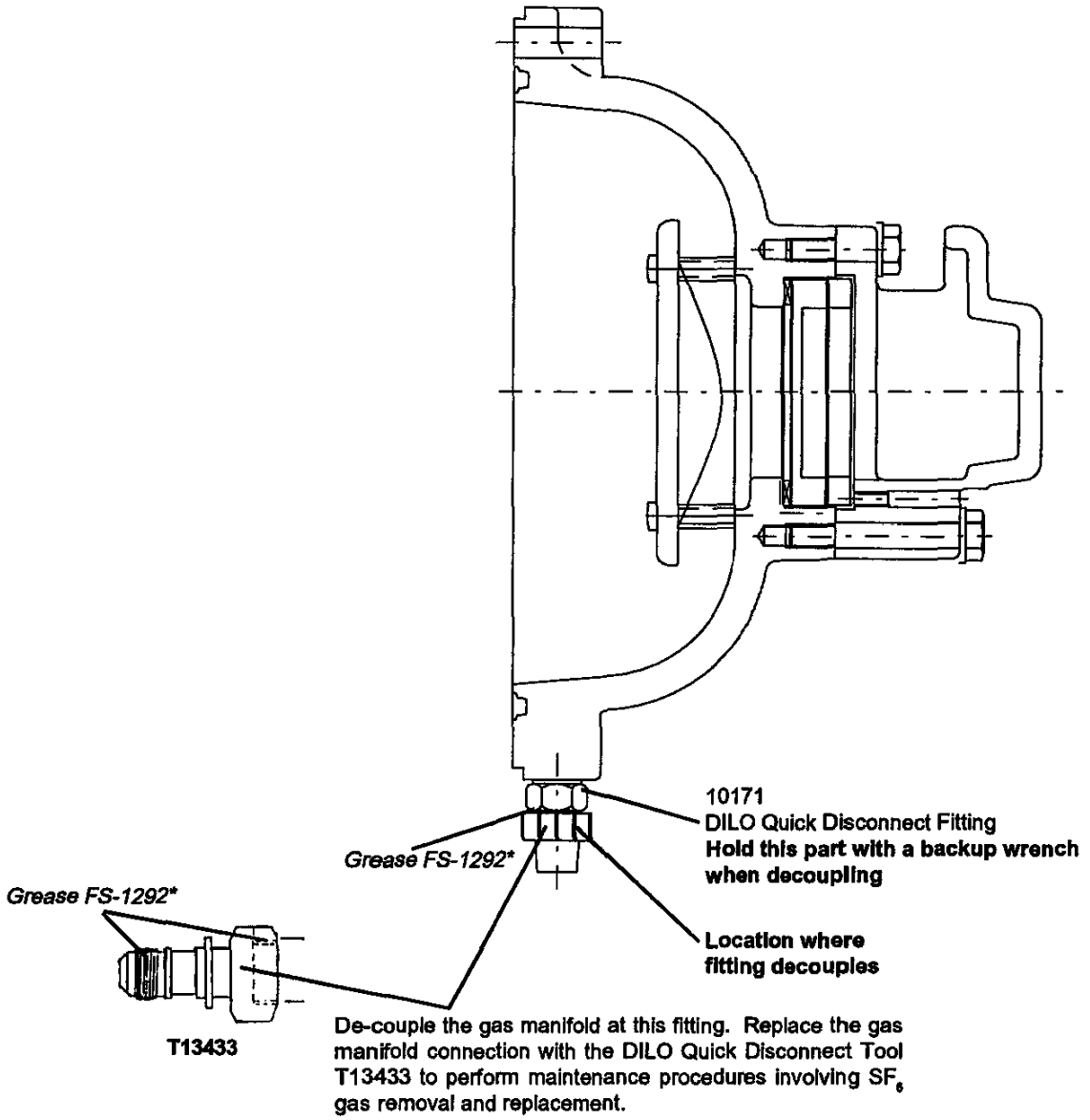


Figure 13
Rear Tank Cover Assembly 10032

10171	DILO Quick Disconnect Fitting
T13433	DILO Quick Disconnect Tool

*Apply Dow Corning FS-1292 Grease to lubricate the threads of the quick disconnect fitting.

145 PM Circuit Breaker

Type PM

Publication No. 526P305-01

145 PM Checklists©

ASEA BROWN BOVERI

10 February 1993

Contents

Notice 1

Based on our own experience, you will obtain the best possible operational reliability by following the recommendations given in these instructions. The data contained herein purports solely to describe the product, and it is not a warranty of performance or characteristics. It is with the best interests of our customers in mind that we constantly strive to improve our products and keep them abreast of advances in technology. This may lead to discrepancies between a product and these instructions.

Notice 2

Within the scope of these instructions, it is impossible to take into account every eventuality which may arise with technical equipment in service. Please consult our local salesman in the event of any irregularities, especially if not referred to herein.

Notice 3

We expressly decline liability for damages resulting from any incorrect operation or wrong handling of our equipment, even if these instructions contain no specific indication in this respect. We stress the fact that only genuine spare parts should be used for replacements.

Notice 4

This publication is a copyrighted work. Therefore, it is not permissible to disclose, reprint, copy, or reproduce any part of these instructions without express written permission from ABB.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the ABB Power T & D Company Inc. Power Circuit Breaker Division, 125 Theobold Ave., Greensburg, PA 15601, Phone No. (412) 838-5200.

Installation and Commissioning Checklist

Note: Make copies of the pages herein. Keep the sheets in this module as your original master.

145 PM Installation and Commissioning Checklist

Date:_____			
Substation:_____		**Breaker ID Number:** _____	
Line or Bus:_____			
Item/Conditions to Check (Units)	**Check**		
Breaker Data:			
Breaker Type: _____	Serial Number: _____		
Maximum Rated Voltage (kV)	kV		
Maximum Rated Continuous Current (A)	A		
Maximum Short Circuit Current (kA)	kA		
Control Voltage (VDC)	VDC		
Auxiliary Voltage (VAC)	VAC		
SF6 Pressure at 20°C (68°F)	87 psig (600 kPaG)		
Mechanism Type: _____	Serial Number: _____		
Breaker leveled and properly anchored?			
All grounding connections properly made?			
Control wiring landed?			
CTs connected to relaying or metering burden (or short circuited)?			
SF6 Gas Filling Pressure (psig) (kPaG) Filling Temperature	_____ psig _____ kPaG _____ °C or _____ °F		
Note: The breaker must be filled as specified on the Density Monitor Calibration Chart as shown in the Installation module.			
SF6 Gas Density Monitor Settings			
Manufacturer: Type:	Serial Number:		
Temperature	_____ °C or _____ °F		
Contact and Function	Nominal Pressure at 20°C (68°F)	Contact Make (Falling Pressure)	Reset
63-C Alarm	76 psig 524 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
63-B1 Operation Lock-Out or Auto-Trip	72 psig 496 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
63-B2 Operation Lock-Out or Auto-Trip	72 psig 496 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
Note: Refer to the Density Monitor Calibration Chart as shown in the Installation module for correct alarm and lock-out pressure settings for any given ambient temperature.			

Continued on the next page.

145 PM Installation and Commissioning Checklist

Date:_____

Substation:_____ **Breaker ID Number:** _____

Line or Bus:_____

Item/Conditions to Check (Units)	Check
Check for loose hardware	
Clean entrance bushings	
Touch up chipped or scratched paint	
Check the anti-pumping circuit	
Check control cabinet anti-condensation heaters	
Check alarms and lock-outs	
Leak Check Testing	
Leak check tube connections and fittings	
Leak check the SF6 Gas Density Monitor	
Leak check the SF6 gas plumbing	
Leak check the rupture disk	
Leak check the bushing flanges	
Leak check the rear tank cover assembly	
Leak check the bellcrank housing	
Leak check the interphase shaft seals with the breaker in the OPEN and CLOSED positions	
Contact resistance terminal to terminal specified less than < 150 micro-ohms	Pole 1: _____micro-ohms Pole 2: _____micro-ohms Pole 3: _____micro-ohms
SF6 Gas Moisture Content (to be taken no sooner than 24 hours after filling the breaker with gas) *200 PPMV maximum	_____PPMV at _____ °C or _____ °F
Complete the Mechanism Commissioning Checklist (in the Mechanism module)	
Check the breaker timing - refer to the 145 PM Timing Specification Checklist	
Reading on the operations counter	
Test performed by	
*Refer to the Installation module for further details.	

Continued on the next page.

145 PM Installation and Commissioning Checklist

145 PM Timing Specifications		
Item to Check	**Actual Measurement**	**Specified Parameter**
Opening Time		30 ms maximum
Opening Velocity for FSA-2 Spring Mechanism		3.8 to 4.2 m/s
		12.4 to 13.8 ft/s
Opening Velocity for HMB Hydraulic Mechanism (40 kA interrupting rating)		4.6 to 5.0 m/s
		15.0 to 16.4 ft/s
Opening Velocity for HMB Hydraulic Mechanism (50/63 kA interrupting rating)		4.3 to 4.8 m/s
		14.1 to 15.7 ft/s
Inter-Pole Spread Opening		2 ms maximum
Closing Time		50 to 65 ms
Closing Velocity for FSA-2 Spring Mechanism		2.5 to 2.8 m/s
		8.2 to 9.2 ft/s
Closing Velocity for HMB Hydraulic Mechanism (40 kA interrupting rating)		2.5 to 2.9 m/s
		8.2 to 9.5 ft/s
Closing Velocity for HMB Hydraulic Mechanism (50/63 kA interrupting rating)		2.1 to 2.5 m/s
		6.9 to 8.2 ft/s
Inter-Pole Spread Closing		2 ms maximum
Close-Open Time for FSA-2 Spring Mechanism		25 to 50 ms
Close-Open Time for HMB Hydraulic Mechanism (40 through 63 kA interrupting rating)		20 to 38 ms
Reclose Time*		20 cycles minimum
**Important: Refer to the Maintenance module for important information regarding reclose time.*		

Continued on the next page.

145 PM Installation and Commissioning Checklist

REMARKS/COMMENTS/NOTES:

Maintenance Checklists:

- **Monthly Checklist**
- **Yearly Maintenance Checklist**
- **5-Year Maintenance Checklist**

For the 10-year major maintenance, complete all of the standard 5-year checks and tests plus the Interrupter Checklist found at the end of the Interrupter module.

Refer to the Mechanism module for Mechanism Maintenance

Notice: *For your convenience, you can make copies of the pages in this module as well as the checklists found in both the Mechanism and Interrupters modules. It is wise, after copying, to return and store the sheets in this instruction book for ready reference as your original master sheets.*

Monthly Checklist for the 145 PM Circuit Breaker

Date	SF6 Gas Pressure	Temperature °C	°F	Operations Counter Reading

145 PM Yearly Maintenance Checklist

Date:_____

Substation:_____ **Breaker ID Number:** _____

Line or Bus:_____

Item/Conditions to Check (Units)	Data		
Breaker Data:			
Breaker Type: _____	Serial Number: _____		
Maximum Rated Voltage (kV)	kV		
Maximum Rated Continuous Current (A)	A		
Maximum Short Circuit Current (kA)	kA		
Control Voltage (VDC)	VDC		
Auxiliary Voltage (VAC)	VAC		
SF6 Pressure at 20°C (68°F)	87 psig (600 kPaG)		
Mechanism Type: _____	Serial Number: _____		
SF6 Gas Filling Pressure (psig) (kPaG) Filling Temperature	_____ psig _____ kPaG _____ °C or _____ °F		
Note: The breaker must be filled as specified on the Density Monitor Calibration Chart as shown in the Maintenance module.			
SF6 Gas Density Monitor Settings			
Manufacturer: Type:	Serial Number:		
Temperature	_____ °C or _____ °F		
Contact and Function	Nominal Pressure at 20°C (68°F)	Contact Make (Falling Pressure)	Reset
63-C Alarm	76 psig 524 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
63-B1 Operation Lock-Out or Auto-Trip	72 psig 496 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
63-B2 Operation Lock-Out or Auto-Trip	72 psig 496 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
Note: Refer to the Density Monitor Calibration Chart as shown in the Maintenance module for correct alarm and lock-out pressure settings for any given ambient temperature.			

Continued on the next page.

145 PM Yearly Maintenance Checklist

Date:_____ **Substation:**_____ **Breaker ID Number:** _____ **Line or Bus:**_____	
Item/Conditions to Check (Units)	**Check**
Check for loose hardware	
Check the anti-pumping circuit	
Check control cabinet anti-condensation heaters	
Check alarms and lock-outs	
Leak Check Testing	
Leak check tube connections and fittings	
Leak check the SF6 Gas Density Monitor	
Leak check the SF6 gas plumbing	
Leak check the rupture disk	
Leak check the bushing flanges	
Leak check the rear tank cover assembly	
Leak check the bellcrank housing	
Leak check the interphase shaft seals with the breaker in the OPEN and CLOSED positions	
SF6 Gas Moisture Content (to be taken no sooner than 24 hours after filling the breaker with gas) 200 PPMV maximum*	_____PPMV at _____ °C or _____°F
Complete the Mechanism Maintenance Yearly Checklist found at the end of the Mechanism module	
Reading on the operations counter	
Test performed by	
*Refer to the Maintenance module for further details.	

Continued on the next page.

145 PM Yearly Maintenance Checklist

REMARKS/COMMENTS/NOTES:

145 PM 5-Year Maintenance Checklist

(Perform every 5 years)

Date:_____			
Substation:_____ **Breaker ID Number:** _____			
Line or Bus:_____			
Item/Conditions to Check (Units)	**Data**		
Breaker Data:			
Breaker Type: _____	Serial Number: _____		
Maximum Rated Voltage (kV)	kV		
Maximum Rated Continuous Current (A)	A		
Maximum Short Circuit Current (kA)	kA		
Control Voltage (VDC)	VDC		
Auxiliary Voltage (VAC)	VAC		
SF6 Pressure at 20°C (68°F)	87 psig (600 kPaG)		
Mechanism Type: _____	Serial Number: _____		
SF6 Gas Filling Pressure (psig) (kPaG) Filling Temperature	_____ psig _____ kPaG _____ °C or _____ °F		
Note: The breaker must be filled as specified on the Density Monitor Calibration Chart as shown in the Maintenance module.			
SF6 Gas Density Monitor Settings			
Manufacturer: Type:	Serial Number:		
Temperature	_____ °C or _____ °F		
Contact and Function	Nominal Pressure at 20°C (68°F)	Contact Make (Falling Pressure)	Reset
63-C Alarm	76 psig 524 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
63-B1 Operation Lock-Out or Auto-Trip	72 psig 496 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
63-B2 Operation Lock-Out or Auto-Trip	72 psig 496 kPaG	_____ psig _____ kPaG	_____ psig _____ kPaG
Note: Refer to the Density Monitor Calibration Chart as shown in the Maintenance module for correct alarm and lock-out pressure settings for any given ambient temperature.			

Continued on the next page.

145 PM 5-Year Maintenance Checklist

Date:_____

Substation:_____ **Breaker ID Number:** _____

Line or Bus:_____

Item/Conditions to Check (Units)	Check
Check for loose hardware	
Check the anti-pumping circuit	
Check the control cabinet anti-condensation heaters	
Check alarms and lock-outs	
Leak Check Testing	
Leak check tube connections and fittings	
Leak check the SF6 Gas Density Monitor	
Leak check the SF6 gas plumbing	
Leak check the rupture disk	
Leak check the bushing flanges	
Leak check the rear tank cover assembly	
Leak check the bellcrank housing	
Leak check the interphase shaft seals with the breaker in the OPEN and CLOSED positions	
Contact resistance terminal to terminal specified less than < 150 micro-ohms	Pole 1: _____micro-ohms Pole 2: _____micro-ohms Pole 3: _____micro-ohms
SF6 Gas Moisture Content (to be taken no sooner than 24 hours after filling the breaker with gas) *200 PPMV maximum	_____PPMV at _____ °C or _____ °F
Complete the Mechanism Maintenance 2500 Operations (5-Year) Checklist found at the end of the Mechanism module	
Check the breaker timing - refer to the 145 PM Timing Specification Checklist	
Reading on the operations counter	
Test performed by	
*Refer to the Maintenance module for further details.	

Continued on the next page.

145 PM 5-Year Maintenance Checklist

145 PM Timing Specifications		
Item to Check	**Actual Measurement**	**Specified Parameter**
Opening Time		30 ms maximum
Opening Velocity for FSA-2 Spring Mechanism		3.8 to 4.2 m/s
		12.4 to 13.8 ft/s
Opening Velocity for HMB Hydraulic Mechanism (40 kA interrupting rating)		4.6 to 5.0 m/s
		15.0 to 16.4 ft/s
Opening Velocity for HMB Hydraulic Mechanism (50/63 kA interrupting rating)		4.3 to 4.8 m/s
		14.1 to 15.7 ft/s
Inter-Pole Spread Opening		2 ms maximum
Closing Time		50 to 65 ms
Closing Velocity for FSA-2 Spring Mechanism		2.5 to 2.8 m/s
		8.2 to 9.2 ft/s
Closing Velocity for HMB Hydraulic Mechanism (40 kA interrupting rating)		2.5 to 2.9 m/s
		8.2 to 9.5 ft/s
Closing Velocity for HMB Hydraulic Mechanism (50/63 kA interrupting rating)		2.1 to 2.5 m/s
		6.9 to 8.2 ft/s
Inter-Pole Spread Closing		2 ms maximum
Close-Open Time for FSA-2 Spring Mechanism		25 to 50 ms
Close-Open Time for HMB Hydraulic Mechanism (40 through 63 kA interrupting rating)		20 to 38 ms
Reclose Time*		20 cycles minimum
**Important: Refer to the Maintenance module for important information regarding reclose time.*		

Continued on the next page.

145 PM 5-Year Maintenance Checklist

REMARKS/COMMENTS/NOTES:

145 PM Circuit Breaker

Spare Parts©

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145 PM Circuit Breaker

Index Part Number	Description	Quantity per Breaker
Recommended Spare Parts List		
Desiccant, Rupture Disk, and Seals		
10008	Desiccant Bag	3
10017	Rupture Disk	3
10039	Solid Gasket	3
10040	Gasket (1/32-inch)	3
10041	Pressure Gaskets	6
Bellcrank Assembly		
10164	Bearing	6
10168	Gas/Vacuum Lip Seal	8
10169	Weather Seal	4
Interrupters		
30004	Auxiliary Nozzle	3
30005	Insulating Nozzle	3
30006	Moving Arcing Contact	3
30007	Puffer Cylinder	3
30014	Multi-Lam Contact	3
30020	Stationary Arcing Contact	3
30026	Contact Fingers	144
30103	Inner Guide Bearing	3
30104	Outer Guide Bearing	3
30107	Mesh Cooler	3
30116	Main Moving Contact/Self-Blast Chamber	3
30120	Teflon Disk	3

Recommended Spare Parts List

Index Part Number	Description	Quantity per Breaker
Mechanism		
53008	Charging Motor and Gearbox Assembly	1
53009	Motor Brushes	2
53014	Close Coil	1
53016	Trip Coil	1
53017	Limit Switch	4
53040	Auxiliary Switch	2
53066	Secondary Trip Coil	1
Control Cabinet		
60001	Anti-Condensation Heater	4
60002	SF_6 Gas Density Monitor	1
60003	SF_6 Gas Pressure Gauge	1
60007	Sample Valve	1
O-Rings		
90001	O-Ring, Top Flange, (Bushing)	6
90002	O-Ring, Tank End	6
90003	O-Ring, Bottom Flange, (Bushing)	6
90004	Insulating Nozzle O-Ring	3
90005	O-Ring, Shaft Seal Assembly	8
90014	O-Ring, Tank Center (Inner)	3
90015	O-Ring, Tank Center (Outer)	3
90016	O-Ring, Dashpot Cylinder	2
90017	O-Ring, Dashpot Piston	2
90018	O-Ring, Dashpot Main	1
Miscellaneous		
20009	Front Bushing Assembly	3
20010	Rear Bushing Assembly	3