

Waukesha[®] UZD[®] LTC Field Maintenance Manual



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SECTION 1

Annual Inspection

Tools Required for Annual Inspection

To prepare for an annual inspection, the following tools and expendables will prove helpful:

- Appropriate Personal Protective Equipment
- Ladder
- Digital Camera
- Inspection form
- Portable lamp
- Clean, lint-free rags
- SAE (English) wrenches
- Volt-ohm meter
- Oil sample containers
- 5 gallons of new oil for make-up if needed
- Filter press with 0.5 micron filters and water removal capability (for installing the make-up oil)
- Oil-proof rubber or plastic hoses
- Plastic pail (1 gallon)
- New oil filter cartridge for online oil filtration system
- Low pressure gas equipment to test pressure switch
- Solvent—such as Toluol, denatured alcohol or mineral oil
- Dielectric test set for oil
- Equipment manual

GENERAL

A complete annual inspection will consist of the following work:

- 1) Samples of the switch compartment oil for Dissolved Gas Analysis (DGA) and Oil Quality testing
- 2) Verify proper oil level after samples have been taken
- 3) Functional check of the pressure control switch
- 4) Verification that ARDB (Auto-Recharging Dehydrating Breather) is functioning properly. If a conventional silica gel breather is provided, a visual check of the breather and replacement of the silica-gel, if necessary.
- 5) Verification that the breather tube between the silica gel breather and the gas space above the oil in the switch compartment is open and not plugged.
- 6) Verify proper operation of the oil filtration system, if so equipped.
- 7) Check for leaks.
- 8) Visual inspection and functional check of the motor drive.
- 9) Record all findings on Annual Inspection Sheet and file for future reference. Suggested form for this Annual Inspection Sheet is shown on page 13.

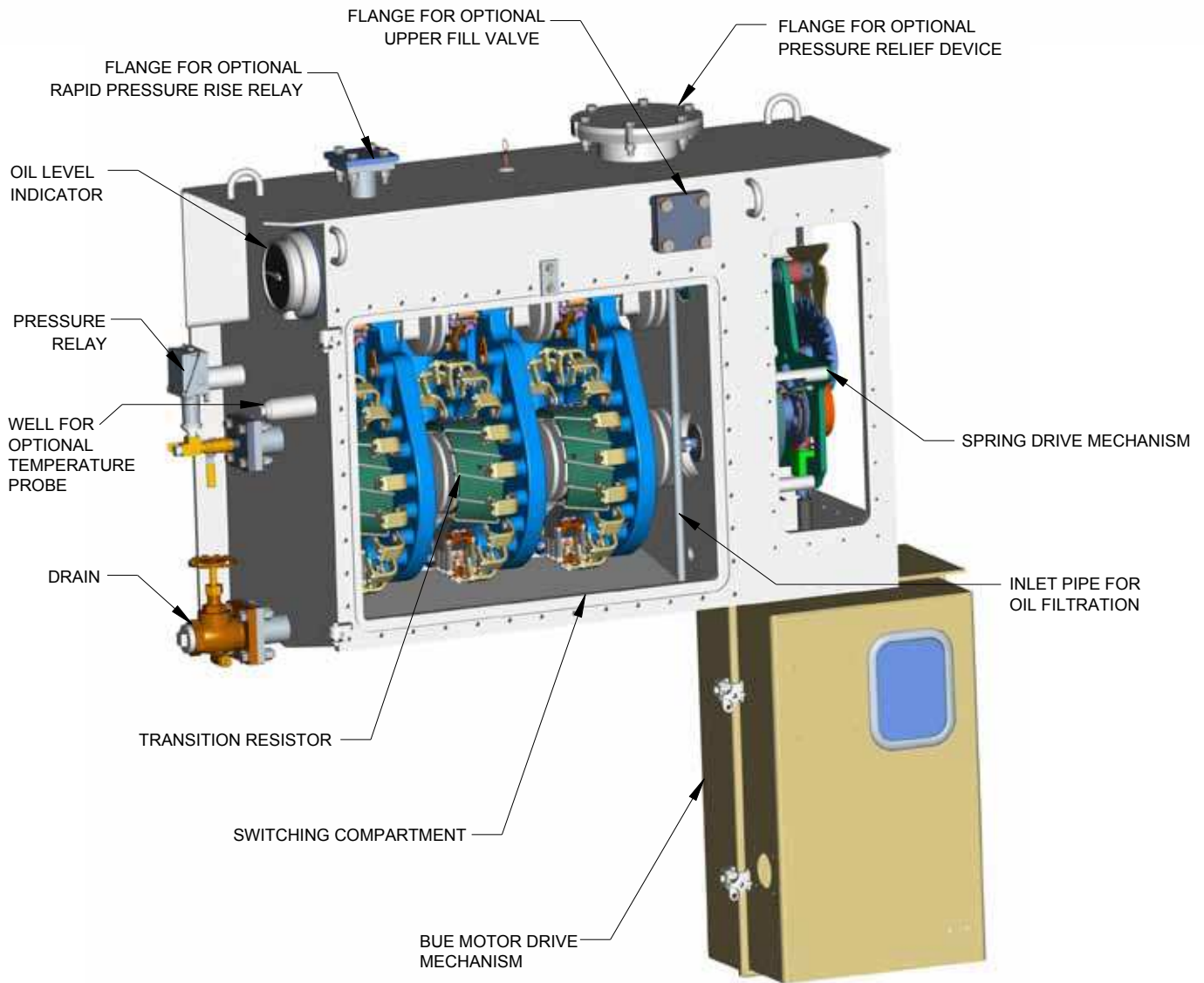


To prevent injury due to unwanted operation and electrical shock, automatic operation should be blocked and power supply(s) to the UZD® turned off when cleaning, lubricating or making adjustments.

A record should be made of the number of tap changer operations, and the range of operation, whenever a tap changer inspection is performed. This will help you plan major inspections in a timely and convenient way. This record, coupled with observations on contact wear made during major inspections, will also help you determine if contact replacement will be necessary. An Annual Inspection sheet is provided for this purpose at the end of this section.

In a few cases these records will highlight unique patterns of operation for a particular application. The most notable pattern is one where the tap changer operates only in either the raise or lower mode. This pattern of operation does not take the UZD® through the neutral position. In this case, the “reversing switch” is not operated or exercised which helps wipe away film that forms on contacts. This switch is designed with sufficient contact pressure to provide a natural cleaning action on the contacts as they wipe across the fixed contact. If your annual inspections show this pattern of operation, enhance its reliability by simply running the mechanism through neutral several times per year. If the UZD® does not normally go through neutral, you should consider changing the de-energized tap changer position so the UZD® does normally go through neutral. Please refer to the transformer nameplate for voltage and impedance changes associated with the various DETC positions.

FIGURE 1: GENERAL ARRANGEMENT



Oil Test

Condition based maintenance programs which assess attributes such as Dissolved Gas Analysis (DGA), oil quality, main tank to LTC tank oil temperature differential data, infrared thermography and acoustic analysis are good tools and may be used to indicate when a Major Inspection procedure is required.

NOTE: These predictive diagnostic tools should complement the annual inspection procedure outlined and should never be used as justification to skip the annual inspection.

For removing oil samples for testing, specific procedures from your oil testing laboratory should be followed. In general, flush the sample valve by removing about a quart of oil until oil runs clear and discard. Then fill a one quart, clean oil sample container using appropriate sampling procedures. This sample will be used for testing interfacial tension, power factor, dielectric strength, acidity (neutralization number) and color.

Next, fill a syringe or sealed cylinder using appropriate sampling procedures. This sample will be used for the DGA and dissolved water (moisture) test.

If the oil does not meet minimum test values, further investigations should be made to determine an appropriate course of action. This may require an internal inspection of the tap changer as described in the Major Inspection section of this manual. A likely next step would be to take a second set of oil samples and re-do the oil tests to verify original test data.

Verify Proper Oil Level

After oil samples have been removed, view the liquid level gauge and verify that the liquid is at the proper level, compensating for present liquid temperature. Add appropriate liquid as needed. If the transformer is equipped with an OF2 Oil Filtration system, additional make-up oil can be added by switching the 3-way valve ahead of the pump to draw oil through tubing from the amount at ground level.

Verify the properties of the new oil to be installed, as described in the Transformer Oil Specification section of this manual, before introducing new oil to the switch compartment. Record oil test values on the Annual Inspection Sheet. Use of a filter press is recommended unless oil is added through the OF2 or other oil filtration system where the makeup inlet is before the filter element. Vacuum oil filling is not required as there is no hygroscopic material in this compartment. Verify proper oil level is achieved by observing the liquid level gauge, compensating for oil temperature. If the temperature of the oil in the UZD® is about 25°C, then fill to the 25°C mark on the oil level gauge. See the Waukesha® UZD® Technical Manual for information on proper oil level for temperatures other than 25°C.

Mineral Oil Criteria

SPX Waukesha recommends that DGA and Oil Quality tests be performed at six to twelve month intervals and trended over time. Test standards and suggested limits are listed below:

- Dissolved Gas Analysis (D-3612) — Suggest every 6 to 12 months for UZD®; see DGA section below for details
- Moisture (D-1533) — Maximum 40 ppm at 20°C
- Interfacial Tension (D-971) — Minimum 20 dynes/cm
- Dielectric Breakdown Voltage
 - (D-1816) minimum 20 kV for 1mm gap
 - (D-1816) minimum 27 kV for 2mm gap
 - (D877) minimum 26 kV

- Acid Number (D-974) — Maximum 0.3 mg of KOH/g
- Color (D-1500) — Maximum 3.0 with an on-line oil filtration system
- Corrosive sulfur, (D1275 method B) — No Corrosive Sulfur in Oil
- Fluid Quality Index (FQI) = (Acidity x 1,000) / IFT < 18

Mineral Oil Test Not Meeting Requirements

The best remedy for poor oil quality is replacement of the oil, and this is highly recommended.

Dissolved Gas Analysis and Oil Quality

IEEE has published C57.139, a Guide for Dissolved Gas Analysis of load tap changers, which combines the knowledge of many industry experts. SPX Transformer Solutions recommends that this guide be consulted in analyzing LTC oil samples and when performing DGA on LTC oil.

Historically, DGA in LTCs has not been used as an indicator of problems since arcing in oil was considered routine operation and produced gasses. In the 1990s, however, an investigation into its usefulness began. Normal levels of gas generation for both heating and arcing gasses exist, and abnormal levels of these gasses are generated when a problem is present. The challenge lies in distinguishing normal from abnormal levels. C57.139 shows how to do this.

Arcing in oil can produce temperatures in the arc at thousands of degrees without changing the bulk oil temperature. Different gasses are produced at different temperatures. Since there is a temperature gradient from the arc to the bulk oil, all of these temperatures are present, generating arcing gas (acetylene and hydrogen) and thermal fault gasses (methane, ethane and ethylene). In normal arcing, these gasses are produced in relatively similar proportions. If a heating issue exists, an elevated level of the heating gasses would likely be present. If there is more arcing than normal, an elevated level of arcing gasses would, potentially, be present.

Restriction of air flow due to dehydrating breathers may cause more gas to be held in solution in the oil than in tap changers without dehydrating breathers. On-line oil filtration units will also absorb water, reducing the rate of gas generation. The filters will also

remove a significant amount of particles from the oil which further reduces the arcing time and rate of gas generation. Other sources of gas generation variation include the following:

- Load
- Number of operations
- Temperature
- Energy being switched relative to the rating of the tap changer
- Insulating fluid quality

For these reasons, the ratio of gasses produced has been one of the best predictors of problems, and SPX Waukesha recommends that a ratio of heating gasses to arcing gasses should be used for predictive maintenance purposes. The suggested ratios are:

$\frac{\text{Ethylene}}{\text{Acetylene}}$ OR $\frac{\text{C}_2\text{H}_4}{\text{C}_2\text{H}_2}$

Using this equation, SPX Waukesha recommends a value of <0.36 be viewed as normal. For a value between 0.36 and 1.5, more frequent samples should be taken to clarify the trend, with higher levels requiring more frequent sampling and further investigation. For values over 1.5, the transformer should be taken out of service as soon as possible for further investigation. See Major Inspection section of this manual. As this is an evolving science, these suggested values may change over time so please check our website for possible updates to this manual.

$\frac{\text{Nitrogen}}{\text{Oxygen}}$ OR $\frac{\text{N}_2}{\text{O}_2}$

Using the above equation for Nitrogen to Oxygen ratio, SPX Waukesha recommends a value of <4 be viewed as normal. For values between 4 and 12, plan on investigating the problem at the next convenient opportunity. Values >12 indicate the breather or breather tube may be partially or completely blocked and should be investigated and corrected in the near future.

The Fluid Quality Index (FQI) is defined as:

$\frac{\text{Acidity} \times 1,000}{\text{IFT}}$ OR $\frac{\text{Acidity} \times 1,000}{\text{IFT}}$

Using this equation, SPX Waukesha recommends a value of <8 be noted as normal. For values between 8 and 18, consider resampling to verify value and perform more frequent sampling. For values >18, sludge is likely forming due to poor oil quality even if the

Ethylene/Acetylene ratio is less than 0.36; plan on completing a Major Inspection within the next 12 months. For values >18 and where the ethylene/acetylene ratio is >1.5, plan on performing a Major Inspection within the next month. In either case, plan on replacing the oil at the next Major Inspection.

Some utilities have developed their own ratios with good success rates. If you feel comfortable with the method you have been using and are confident in its ability to predict incipient faults, please continue to use your own method. Consider adding the Fluid Quality index and N_2/O_2 ratio if not presently using them.

As of this writing, the field of DGA and oil quality in LTCs is an evolving field drawing considerable attention and increasing acceptance. SPX Waukesha embraces this technology as a good predictor and source for scheduling condition-based maintenance.

Moisture

If moisture is high and all other numbers are within acceptable limits, dehydration of the oil may be appropriate. If in doubt, replace the oil.

If the moisture level is high, the water source should be identified and corrected, i.e. non-functional desiccant breather, blocked breather tube or gasket leak.

Interfacial Tension, Neutralization Number, Color, Corrosive Sulfur

If interfacial tension, neutralization number, color, corrosive sulfur or fluid quality index exceed suggested limits, the oil should be replaced (see Mineral Oil section on page 6).

Dielectric Breakdown Voltage

If the dielectric breakdown voltage is low, the moisture level is high and all other values are within acceptable limits, reducing the moisture may correct the dielectric breakdown voltage levels. If moisture is not the source of the low dielectric breakdown voltage, then the oil should be replaced.

If you determine that the oil should be replaced, you should also conduct a Major Inspection at this time while the oil is drained and an outage already scheduled. See Major Inspection section on pages 14-51.

EQUIPMENT CHECKS

Pressure Switch

The pressure switch signals protective equipment to take the transformer out of service before pressure in the UZD® builds to dangerously high levels, such as if a fault occurs in the oil-filled switch compartment. This relay MUST be wired to remove the transformer from service. Proper operation of the pressure switch can limit damage to the UZD® and transformer should a malfunction occur. The pressure-control contact is set to close at 4.3 ± 0.5 psi overpressure. Another rate of pressure rise relay can also be used for this purpose.

Test the pressure switch in the following way:

Temporarily disconnect electrical circuit from protective relaying so as not to cause false tripping. Close the ball valve (see Figure 2). Remove the protective cap covering the test vent. Apply a positive dry gas pressure into the vent. Slowly increase the pressure and verify the switch actuates at 4.3 ± 0.5 psi by use of an ohmmeter on the appropriate contacts in the control box. Verify that the contacts return to their original state after the test pressure is removed. If the pressure switch tests outside specified limits, replace switch.

Remove cover to expose electrical connections and verify moisture is not present. If moisture appears to have entered this device, check the electrical insulation, wiring and switch for moisture damage. If none of these items are damaged, identify the source of moisture ingress and remedy. If inspection shows moisture in the other areas and these parts are damaged, identify source of moisture ingress, remedy the problem and replace the entire pressure switch.

After the test, replace protective cap, open and lock ball valve and reconnect electrical circuit to protective relaying. For additional information on this device, see Pressure Switch section, page 58, of the Waukesha® UZD® Technical Manual.

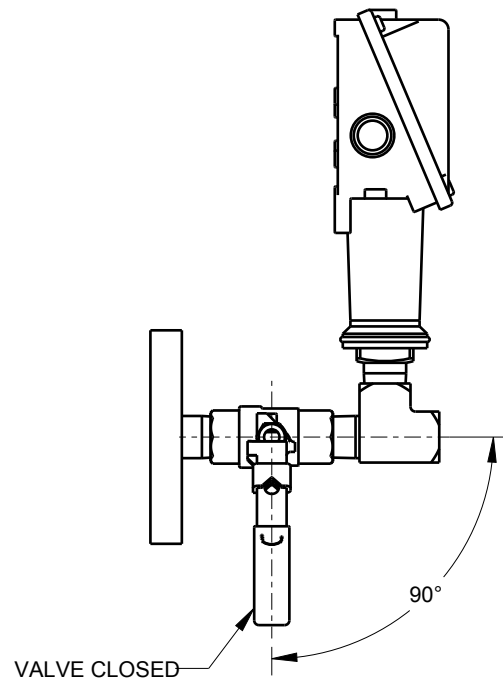
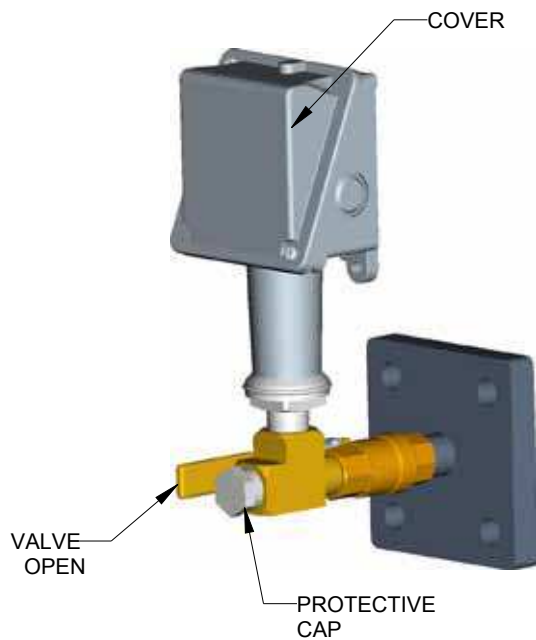
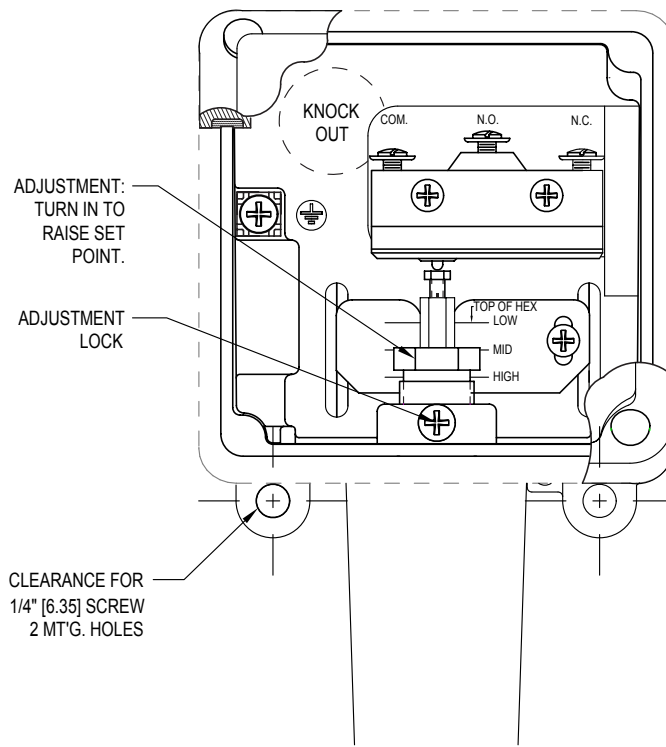


FIGURE 2: PRESSURE SWITCH

FIGURE 3: PRESSURE SWITCH (BACK VIEW)



Breather

The UZD® is designed to be free breathing through a dehydrating silica gel breather. Maintaining dry silica gel and an unobstructed breather tube path to the oil compartment are important for normal operation. A plugged breather or breather tube can result in extremely high concentrations of combustible gasses, making DGA difficult to interpret and causing potentially explosive conditions to exist. Utilization of the N_2/O_2 ratio and moisture analysis can be used to detect a plugged breather or breather tube.

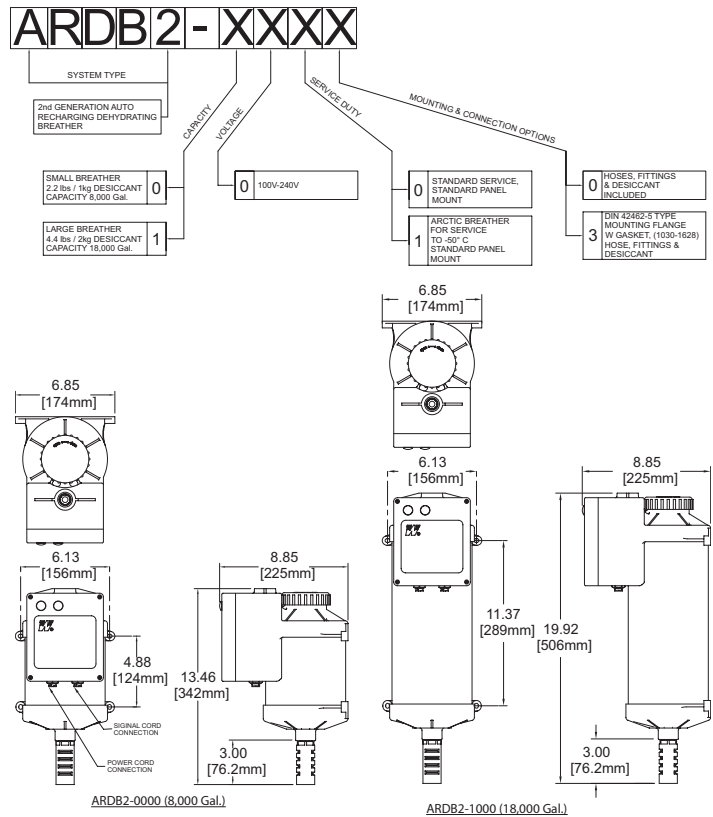
UZD®s manufactured prior to May 1995 were equipped with non-regenerating silica gel breathers to dehydrate air entering the UZD®s to keep the oil dry. These breathers require periodic replacement of the silica gel when the gel becomes saturated with moisture.

UZD®s manufactured after May 1995 are equipped with Auto-Recharging Dehydrating Breathers (ARDB) which have an internal heater controlled by a timer that periodically heats and dries the silica gel, see Figure 4, page 10.

Visually inspect the silica gel and confirm that it is orange or blue, depending on the type of desiccant used. Blue desiccant should not be pink more than halfway up the column of gel to prevent wet air from entering the tap changer. Orange gel keeps the air dry until the color change to green has reached the top of the gel column. Oil should not be present in the silica gel breather assembly as oil coated gel will not absorb moisture.

On UZD®s with ARDBs, interrupt power to the ARDB to initiate a regeneration cycle. After a few minutes, the head of the ARDB should be hot to the touch. Look through the cylinder and verify that no debris or standing water resides in the bottom of the device. If debris or standing water is found, remove the screened vent at the bottom of the assembly to gain access to the float ball. Clean any silica gel dust from the ball and filter screen, then reassemble. Refer to the Accessories section in the transformer instruction book for more detailed information.

FIGURE 4: 2ND GENERATION AUTO-RECHARGING DEHYDRATING BREATHERS (ARDB2)



Oil Filtration System

Refer to the Accessories section of the transformer instruction manual for detailed inspection and maintenance procedures for your specific oil filtration system. The Annual Inspection is an opportune time to replace the on-line oil filter system cartridge, if needed.

Leaks

Check the UZD® and BUE motor drive mechanism for oil leaks. Oil leaking out of the UZD® tank would be visible from outside the tank. Oil leaking from the oil compartment to the spring drive mechanism can be seen as oil dripping from the lower vent of the spring drive mechanism housing, on the oil drip pan at the top of the drive shaft in the BUE motor drive mechanism or out the bottom of the BUE motor drive mechanism (see Figure 5, page 11). If you suspect a leak in the spring drive mechanism and are planning to open the spring drive compartment, see the Major Inspection section of this manual for details prior to performing the inspection.

Normal design practice places the oil level in the main transformer tank higher than the oil level in the UZD® tank. Also, the oil

preservation system will normally add a positive pressure to the oil in the transformer tank. Therefore, if a leak exists between the main transformer tank and the UZD®, the oil will normally flow from the main transformer tank into the UZD® oil compartment. This would be observed as a high oil level on the oil level gauge of the UZD® or as oil dripping from the silica gel breather.

Check the condition of the gasket on the BUE Motor Drive Mechanism door. Look for signs of water leaks or condensation in the BUE motor drive, manifested as rusty or corroded parts. If you are not using any predictive maintenance tools such as dissolved gas analysis, oil quality analysis, infrared scan, LTC to main tank temperature differential monitor, etc., SPX Waukesha suggests that after the first year of operation the oil compartment be opened, the spring drive and motor drive mechanisms checked for abnormal wear, loose or broken components and proper functioning of the brakes verified. Also verify no signs of water leaks, condensation or rust. Thereafter, refer to Major Inspection section of this manual for suggested inspection intervals.

Motor Drive Inspection

⚠️ If control power is interrupted during operation, the operation will be completed when the power is restored. For safety, turn the breaker supplying power to the motor drive mechanism OFF before working on the motor drive mechanism.

⚠️ The hand crank must not be inserted during electrical operation.

Recommend observation of the UZD® while operating it one step up and one step down with the transformer energized. This can be done using either manual or automatic mode or both. Listen for unusual noises or abnormal operation. The BUE motor drive mechanism takes about 6 seconds to wind up the spring battery in the spring drive compartment and about 70 milliseconds for the spring battery to discharge, moving the selector switch to the next tap in the oil-filled compartment.

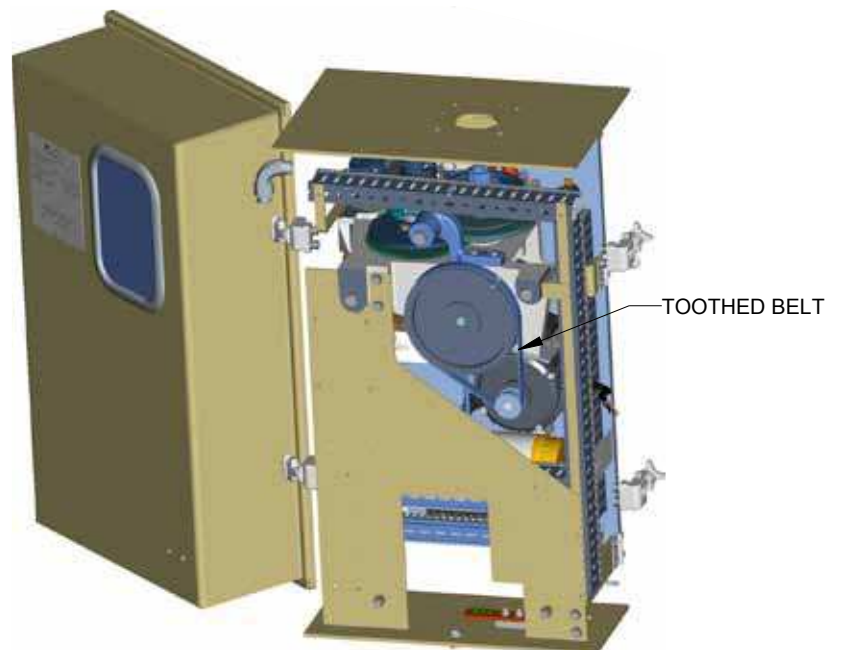
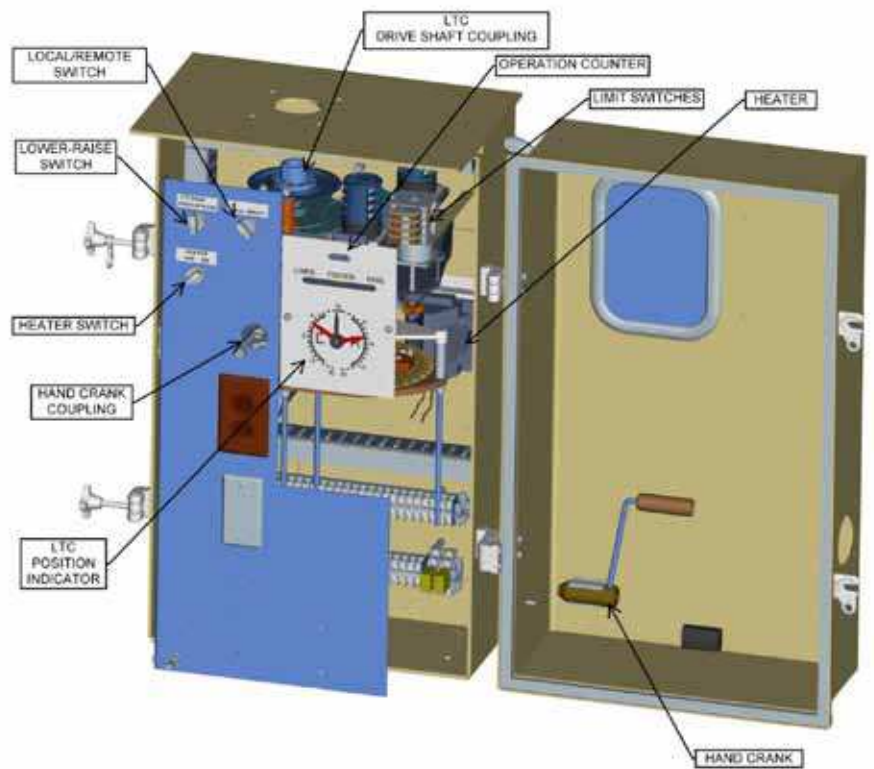
Operations Counter

Operate the tap changer in both raise and lower directions and verify that the operations counter advances one count per operation. The counter is mechanically activated, so no control power is required. Repair or replace if not functioning properly. Record the number on the operations counter and compare to historic trend in number of operations for abnormalities.

Position Indicator

Verify that the position indicator is working by observing it during both raise and lower tap change operations. Verify that the MAX-MIN drag hands are functioning properly. Record the maximum and minimum taps since last inspection and reset drag hands.

FIGURE 5: BUE MOTOR DRIVE MECHANISM



Indicator Flag and Brake

Check that the red indicator flag returns to the center position of the operation indicator after a tap change operation. This function should be checked in both the raise and lower direction. If the red indicator flag does not return to the center of the operation indicator, refer to the Indicator Flag and Brake section starting on page 40 and Lubrication section starting on page 42.

Timing Belt

Check the motor drive timing belt (item 101 in Figure 29, page 41) for cracks, splits, missing teeth, fraying, unusual wear, etc. Replace if damaged or worn. Check the tension on the motor belt. With a force of 2.2 lbs (1 KG), the belt should deflect in about 1/4 inch (5mm). If the deflection is more than 1/4 inch (5mm), the belt should be tightened by loosening the bolts in the elongated holes on the motor mounting and sliding the motor until the correct tension is obtained. If the belt needs to be changed, slide the motor in the opposite direction until the belt is free. Check that the belt is running freely, not rubbing on the back wall of the compartment and not slipping.



FIGURE 6:
2ND GENERATION POSITIVE TEMPERATURE COEFFICIENT (PTC2) HEATERS

Heating Element

Check that the heating element (see Figure 5, 6 and 7) is operating properly. This heater is a Positive Temperature Coefficient (PTC) heater and intended for continuous operation, therefore the heater circuit breaker and heater on/off switch should always be closed. A thermostat is not required. The resistance of the heater element changes with ambient temperature. Verify the heater fan is running and that some amount of heat is coming from the heater.

Visual Inspection

Examine the equipment to see if any screws or wires are loose or corroded and take corrective action, if necessary. Also check for any parts that appear broken, bent or otherwise not in normal working order.

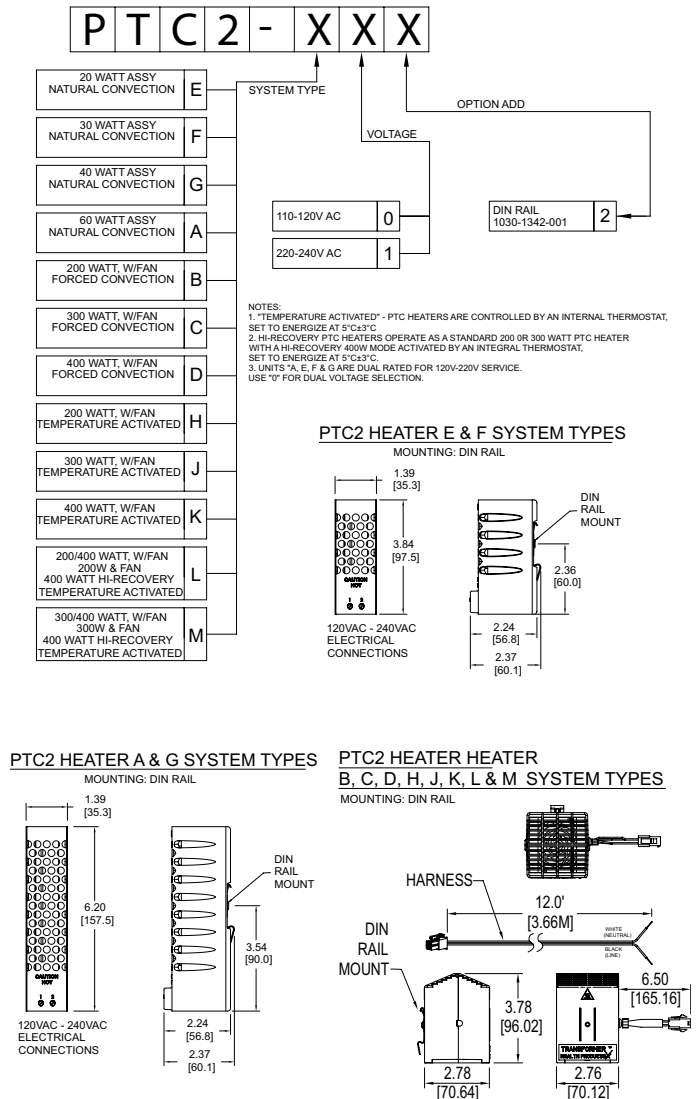


FIGURE 7: PTC2 HEATERS SPECIFICATIONS

ANNUAL INSPECTION FORM

Refer to this form on pages 64-65 or download it from our website at www.spxtransformersolutions.com/tools_resources.html under the Waukesha® Transformers heading.

LTC LEAKS	INFORMATION	NOTES/EXPLANATIONS
Check for Leaks	<input type="checkbox"/> No Leaks <input type="checkbox"/> Leaks Location:	

MOTOR PROTECTION MECHANISM COMPLIANCE

- Check for
- Operate T
- Unusual S
- Operation
- Record N
- Max-Min T
- Passed th
- Raise/Low Operated
- Check Dri
- Heater Sv
- General V
- OPERAT**
- Check Op



Waukesha® UZD® LTC Annual Inspection Form

TRANSFORMER DESCRIPTION	INFORMATION	NOTES/EXPLANATIONS
Manufacturer		
Year Manufactured		
Serial Number		
High Voltage		
Low Voltage		
MVA		
Substation Name		
Transformer Designation		
INSPECTION DATA		
Date of Inspection		
Inspected by		
OIL SAMPLES AND OIL LEVEL VERIFICATION		
Pull Oil Samples for Laboratory Tests	<input type="checkbox"/> Completed	
Verify Proper Oil Level	<input type="checkbox"/> Current Temp <input type="checkbox"/> Level OK <input type="checkbox"/> Oil Added	
Amount of New Oil Added <small>(meets requirements of UZD® Technical Manual, pages 60-62)</small>	_____ Gallons Added	
PRESSURE CONTROL SWITCH		
Pressure Control Switch Functioning Properly (4.3 psi ± 0.5%)	<input type="checkbox"/> Y <input type="checkbox"/> N _____ psi	
AUTO-RECHARGING DEHYDRATING BREATHER (ARDB)		
ARDB Functioning Properly	<input type="checkbox"/> Y <input type="checkbox"/> N	
De-Energize and Re-Energize ARDB to Verify Heating Cycle	<input type="checkbox"/> Completed	
Verify Water Drains from Bottom of ARDB	<input type="checkbox"/> Completed	
OIL FILTRATION SYSTEM		
System Functions Properly	<input type="checkbox"/> Y <input type="checkbox"/> N	
Check for Alarm Trips	<input type="checkbox"/> No Trips <input type="checkbox"/> Trips	
Replace Oil Filter Element, if necessary	<input type="checkbox"/> OK <input type="checkbox"/> Replaced	
Check for Leaks	<input type="checkbox"/> No Leaks <input type="checkbox"/> Leaks Location:	
Record System Operating Pressure	_____ psi	
All Gauges and Switches Working Properly	<input type="checkbox"/> Y <input type="checkbox"/> N If no, which ones:	
Hours of Operation	_____ Hours	

For assi

SPX TRANS

continued on next page...

SECTION 2

Major Inspections

If you don't have a person you consider an expert on the UZD® and BUE, consider hiring a Waukesha® Service field technician to conduct a major inspection in order to benefit from years of training and experience that can identify potential problem areas when others can not.

If you are unfamiliar with the UZD® load tap changer, training is recommended prior to performing any type of inspection on this device. Our Dallas training center offers these courses. Please visit our website, at www.spxtransformersolutions.com for details.

PAST MODIFICATIONS TO THE UZD® AND BUE

The following is a list of significant modifications made to the Waukesha® UZD® load tap changer prior to August 22, 2011, along with the dates initiated:

- 1) **Main Moving Contacts** (part #1030-021K-OEM): Hollow pins securing the rollers were changed to a solid pin. Also moved from two leaf springs to three (October, 1980).
- 2) **Main UZD® Door Gasket:** This main door gasket groove dimensions were changed to accommodate an "O" ring gasket in place of the original flat door gasket; p/n: 2011486. The new "O" ring gasket is p/n: 2007012. (October 1988)
- 3) **Drive Motor** (part #1030-025K): Changed the BUE drive motor and mounting configuration from an ASEA motor to a Bodine motor and lowered the internal assembly inside the enclosure to accommodate the taller American Solenoid limit (blue) switches (January 1991).
- 4) **Contact Tube for Slip Contacts** (part #1030-017K, for both the main and reversing switch): Changed to machined copper with a shoulder. The shoulder replaced a steel washer, and the wall of the tube was made thicker to reduce the operating current density (April 1991).
- 5) **Reversing Switch Fixed Contacts** (part #1030-025K): Hole was offset to foster better alignment between fixed and moving contacts (June 1991).
- 6) **Slip Contacts** (part #1030-017K, Bowties - both main and reversing switch): Changed configuration to provide better contact surface (August 1992).
- 7) **Reversing Switch Fixed Contacts:** Finish on contact surfaces changed to a 32 micro-inch polish (October 1994).
- 8) **Oil Filter Pipe Fittings** (part #ARDB2-0000): Fittings were added so an UZD® oil filter could be added without having to drill holes and weld in field (June 1995).
- 9) **Auto-Recharging Dehydrating Breather:** Silica gel regenerates automatically so maintenance personnel do not have to change or regenerate silica gel; UZD® oil stays dry (March 1996).
- 10) **Integrated Oil Filter** (part #1030-017K): Oil filter built into UZD® so oil stays clean. Transformer does not need to be taken out of service to improve oil quality (June 1997).
- 11) **Reversing Switch, Moving Contacts:** Design changes included springs moved to outside the current path, contact pressure increased, number of contact points increased, main current transfer point equipped with self-aligning feature and back-up current shunt provided (December 1997).
- 12) **Dual Pressure Switch** (part #1030-043K): Dual pressure switch for the integrated UZD® oil filtration system was replaced with two devices: flow switch and single high pressure switch (May 2001).
- 13) **Nylon Brake Roller** (located on spring drive compartment): Material changed from white nylon to black nylon with a lubricated bronze insert to improve wear characteristics (July 2003).
- 14) **Airotronics Breather/Oil Filter Timer:** Breather program for MC1001963H1JN was changed to allow continuous oil filter run and remain unaffected by Sw1 and Sw2 (high pressure and no-flow alarms) (December 2003).
- 15) **Main Moving Roller Contacts and Collar:** Edge radius added to roller contacts to reduce wear. Nib added to collar to improve alignment in assembly fixture (July 2002).
- 16) **Brake Pad** (located in spring drive): Changed the securing method for the pad-to-shoe from two rivets to a glued pad-to-shoe provided by our supplier (January 2005).
- 17) **Limit Switch Gear** (located in the motor drive assembly attached to the shaft of the limit switch (LS): Changed material from white phenolic to brass (December 2005).
- 18) **Bronze Bearing** (used in motor drive casting for the raise lower flag shaft): Changed material from a split steel tin-plated bearing to a bronze bearing (June 2006).
- 19) **Motor Drive Limit Switch:** Changed to different manufacturer, old and new switches are not interchangeable (January 2010).

Field Replacement Kits

Field replacement kits are available from Waukesha® components in Dallas, TX (see Figures 8A-8F, pages 15-17). Contact the Waukesha® components group for details at 800-338-5526 or visit our website, at www.spxtransformersolutions.com.

- Item 1 above is included in part #1030-021K-OEM – Kit-Main Contact Arm with Rollers (12 per phase); three kits required per UZD®.
- Items 3 and 5 above are included in part #1030-025K – Kit-Main Slip Contact (Bowtie); six kits required per UZD®, one for each phase for the reversing switch and one for each phase for the main tap selector contact.
- Items 4, 6 and 10 above are included in part #1030-017K – Kit-Reverse Switch Upgrade; three required per UZD®.
- Item 12 above is covered by part #1030-043K – Kit-Brake Roller Bulletin; one required per UZD® (part #1030-042K includes the brake assembly and should be used if the assembly is damaged or the brake pads need replacing).
- Item 8 above is covered by part #ARDB2-0000. This Auto-Recharging Dehydrating Breather is sized for a Waukesha® UZD® load tap changer. Other ARDBs are available for other model LTCs, conservators and other dehydrating applications. Contact Waukesha® Components for details.
- Item 9 Oil filtration systems are available from a number of suppliers. The Waukesha® components group has one specifically designed to work reliably on the UZD®. Contact the Waukesha® components group for details.
- Drawing 1030-036K is a set of tools that makes working on the UZD® a little easier.

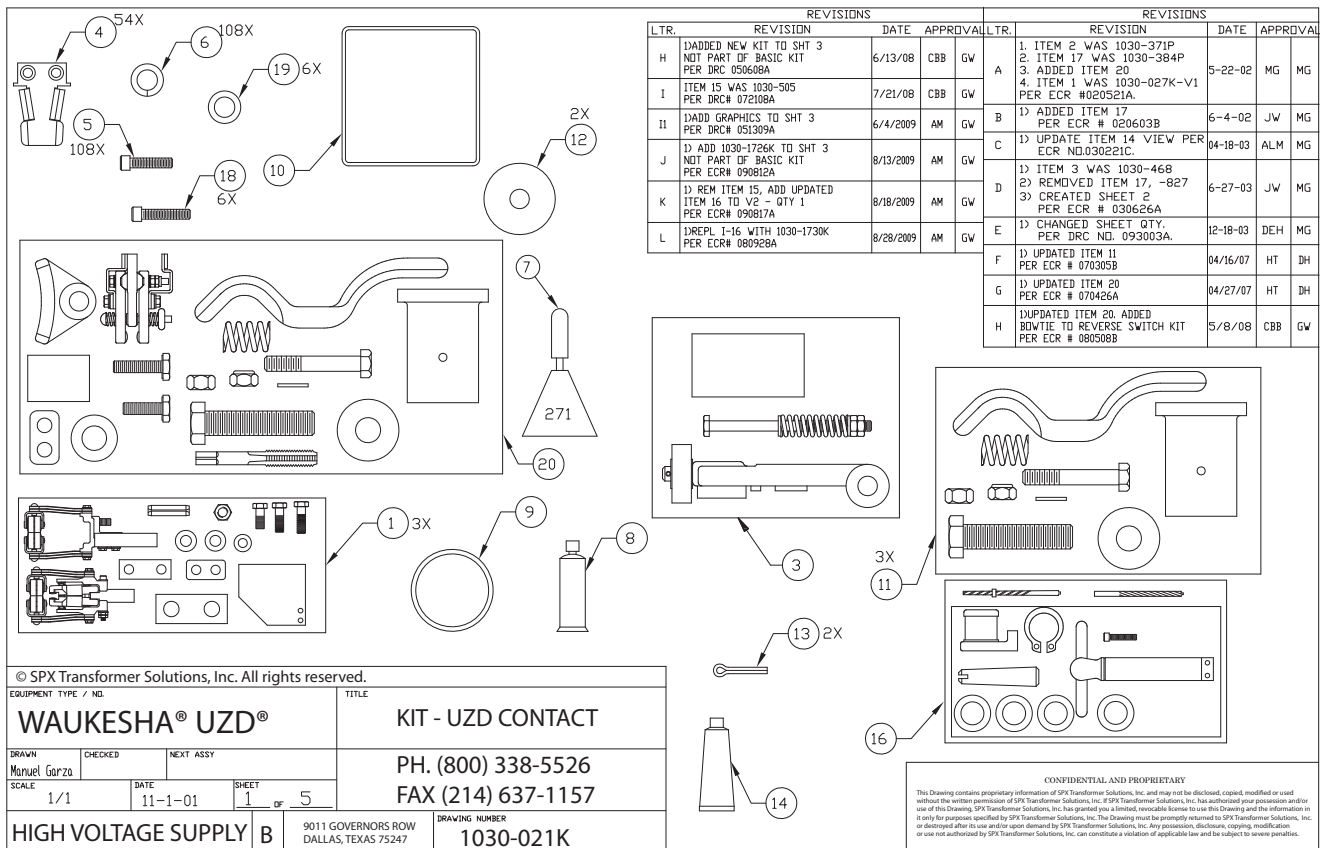


FIGURE 8A: UZD CONTACT, KIT #1030-021K

FIGURE 8B: MAIN SLIP CONTACT (BOWTIE), KIT #1030-025K

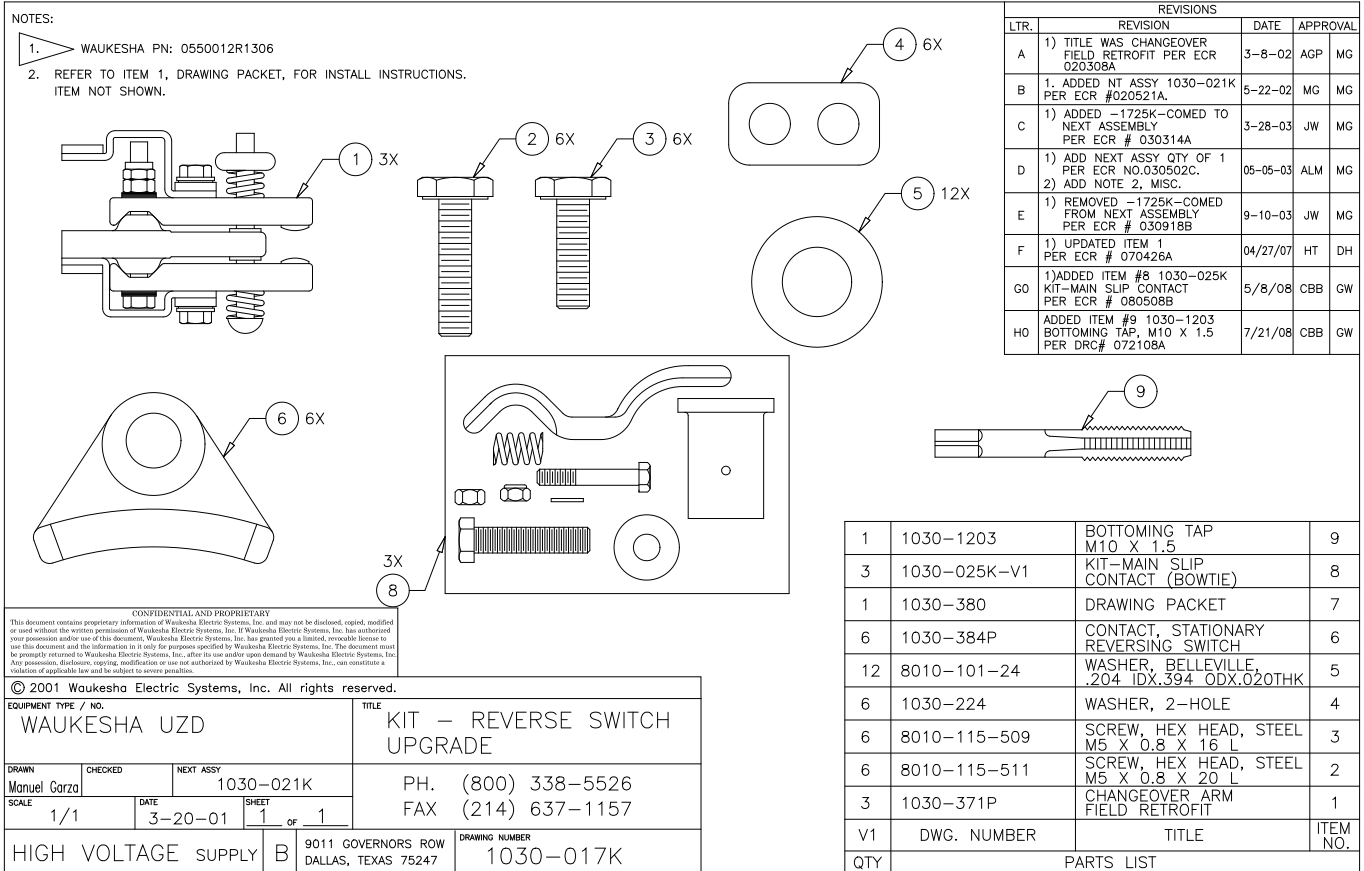
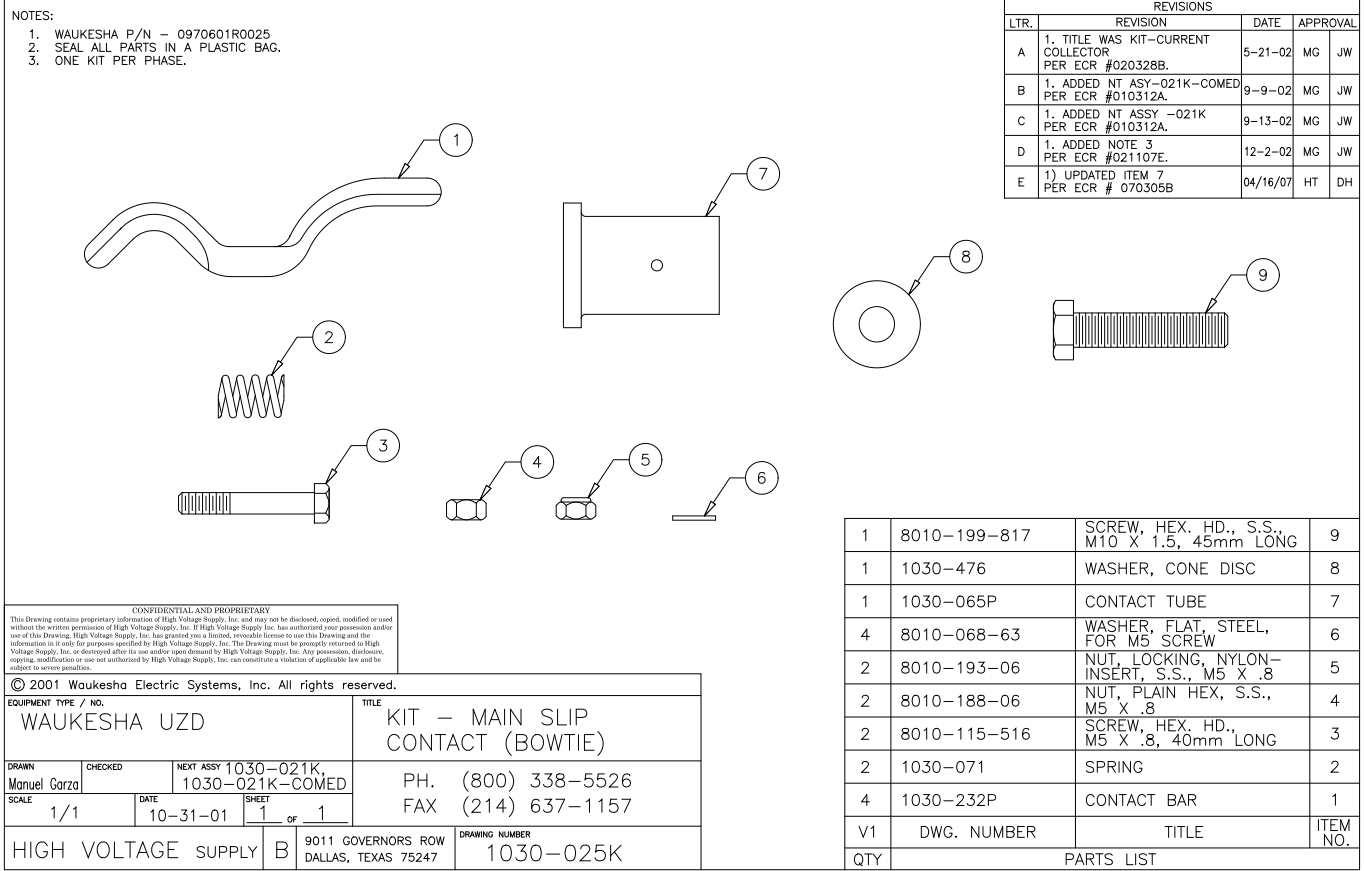
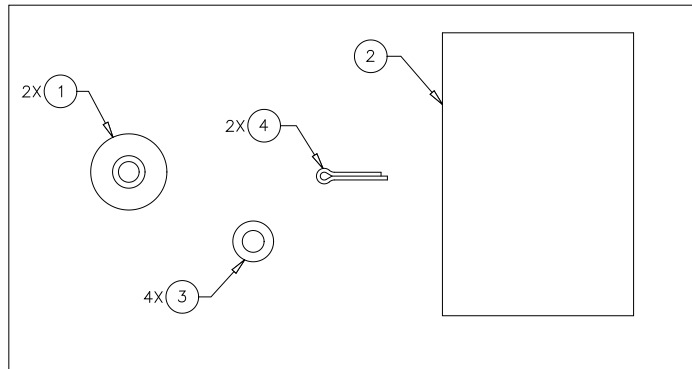


FIGURE 8D: REVERSE SWITCH UPGRADE, KIT 1030-017K

FIGURE 8C: BRAKE ROLLER BULLETIN, KIT #1030-043K

NOTES:
1. SEAL ALL PARTS IN A PLASTIC BAG.

REVISIONS			
LTR.	REVISION	DATE	APPROVAL
A	1) ITEM 2 WAS 1030-863-2 PER ECR # 030722A	7-22-03	JW MG

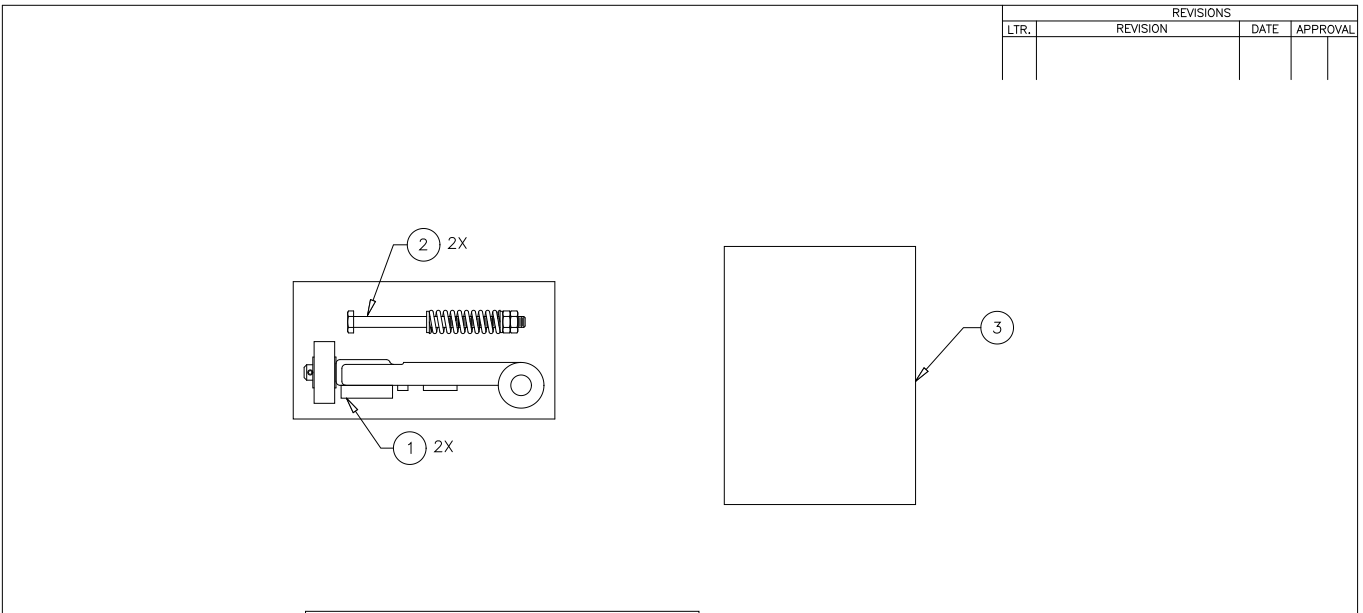


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EQUIPMENT TYPE / NO. WAUKESHA UZD		TITLE KIT -- BRAKE ROLLER BULLETIN	
DRAWN JW	CHECKED <i>M Barga</i>	NEXT ASSY	PH. (800) 338-5526
SCALE 1/1	DATE 7-21-03	SHEET 1 OF 1	FAX (214) 637-1157
HIGH VOLTAGE SUPPLY B		9011 GOVERNORS ROW DALLAS, TEXAS 75247	DRAWING NUMBER 1030-043K

QTY	DWG. NUMBER	TITLE	ITEM NO.
2	8010-261-101	PIN, COTTER, SS STEEL PIN DIA. .062, .50 LG.	4
4	8010-166-25	WASHER, FLAT, SS STEEL OD .47, ID .25, .02 THK.	3
1	1030-863	INSTRUCTION SHEET	2
2	1030-470	ROLLER ASSEMBLY	1
V1	DWG. NUMBER	TITLE	ITEM NO.
QTY	PARTS LIST		



REVISIONS			
LTR.	REVISION	DATE	APPROVAL

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1 QTY PER KIT		TITLE KIT -- BRAKE ROLLER	
DRAWN JW	CHECKED <i>M Barga</i>	NEXT ASSY 1030-021K, -021K-COMED	PH. (800) 338-5526
SCALE 1/1	DATE 6-26-03	SHEET 1 OF 1	FAX (214) 637-1157
HIGH VOLTAGE SUPPLY B		9011 GOVERNORS ROW DALLAS, TEXAS 75247	DRAWING NUMBER 1030-042K

QTY	DWG. NUMBER	TITLE	ITEM NO.
1	1030-863	INSTRUCTION SHEET	3
2	1030-827	HARDWARE ASSEMBLY	2
2	1030-468	BRAKE ASSEMBLY	1
V1	DWG. NUMBER	TITLE	ITEM NO.
QTY	PARTS LIST		

FIGURE 8E: BRAKE ROLLER, KIT #1030-042K

FIGURE 8F: UZD TOOLS, KIT #1030-036K

NOTES:
 1. REMOVE ALL SUPPLIER PACKAGING FROM EACH AND EVERY TOOL.
 2. PACK THE TOOLS IN THE ITEM 11 CASE USING THE INDIVIDUAL COMPARTMENTS THAT ARE MARKED FOR EACH TOOL. SEE FOAM DRAWING FOR TOOL/POCKET ASSIGNMENTS

REV	REVISION	DATE	APPROVAL
A	1. ADDED ITEM 19 & 20 PER ECR #020129A.	1-30-08	MG DC
B	1) ITEM 7, PMS 1030-752 2) UPDATED ITEM 9, IT WAS 1030-752 PER ECR # 0609080	9/29/04	HT DH
C	1) ADD ITEM 21 PER DRG# 030210A	02/02/05	AM CW
D	1) NEW ITEM 11 2) ADD ITEM 7 PER ECR# 100268A	6/8/2010	AM RB
E	1) ADD CASE, ITEM 11, NOTES PER ECR# 110775A	07/09/11	AM JP

1	1030-1503	ALIGNMENT TOOL FOR MAIN CONTACT	22
1	1030-776	ALIGNMENT TOOL FOR RESERVARY SW. CONTACT	21
1	1030-772	GAGE, CONTACT ROLLER	20
1	1030-767	3/8 DRIVE HEX DRIVER SOCKET	19
1	1030-766	3/8 DRIVE HEX DRIVER SOCKET	18
1	1030-765	3/8 DRIVE HEX DRIVER SOCKET	17
1	1030-764	1/4 DRIVE HEX DRIVER SOCKET	16
1	1030-763	SOCKET, MODIFIED	15
1	1030-760-003	WRENCH, BOX END, MODIFIED	14
1	1030-760-001	WRENCH, OPEN END, MODIFIED	13
1	1030-036K-FM	FOAM INSERT FOR CASE W/COMPARTMENTS	12
1	1030-1693	HI-IMPACT CASE (BLACK)	11
1	1030-758	DRILL BIT	10
1	1030-1125	TAPERED REAMER WITH SHAFT COLLAR	9
1	1030-754	WRENCH, RATCHETING BOX END, 22" OFFSET	8
1	1030-1560	DRILL EXTENSION, 5/16"	7
1	1030-747	MODIFIED C-CLAMP ASSY	6
1	1030-746	MIRROR, EXTENDABLE	5
1	1030-745	DRILL EXTENSION, 1/4"	4
1	1030-743	HEX WRENCH TOOL	3
1	1030-742	SCALE, STEEL	2
1	1030-741	TOOL BLOCK ASSEMBLY	1
V1	DWG. NUMBER	TITLE	ITEM NO.
QTY	PARTS LIST		

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WAUKESHA® UZD® KIT - UZD TOOLS

PH. (800) 338-5526
 FAX (214) 637-1157


0011 0207090303 B03W DALLAS, TEXAS 75247

1030-036K

GENERAL

Major inspections consist of all checks and adjustments recommended in the Annual Inspection plus an internal inspection of the liquid-filled switch compartment which will require the transformer to be de-energized and oil drained from the switch compartment. Oil in the UZD® should be replaced at every major inspection interval to ensure optimum performance. If the oil will be replaced, take oil samples before replacement to correlate DGA and oil quality results with inspection findings.

Gather and review all previous maintenance inspection reports for this specific tap changer to help with the effectiveness of the inspection.

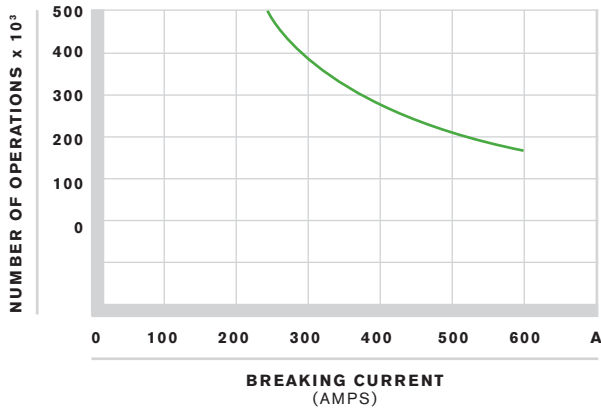
 **Before any work is carried out on the UZD®, verify that the transformer is disconnected and properly grounded. Follow your company's Lock Out / Tag Out procedures. While working on any part of the UZD®, confirm that the control power is turned off. There may be more than one auxiliary power circuit. Put LOCAL/REMOTE switch in LOCAL position.**

FREQUENCY OF MAJOR INSPECTIONS

Poor oil quality can contribute to accelerated contact wear, contact filming and the formation of sludge. These conditions can lead to increased contact resistance, increased contact heating and coking. Low dielectric strength can lead to increased arcing time, increased gassing and excessive carbon contamination of oil. Keeping the oil clean and dry using an online oil filtration system and Auto-Recharging Dehydrating Breather (ARDB) will help minimize the chance of problems. When the UZD® includes a properly functioning online oil filtration system and ARDB, SPX Waukesha recommends a major inspection every 7 years or 100,000 operations, whichever occurs first. This inspection interval is one that SPX Waukesha feels is prudent and conservative and should cover most applications of the UZD®.

The UZD® should achieve a contact life of 500,000 operations if the phase current at maximum nameplate rating is limited to 300 amperes, (see Table 1, page 19). This current is a function of the transformer MVA and voltage of the winding being regulated and of the turns ratio of the series transformer, if one is used. 500,000 operations is more than would be typically required in the life of a transformer. The contact load current and frequency of operations determine the time interval between major inspections. In certain

TABLE 1: PREDICTED CONTACT LIFE WITH BREAKING CURRENTS



applications, UZDs® operating with a more severe duty cycle may require more frequent inspections. Contact life is stated on the rating plate of the BUE motor drive mechanism. Major inspections should be performed at intervals of 20% of the estimated contact life. The frequency of inspection requirement of 100,000 operations stated above is based on 500,000 operations of contact life. If contact life is estimated to be less than 500,000 operations based on the contact life curve, then the inspection interval should be every 20% of the estimated life or 7 years, whichever comes first.

SPX Waukesha believes that diagnostic testing and evaluation are good means to determine the condition of a UZD®. These condition-based diagnostic tests often include condition of the UZD® oil through physical, chemical and electrical analysis; dissolved gas analysis (DGA); thermal imaging (infrared) of the UZD® and other diagnostic testing. These diagnostic test results, knowledge of whether the UZD® has been lightly or heavily loaded and prior experience with other UZDs® on your system should be used in deciding if a major inspection should be done more or less frequently than recommended above. If you have a predictive maintenance system that is working well, and you are confident in its ability to identify problems before a failure occurs, then you may choose to schedule major inspections based on that system rather than either the time-based or operations count-based recommendations above.

If an UZD® protective device, such as a pressure switch, sudden pressure relay or pressure relief device has operated and that protective device is functioning properly, a major inspection should be performed prior to placing the transformer back into service.

Tools Required for Major Inspection

The following items are required to perform an internal inspection of the switch compartment:

- Appropriate Personal Protective Equipment
- Scaffolding and/or man lift
- Digital Camera
- Inspection form
- Mirror
- Portable lamp
- Contact Cleaner
 - NOTE: DO NOT use any compound containing chlorides, sulphates or silicates. Suggest using 00 bronze or brass wool. Scotchbrite is not recommended as it may leave insulating particles on the contacts.*
- Loctite, grade AAV 271 (see diagrams for locations)
- Lubricating oil, hydraulic oils with viscosity 46 cSt @ 40C – ISO Grade 46.
 - Suggested oils:
 - BP: Energol HLM
 - Castrol: Hyspin AW 46
 - Mobil: DTE 25
 - Petro-Canada: Hydex AW 46
 - Shell: Tellus 46
 - Texaco: Rando HD46

- Lubricating grease, lithium soap-based, low temperature grease.
 - Suggested greases:
 - Exxon: Beacon P-290
 - Mobil: Mobilux 2
 - Mobil: Mobilgrease 28
 - Shell: Aeroshell Grease 6
 - SKF: LGLT 2
 - Texaco: Starfak PM
- Solvent, such as Toluol, for cleaning brakes
- Pipe thread sealant
- Clean, lint-free rags
- SPX Waukesha recommends replacing gaskets for doors and access panels
- Metric wrenches
- Inch pound & foot pound torque wrenches
- Small 1/4" drive socket set with metric sockets (needed to work in restricted space)
- Metric allen socket wrench set
- Set of screwdrivers
- Feeler gauges
- Calipers for measuring contact wear
- UZD-specific tool kit (available from Waukesha® Components)
- Micro-Ohm Meter for measuring contact resistance

- Fish Scale or Load Cells, such as Economical Load and Force System (by Flexiforce), for measuring spring pressure
- Volt-ohm meter
- Low pressure gas supply (5 lbs to check Pressure Switch)
- Dielectric test set for oil
- Clean pressure sprayer (garden sprayer)
- Two 55-gallon drums or other container for disposing of 100 to 106 gallons of oil
- Two 55-gallon drums of new oil
- Filter press with 0.5 micron filters and water removal capability for installing new oil
- Oil-proof rubber or plastic hoses
- Plastic pail (1 gallon)
- Oil test syringes (2) — one for pre-maintenance test and one for post-maintenance test
- New oil filter cartridge for online oil filtration system
- Clean/Dry silica gel for units with non-regenerating breathers

RECOMMENDED STEPS

The work to be performed should be performed in the order outlined. For routine inspections (not investigating a suspected failure), operate UZD® electrically, with switching compartment still filled with oil and listen for proper operation. UZD® tap changes should not exceed about 6 seconds per tap change operation. If unusual sounds exist, attempt to locate the source prior to proceeding.



After failure or trip due to fault condition, high levels of combustible gasses can accumulate in the UZD® compartment. To minimize the potential for hazardous explosive conditions, follow these steps:

- 1) Calculate the safe handling limit (refer to Doble calculation).**
- 2) Apply dry nitrogen to the top fill valve and head space of the UZD® at low pressure while removing the oil to limit the amount of available oxygen.**
- 3) Verify that all oil handling equipment is solidly grounded and sections of oil hoses bonded from one section to the next to prevent the possibility of static electric sparks.**

If this inspection is being performed due to suspected failure or protective relay operation, do not operate electrically or manually prior to opening oil compartment, checking the spring drive mechanism and motor drive. If a failure is suspected, contact our warranty department at 800-835-2732. After draining the oil, perform a visual inspection before touching or cleaning anything in the oil compartment.

- Take pictures of findings
- Take oil samples for oil quality and OGA
- Disconnect desiccant breather
- Drain oil and dispose
- Open front door
 - Open the doors to the spring drive mechanism

- Perform visual inspection
- Clean the switch mechanism
 - Rinse/flush with clean insulating oil
 - Remove transition resistors
 - Wipe the switch components down with clean, lint-free cloth
 - Check stationary selector switch contacts for wear
 - Check selector switch moving contacts for wear
 - Check the reversing switches
 - Check for proper contact position and alignment
 - Check contact pressure and resistance
 - Replace transition resistors
- Check silica gel breather and connections
- Check Pressure Switch
- Check liquid level gauge
- Perform maintenance on spring drive mechanism
- Perform maintenance on motor drive mechanism
- Perform all activities described in the routine Annual Inspection not included in this Major Inspection
- Fill with new oil
- Reconnect desiccant breather

Draining the Oil

Inspection inside the UZD® oil-filled compartment can be accomplished without lowering the oil level in the main transformer tank. The tap changer tank is fitted with a drain valve in the bottom. The drain valve typically has a 1" or 2" internal pipe thread for connection of pipe and hose.



Disconnect breather before draining oil to keep silica gel out of the switch compartment. If the silica gel breather is equipped with an oil cup on the bottom, disconnection will prevent oil from being deposited on the gel. Oil-coated silica gel will not absorb moisture. Do not reconnect the breather until after refilling the compartment with oil to prevent oil mist from coating the silica gel.

NOTE: Connect the hose to the drain valve and drain off oil into two 55-gallon drums or other waste oil container. Oil can be gravity-fed into drums. SPX Waukesha recommends replacing the oil and disposing of oil removed for this inspection. Reuse of the used oil can cause faster degradation of the oil and will not reduce the acid number or other undesirable oil characteristics. Replacing the oil should ensure good oil quality for higher reliability operation. Replacing the oil will also result in near zero levels of dissolved combustible gasses.

Cleaning the Switch Mechanism

Open the front door of the tap changer tank. The door may be removed to improve access, as desired; however, note that the door weighs 72 pounds (33 kg). Before physically handling any component, perform a visual inspection to identify damaged, loose or broken parts; signs of heating and/or coking; debris in the bottom of the tank; excessive arcing or mechanical wear, rust or paint damage. Take photos of any findings or observations and file in inspection report.

Thoroughly wash/spray switch components with new transformer oil. A common garden sprayer can be used but only if it is dedicated to this service and has not been contaminated with other liquids.

After cleaning with oil, the tap changer and all inside surfaces of the switch compartment should be wiped clean with lint-free cloth. While performing the wiping operation, check components for loose fasteners, rough or worn areas, broken parts, etc. Tighten loose hardware per Torque Values Table (Table 2, page 51). Replace broken or worn parts. Wipe and inspect epoxy phase moldings and couplings for signs of splits, chips, crack, tracking or discoloration due to overheating. Replace as necessary.

Remember to review prior inspection reports for this tap changer and specifically check on any problem areas found or fixed in prior inspections. If corrections were made, confirm these areas/parts are still intact and performing properly. If a previously identified problem still exists, consider the possibility that the root cause may not have been found in the previous inspection.

Remove Transition Resistors

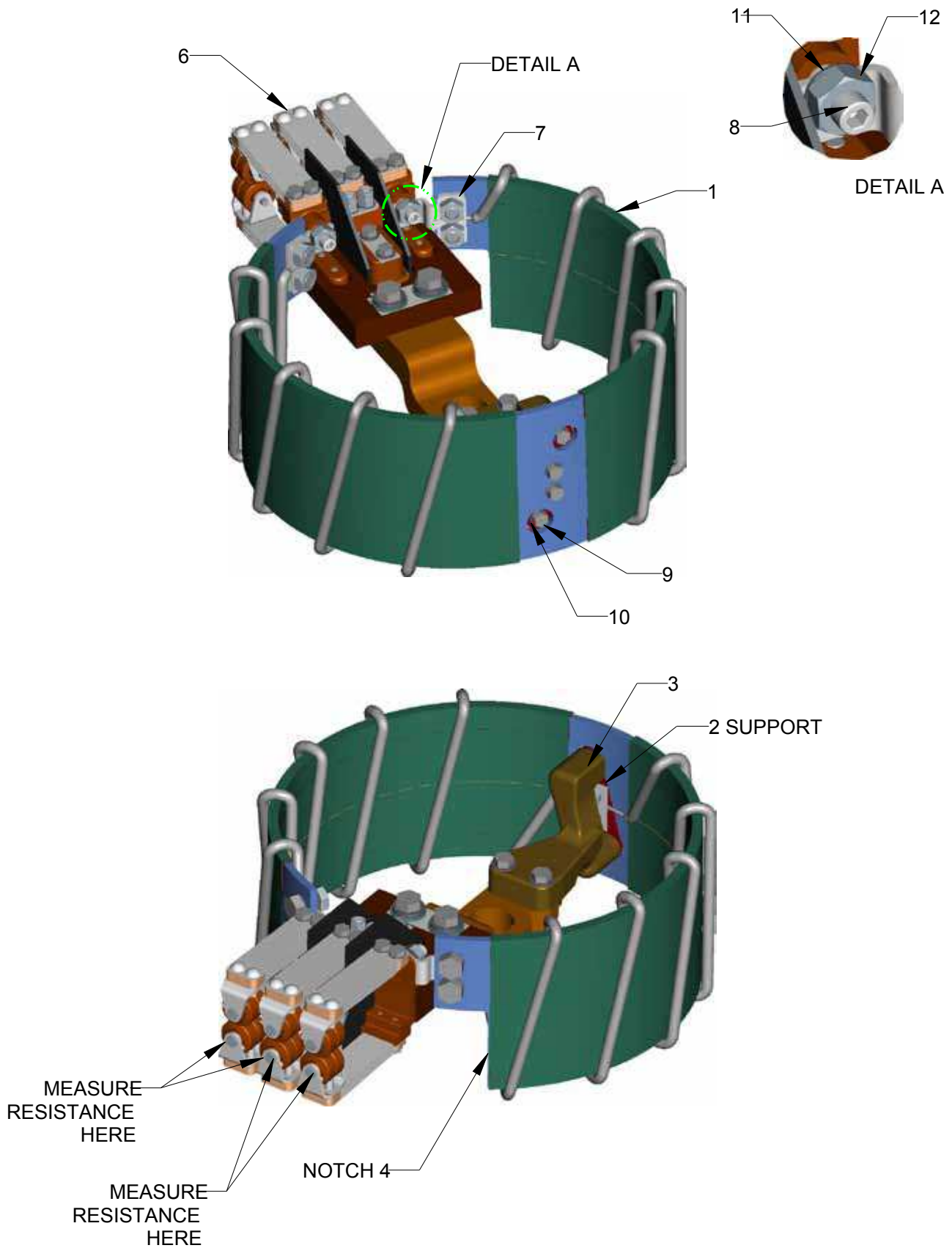
Removing the transition resistors is recommended for a more thorough inspection. Prior to removing the resistors from the tap changer, measure and record the resistance from each outside roller to the center roller (see Figure 9B, page 22). The measured value should be within $\pm 10\%$ of the value handwritten on one end of the resistor bobbin (see Figure 9A). All six resistance measurements are typically within 10% of each other. To aid in the selection of resistance measuring equipment, this value should be in the range of 0.1Ω to 6Ω , with typical values in the 0.5Ω to 1.5Ω range.

To remove the resistors, operate the tap changer to such a position that the nut and spring washer (items 11 and 12 on Figure 9B, page 22) can be removed from the ends (item 7) of the transition resistor. Next, operate the tap changer to such a position that the support (2) for the transition resistor is directly toward you. Remove screw (9) and spring washers (10) as shown on Figure 9B, page 22. Pass the resistor (1) over the area of the shaft (3) which is narrowest. The resistor has a notch (4) which passes over the flanges of the shaft. The resistor may be pulled apart slightly to pass the flanges; however, take care not to crack the bobbin of the resistor. Inspect the resistor for damage such as cracked or broken bobbin, signs of overheating, broken strands of polyester tape (tie downs). Check that the resistor wire remains securely tied to the bobbin. Repair or replace damaged parts.

**FIGURE 9A:
LOCATION OF
MEASURED
RESISTANCE
VALVE**



FIGURE 9B: TRANSITION RESISTORS



Check Stationary Selector Switch Contacts for Wear

The contact system consists of L-shaped brackets (which should NOT be loosened or removed) and stationary tap selector switch contacts fastened to the L-shaped brackets with two Allen head screws (these can be removed).



The bolt holding the L-shaped bracket to the phase molding should not be loosened or removed.

The stationary contacts are constructed from a copy contact body with copper tungsten arcing tips brazed to the middle sides of the copper body. The contacts are then silver plated.

Referring to Figure 11, page 24, the main current carrying contact buttons of the moving selector switch are made from hardened silver. No burning of these button contacts should occur, as all arcing is designed to take place between the transition rollers and the copper tungsten tip of the stationary contacts. In an on-tap position, the current conduction occurs between the silver-plated, stationary contacts and the silver buttons on the moving main contacts. If arcing is observed between the tongue (no arcing here) of the fixed contact and the moving main contacts, the fixed contacts should be replaced. Carefully inspect the moving main contacts for damage and replace moving contact assembly, if necessary.

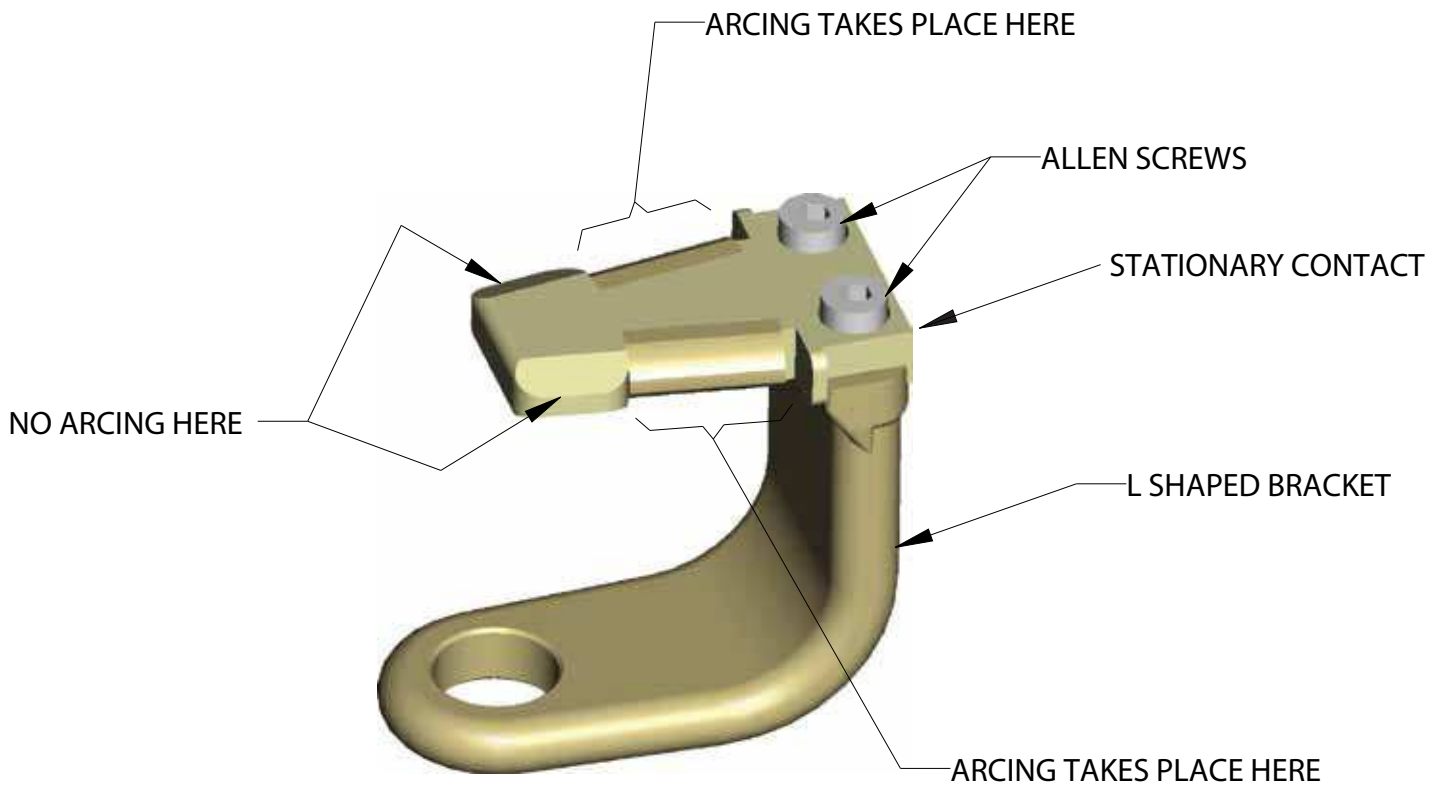



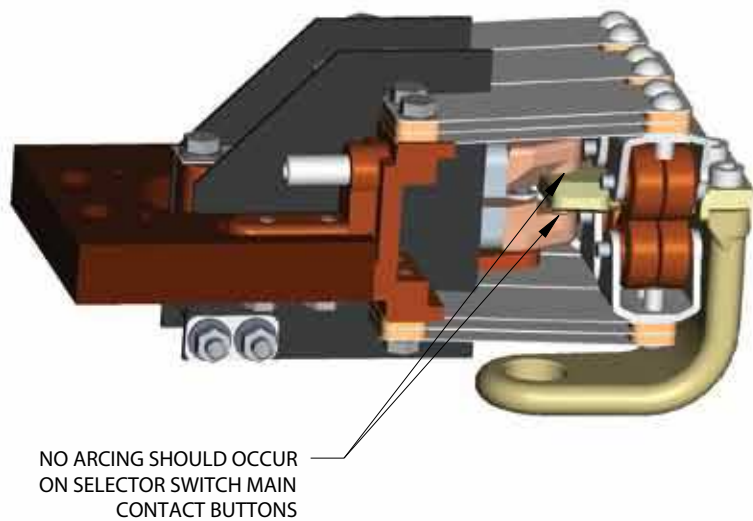
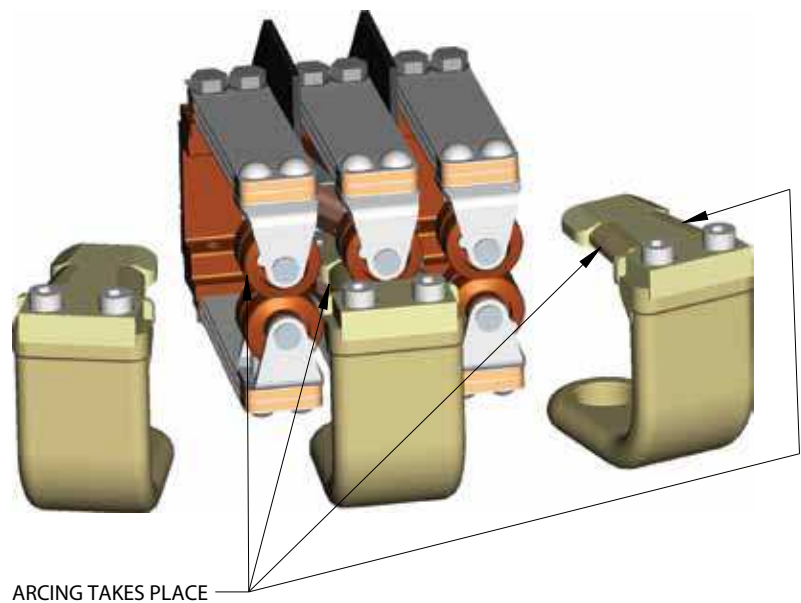
FIGURE 10: STATIONARY SELECTOR SWITCH CONTACT

Measure the degree of arcing surface contact wear of the stationary contacts and record in the inspection report. Compare with past measurements and observe trend for determining possible future contact replacement intervals. Digital photos are useful for this purpose.

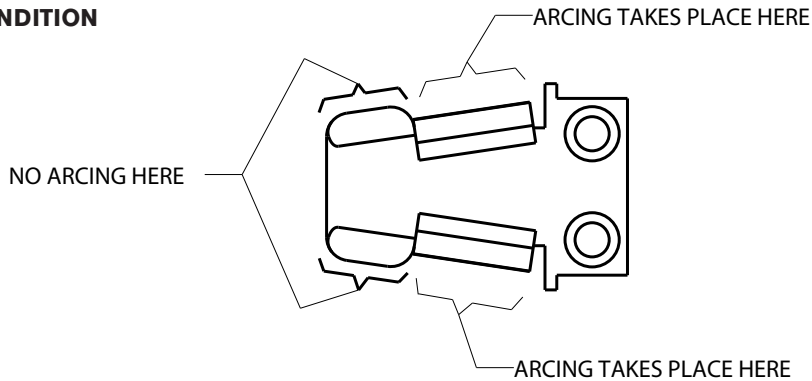
 **Do not file or smooth the burnt and/or pitted contact surfaces as this may reduce the life of the contact.**

A stationary contact should be replaced when the minimum amount of remaining copper tungsten along its length is 1 mm (see Figure 12, page 25).

**FIGURE 11:
MOVING SELECTOR
SWITCH CONTACTS**



NEW CONDITION



WORN CONDITION

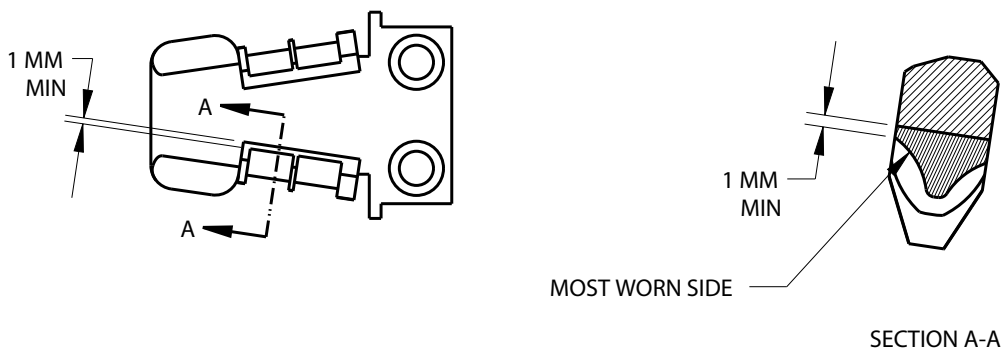


FIGURE 12:
MAXIMUM ALLOWABLE WEAR
ON STATIONARY SELECTOR
SWITCH CONTACT

Check Selector Switch Moving Contacts for Wear

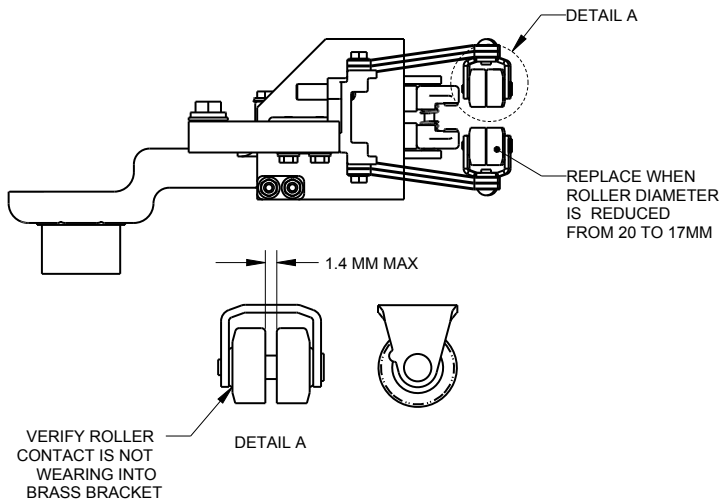
New rolling contacts have a diameter of 20mm. Rolling contacts should be replaced when the diameter of the rolling contact is reduced to 17mm. If any one of the twelve roller contacts on a phase measures below 17mm in diameter, replace all roller contacts on that phase. Replace rolling contacts that do not turn freely or have flat spots. If data points determine the diameter may fall below 17mm before the next major inspection, consider replacing the moving contact assembly at this time. Also, check that the roller contacts are not wearing into the brass bracket that holds them (see Figure 13, page 26).

A spring is located between the two roller contacts which applies about three pounds of pressure. Push one roller contact towards the other roller contact and release. The roller should move back so the shoulder on the roller is in contact with the brass bracket.

Check the gap between all 6 pairs of rolling contacts on each phase. This gap is nominally 0.6mm. The moving contact assembly should be replaced when the gap exceeds 1.4mm.

SPX Waukesha recommends replacing the entire moving contact assembly if any parts in the assembly are in need of replacement. The parts are assembled in the factory using special fixtures to assure proper contact alignment in all directions. This alignment is difficult to achieve without use of these special fixtures.

FIGURE 13: WEAR ON ROLLER CONTACTS



NOTE: If the moving contacts are replaced, replace any fixed contacts that are considerably worn in order to minimize wear of the new moving contacts.

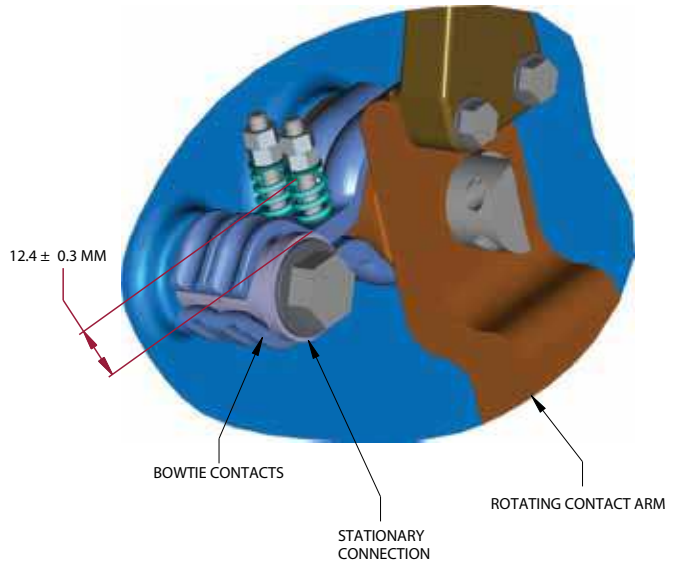
Carefully check the current collectors (a.k.a. slip contacts or bowties) that transfer current from the contact arm hub to the connection in the epoxy molding. There are two sets of these slip contacts per phase, one set on the reversing switch (see Figure 15) and one set on the selector switch (see Figure 14). Slip contacts should ride squarely on their mating surfaces without pitting, carbon deposits or contact sludge / filming of any kind. Verify the height of the spring holding the bowties to the current collector is 12.4mm \pm 0.3mm (see Figure 14).

Check Reversing Switches

The contacts of the reversing change-over selector (reversing switch) are shunted during operation and neither break nor make current. Any indication of burning or arcing is a sign of abnormal operation and should be investigated.

Carefully check the current collectors, (a.k.a. slip contacts or bowties) that transfer current from the contact arm hub to the connection in the epoxy molding. The slip contacts should ride squarely on their mating surfaces without pitting, carbon deposits or

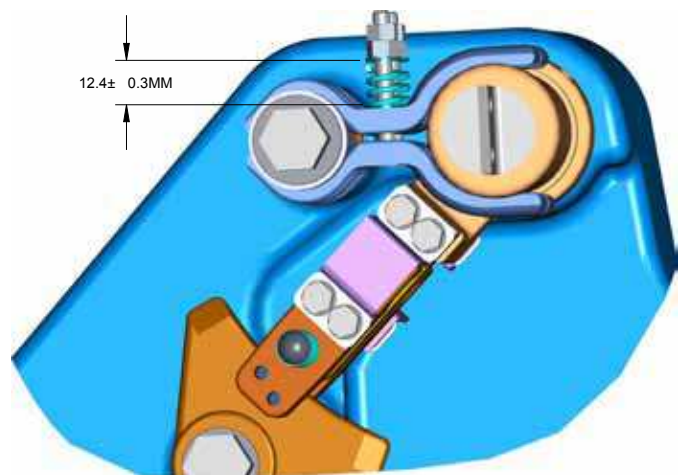
FIGURE 14: SPRING ADJUSTMENT OF BOWTIE CONTACTS



contact sludge / filming of any kind. Verify the height of the spring holding the bowties to the current collector is 12.4mm \pm 0.3mm (see Figure 15).

Design upgrades to the reversing switch and bowtie contacts were instituted in June 1991, August 1992, October 1994 and December 1997. If you have UZD[®] manufactured before that time, consider installing the upgraded contacts at the next major inspection. Contact the Waukesha[®] Components group for further information. See further information about upgrade kits on pages 14-18.

FIGURE 15: SPRING ADJUSTMENT OF BOWTIE CONTACTS



Check for Proper Contact Position and Alignment

To check this alignment, the epoxy coupling, Item 118 (see Figure 41, page 57) between the spring drive and the first phase assembly, must be removed.

NOTE: Mark all contact positions before removing any hardware so unit can be returned to this same position upon reassembly.

Remove the two Allen head screws on the T-handle in the drive shaft. With the T-handle and epoxy coupling removed, the moving contact assembly can be turned by hand from one fixed contact to the next. As the moving contact approaches the stationary contact, confirm that equal deflection and spring compression exists on both sides of the moving contacts (roller contacts and main current carrying contacts). The stationary contact should be in the middle of the moving contacts as they approach. Also, check that the roller contacts are parallel to each other and to the fixed contact to assure even wear of the contacts. Do this when the roller contacts are on the fixed contact. This requires manually moving the contact assembly for each pair of rollers. Also remove the T-handle and epoxy coupling from the reversing switch and check alignment. The stationary contact should be in the middle of the moving contacts as they approach. This is especially important if contacts have been replaced.



Be mindful of where your fingers, hands, clothing, etc. are before moving the contact assemblies or operating the tap changer from the motor drive as significant force can exist that can cause personal injury.

Replace the epoxy couplings and T-handles so the contacts can be driven by the spring drive mechanism. The moving, main current carrying contacts (not the rollers) include buttons that mate with the stationary contacts. With the moving contacts stopped in final operating position, verify that these buttons on both sides are fully on the flat part of the stationary contact and not partially on the ramp of the stationary contact. If buttons are not fully on the flat part of the stationary contact, excessive play may exist in the drive shaft components and spring drive mechanism.

This contact alignment should be checked in all tap positions in both directions.

The two outer sets of roller contacts do not touch a stationary contact in a normal (at rest) operating position. As the tap changer ages with use, the amount of play in the spring drive mechanism, couplings, bearings and shafts can increase such that the outer roller contacts may touch a stationary contact in the normal operating position. If this condition is found, it should be corrected by replacing the worn parts. Contact the Waukesha® service group for assistance as needed. This contact alignment should be checked in all tap positions in both directions on all phases. Check that the gap between leaf springs (or roller contact saddles) is $6.0\text{mm} \pm 0.2\text{mm}$ (see Figure 41, page 57).

Observation of the UZD® is recommended while operating it across the complete tap range using the manual mode of operation. Listen for unusual noises and watch for abnormal operation. A complete tap change operation should take about 6 seconds. The BUE motor drive mechanism takes about 6 seconds to wind up the spring battery in the spring drive compartment and about 70 milliseconds for the spring battery to discharge, moving the selector switch to the next tap in the oil-filled compartment. The reversing change-over selector moves at motor speed, and it takes about 2 seconds to move from one position to the other.

Reinstall transition resistors at this time. Numbers in parentheses are item numbers in Figure 44, page 59. If necessary rotate tap selector so the resistor support (2) is facing you. Pass the resistor (1) over the flat shaft (3) of the epoxy coupling. The resistor has a notch (4) which allows the resistor to pass over the shaft. The resistor may be pulled apart slightly to allow it to pass but be careful not to crack/break the resistor resin. Fasten the resistor with screws (9) and spring washers (10) through the two holes in the resistor and into the resistor support (2). Torque to 69 in-lb. Next, operate the tap changer to such a position that the ends (7) of the resistor can be fastened to the screws (8) on the resistor contacts. Use nuts (11) and spring washers (12). Torque to 132 in-lb. These four connection points are the electrical connection points for the resistor. Make a few more tap change operations to ensure the resistors are moving without interference.

Check Contact Pressure and Resistance

Having verified all contacts are in acceptable operating condition, SPX Waukesha recommends contact pressure and resistance also be verified at this time. Contact resistance is inversely proportional to contact pressure. Contact pressure is applied by springs. Discoloration of a spring may indicate that the spring has been hot and may have annealed and has reduced spring pressure allowing for higher contact resistance.

There are three common methods of checking contact pressure: manual comparison of one contact to the next, measurement with a fish scale and measurement with a load cell. The manual comparison is accomplished by using a smooth, non-metallic bar tapered on one end similar to the shape of a pencil or straight tip screwdriver. Slide the tapered end between contacts and rock back and forth slightly to feel the spring pressure. Do this on all like contacts and compare. If one or more contacts feel noticeably different than the others, further investigation is required. This can also be done with the bare hand if a tool is not available or is a personal preference.

Measurement of contact pressure using a fish scale can be accomplished by attaching the scale to the contact and pulling perpendicular to the contact mating surfaces until the contacts just start to separate. Read scale. This method can be problematic as all contacts may not be accessible with the scale. This fish scale method in combination with the manual comparison method mentioned above is a hybrid option.

The third method of checking contact pressure is to measure the pressure with a thin profile load cell by placing the load cell between the contacts to be measured. This method is not practical for measuring bowtie contact pressure.

Typical pressures:

- Roller contacts — 7-10 pounds
- Main current carrying contact on selector switch — 7-10 pounds
- Reversing switch — 16-21 pounds
- Bowtie current collector contacts (both selector switch and reversing switch) — 20-24 pounds

Record all contact pressure measurements and observations in the inspection report and compare readings between phases.

Check contact resistance by placing the probes of a micro-ohm meter as close to the contact connection as possible. Be aware that windings are connected to the UZD®, and the contact resistance measurement will see these winding parts in parallel with the contact you are measuring and may be in a similar order of magnitude. Beware of inductive kickback if using a DC instrument. Typical contact resistances should be below 200μΩ. If contact resistance is above this value, further investigation and corrective action is required.

Record all contact resistance values on the Inspection Report. Compare current reading to prior readings and observe trend.

After checking all contacts as further described below, replace the transition resistors just prior to oil filling by reversing the process described above.

Notes on Silver Plating

After some amount of use, the silver plating may abrade. This is considered normal wear. Lack of silver plating will not affect performance or temperature rise of the contacts. Silver plating is provided to reduce film formation on the contacts. If contacts are used sufficiently to wear the silver plating away, enough abrasion also exists to wipe film away.

Notes on Contact Filming and Coking

Some UZD® operating conditions and environments contribute to a filming or coking of contact surfaces. This is more often seen on the reversing switches. Factors that are likely contributors to this filming are high levels of the following in the oil: water, carbon particles, acid, corrosive sulfur and potentially other airborne chemicals such as chlorine and sulfur. These may result in low Interfacial Tension (IFT). Heat accelerates the filming process in the presence of one or more of these compounds. This film is undesirable because it increases contact resistance and, therefore, increases contact temperature due to I²R heating. This can lead to a thermal runaway and, eventually, contact failure. This failure mode has been an occasional problem with tap changers of all types, and the cause is not fully understood.

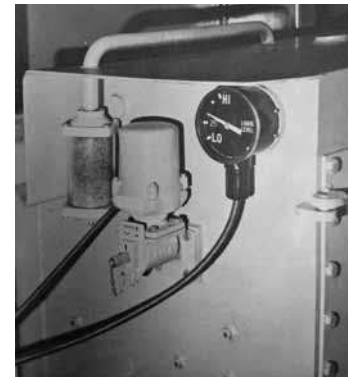
Contact operation can help wipe this film from the contact surfaces. This acts to help keep the contact resistance low. If the UZD® does not normally go through neutral, you should consider changing the de-energized tap changer setting so the UZD® regularly goes through neutral.

Inspect both the moving contacts and the stationary contacts for evidence of tightly adhering carbon particles or excessive build-up of tarnish. The tarnish will appear as a tightly-adhering, dark, yellowish-brown to yellowish-black stain or film on top of the silver plating. Its appearance is similar to that of the gum which forms on automotive carburetors. Few effective means exist for cleaning this material from the silver plated contacts without leaving harmful residue, thus raising contact resistance. Brass or bronze wool may be used to attempt to clean the film away. These materials will not leave small insulating particles on the contacts as some other abrasive materials can. The most effective fix is to replace the contacts and the oil. Even though contacts may look bright and shiny after cleaning with compounds containing chlorides, sulphates or silicates, we recommend against using them as they leave a residue on the contact surface that seems to be conducive to faster film formation. After cleaning contacts, you should flush with transformer oil and wipe clean. SPX Waukesha recommends replacing the mineral oil as service aged oil is a likely contributor to contact filming.

Check Silica Gel Breather and Connections

The silica gel auto-recharging dehydrating breather (ARDB) breather tube to the UZD® should be disconnected during oil draining and filling as oil can coat the gel and prevent absorption of moisture. If in doubt, replace gel. Check to see that enough slack is available in the hose to make up for what is lost in this disconnection.

Verify that the hose connection from inside the oil compartment to the top of the silica gel breather is open and not kinked or damaged (cut, cracked, leaking, etc.). On older designs with a steel tube, run a fish tape through this breather tube to verify the tube is open. This operation will positively verify there are no restrictions in the breathing tube.



On units built after March 1996, there are no restrictions in the breather tube.

Verify that the silica gel is dry. Blue gel turns pink when wet. Orange gel turns green when wet. SPX Waukesha recommends use of the orange gel as the test data suggests it will let less water into the tap changer.

Please refer to, "Breather" on page 9 in the Annual Inspection section for further information on how to verify proper operation of the silica gel breather.

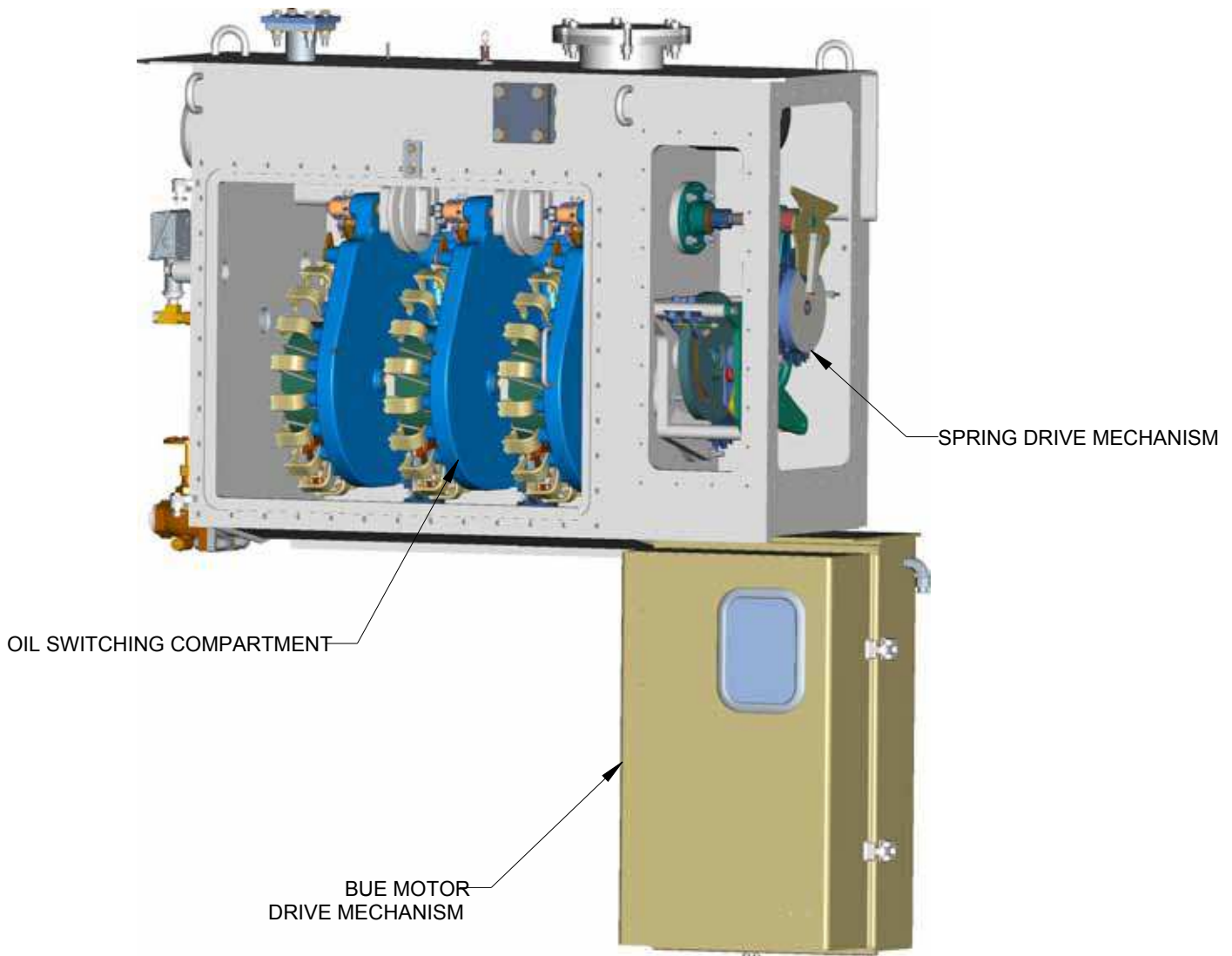
Check Liquid Level Gauge

Manually raise and lower the float arm from inside the oil-filled compartment and verify the liquid level gauge indicator is operating properly. If equipped with switches, manually raise and lower the float arm from inside the oil-filled compartment and verify that the contacts operate by checking at the terminal block in the main control cabinet. This will verify operation of the contacts and wiring.

Optional UZD® Tank Accessories

If your tap changer includes additional equipment beyond what is mentioned above, verify the proper operation of each of these devices. Instructions for each device can be found in the accessories section of the transform instruction book.

FIGURE 17: GENERAL ARRANGEMENT



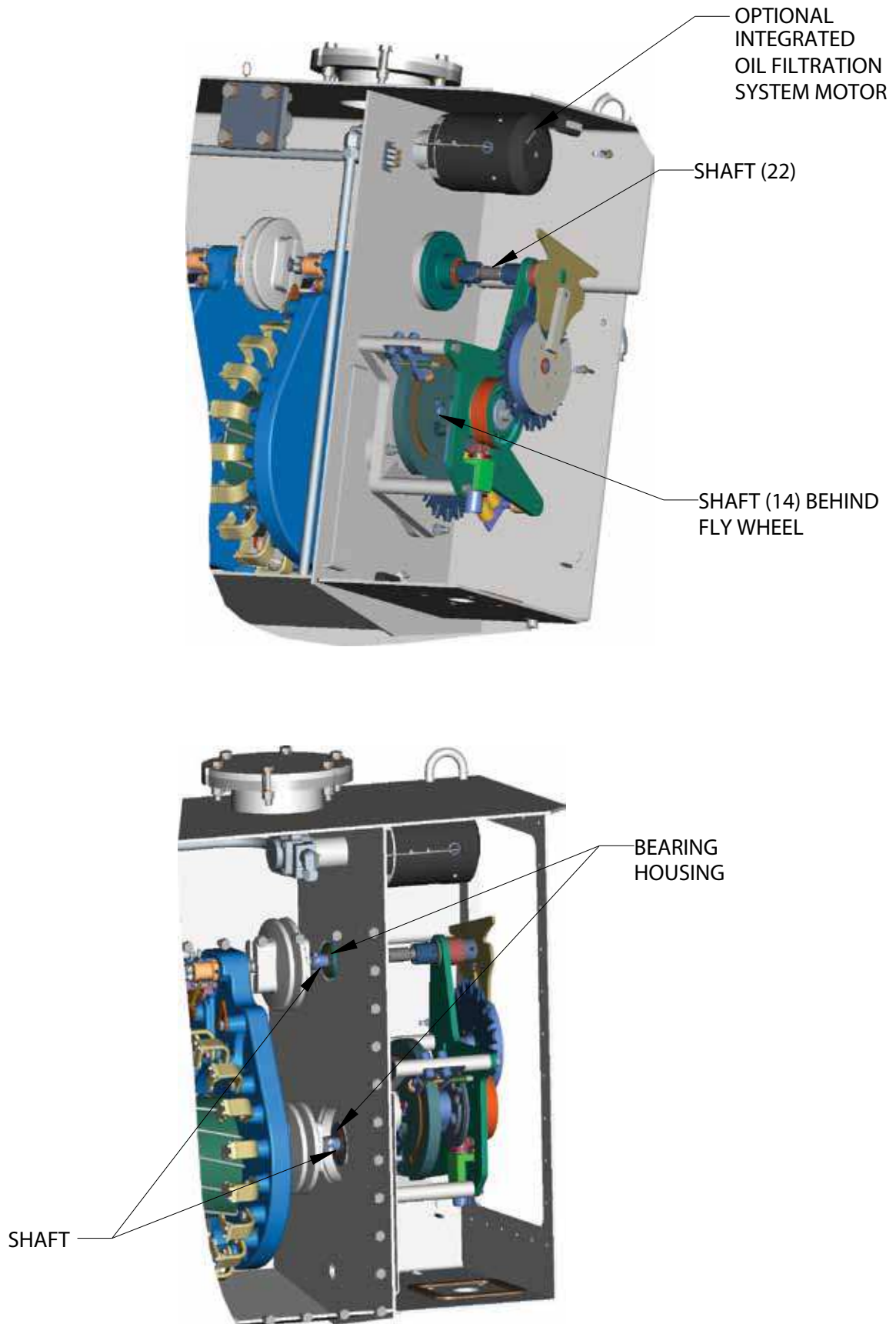
PERFORM MAINTENANCE ON SPRING DRIVE MECHANISM

Check for Leaks

With the spring drive mechanism inspection doors removed, check for leaks at the oil filter motor (or cover plate, if different oil filter system is used).

Also check for leaks at the mechanical connections between the spring drive housing and the oil-filled switch compartment as shown in Figure 18, page 31 and Figure 22, page 34. Both shafts (22 and 14) connect the spring drive and the oil-filled switch compartments. Shaft 22 enters the oil-filled switch compartment through bearing housing 23. A similar bearing housing exists for shaft 14. Additionally, an O-ring gasket is located at each of these shaft locations. Check also along weld lines and at the brass pipe plug (or temperature probe, if so equipped) at the bottom center of the spring drive mechanism compartment.

FIGURE 18: SPRING DRIVE MECHANISM



Adjust the brake, lubricate the assembly, and check for proper mechanical functioning as described below.

Brake Adjustment

The brake shoes (item 118) and the fly-wheel (item 115) as shown in Figure 19 should be checked to verify they are free of dirt, grease and foreign material. Wipe clean with Toluol if required. The tap changer should be operated in both the raise and lower direction to verify the fly-wheel stops so that the red line on the brake is between the two outer marks on the fly-wheel, as shown in Figure 20, page 33. Operate the tap changer from 3R to 4R and the red mark should stop between the pair of marks indicated for the counterclock-wise direction.

At this time, visually check the nylon brake rollers (black with bronze insert) which ride in the circular grooves of the fly-wheel (see Figure 20, page 33). There should be no sign of damage or wear, either on the axles or outer diameters.

The nylon brake roller I.D. should fit snugly on the axle. The nylon brake roller I.D. should be 6.35mm (1/4 inch) and O.D \geq 21.00mm (0.827 inch). Replace if out of tolerance (see Figure 21, page 33).

If you have an older UZD[®] with white nylon brake rollers, contact the Waukesha[®] components group and ask for the SPX Waukesha Service Advisory SRV-SA-0312 and request the upgraded rollers.

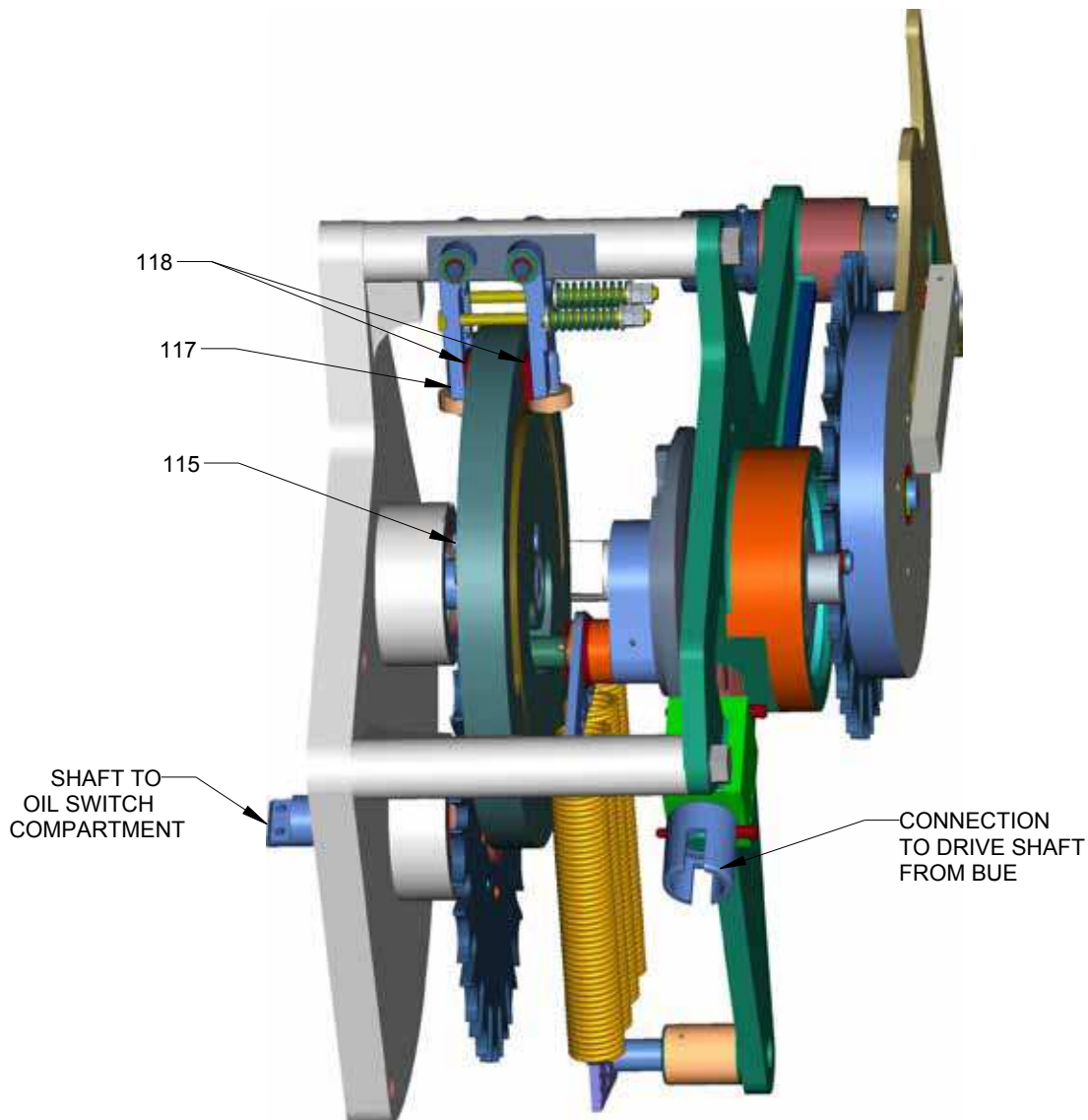


FIGURE 19: BRAKE

FIGURE 20: FLY WHEEL STOP MARKS

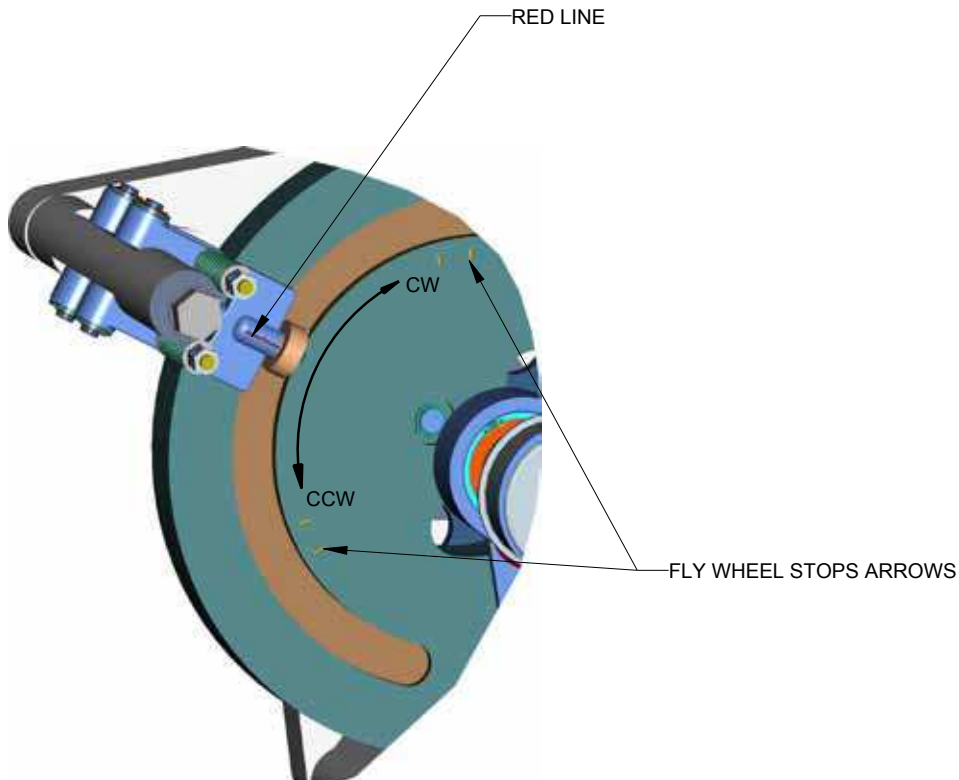
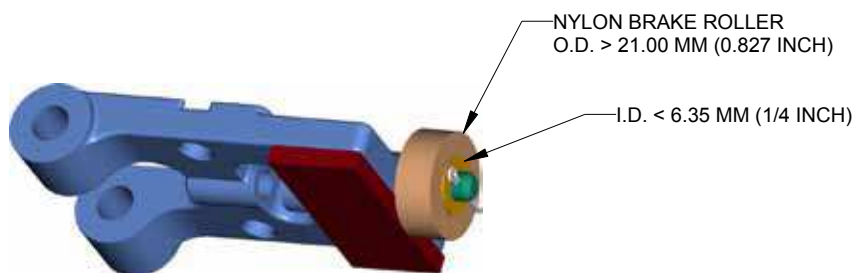


FIGURE 21: NYLON BRAKE ROLLER



Lubrication of Spring Drive Mechanism

The Geneva wheels and conical toothed gears should be checked for lubrication. If they are dry, they should be sparingly lubricated. Excessive lubrication should be wiped off.

Refer to Figure 23, page 35 for points of lubrication.

FIGURE 22: SPRING DRIVE MECHANISM

LEGEND ITEMS FOR FIGURE 22

- 1) SHAFT COUPLING AND SHAFT
- 2) BEVEL GEAR (SMALL)
- 3) BEVEL GEAR (LARGE)
- 4) CAM SHAFT
- 5) GEAR DRIVE SUPPORT
- 6) SPRING OPERATOR CRANK
- 7) DRIVE PIN
- 8) SPRING BATTERY
- 9) FLY WHEEL
- 10) FLYWHEEL SHAFT
- 11) DISK BRAKE
- 12) GENEVA GEAR DRIVE
- 13) GENEVA GEAR
- 14) LTC SHAFT
- 15) DRIVE SUPPORT
- 16) BACKLASH COUPLING
- 17) GENEVA GEAR DIVE
- 18) GENEVA GEAR
- 19) CONTROL DISK
- 20) CHANGE-OVER ARM
- 21) COUPLING SHAFT
- 22) SHAFT
- 23) BEARING HOUSING

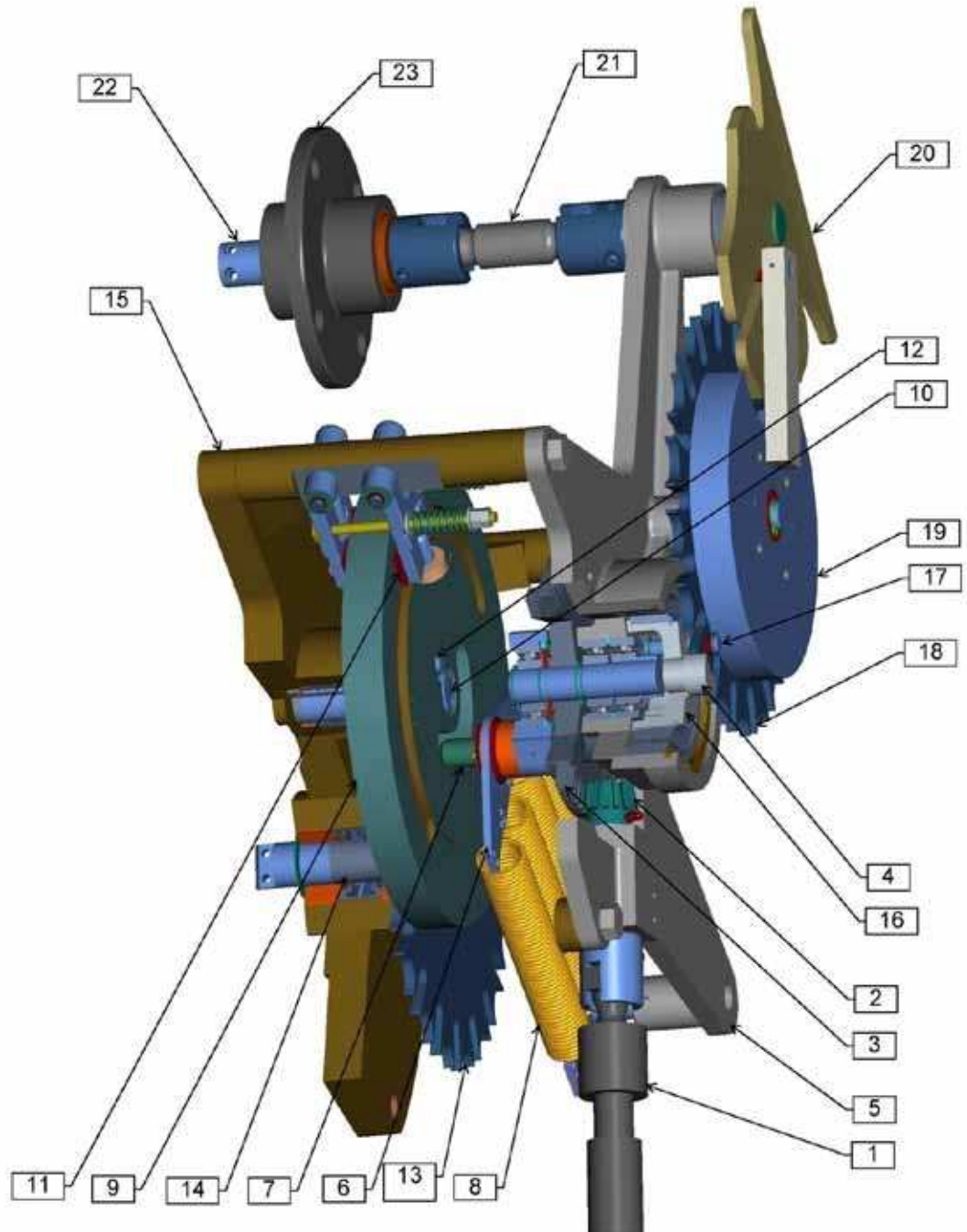
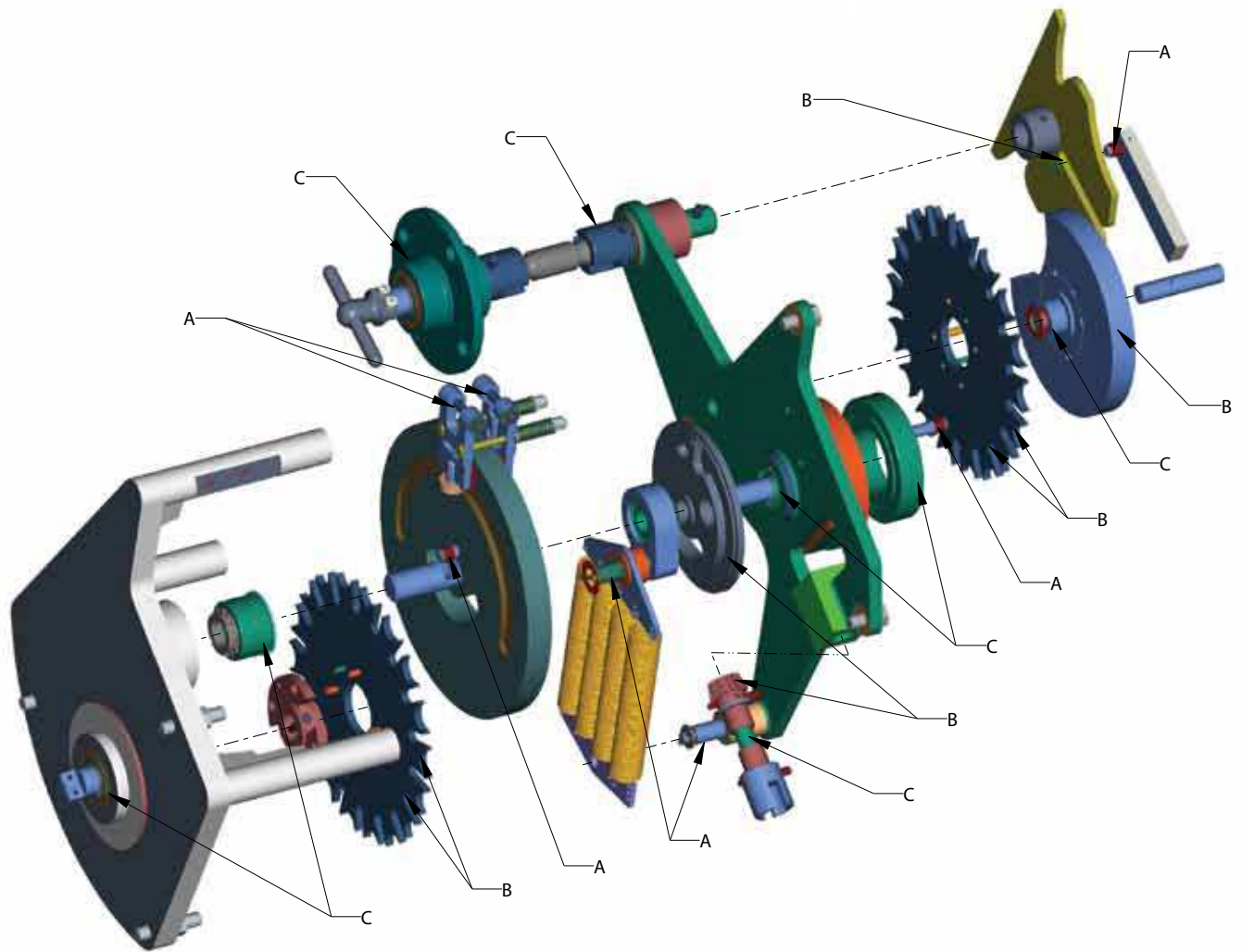


FIGURE 23: EXPLODED SPRING DRIVE MECHANISM

Some items shown in cutaway for clarity



The points labeled “A” should be sparingly lubricated with one of the following oils:

- Lubricating oil, hydraulic oils with viscosity 46 cSt @ 40C – ISO Grade 46
 - BP – Energol HLM
 - Castrol – Hyspin AW 46
 - Mobil – DTE 25
 - Petro-Canada – Hydex AW 46
 - Shell – Tellus 46
 - Texaco – Rando HD46

Points labeled “B” should be sparingly lubricated with one of the following greases:

- Lubricating grease, lithium-soap based low temperature grease.
- Suggested greases are:
 - Exxon: Beacon P-290
 - Mobil: Mobilux 2
 - Mobil: Mobilgrease 28
 - Shell: Aeroshell Grease 6
 - SKF: LGLT 2
 - Texaco: Starfak PM

Points labeled “C” should NOT be lubricated.

NOTE: The fly-wheel and brake linings should be protected from all lubricants.

Mechanical Checks

Run the UZD[®] to the end of its range of travel in both directions. Verify proper operation on all tap positions. If unusual sounds exist, attempt to locate the source and make necessary corrections. Note engagement of the drive pin on the end of the reversing operating arm on item 19 (see Figure 26, page 37) in the center slot of item 20 as it moves the reversing switch through neutral (see Figure 24). Check to ensure the position of the reversing switch drive pin is in the location in Figure 25 at the lower tap extreme (16L) and in a similar position on the other side of the butterfly drive at the raise tap extreme (16R). No wear or galling on the OD of item 19 or the mating surface of item 20 should be present. Check that the drive pin is intact and that the arm on item 19 is straight (not bent). Contact the Waukesha[®] service group if wear is seen at any of these points. Note that when the reversing switch is passing through neutral, the main selector switch will make two operations and should stop in the straight up (or 12:00 o'clock position) at N.



FIGURE 24: REVERSING SWITCH GENEVA DRIVE AT NEUTRAL

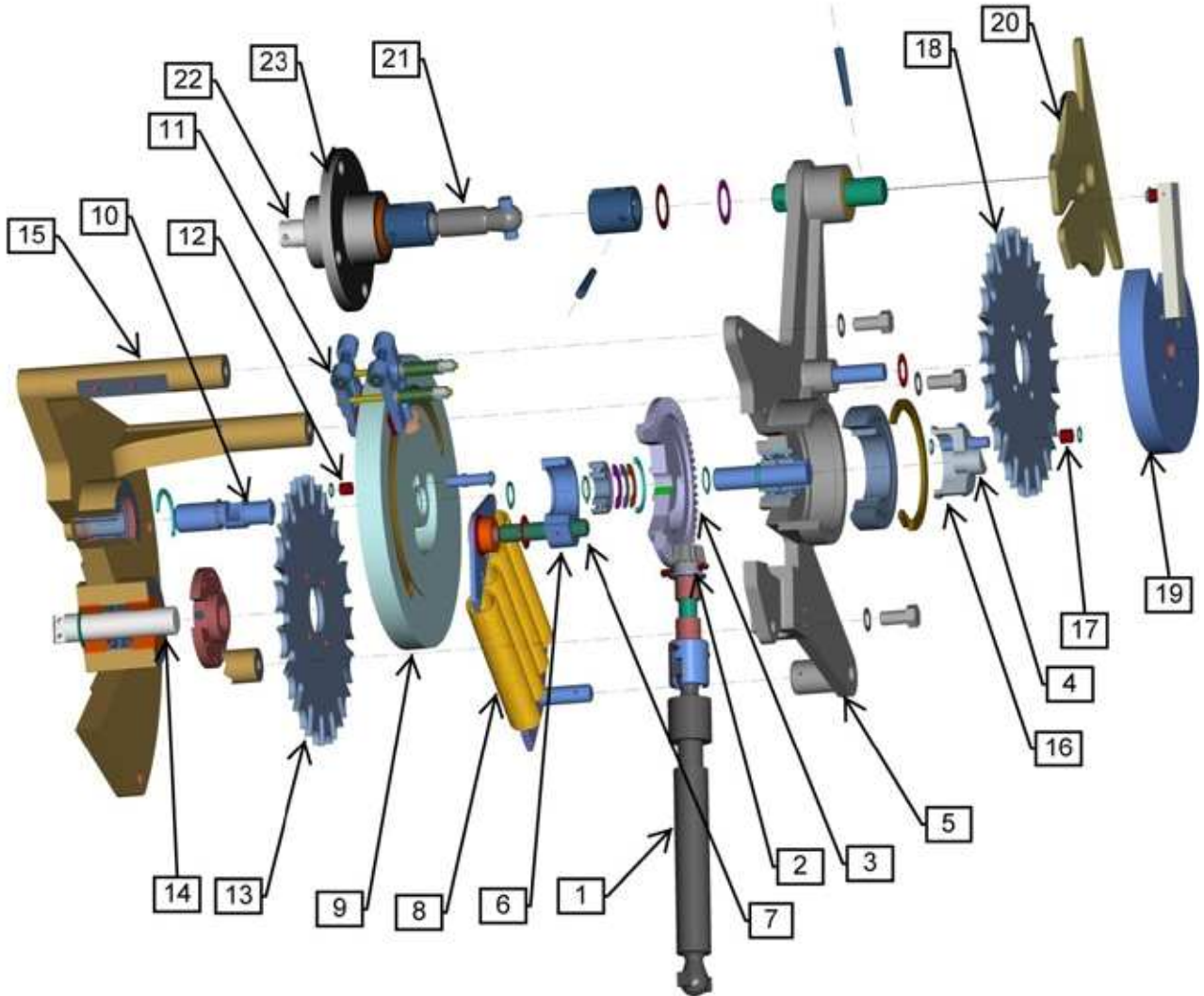


FIGURE 25: REVERSING SWITCH GENEVA DRIVE AT TAP EXTREME

FIGURE 26: EXPLODED VIEW OF SPRING DRIVE MECHANISM

LEGEND ITEMS FOR FIGURE 26

- | | | |
|-----------------------------|-----------------------|----------------------|
| 1) SHAFT COUPLING AND SHAFT | 9) FLY WHEEL | 17) GENEVA GEAR DIVE |
| 2) BEVEL GEAR (SMALL) | 10) FLYWHEEL SHAFT | 18) GENEVA GEAR |
| 3) BEVEL GEAR (LARGE) | 11) DISK BRAKE | 19) CONTROL DISK |
| 4) CAM SHAFT | 12) GENEVA GEAR DRIVE | 20) CHANGE-OVER ARM |
| 5) GEAR DRIVE SUPPORT | 13) GENEVA GEAR | 21) COUPLING SHAFT |
| 6) SPRING OPERATOR CRANK | 14) LTC SHAFT | 22) SHAFT |
| 7) DRIVE PIN | 15) DRIVE SUPPORT | 23) BEARING HOUSING |
| 8) SPRING BATTERY | 16) BACKLASH COUPLING | |



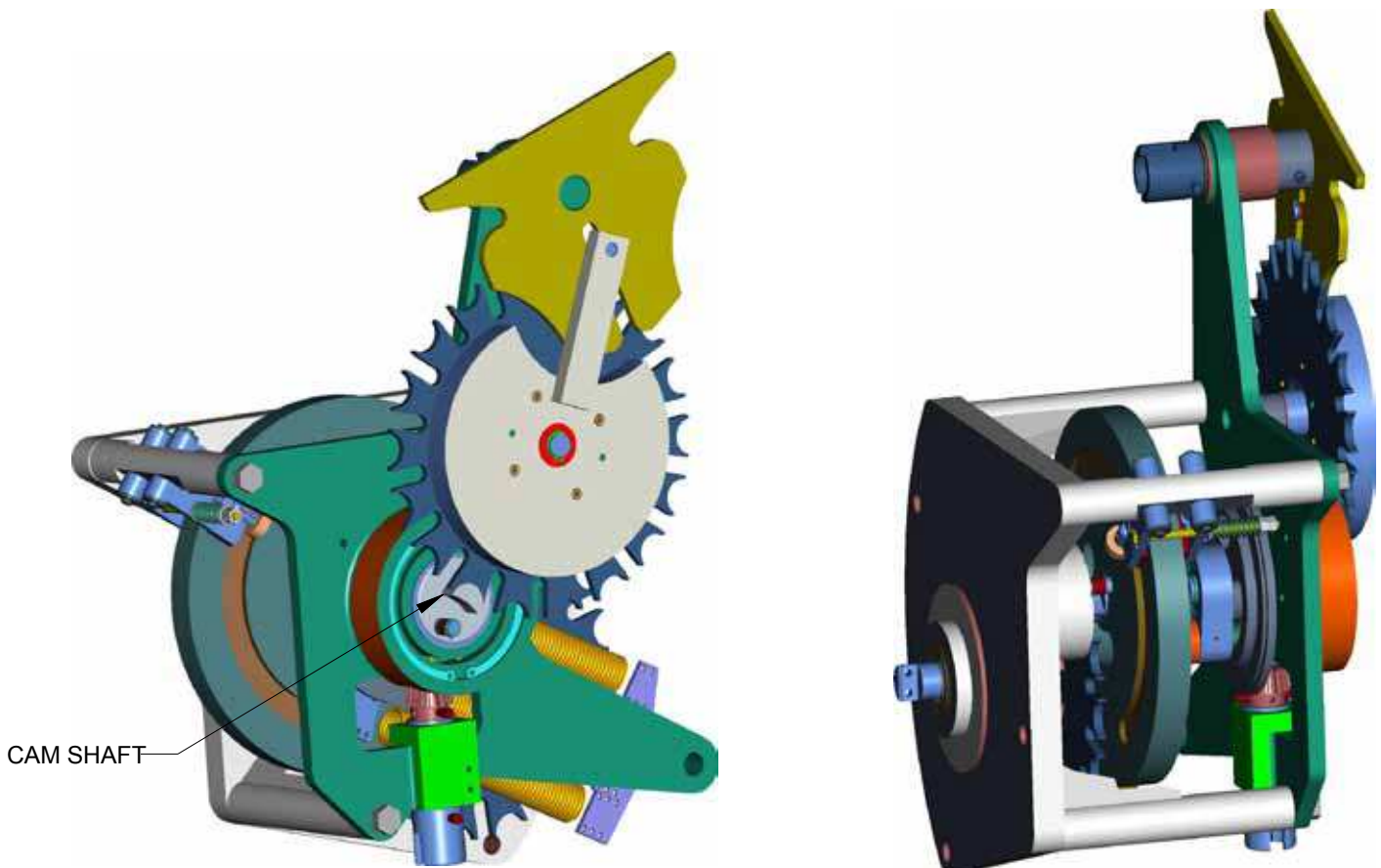
Check for excess wear on Geneva wheel (item 13 and 18 on Figure 26) by attempting to move the Geneva wheel back and forth in the direction of rotation. The Geneva wheel should remain virtually motionless during this process. Also check for wear on Geneva wheel drive pin (items 12 and 17, respectively) and brass cam shaft (half-moon) items 12 and 17 respectively for damage, wear, galling, etc. as well as damage, wear, galling, etc. on Geneva wheel itself.

Check for excess wear and broken springs on the spring battery; repair or replace as necessary.

Check for missing or loose hardware; replace and tighten as necessary.

Operate the tap changer several times in both directions to verify the flywheel and spring battery are operating at high speed (about 70 milliseconds: second spring discharge time). If they appear to be moving slower than normal, a problem may exist and should be investigated.

FIGURE 27: CAM SHAFT



Access Panel Gaskets

Before closing the two access panels on the spring drive compartment, check the gaskets and replace if damaged. Before closing the spring drive compartment, make one last check of the interior to verify no rags or tools remain inside. Replace access panels on spring drive compartment. Tighten each bolt to a torque of 4 ft-lbs using a star pattern tightening sequence.

Oil Filling

Before closing the switch compartment to prepare for oil filling, make one last check of the interior to verify no rags or tools remain inside. Run electrically to 16R (or raise tap extreme) and verify electrical limit switch operates properly. Next, insert manual

handle and crank in raise direction, verifying the mechanical stop is contacted before the contact moves. Repeat same procedure in lower direction.

Inspect the door gasket and replace if damaged.

NOTE: SPX Waukesha suggests replacing this gasket if it is more than six years old to minimize chances of leaks. Lubricate O-ring gaskets with light coating of petroleum jelly before replacing the door to help prevent pinching the gasket and allowing for more even compression of the gasket.

Replace the door and tighten the bolts to 30 ft-lbs of torque using a star pattern tightening sequence.

Verify properties of the new oil to be installed, as described in the Transformer Oil Specification section of the transformer instruction manual or in the Waukesha® UZD® Technical Manual, before refilling the switch compartment. Use of a filter press is recommended. Record oil test values in the Inspection Report. Vacuum oil filling is not required as there is no hygroscopic material in this compartment. Verify proper oil level is achieved by observing the liquid level gauge, compensating for oil temperature. If the temperature of the oil in the UZD® is around 25°C, fill to the 25°C mark on the oil level gauge. See Waukesha® UZD® Technical Manual, pages 61-62, for information on proper oil level for temperatures other than 25°C.

NOTE: The oil-filled switch compartment of the UZD® is designed to be free-breathing under normal operation. Nevertheless, this compartment will withstand a full vacuum, should it ever be applied, with atmospheric pressure and no oil in the main tank. The fact that the switch compartment is designed to maintain a seal between itself and the main transformer tank when the transformer tank is being vacuum-filled is extremely important. Only atmospheric pressure should be applied on the UZD® tank while vacuum is applied to the transformer tank; equalizing the pressures in these two compartments during vacuum filling of the transformer is not necessary and having oil in the UZD® compartment when vacuum filling the main transformer tank is permissible.

Recent research indicates that there are certain agents in transformer oil that cause or promote the formation of resistive film on contacts. Higher contact resistance increases I^2R heating of the contact which increases the rate of film formation and can lead to a coking failure of the contacts. The film formed by these materials is stable and tough, resisting mechanical removal. The chemical agents responsible for the formation of these films are too many and too varied to list. A test to assess the “Coking Potential” of mineral oil was invented by others but is not presently commercially available. Presently there is no known way of neutralizing or removing these agents from the oil. Therefore, SPX Waukesha recommends that oil be replaced with new oil rather than reusing oil after it has been removed for inspection or maintenance. Service

aged oil that is reconditioned or reclaimed may deteriorate more quickly than new oil. Considering the cost of opening a tap changer or of a tap changer failure, replacing the oil is a prudent and cost-effective safeguard.



Do not reconnect the silica gel breather until after refilling the compartment with oil to prevent oil mist from coating the silica gel as oil-coated gel will not absorb moisture.

After oil filling, operate the tap changer from one tap extreme to the other several times to help shake loose many of the bubbles. We also recommend letting the tap changer stand for at least three hours prior to re-energization so that any remaining bubbles have a chance to dissolve into the oil.

If the transformer was tripped offline by a protective device, verify through testing (such as TTR, power factor, etc.) the transformer is in proper condition to be returned to service.

PERFORM MAINTENANCE ON THE BUE MOTOR DRIVE MECHANISM

All electrical and mechanical components should be checked for proper condition and operation with maintenance being performed where necessary. This list of maintenance procedures can include lubrication, brake adjustments and operation of the tap changer through its entire range. For a better understanding of how the motor drive and its control circuits function, see Waukesha® UZD® Technical Manual, pages 33-37.

Examine the motor drive mechanism equipment for any loose screws or wires and tighten if necessary. Check for broken, damaged or worn parts and replace. Verify that drive shaft coupling at the top of compartment going to the spring drive mechanism is in working order. Check gears for signs of excessive wear and proper engagement. Check control wiring insulation for signs of damage, wear, cracks or overheating and repair as necessary.

Operations Counter

Operate the tap changer in both raise and lower directions and verify that the operations counter advances one count per operation. The counter is mechanically activated so no control power is required. Repair or replace if not functioning properly.

Indicator Flag and Brake

The red mechanical flag which indicates whether a raise or lower operation is underway is located at the end of arm 116 on Figure 29, page 41. The brake which determines the stopping point of this flag is called the 'brake for maintaining contact', item 129 on Figure 29, page 41.

The maintaining, interlocking and auxiliary contact switch (33), item 138 on Figure 29, page 41, should move freely without binding when toggled by hand.

The brake (item 129) should be checked for proper operation by observing that the red indicator flag on the end of arm (item 116, Figure 29, page 41) returns to the center position of the operation indicator (item 119). This function should be checked in both raise

and lower directions by operating the UZD[®] with either the motor or the hand crank. The shaft the indicator flag is mounted on is also connected to the 33 switch (maintaining interlocking and auxiliary contact) which keeps the drive motor running to complete a tap change. If the brake on the indicator flag shaft is set too tight, the 33 switch (item 138) will not open and another tap change will be initiated in the same direction. This may likely continue to a tap extreme, possibly causing an over or under voltage condition. If the flag fails to return all the way to the central position, loosen the brake. DO NOT, under any circumstances, get lubricant on the brake or the cam bar (Item 128) in the vicinity of the brake.

If the brake on the indicator flag shaft is set too loose, the shaft may travel past center and initiate a tap change in the opposite direction, which will cause hunting and an excessive number of tap change operations. If this loosening has occurred, tighten brake (129) until the flag stops in the center of its viewing slot. The indicator flag may travel past center and return to center faster than can be seen. If over travel is suspected, insert a pencil in the slot next to the flag and determine by feel if the flag hits the pencil when returning to center.

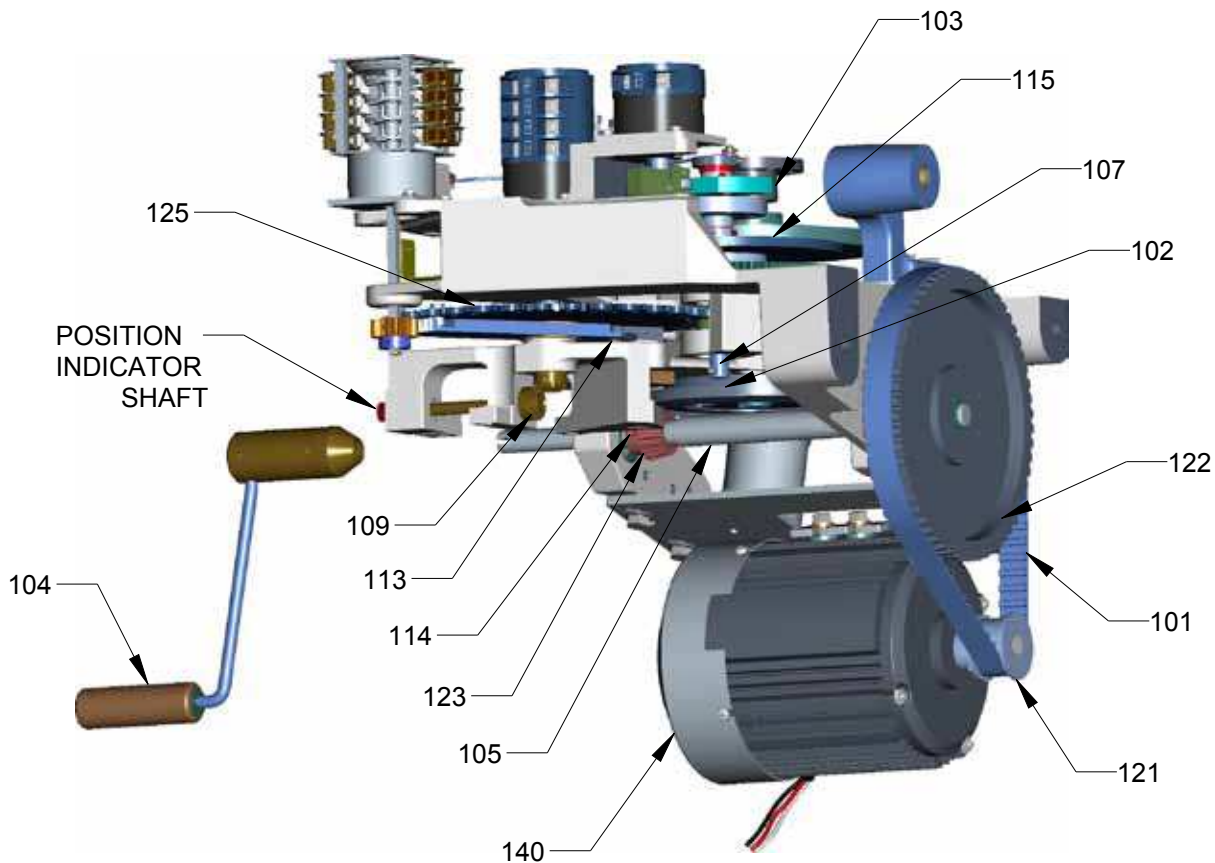
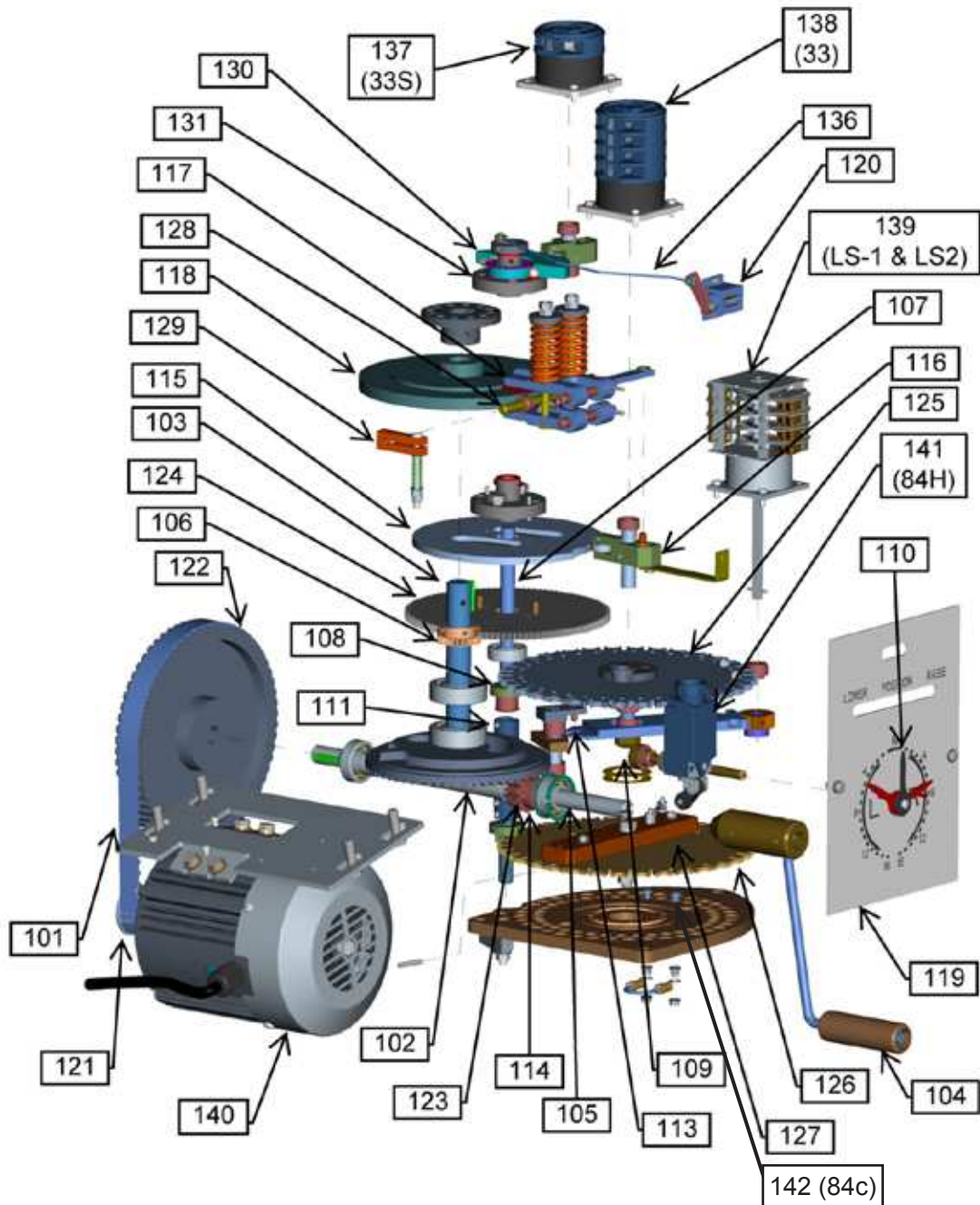


FIGURE 28: BUE MOTOR DRIVE MECHANISM SEEN FROM SIDE/BACK WITHOUT CABINET

FIGURE 29: EXPLODED VIEW OF BUE MOTOR DRIVE MECHANISM

LEGEND – ITEMS FOR FIGURES 28 AND 29

- | | | |
|---------------------------|-------------------------|--|
| 101) TIMING BELT | 115) CAM DISK FOR (138) | 128) CAM BAR |
| 102) BEVEL GEAR (LARGE) | 116) ARM | 129) BRAKE FOR MAINTAINING CONTACT |
| 103) COUPLING SHAFT | 117) BRAKE | 130) CAM DISC FOR 137 |
| 104) HAND CRANK | 118) BRAKE DISC | 131) DRIVING DISC FOR 130 |
| 105) OPERATING SHAFT | 119) FRONT PLATE | 136) COUNTER ARM |
| 106) SPUR GEAR (SMALL) | 120) OPERATION COUNTER | 137) START CONTACTS (33S) |
| 107) "ONE TURN" SHAFT | 121) PULLEY (MOTOR) | 138) MAINTAINING, INTERLOCKING, AUXILIARY CONTACTS |
| 108) GENEVA GEAR DRIVE | 122) PULLEY (GEAR) | 139) LIMIT SWITCH (LS-1 AND LS-2) |
| 109) BEVEL GEAR | 123) BEVEL GEAR (SMALL) | 140) MOTOR |
| 110) MECH. POS. INDICATOR | 124) SPUR GEAR (LARGE) | 141) INTERLOCK SWITCH |
| 111) COUPLING | 125) GENEVA GEAR | 142) CONTINUATION CONTACTS (84C) |
| 113) MECHANICAL END STOP | 126) GENEVA GEAR | |
| 114) BREAK-OFF SAFETY PIN | 127) CONTACT DEVICE | |



Flywheel Brake

Refer to Figure 29, page 41. Visually inspect the brake disc, item 118, and remove any grease, dirt or foreign material. The brake, item 117, should absorb the moving energy in the motor, the toothed pulley and other components at the end of each operation. This brake should be adjusted so the red timing mark on the flywheel stops within the width of the brake, checking for operation in both raise and lower directions. When the red timing mark is within the width of the brake, the roller on arm (item 116) should reside in the middle of the notch in the cam disc, item 115.

If the brake is too loose, the cam disc will continue turning and the end of the notch will hit the roller, causing the tap changer to operate another cycle. If the brake is too tight, the tap changer will operate to one tap extreme, preventing electrical operation in the other direction. To tighten brake, loosen jam nut and turn lower nut clockwise, then retighten jam nut. To loosen brake, loosen jam nut and turn lower nut counterclockwise, then retighten jam nut.

If the brake does not function correctly after adjustments have been made, the problem is likely being caused by oil or grease on the brake lining. The brake lining should be cleaned as follows:

- 1) Remove the roll pins holding the supporting shafts on the brake shoe with a pair of pliers.
- 2) Remove the shafts and brake shoes.
- 3) Clean the brake linings on the two brake shoes with a suitable grease-dissolving solvent.

NOTE: If the brake linings are saturated with oil or grease, they should be replaced.

Timing Belt (Toothed Belt)

Check the motor drive timing belt (item 101, Figure 29, page 41) for cracks, splits, missing teeth, fraying, unusual wear, etc. Replace if damaged or worn. Check tension on the motor belt. With a force of 2.2 lbs (1 KG), the belt should deflect by about 1/4 inch (5mm). If the deflection is more than 1/4 inch (5mm), the belt should be tightened. This is accomplished by loosening bolts in the elongated holes on the motor mounting and sliding the motor until the correct tension is obtained. If the belt needs to be changed, slide the motor in the opposite direction until the belt is free. Check that the belt is moving freely, not rubbing on the back wall of the compartment or slipping.

Wiring and Termination

Check all wire terminations to insure they are tight and not corroded. Wires should not move when reasonable force is applied, by hand, to the connection. Also, verify that the wire insulation is not damaged.

Starting Contactors

Manually depress plunger of raise and lower starting contactors (position shown in Figure 30, page 43) to verify unobstructed operation.

Continuation Contacts

The continuation contacts Item 142 (84C) are located on the rotating arm beneath Geneva wheel (item 125, Figure 29, page 41). These contacts enable the tap changer to move through RN and LN tap positions without stopping. Visually verify that contacts are clean and free to move by electrically operating them through neutral.

Start Switch

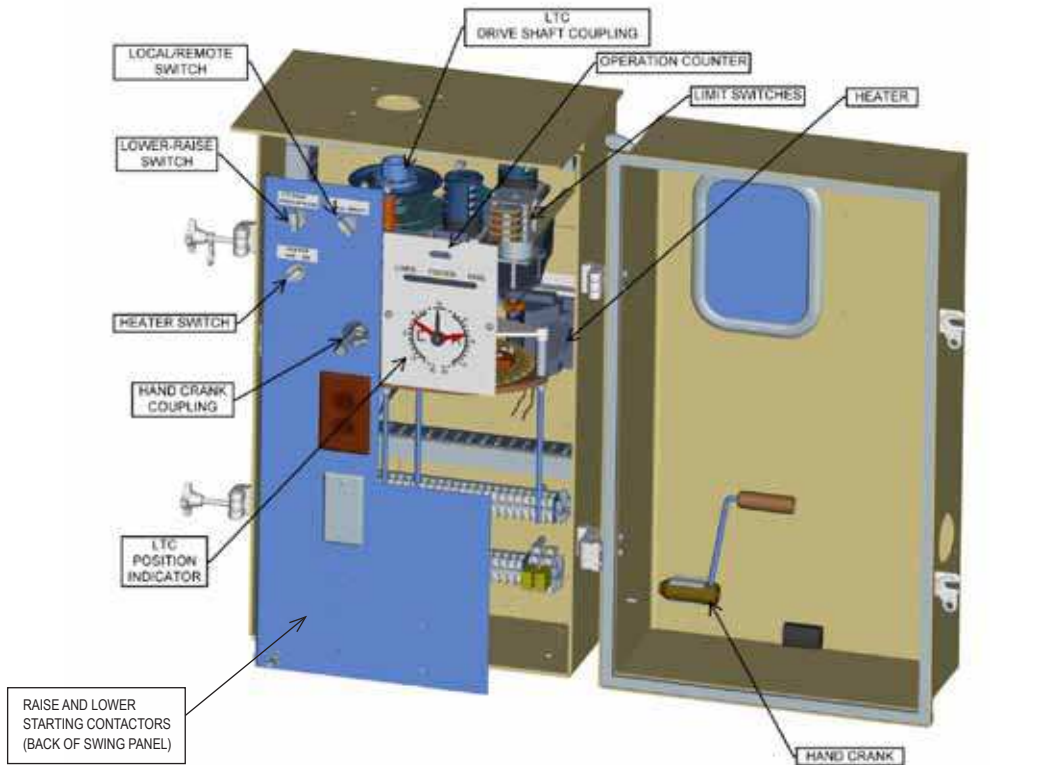
The start switch (33S)(item 137 on Figure 29, page 41) should move freely without binding when toggled by hand. Verify that this switch operates electrically after power is restored. Replace as necessary.

Anti-Condensation Heater

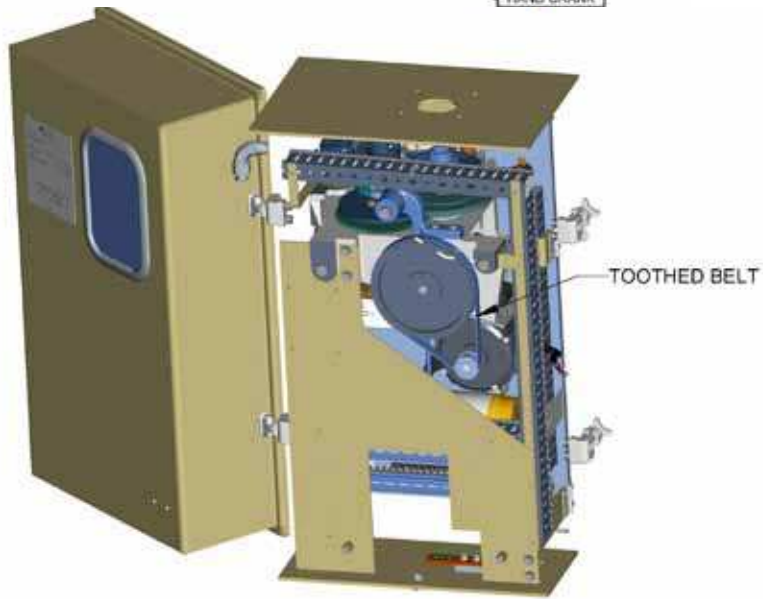
Check that the heater (see Figure 30 and 31, page 43) is operating properly. This heater is a Positive Temperature Coefficient (PTC) heater and intended for continuous operation; therefore, the heater circuit breaker and heater on/off switch should always be closed. A thermostat is not required. The resistance of the heater element changes with ambient temperature. Verify the heater fan is running and that some amount of heat is coming from the heater. Clean dust, dirt or debris from the fan and from the fins on the heater.

Lubrication

To keep the BUE motor drive mechanism in top working order, adding a small amount of lubrication is recommended during the major inspection. If predictive indicators are being used to choose timing for major inspections, consider adding this lubrication at least once every 10 years. See Tools Required for Major Inspection, page 19, for recommended greases and oils.



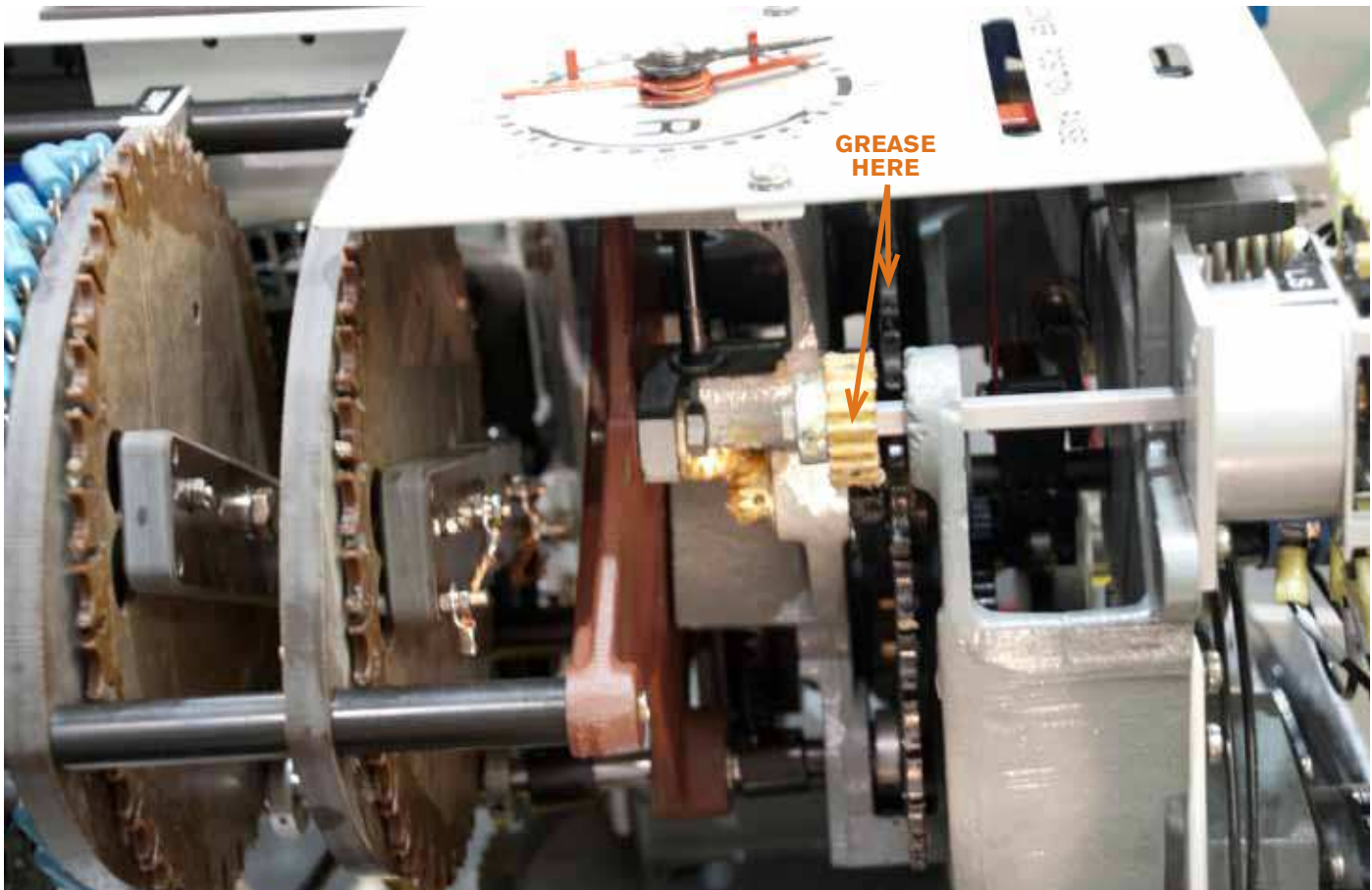
**FIGURE 30:
BUE MOTOR DRIVE
MECHANISM**



**FIGURE 31:
2ND GENERATION
POSITIVE
TEMPERATURE
COEFFICIENT (PTC2)
HEATERS**



FIGURE 32: GREASE LOCATIONS IN BUE MOTOR DRIVE MECHANISM



A small amount of grease should be added to the edges of the gear teeth and Geneva wheels shown in Figure 32.

A drop of oil should be placed at three points on the Cam Bar (item 128, Figure 29, page 41). DO NOT OVER OIL.

One drop should be applied to the end of the cam bar where it extends from the end of the casting. When the Cam Bar is at rest, the end is flush with the surface of the casting. Use a screwdriver or other tool to move the Position Indicator Flag to the Lower position (to the left when facing the indicator plate). This will push the cam bar out of the casting so the drop of oil can be applied (see Figure 33, page 45). Moving the position indicator flag and cam bar will initiate a tap change, so set the Manual-Off-Auto switch to "Off" or open the appropriate circuit breaker in the transformer control cabinet PRIOR TO performing this maintenance to prevent a tap change operation.

Two other places exist where the cam bar passes through the casting. These can be reached on either side of the disc brake, as shown in Figure 33, page 45. Be careful not to get any oil on the brake (item 129, Brake for Maintaining contact, in Figure 29, page 41).

These areas will be more accessible if the front plate (item 119, Figure 29, page 41) is removed.

NOTE: Put the UZD® in neutral prior to removing the front plate so the BUE gets reassembled in the correct position. Three circlips, two spring washers, three indicator flags and three screws must be removed to detach the front plate. These items are shown in Figure 34, page 45. With the front plate removed, place a drop of oil where the red position indicator flag pivots on item 116, Figure 29, page 41 and on the roller on the opposite end from the red indicator flag on item 116. Also place a drop of oil on the pivot point at the connection to the cam bar.

FIGURE 33: OILING OF CAM BAR

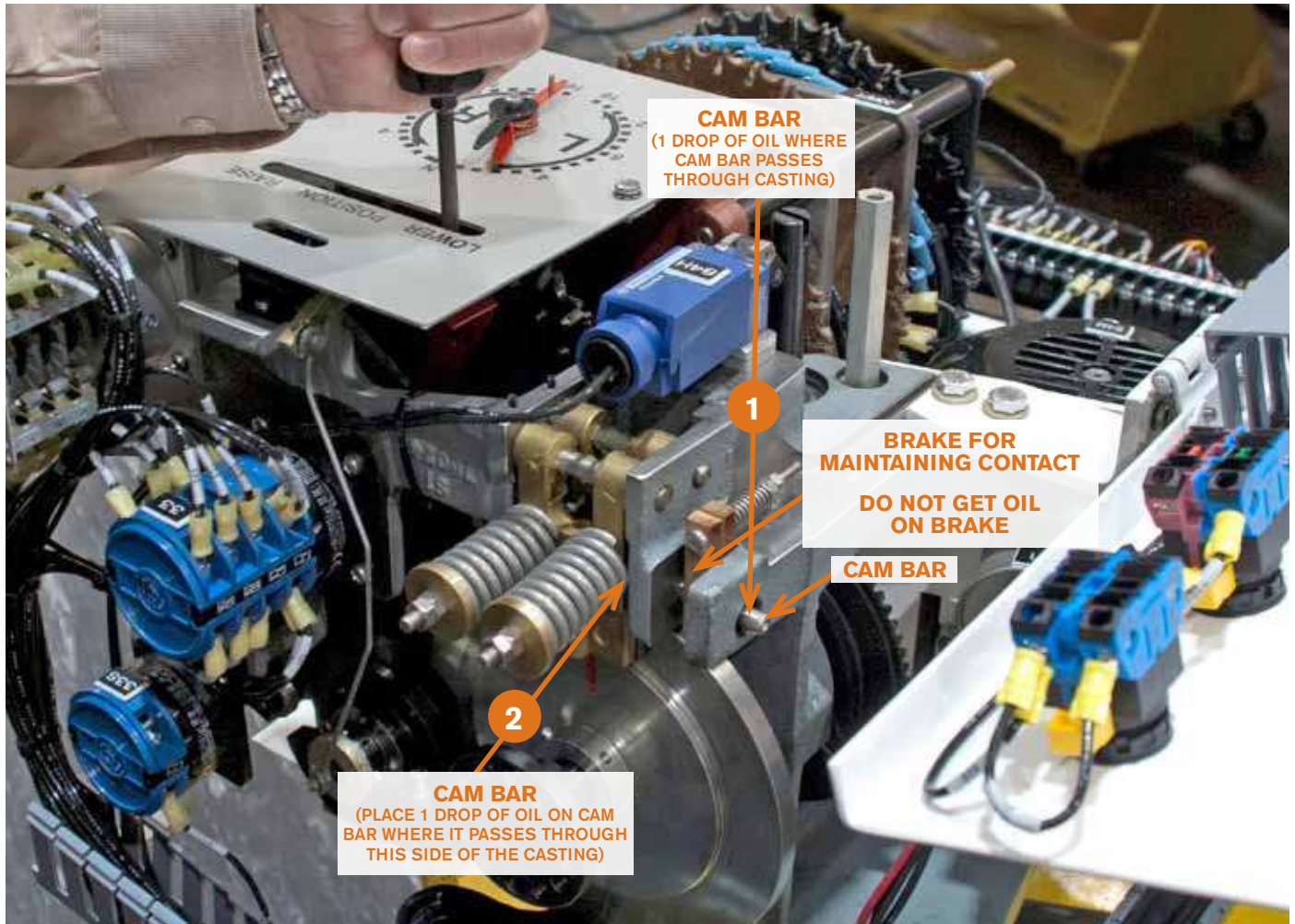
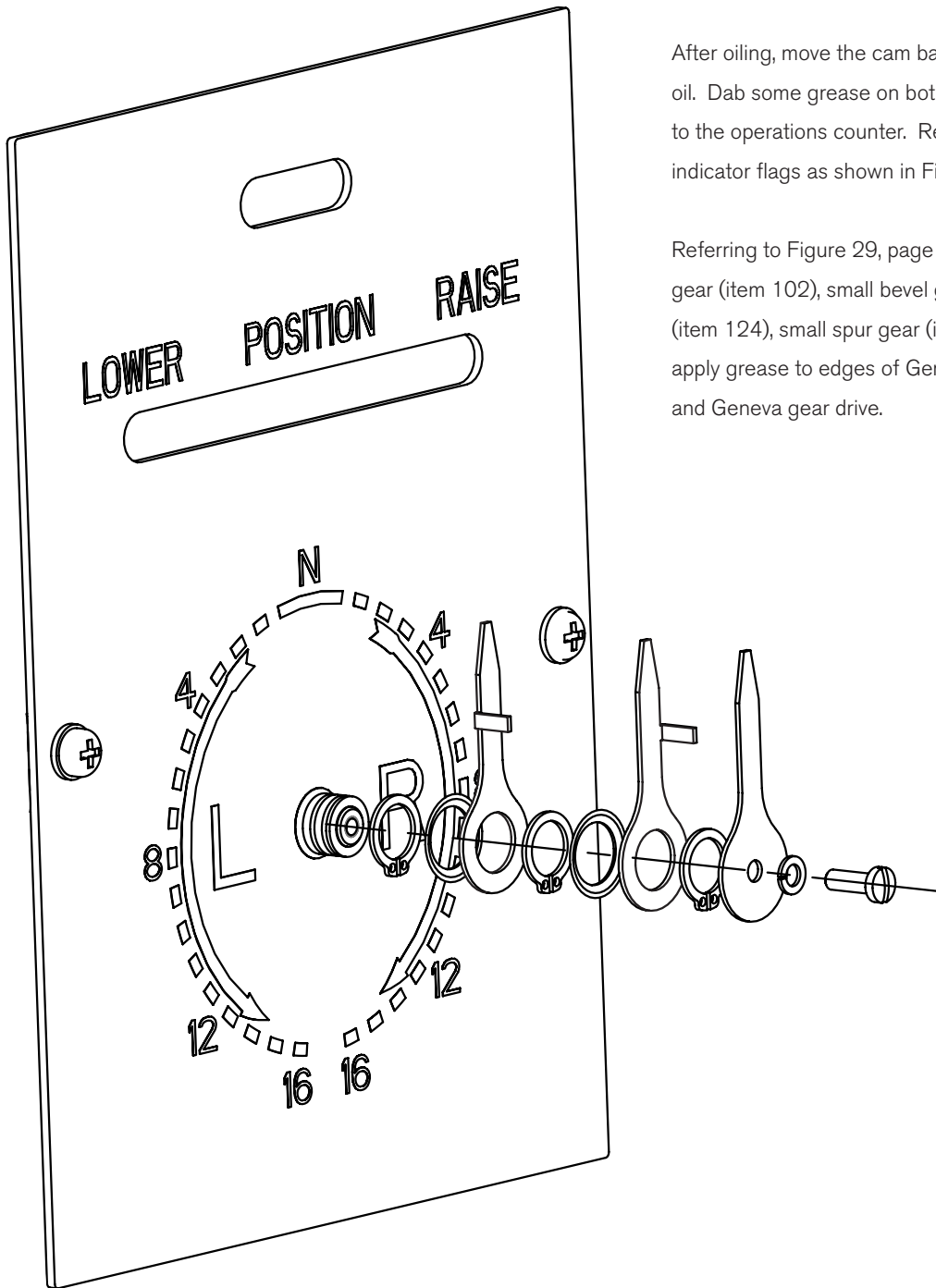


FIGURE 34: OILING OF CAM BAR, GREASING GENEVA WHEEL



FIGURE 35: INDICATOR PLATE REMOVAL



After oiling, move the cam bar back and forth to work in the oil. Dab some grease on both ends of the wire rod connected to the operations counter. Replace front plate and position indicator flags as shown in Figure 35.

Referring to Figure 29, page 41, apply grease to large bevel gear (item 102), small bevel gear (item 123), large spur gear (item 124), small spur gear (item 106), as mentioned above apply grease to edges of Geneva gears (items 125 and 126) and Geneva gear drive.

Operating Test

Since owner requirements vary, consult the control equipment and schematic drawings for your specific transformer which should be included in the transformer's instruction book. In the following descriptions for testing and calibration of the tap changer controls, references are made to Figures 36 which represents typical control circuits.

The owner's power supply, current transformer leads, alarms and other wiring connections are normally wired to the main transformer control compartment so the owner can make all connections in one compartment.

The following symbols will be used in reading the schematics:

- Point brought to a terminal block in the main transformer control compartment.
- Point brought to a terminal block in the LTC drive mechanism cabinet.

FIGURE 36: TYPICAL CONTROL CIRCUIT

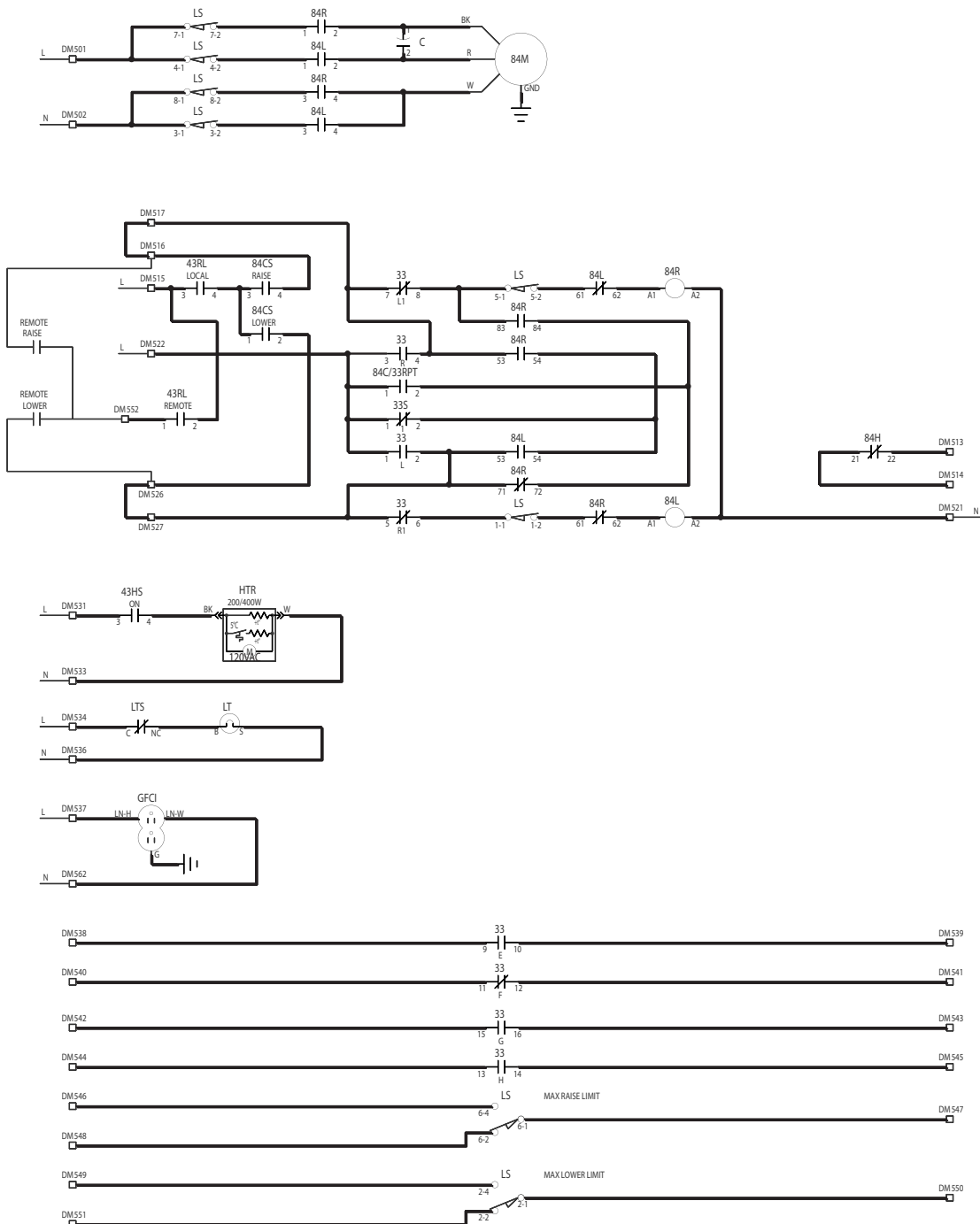


FIGURE 37: POSITION CHART

DRIVE MECHANISM

DEVICE NO. DESCRIPTION

33	MAINTAINING CONTACT
33S	STARTING CONTACT
33SPT	SYNCHRO POSITION TRANSMITTER
43T-1	LTC LOWER-OFF-RAISE SWITCH
84C/33N	CONTINUATION CONTACT W/CLOSED NEUTRAL
84H	HAND CRANK LOCKOUT SWITCH
84L	MOTOR CONTACTOR, LOWER
84M	MOTOR ASSEMBLY
84R	MOTOR CONTACTOR, RAISE
C1	CAPACITOR
CO-2	CONVENIENCE OUTLET 125V, 20A
H-3	HEATER ASSEMBLY 200W, 120VAC
HS-2	HEATER SWITCH, OFF-ON 2 POS., 1NO – 1NC
LS	LIMIT SWITCH
LT-3	CABINET LIGHT
LTS-2	DOOR OPERATED LIGHT SWITCH

INTEGRATED OIL FILTRATION SYSTEM

DEVICE NO. DESCRIPTION

84PM	LTC OIL PUMP FILTER MOTOR
63PS	LTC OIL FILTER HIGH PRESSURE SWITCH
80FS	LTC OIL FILTER LOW FLOW SWITCH
ARDB	AUTO-RECHARGING DEHYDRATING BREATHER
T1	TIMER FOR INTEGRATED OIL FILTER ASSEMBLY ADJUSTABLE TIMER, 120VAC, 10 AMP CONTACTS
L1	LTC OIL FILTER POWER ON INDICATING LAMP AMBER 120VAC LED PILOT LIGHT
L2	LTC OIL FILTER LOW FLOW INDICATING LAMP RED 120VAC LED PILOT LIGHT
L3	LTC OIL FILTER HIGH PRESSURE INDICATING LAMP RED 120VAC LED PILOT LIGHT
43OF	LTC OIL FILTER RESET SWITCH
63PSX	AUXILIARY RELAY FOR 63PS
80FSX	AUXILIARY RELAY FOR 80FS

HS-2

CONTACTS	PIN	POSITION	
		OFF	ON
	1-2	X	
	3-4		X

X - CLOSED CONTACT

43OF

CONTACTS	PIN	POSITION	
		OFF/RESET	ON
	1-2	X	
	3-4		X

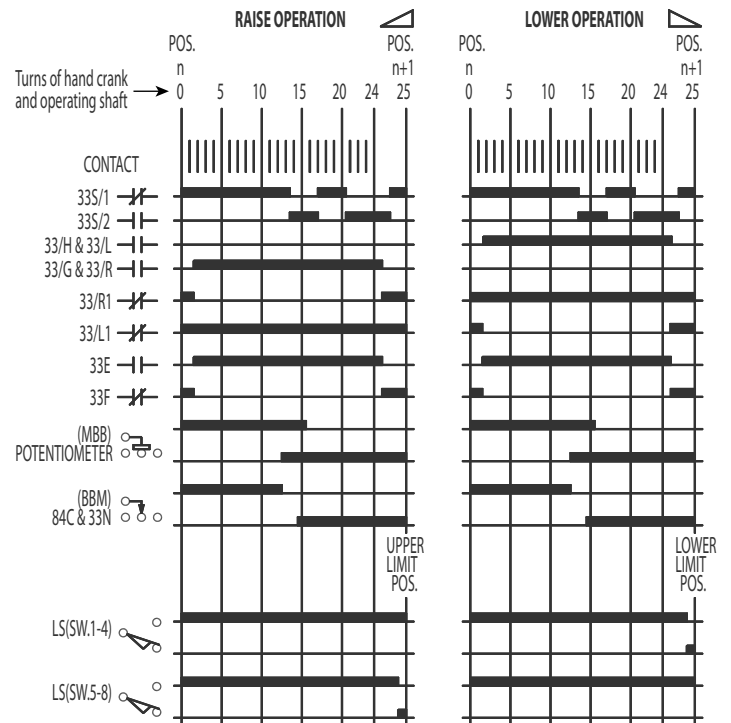
X - CLOSED CONTACT

43T-1

(SPRING RETURN TO CENTER)

CONTACTS	PIN	POSITION		
		LOWER	OFF	RAISE
	1-2	X		
	3-4			X

X - CLOSED CONTACT



Recommended Sequence for Checking and Calibrating Controls

1) Manual Operation

The tap changer can be operated electrically, in the manual mode. Check the schematic and connect the owner's power supply to the terminals designated for Owner's (customer's) supply. Place 43T-2 (Local-Remote switch) in Local, and 43T-3 (Auto-Manual switch) in manual, then 43T-1 (Raise-Lower switch) can be used to manually initiate an electrical operation of the tap changer in the raise or lower direction. Operate in the raise direction and verify the 84R relay operates. Then operate in the lower direction and verify the 84L relay operates.

With the transformer de-energized, move the UZD® to the tap extremes and verify that electrical limit switch LS-1 operates at 16R and electrical limit switch LS-2 operates at 16L and does not allow continued tap change operation in that direction. Moving the tap changer to 15R or 15L can be done electrically. MANUALLY hand crank the tap changer to 16R and 16L, respectively, to verify that LS-1 and LS-2 operate. Manual operation is recommended to minimize the chance of parts being broken by continued operation of the motor past the normal limits in case a problem exists with the LS-1 or LS-2 limit switches.

Next, hand crank beyond 16R and 16L, respectively, to verify that the mechanical stops are working. The mechanical stops should prevent further operation in the same direction. The mechanical stops should engage after 1-2 turns of the hand crank. Do not use excessive force to verify correct operation of the mechanical stops.

Two tap positions exist on either side of neutral: RN (raise neutral) and LN (lower neutral). These are stepped through automatically. When operating the tap changer, verify that the 84-C switch closes properly, and that the UZD® does not stop in either of these tap positions.

Verify that auxiliary switches 33-E, 33-F, 33-G, 33-H, open or close in accordance with the position chart shown in Figure 37, page 48.

2) Test of the '90' Regulating Relay

Place 43T-3 (Auto-Manual switch) in the Auto position. Refer to the appropriate section of the transformer instruction manual for checkout and commissioning information of the regulating relay supplied with your transformer.

3) Test of Convenience Receptacle

Verify outlet is functioning, and upstream breaker and ground fault interrupter are operating properly.

NOTE: These last two devices are typically mounted in the main transformer control cabinet.

4) Checkout of Optional Equipment

Your transformer may have additional accessories, such as a remote position indicator or paralleling equipment. Please refer to the appropriate section of the transformer instruction manual that describes those components for procedures to verify their proper operation.

If a Remote Position Indicator is provided: With the receiver connected, verify that the receiver and tap changer position indicator are showing the same tap position. Refer to the appropriate section of the transformer instruction manual for further information on this device.

If a Potentiometer or Resistance Position Transmitter are provided: Check the output terminals for proper resistance level and operation.

If additional contact outputs, such as incomplete step or off tap position alarms, are required by your specification, verify that they are operating as expected.

MAJOR INSPECTION FORM

Refer to this form on pages 66-67 or download it from our website at www.spxtransformersolutions.com/tools_resources.html under the Waukesha® Transformers heading.

SWITCH COMPARTMENT (LIQUID FILLED) TAP SELECTOR SWITCHES <i>continued</i>	INFORMATION	NOTES/EXPLANATIONS
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Were Any Contacts Replaced (include photos)? Y N Which ones:

Liquid Level C

Check for Le

All Protective

**REVERSIN
(REVERSIN**

Check Contac

Check Contac
Contacts

Check Proper
Tap Positions

Contact Resi
(hub of bow-t

Were Any Cor

**SPRING DR
(DRY COM**

Check for Le

Check Nylon
Replace, if ne

Verify Brake t
and Stops wi

Apply Lubrica
Figure 23 (pa

Check Access
Replace, if ne

MOTOR DR

Apply Lubrica
per Field Mai
(pages 44-46

Check Both i
for Proper Ad

Check Wiring

Check Limit E

Check Mecha

GENERAL

Describe Any
of Concern (i

Oil Filled Con

Check of 90 F

For assista

SPX TRANSFORM



Waukesha® UZD® LTC Major Inspection Form

TRANSFORMER DESCRIPTION	INFORMATION	NOTES/EXPLANATIONS
Manufacturer		
Year Manufactured		
Serial Number		
High Voltage		
Low Voltage		
MVA		
Substation Name		
Transformer Designation		
INSPECTION DATA		
Date of Inspection		
Inspected by		
ANNUAL INSPECTION		
Annual Inspection Requirements (see Annual Inspection Form)	<input type="checkbox"/> Completed	
SWITCH COMPARTMENT (LIQUID FILLED) TAP SELECTOR SWITCHES		
Measure Remaining Arcing Tip on Stationary Tap Selector Switch Contacts (54 Contacts)	PHASE A _____ Average in mm _____ Worst in mm _____ Position	
	PHASE B _____ Average in mm _____ Worst in mm _____ Position	
	PHASE C _____ Average in mm _____ Worst in mm _____ Position	
Gap between Tap Selector Switch Roller Contacts (18 Gaps)	PHASE A _____ Average in mm _____ Worst in mm _____ Position	
	PHASE B _____ Average in mm _____ Worst in mm _____ Position	
	PHASE C _____ Average in mm _____ Worst in mm _____ Position	
Measure Roller Diameters (36 Rollers)	PHASE A _____ Average in mm _____ Worst in mm _____ Position	
	PHASE B _____ Average in mm _____ Worst in mm _____ Position	
	PHASE C _____ Average in mm _____ Worst in mm _____ Position	
Confirm Rollers Turn Freely	<input type="checkbox"/> Y <input type="checkbox"/> N	
Check Roller Contact Pressure (18 Rollers)	PHASE A _____ Average in lbs _____ Worst in lbs _____ Position	
	PHASE B _____ Average in lbs _____ Worst in lbs _____ Position	
	PHASE C _____ Average in lbs _____ Worst in lbs _____ Position	
Check Main Current Carrying Tap Selector Switch Contact Pressure	PHASE A _____ Average in lbs _____ Worst in lbs _____ Position	
	PHASE B _____ Average in lbs _____ Worst in lbs _____ Position	
	PHASE C _____ Average in lbs _____ Worst in lbs _____ Position	
Check Contact Pressure of Slip Ring (Bow-Tie) Contacts	A _____ lbs B _____ lbs C _____ lbs	
	A _____ lbs B _____ lbs C _____ lbs	
Check Proper Contact Alignment in All Tap Positions in Both Directions and Adjust, if necessary	<input type="checkbox"/> OK <input type="checkbox"/> Adjustments Made	
Check Transition Resistor	A _____ Ω B _____ Ω C _____ Ω	
	A _____ Ω B _____ Ω C _____ Ω	
Contact Resistance Measurement (hub of bow-tie to fixed contact)	A _____ μΩ B _____ μΩ C _____ μΩ	

continued on next page...

TABLE 2: TORQUE VALUES TABLE

BOLT SIZE	GRADE 2	GRADE 5	GRADE 8	18-8 STAINLESS	BRASS	SILICON BRONZE	2024-T2 ALUMINUM
1/4 - 20	66	96	144	75	62	69	46
1/4-28	76	120	168	94	77	87	57
5/16-18	132	204	300	132	107	123	80
5/16-24	144	228	300	142	116	131	86
3/8-16	240	360	540	236	192	219	143
3/8-24	276	420	600	259	212	240	157
7/16-14	360	600	840	376	317	349	228
7/16-20	420	660	960	400	327	371	242
1/2-13	600	900	1320	571	422	480	313
1/2-20	660	1080	1440	541	443	502	328
9/16-12	780	1320	150	682	558	632	413
9/16-18	900	1440	170	752	615	697	456
5/8-11	1080	150	220	1110	907	1030	715
5/8-18	1200	180	240	1244	1016	1154	798
3/4-10	160	260	380	1530	1249	1416	980
3/4-16	180	300	420	1490	1220	1382	958
7/8-9	140	400	600	194	159	178	1495
7/8-14	155	440	660	193	158	179	1490
1-8	220	580	900	287	235	265	184
1-14	240	640	1000	259	212	240	166
1-1/8-7	300	800	1280	413	337	383	265
1-1/8-12	340	880	1440	390	318	361	251
1-1/4-7	420	1120	1820	583	428	485	336
1-1/4-12	460	1240	2000	480	394	447	308
1-1/2-6	740	1940	3160	888	727	822	570
1-1/2-12	840	220	3560	703	575	651	450

BLUE VALUES ARE IN FOOT POUNDS
 WHITE VALUES ARE IN INCH POUNDS

Conversion of Metric measures of torque:

Every effort has been made to present torque measurements in this instruction book in the English system.

Should you be confronted, for some reason, with a metric value the following conversion applies:

Nm times 8.85 = inch pounds Nm times 0.738 = foot pounds
 kpm times 86.8 = inch pounds kpm times 7.23 = foot pounds

SECTION 3

Replacing Selector Switch Fixed Contacts

Tools Required

(assuming the tap changer is already open)

- 1/4 Drive socket set
 - 1-Ratchet
 - 1-4mm Allen socket
- 1/4 Drive torque wrench

Special tools are not required. However, the Waukesha® Components group does have custom tools available to make maintenance tasks easier.

GENERAL

The Waukesha® UZD® Load Tap Changer utilizes an arcing tap switch which has both tap-selector contacts and transition (breaking) contacts on the same moving arm. It is operated by a high-speed, spring drive mechanism, driven by the BUE motor-drive mechanism.

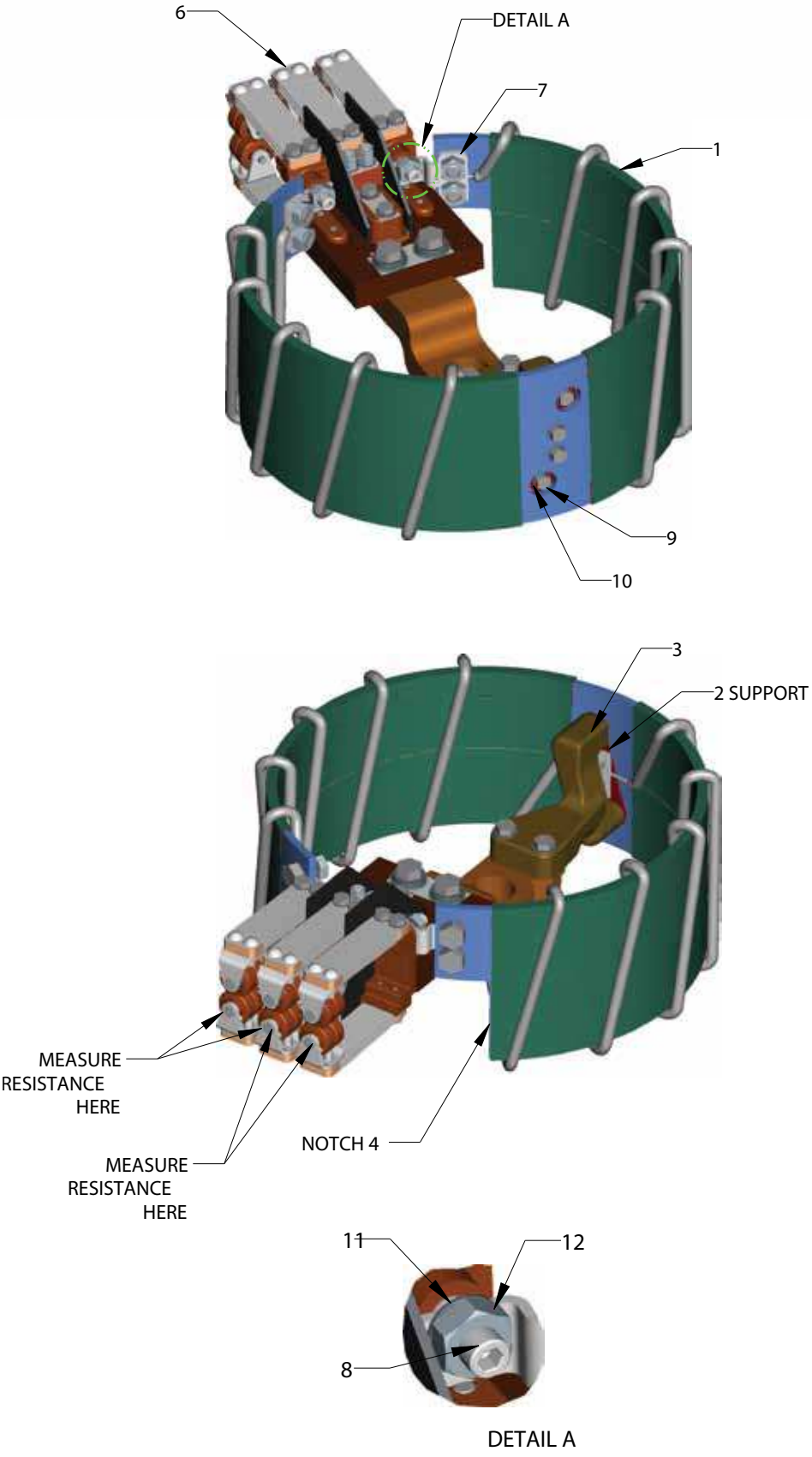
At each tap change operation, the transition contacts must break and make a certain load. When the current is interrupted, arcing causes some burning of the contacts and a chemical breakdown of some of the oil in which the tap changer is immersed. For this reason, an on-line oil filtration system is a standard feature of the UZD®. This system keeps the oil clean of most arcing by-products to maintain adequate dielectric strength and reduce the probability of film formation on contacts.

Contact wear measurement should be obtained during periodic inspections described in the Major Inspections section of this manual. Trending of this data and observations made during these major inspections should help predict when contacts need to be replaced.

Replacement of rolling contacts on the main moving contact arm is covered in Section 4, page 58, of this manual.

It is easier to replace the fixed contacts with the transition resistors removed. Numbers in parentheses are items in Figure 38, page 53. To remove the resistors, operate the tap changer to such a position that the nut and washer (11 and 12) can be removed from the ends (7) of the transition resistor. Next, operate the tap changer to such a position that the support (2) for the transition resistor is directly in front of you. Remove two screws (9) and spring washers (10). Pass the resistor (1) over the part of the shaft (3) which is narrowest. The resistor has a notch (4) which shall pass over the flanges of the shaft. The resistor may be pulled apart slightly to pass the flanges; be careful not to crack the bobbin of the resistor by opening it too far. Inspect the resistor for damage such as cracked or broken bobbin, signs of overheating, and broken strands of polyester tape (tie downs). Check that the resistor wire is still securely tied to the bobbin. Repair or replace damaged parts.

FIGURE 38: TRANSITION RESISTORS



Check Stationary Selector Switch Contacts for Wear

The contact system consists of L-shaped brackets (which should NOT be loosened or removed) and stationary tap selector switch contacts fastened to the L-shaped brackets with two Allen head screws (these can be removed).

⚠ The bolt holding the L-shaped bracket to the phase molding should not be loosened or removed.

The stationary contacts are constructed from a copy contact body with copper tungsten arcing tips brazed to the middle sides of the copper body. The contacts are then silver plated.

Referring to Figure 11, page 24, the main current carrying contact buttons of the moving selector switch are made from hardened silver. No burning of these button contacts should occur, as all arcing is designed to take place between the transition rollers and the copper tungsten tip of the stationary contacts. In an on-tap position, the current conduction occurs between the silver-plated, stationary contacts and the silver buttons on the moving main contacts. If arcing is observed between the tongue (no arcing here) of the fixed contact and the moving main contacts, the fixed contacts should be replaced. Carefully inspect the moving main contacts for damage and replace moving contact assembly, if necessary.

Measure the degree of arcing surface contact wear of the stationary contacts and record in the inspection report. Compare with past measurements and observe trend for determining possible future contact replacement intervals. Digital photos are useful for this purpose.

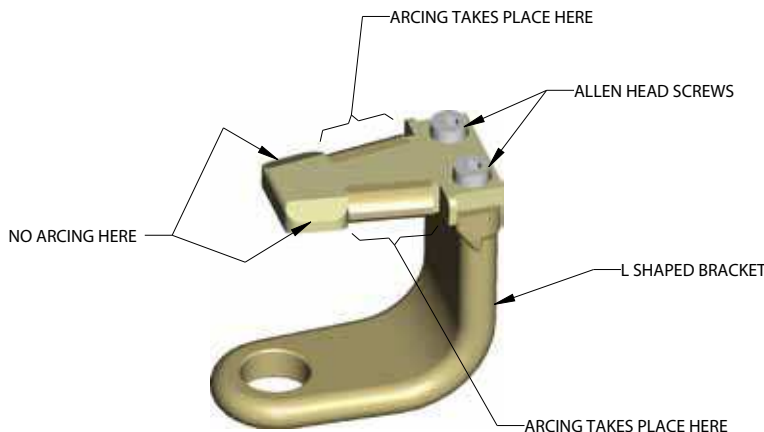


FIGURE 39: STATIONARY SELECTOR SWITCH CONTACT

⚠ Do not file or smooth the burnt and/or pitted contact surfaces as this may reduce the life of the contact.

A stationary contact should be replaced when the minimum amount of remaining copper-tungsten along its length is 1 mm (see Figure 40).

Replacement of Contacts

Replacing contacts is easier if the tap changer selector switch is rotated to position R3 or L13. Remove the Allen head screws holding the fixed contacts using a 4mm Allen wrench. After all have been removed except the one between the moving main contacts, rotate the switch to position R4 or L12 and remove the last fixed contact.

Do not, at any time, remove or loosen the L-shaped bracket to which the fixed contacts are attached. These are aligned accurately in the factory with a special fixture to ensure equal timing between each of the contacts and for proper alignment of the moving contact assembly.

The new fixed contacts should now be assembled. New Allen head screws and lock washers should be used with the new contacts. As the screws are being turned in, the contact should be pushed towards the L-shaped bracket.

Torque all new Allen head screws to 50 in-lbs (5.6 Nm).

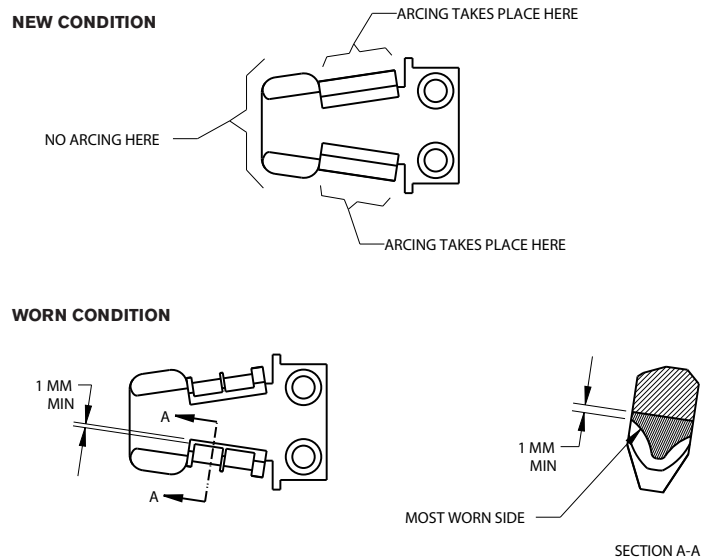


FIGURE 40: MAXIMUM ALLOWABLE WEAR ON STATIONARY SELECTOR SWITCH CONTACT

Check for Proper Contact Position and Alignment

To check this alignment, the epoxy coupling, Item 118 (see Figure 41, page 57) between the spring drive and the first phase assembly, must be removed.

NOTE: Mark all contact positions before removing any hardware so unit can be returned to this same position upon reassembly.

Remove the two Allen head screws on the T-handle in the drive shaft. With the T-handle and epoxy coupling removed, the moving contact assembly can be turned by hand from one fixed contact to the next. As the moving contact approaches the stationary contact, confirm that equal deflection and spring compression exists on both sides of the moving contacts (roller contacts and main current carrying contacts). The stationary contact should be in the middle of the moving contacts as they approach. Also check that the roller contacts are parallel to each other and to the fixed contact to assure even wear of the contacts. Do this when the roller contacts are on the fixed contact. This requires manually moving the contact assembly for each pair of rollers. Also remove the T-handle and epoxy coupling from the reversing switch and check alignment. The stationary contact should be in the middle of the moving contacts as they approach. This is especially important if contacts have been replaced.



Be mindful of where your fingers, hands, clothing, etc. are before moving the contact assemblies or operating the tap changer from the motor drive as significant force can exist that can cause personal injury.

Replace the epoxy couplings and T-handles so the contacts can be driven by the spring drive mechanism. The moving, main current carrying contacts (not the rollers) include buttons that mate with the stationary contacts. With the moving contacts stopped in final operating position, verify that these buttons on both sides are fully on the flat part of the stationary contact and not partially on the ramp of the stationary contact. If buttons are not fully on the flat part of the stationary contact, excessive play may exist in the drive shaft components and spring drive mechanism.

This contact alignment should be checked in all tap positions in both directions.

The two outer sets of roller contacts do not touch a stationary contact in a normal (at rest) operating position. As the tap changer ages with use, the amount of play in the spring drive mechanism, couplings, bearings and shafts can increase such that the outer roller contacts may touch a stationary contact in the normal operating position. If this condition is found, it should be corrected by replacing the worn parts. Contact the Waukesha® service group for assistance as needed. This contact alignment should be checked in all tap positions in both directions on all phases. Check that the gap between leaf springs (or roller contact saddles) is $6.0\text{mm} \pm 0.2\text{mm}$ (see Figure 41, page 57).

Observation of the UZD® is recommended while operating it across the complete tap range using the manual mode of operation. Listen for unusual noises and watch for abnormal operation. A complete tap change operation should take about 6 seconds. The BUE motor drive mechanism takes about 6 seconds to wind up the spring battery in the spring drive compartment and about 70 milliseconds for the spring battery to discharge, moving the selector switch to the next tap in the oil-filled compartment. The reversing change-over selector moves at motor speed, and it takes about 2 seconds to move from one position to the other.

Reinstall transition resistors at this time. Numbers in parentheses are item numbers in Figure 44, page 59. If necessary rotate tap selector so the resistor support (2) is facing you. Pass the resistor (1) over the flat shaft (3) of the epoxy coupling. The resistor has a notch (4) which allows the resistor to pass over the shaft. The resistor may be pulled apart slightly to allow it to pass but be careful not to crack/break the resistor resin. Fasten the resistor with screws (9) and spring washers (10) through the two holes in the resistor and into the resistor support (2). Torque to 69 in-lb. Next, operate tap changer to such a position that the ends (7) of the resistor can be fastened to the screws (8) on the resistor contacts. Use nuts (11) and spring washers (12). Torque to 132 in-lb. These four connection points are the electrical connection points for the resistor. Make a few more tap change operations to ensure the resistors are moving without interference.

Check Contact Pressure and Resistance

Having verified all contacts are in acceptable operating condition, SPX Waukesha recommends contact pressure and resistance also be verified at this time. Contact resistance is inversely proportional to contact pressure. Contact pressure is applied by springs. Discoloration of a spring may indicate that the spring has been hot and may have annealed and has reduced spring pressure allowing for higher contact resistance.

There are three common methods of checking contact pressure: manual comparison of one contact to the next, measurement with a fish scale and measurement with a load cell. The manual comparison is accomplished by using a smooth, non-metallic bar tapered on one end similar to the shape of a pencil or straight tip screwdriver. Slide the tapered end between contacts and rock back and forth slightly to feel the spring pressure. Do this on all like contacts and compare. If one or more contacts feel noticeably different than the others, further investigation is required. This can also be done with the bare hand if a tool is not available or is a personal preference.

Measurement of contact pressure using a fish scale can be accomplished by attaching the scale to the contact and pulling perpendicular to the contact mating surfaces until the contacts just start to separate. Read scale. This method can be problematic as all contacts may not be accessible with the scale. This fish scale method in combination with the manual comparison method mentioned above is a hybrid option.

The third method of checking contact pressure is to measure the pressure with a thin profile load cell by placing the load cell between the contacts to be measured. This method is not practical for measuring bowtie contact pressure.

Typical pressures:

- Roller contacts — 7-10 pounds
- Main current carrying contact on selector switch — 7-10 pounds
- Reversing switch — 16-21 pounds
- Bowtie current collector contacts (both selector switch and reversing switch) — 20-24 pounds

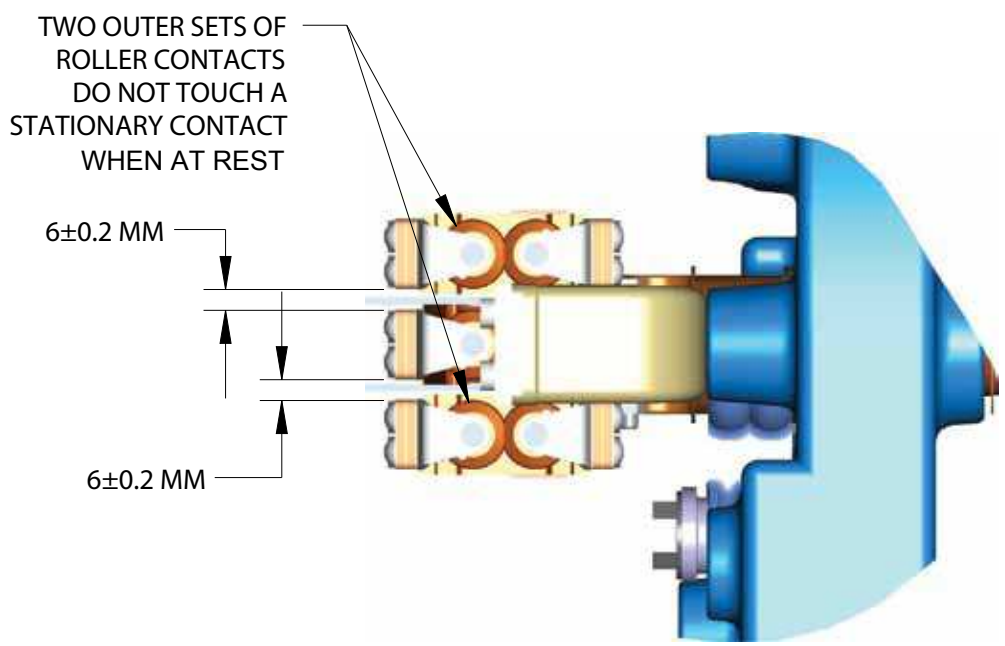
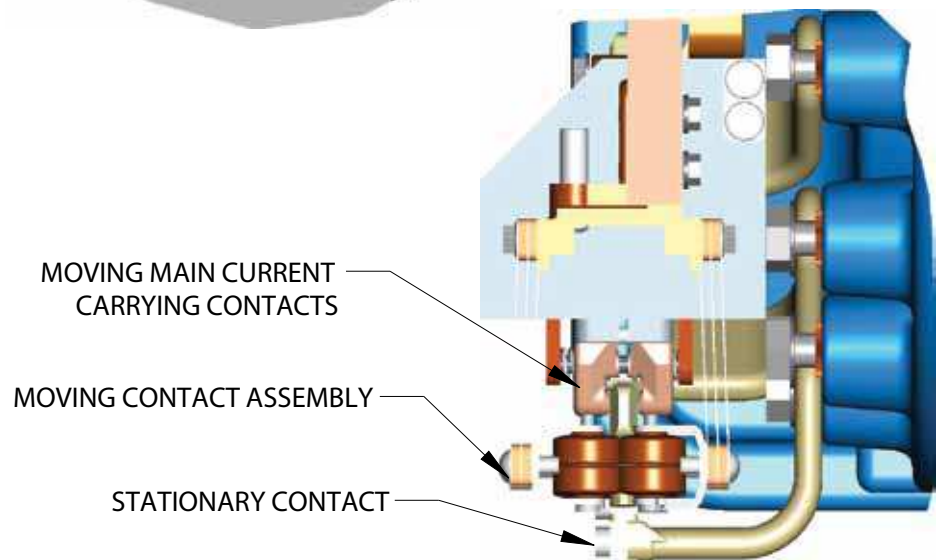
Record all contact pressure measurements and observations in the inspection report and compare readings between phases.

Check contact resistance by placing the probes of a micro-ohm meter as close to the contact connection as possible. Be aware that windings are connected to the UZD®, and the contact resistance measurement will see these winding parts in parallel with the contact you are measuring and may be in a similar order of magnitude. Beware of inductive kickback if using a DC instrument. Typical contact resistances should be below 200 $\mu\Omega$. If contact resistance is above this value, further investigation and corrective action is required.

Record all contact resistance values on the Inspection Report. Compare current reading to prior readings and observe trend.

After checking all contacts as further described below, replace the transition resistors just prior to oil filling by reversing the process described above.

**FIGURE 41:
CHECKING
ALIGNMENT OF
SELECTOR SWITCH
CONTACTS**



SECTION 4

Replacing Moving Tap Selector Switch Contacts

Tools Required

(assuming the tap changer is already open)

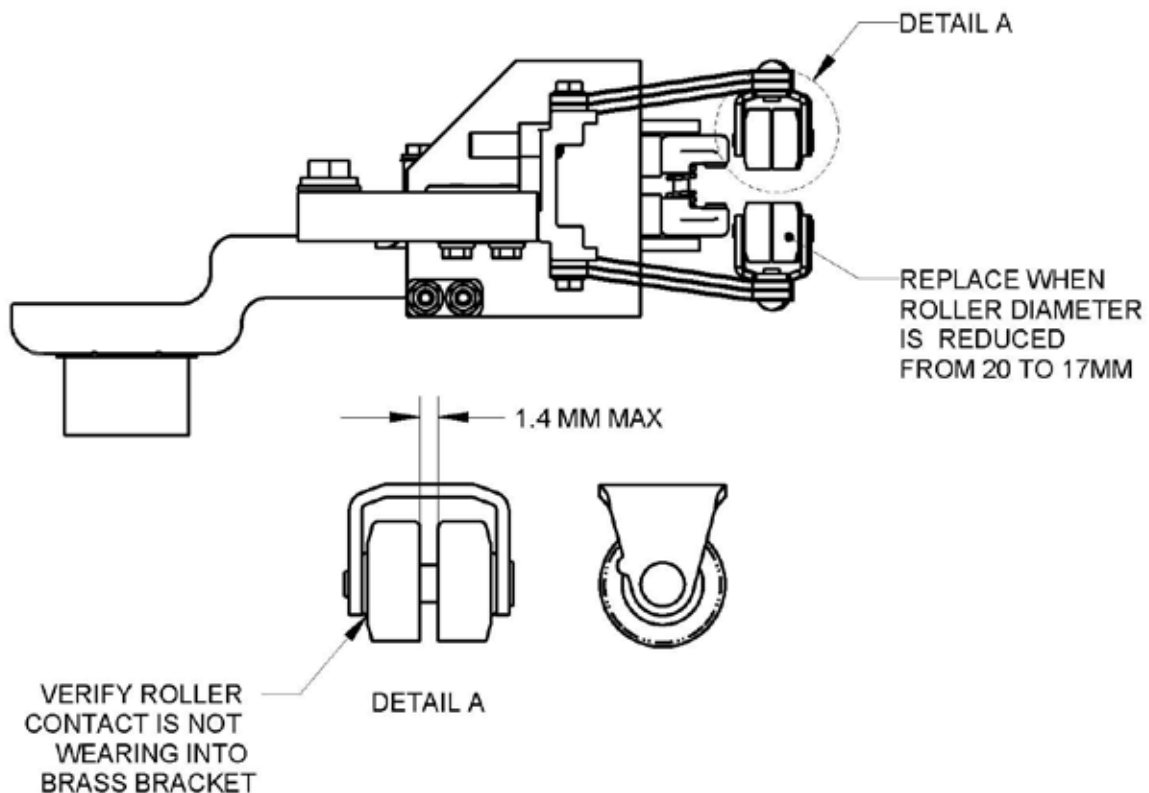
- ¼ inch Drive socket set
 - 1-ratchet
 - 1-8mm socket
 - 1-13mm socket
- 1-straight tip screw driver or chisel
- 1-hammer
- ¼ inch Drive torque wrench
- Volt ohm meter to measure transition resistor resistance

REPLACEMENT PROCEDURE

Replacement of the moving contacts should be done:

- When the gap between the rollers exceeds 1.4mm (see Figure 42)
- When diameter of the moving contact roller is reduced from 20 to 17mm
- When the arcing tips of the fixed contacts are burnt down in a way that they cause arcing between the tongue of the fixed contacts and the moving main contacts
- When the rollers do not roll freely (possible flat spot worn on roller)
- When the pressure from the spring between the rollers (3 pounds) is insufficient to push the shoulders of the rollers up against the brass bracket.

FIGURE 42: WEAR ON ROLLER CONTACTS



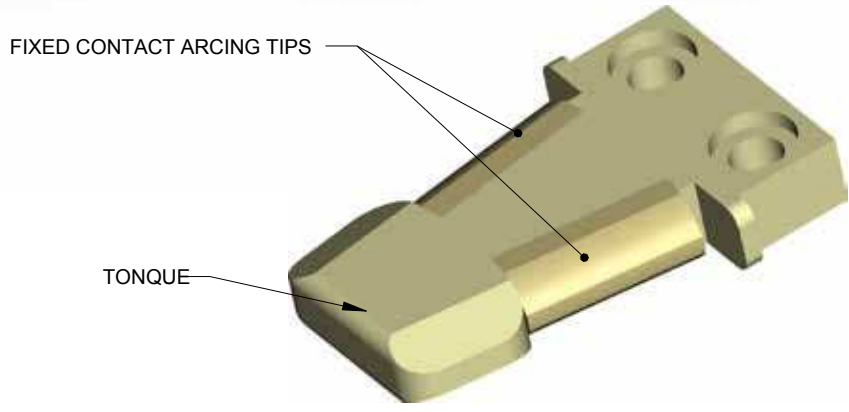


FIGURE 43: SELECTOR SWITCH FIXED CONTACT

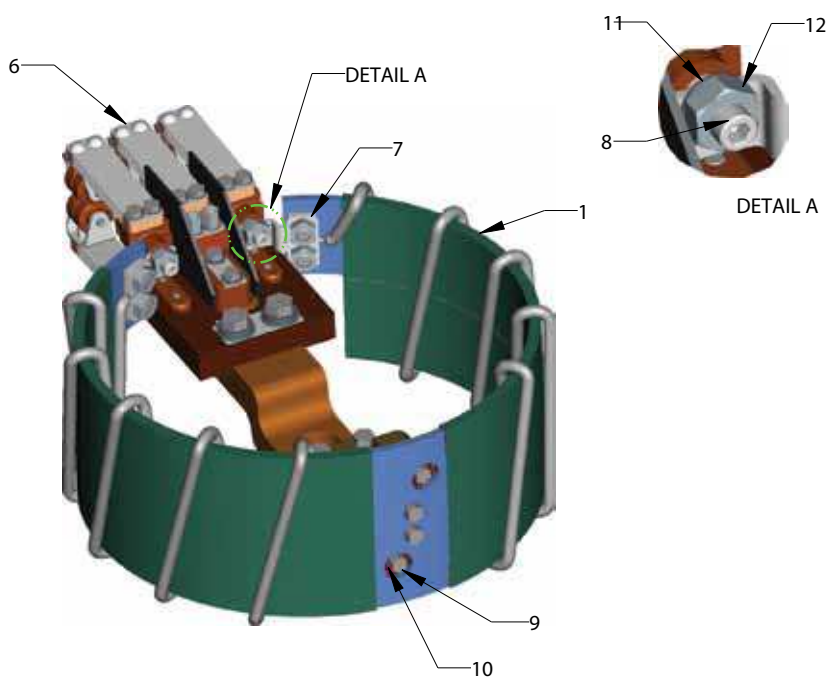
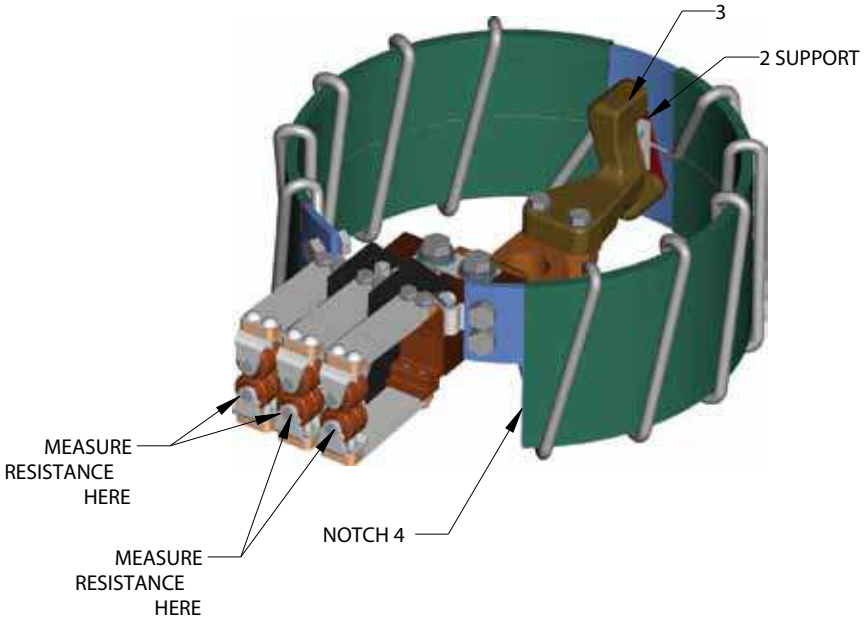


FIGURE 44: TRANSITION RESISTORS



SPX Waukesha recommends replacing the entire moving contact assembly if any parts in the assembly are in need of replacement. The parts are assembled in the factory using special fixtures to assure proper contact alignment in all directions. This alignment is difficult to achieve without use of these special fixtures.

Transition resistors must be removed prior to replacing moving contact assembly. Numbers in parentheses are items in Figure 44, page 59. To remove the resistors, operate the tap changer to such a position that the nut and washer (11 and 12) can be removed from the ends (7) of the transition resistor. Next, operate the tap changer so that the support (2) for the transition resistor is positioned directly toward you. Remove two screws (9) and spring washers (10). Pass the resistor (1) over the part of the shaft (3) which is narrowest. The resistor has a notch (4) which shall pass over the flanges of the shaft. The resistor may be pulled apart slightly to pass the flanges; be careful not to crack the bobbin of the resistor by opening it too far. Inspect the resistor for damage such as cracked or broken bobbin, signs of over-heating, broken strands of polyester tape (tie downs). Check that the resistor wire is still securely tied to the bobbin. Repair or replace damaged parts.

Remove two bolts labeled C on Figure 46, page 61 and remove transition contact assembly. Note that there are two roll pins immediately adjacent to bolts C that will stay on the brass arm when the transition contact assembly is removed. Be careful to remove the transition contact assembly straight up so as to not bend these alignment pins. Next, remove bolts D and remove the main current carrying and center roller contact assembly. The black insulating barriers left behind that fit between roller spring assemblies should be checked for cracks or damage and replaced if necessary.

Replace with new contacts in the reverse order above. Put center contact assembly in first. Snug bolts D finger tight so they can be adjusted using grade AA Loctite on thread. Next, mount new transition contact assembly by sliding over roll pins and installing, torquing bolts C to 50 in-lb. using grade AA Loctite on thread. Align center contact assembly so the gaps between the transition contacts are equal (see Figure 46, page 61) and torque bolts D to 50 in-lb.

NOTE: If the moving contacts are replaced, also replace any fixed contacts that are considerably worn, in order to minimize wear of the new moving contacts.

Inspection of Current Collector (Bowtie) Contacts and Mating Collector Ring

Remove nuts A in Figure 48, page 63 used for spring tensioning as well as springs and bowtie contacts. Inspect all inside surfaces of the bowties and outside surfaces of the collector ring and adjacent stud for signs of excessive wear, pitting, filming or coking. If bowties or current collector stud are damaged, they should be replaced with new parts. If the current collector ring on moving arm is damaged, the whole arm and T-handles should be replaced. Contact the Waukesha® service group for assistance.

If parts are acceptable for continued use, clean and reinstall. Tighten the nut on springs to a height of $12.4 \pm 0.3\text{mm}$, not including washers, then tighten the jam nut against the first nut, taking care not to move the first nut.

Check for Proper Contact Position and Alignment

To check this alignment, the epoxy coupling, Item 118 (see Figure 49, page 63) between the spring drive and the first phase assembly, must be removed.

NOTE: Mark all contact positions before removing any hardware so unit can be returned to this same position upon reassembly.

Remove the two Allen head screws on the T-handle in the drive shaft. With the T-handle and epoxy coupling removed, the moving contact assembly can be turned by hand from one fixed contact to the next. As the moving contact approaches the stationary contact, confirm that equal deflection and spring compression exists on both sides of the moving contacts (roller contacts and main current carrying contacts). The stationary contact should be in the middle of the moving contacts as they approach. Also check that the roller contacts are parallel to each other and to the fixed contact to assure even wear of the contacts. Do this when the roller contacts are on the fixed contact. This requires manually moving the contact assembly for each pair of rollers. Also remove the T-handle and epoxy coupling from the reversing switch and check alignment. The stationary contact should be in the middle of the moving contacts as they approach. This is especially important if contacts have been replaced.

FIGURE 45: PHASE MOLDING ARRANGEMENT

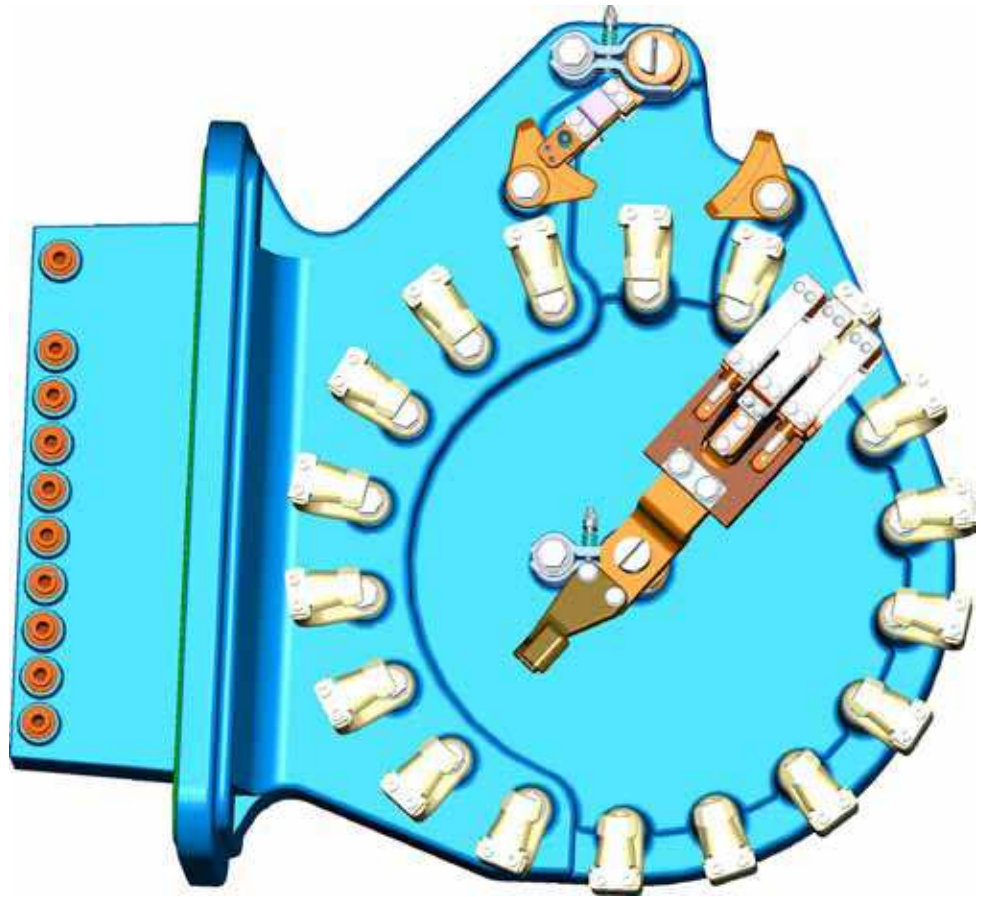
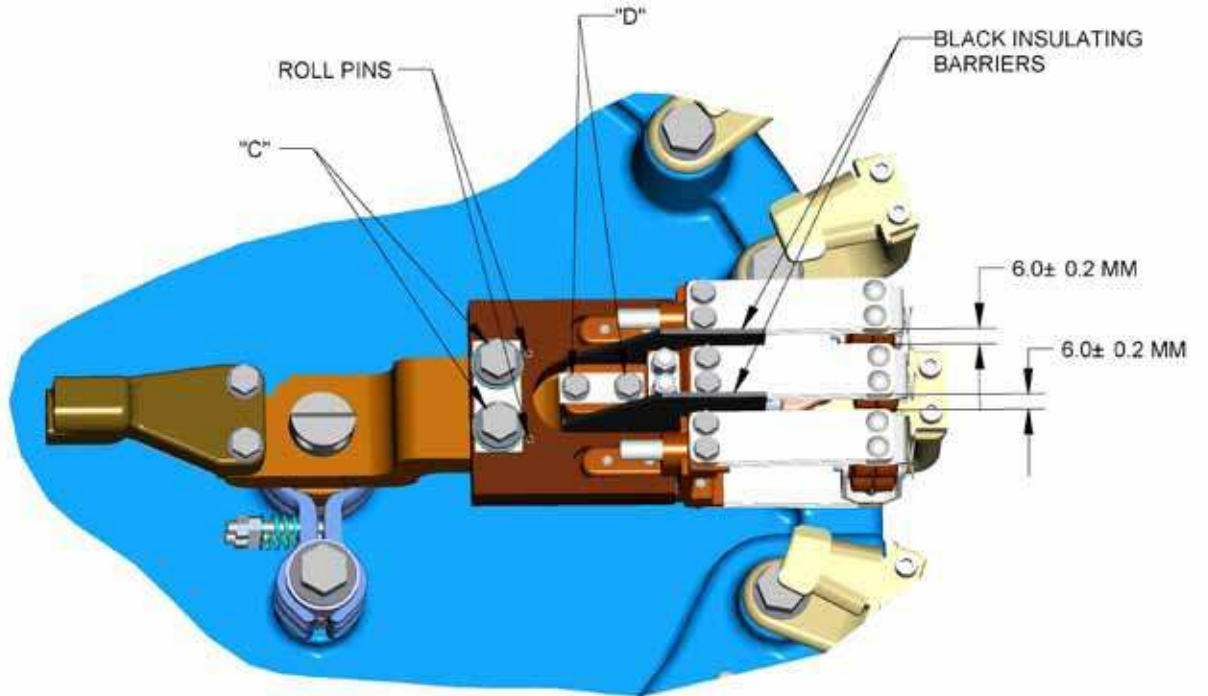


FIGURE 46: MOVING SELECTOR SWITCH





Be mindful of where your fingers, hands, clothing, etc. are before moving the contact assemblies or operating the tap changer from the motor drive as significant force can exist that can cause personal injury.

Replace the epoxy couplings and T-handles so the contacts can be driven by the spring drive mechanism. The moving, main current carrying contacts (not the rollers) include buttons that mate with the stationary contacts. With the moving contacts stopped in final operating position, verify that these buttons on both sides are fully on the flat part of the stationary contact and not partially on the ramp of the stationary contact. If buttons are not fully on the flat part of the stationary contact, excessive play may exist in the drive shaft components and spring drive mechanism.

This contact alignment should be checked in all tap positions in both directions.

The two outer sets of roller contacts do not touch a stationary contact in a normal (at rest) operating position. As the tap changer ages with use, the amount of play in the spring drive mechanism, couplings, bearings and shafts can increase such that the outer roller contacts may touch a stationary contact in the normal operating position. If this condition is found, it should be corrected by replacing the worn parts. Contact the Waukesha® service group for assistance as needed. This contact alignment should be checked in all tap positions in both directions on all phases. Check that the gap between leaf springs (or roller contact saddles) is $6.0\text{mm} \pm 0.2\text{mm}$ (see Figure 49, page 63).

Observation of the UZD® is recommended while operating it across the complete tap range using the manual mode of operation. Listen for unusual noises and watch for abnormal operation. A complete tap change operation should take about 6 seconds. The BUE motor drive mechanism takes about 6 seconds to wind up the spring battery in the spring drive compartment and about 70 milliseconds for the spring battery to discharge, moving the selector switch to the next tap in the oil-filled compartment. The reversing change-over selector moves at motor speed, and it takes about 2 seconds to move from one position to the other.

Reinstall transition resistors at this time. Numbers in parentheses are item numbers in Figure 44, page 59. If necessary rotate tap selector so the resistor support (2) is facing you. Pass the resistor (1) over the flat shaft (3) of the epoxy coupling. The resistor has a notch (4) which allows the resistor to pass over the shaft. The resistor may be pulled apart slightly to allow it to pass but be careful not to crack/break the resistor robin. Fasten the resistor with screws (9) and spring washers (10) through the two holes in the resistor and into the resistor support (2). Torque to 69 in-lb. Next, operate tap changer to such a position that the ends (7) of the resistor can be fastened to the screws (8) on the resistor contacts. Use nuts (11) and spring washers (12). Torque to 132 in-lb. These four connection points are the electrical connection points for the resistor. Make a few more tap change operations to ensure the resistors are moving without interference.

Check Contact Pressure and Resistance

Refer to section, Check Contact Pressure and Resistance on page 56 of this manual.

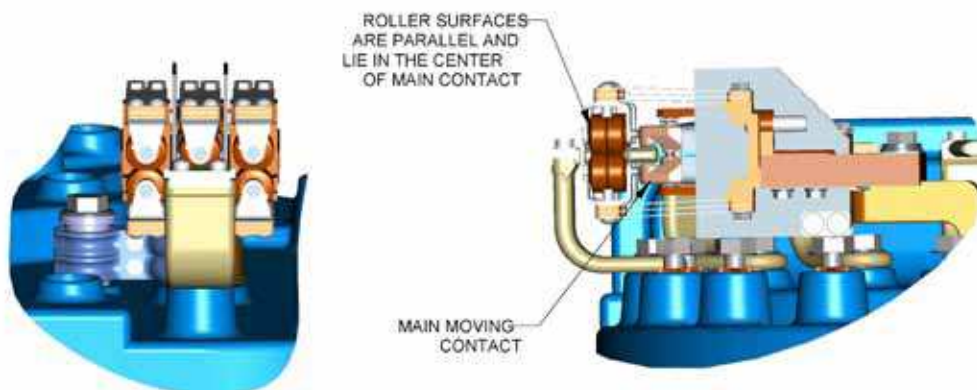


FIGURE 47: CHECKING ALIGNMENT OF SELECTOR SWITCH CONTACTS

FIGURE 48: BOWTIE CONTACTS

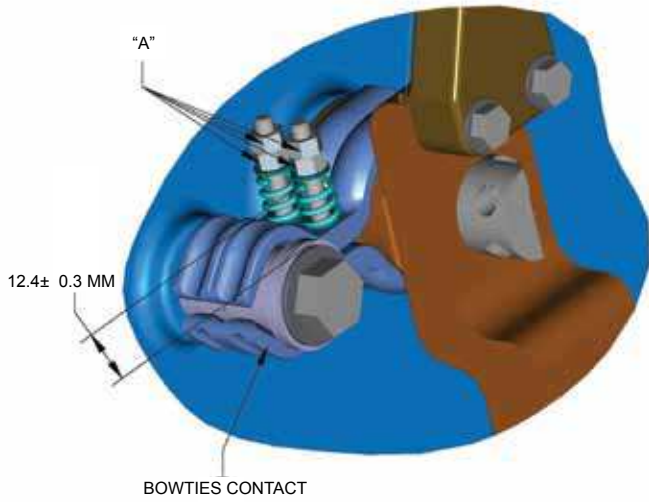
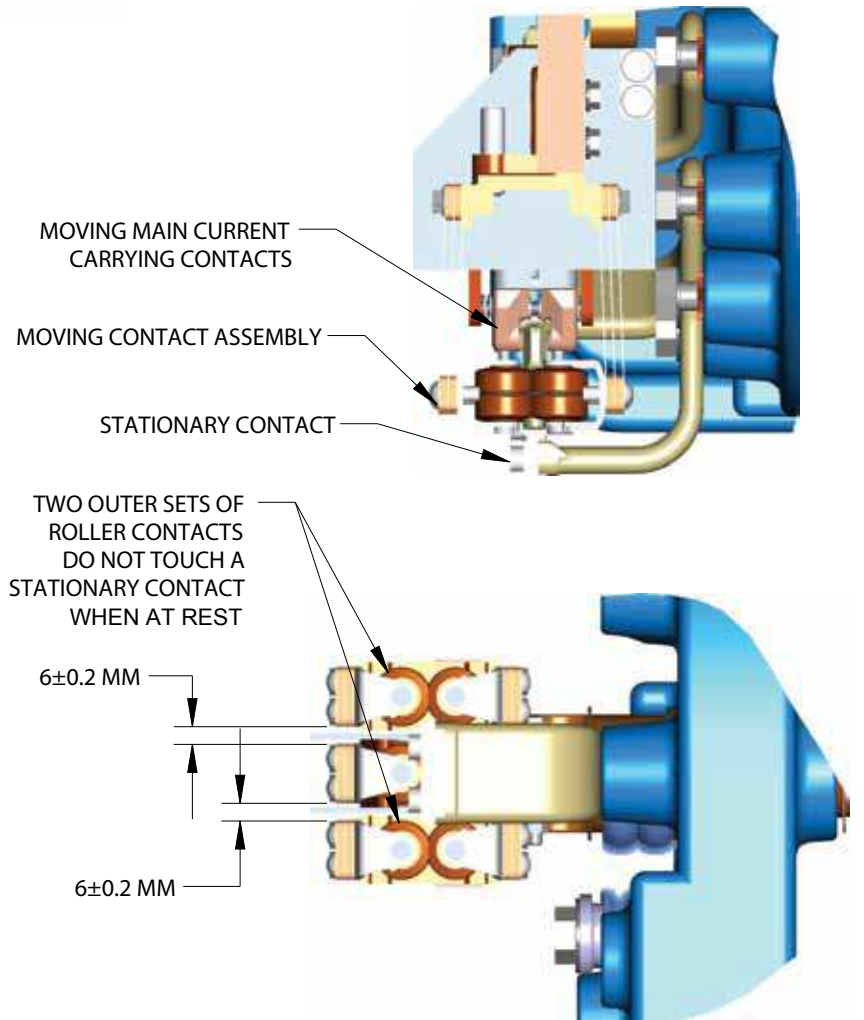
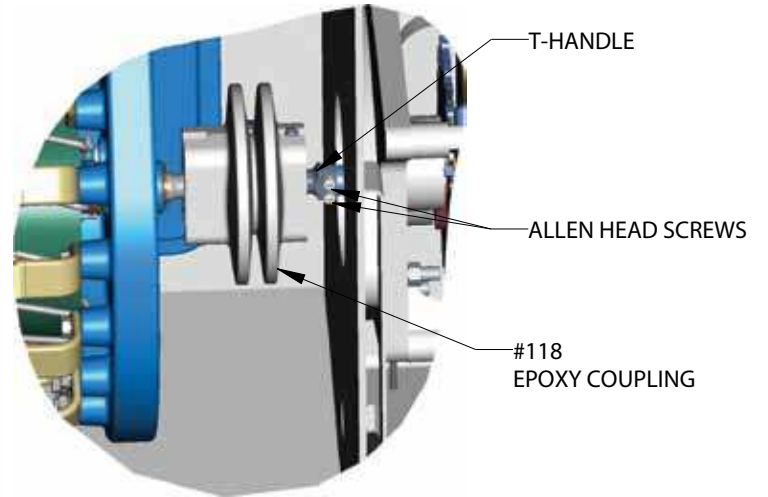


FIGURE 49: CHECKING ALIGNMENT OF SELECTOR SWITCH CONTACTS





Waukesha® UZD® LTC Annual Inspection Form

TRANSFORMER DESCRIPTION	INFORMATION	NOTES/EXPLANATIONS
Manufacturer		
Year Manufactured		
Serial Number		
High Voltage		
Low Voltage		
MVA		
Substation Name		
Transformer Designation		
INSPECTION DATA		
Date of Inspection		
Inspected by		
OIL SAMPLES AND OIL LEVEL VERIFICATION		
Pull Oil Samples for Laboratory Tests	<input type="checkbox"/> Completed	
Verify Proper Oil Level	_____ Current Temp <input type="checkbox"/> Level OK <input type="checkbox"/> Oil Added	
Amount of New Oil Added (meets requirements of UZD® Technical Manual, pages 60–62)	_____ Gallons Added	
PRESSURE CONTROL SWITCH		
Pressure Control Switch Functioning Properly (4.3 psi ± 0.5%)	<input type="checkbox"/> Y <input type="checkbox"/> N _____ psi	
AUTO-RECHARGING DEHYDRATING BREATHER (ARDB)		
ARDB Functioning Properly	<input type="checkbox"/> Y <input type="checkbox"/> N	
De-Energize and Re-Energize ARDB to Verify Heating Cycle	<input type="checkbox"/> Completed	
Verify Water Drains from Bottom of ARDB	<input type="checkbox"/> Completed	
OIL FILTRATION SYSTEM		
System Functions Properly	<input type="checkbox"/> Y <input type="checkbox"/> N	
Check for Alarm Trips	<input type="checkbox"/> No Trips <input type="checkbox"/> Trips	
Replace Oil Filter Element, if necessary	<input type="checkbox"/> OK <input type="checkbox"/> Replaced	
Check for Leaks	<input type="checkbox"/> No Leaks <input type="checkbox"/> Leaks	Location:
Record System Operating Pressure	_____ psi	
All Gauges and Switches Working Properly	<input type="checkbox"/> Y <input type="checkbox"/> N	If no, which ones:
Hours of Operation	_____ Hours	

LTC LEAKS	INFORMATION	NOTES/EXPLANATIONS
Check for Leaks	<input type="checkbox"/> No Leaks <input type="checkbox"/> Leaks	Location:
MOTOR DRIVE MECHANISM COMPARTMENT		
Check for Leaks (Oil or Water)	<input type="checkbox"/> No Leaks <input type="checkbox"/> Leaks	Location:
Operate Tap Changer in Both Directions <i>(operation takes about 6 seconds)</i>	Functioning Properly <input type="checkbox"/> Y <input type="checkbox"/> N	
Unusual Sounds	<input type="checkbox"/> Y <input type="checkbox"/> N	
Operation Counter Working	<input type="checkbox"/> Y <input type="checkbox"/> N	
Record Number of Operations	_____	
Max-Min Tap Positions	_____	
Passed through Neutral Since Last Inspection	<input type="checkbox"/> Y <input type="checkbox"/> N	
Raise/Lower Indicator Flag Returns to Center when Operated in Both Directions	<input type="checkbox"/> Y <input type="checkbox"/> Needs Adjustment	
Check Drive Belt Tension and Adjust, if necessary	<input type="checkbox"/> OK <input type="checkbox"/> Needs Replacement	
Heater Switch On and Heater Working	<input type="checkbox"/> Not Working <input type="checkbox"/> Working	
General Visual Inspection	<input type="checkbox"/> Completed	
OPERATIONAL TEST		
Check Operating Settings	<input type="checkbox"/> Completed	

For assistance or more information, please contact our Waukesha® Components group at 800-338-5526.



Waukesha® UZD® LTC Major Inspection Form

TRANSFORMER DESCRIPTION	INFORMATION	NOTES/EXPLANATIONS
Manufacturer		
Year Manufactured		
Serial Number		
High Voltage		
Low Voltage		
MVA		
Substation Name		
Transformer Designation		
INSPECTION DATA		
Date of Inspection		
Inspected by		
ANNUAL INSPECTION		
Annual Inspection Requirements (see Annual Inspection Form)	<input type="checkbox"/> Completed	
SWITCH COMPARTMENT (LIQUID FILLED) TAP SELECTOR SWITCHES		
Measure Remaining Arcing Tip on Stationary Tap Selector Switch Contacts (54 Contacts)	PHASE A _____ Average in mm _____ Worst in mm _____ Position	
	PHASE B _____ Average in mm _____ Worst in mm _____ Position	
	PHASE C _____ Average in mm _____ Worst in mm _____ Position	
Gap between Tap Selector Switch Roller Contacts (18 Gaps)	PHASE A _____ Average in mm _____ Worst in mm _____ Position	
	PHASE B _____ Average in mm _____ Worst in mm _____ Position	
	PHASE C _____ Average in mm _____ Worst in mm _____ Position	
Measure Roller Diameters (36 Rollers)	PHASE A _____ Average in mm _____ Worst in mm _____ Position	
	PHASE B _____ Average in mm _____ Worst in mm _____ Position	
	PHASE C _____ Average in mm _____ Worst in mm _____ Position	
Confirm Rollers Turn Freely	<input type="checkbox"/> Y <input type="checkbox"/> N	
Check Roller Contact Pressure (18 Rollers)	PHASE A _____ Average in lbs _____ Worst in lbs _____ Position	
	PHASE B _____ Average in lbs _____ Worst in lbs _____ Position	
	PHASE C _____ Average in lbs _____ Worst in lbs _____ Position	
Check Main Current Carrying Tap Selector Switch Contact Pressure	PHASE A _____ Average in lbs _____ Worst in lbs _____ Position	
	PHASE B _____ Average in lbs _____ Worst in lbs _____ Position	
	PHASE C _____ Average in lbs _____ Worst in lbs _____ Position	
Check Contact Pressure of Slip Ring (Bow-Tie) Contacts	A _____ lbs B _____ lbs C _____ lbs A _____ lbs B _____ lbs C _____ lbs	
Check Proper Contact Alignment in All Tap Positions in Both Directions and Adjust, if necessary	<input type="checkbox"/> OK <input type="checkbox"/> Adjustments Made	
Check Transition Resistor	A _____ Ω B _____ Ω C _____ Ω	
	A _____ Ω B _____ Ω C _____ Ω	
Contact Resistance Measurement (hub of bow-tie to fixed contact)	A _____ μΩ B _____ μΩ C _____ μΩ	

SWITCH COMPARTMENT (LIQUID FILLED) TAP SELECTOR SWITCHES <i>continued</i>	INFORMATION	NOTES/EXPLANATIONS
Were Any Contacts Replaced (include photos)?	<input type="checkbox"/> Y <input type="checkbox"/> N	Which ones:
Liquid Level Gauge and Contact Functioning	Trips at correct level? <input type="checkbox"/> Y <input type="checkbox"/> N	
Check for Leaks	<input type="checkbox"/> No Leaks <input type="checkbox"/> Leaks	Location:
All Protective Devices Functioning Properly	<input type="checkbox"/> Y <input type="checkbox"/> N	If no, which devices:
REVERSING CHANGE OVER SELECTOR (REVERSING) SWITCHES		
Check Contact Pressure of Reversing Switches (6)	A ___ lbs B ___ lbs C ___ lbs	
Check Contact Pressure of Slip Ring (Bow-Tie) Contacts	A ___ lbs B ___ lbs C ___ lbs	
Check Contact Pressure of Slip Ring (Bow-Tie) Contacts	A ___ lbs B ___ lbs C ___ lbs	
Check Proper Contact Alignment in Both Tap Positions	<input type="checkbox"/> Good <input type="checkbox"/> Needs Adjustment	
Contact Resistance Measurement (hub of bow-tie to fixed contact)	A ___ $\mu\Omega$ B ___ $\mu\Omega$ C ___ $\mu\Omega$	
Were Any Contacts Replaced (include photos)?	<input type="checkbox"/> Y <input type="checkbox"/> N	Which ones:
SPRING DRIVE COMPARTMENT (DRY COMPARTMENT)		
Check for Leaks	<input type="checkbox"/> No Leaks <input type="checkbox"/> Leaks	Location:
Check Nylon Brake Roller for Wear and Play; Replace, if necessary	<input type="checkbox"/> OK <input type="checkbox"/> Replaced	
Verify Brake Only Engaged when Roller is in Slot and Stops within Range; Adjust Brake, if necessary	<input type="checkbox"/> OK <input type="checkbox"/> Required Adjustment	
Apply Lubrication per Field Maintenance Manual, Figure 23 (page 35)	<input type="checkbox"/> Completed	
Check Access Panel Gaskets; Replace, if necessary	<input type="checkbox"/> OK <input type="checkbox"/> Replaced	
MOTOR DRIVE MECHANISM COMPARTMENT		
Apply Lubrication in BUE Motor Drive Mechanism per Field Maintenance Manual, Figures 32–35 (pages 44–46)	<input type="checkbox"/> Completed	
Check Both Indicator Flag and Flywheel Brakes for Proper Adjustment	<input type="checkbox"/> Completed	
Check Wiring and Controls	<input type="checkbox"/> Completed	
Check Limit Switch Operation	<input type="checkbox"/> Completed	
Check Mechanical Stop Operation	<input type="checkbox"/> Completed	
GENERAL		
Describe Any Other Conditions Found or Areas of Concern (include photos)		
Oil Filled Compartment Door Gasket Replaced?	<input type="checkbox"/> Y <input type="checkbox"/> N	
Check of 90 Regulating Relay	<input type="checkbox"/> Completed	

For assistance or more information, please contact our Waukesha® Components group at 800-338-5526.

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United States locations

WAUKESHA HEADQUARTERS

400 South Prairie Avenue
Waukesha, Wisconsin 53189
800 835 2732

GOLDSBORO PLANT

2701 US HWY 117 South
Goldsboro, NC 27530
800 758 4384

COMPONENTS

9011 Governors Row
Dallas, TX 75247
800 338 5526

SERVICE

Emergency Service Available
24/7/365: 888 365 24x7
800 758 4384

SPX Transformer Solutions, Inc. (formerly Waukesha Electric Systems, Inc.) is one of the largest U.S. manufacturers of power transformers and a valued supplier of complete transformer service solutions, reverse-engineered components and replacement parts as well as a variety of substation-applicable training classes for all skill levels. Manufacturing locations include our headquarters in Waukesha, Wisconsin as well as satellite sites in Goldsboro, North Carolina and Dallas, Texas.

WAUKESHA® TRANSFORMERS

Our modern transformer manufacturing operations in Waukesha, Wisconsin and Goldsboro, North Carolina have amassed over 80 years of combined experience producing high quality power transformers that meet stringent customer demands. Utilizing sophisticated computer-controlled equipment and test systems, SPX Waukesha also maintains one of the shortest production cycles in the industry, which allows the team to respond quickly to customer delivery and installation requirements.

WAUKESHA® SERVICE

Waukesha® Service can provide complete transformer service solutions for almost any manufacturer's units including installation, maintenance, relocation, testing and technical assessments; oil processing, dryouts and retrofills; corrective and preventative maintenance; load tap changer field retrofits and repairs. Along with a vast number of skilled personnel located strategically across the country, we manage one of the largest fleets of specialized transformer service equipment in the United States. This allows us flexibility, optimized installation hours and costs while helping us provide efficient, safe and high quality service to our customers.

WAUKESHA® COMPONENTS AND TRAINING

Waukesha® Components operates a manufacturing, testing and training facility in Dallas, Texas as a leading supplier of parts for most major current and obsolete load tap changer (LTC) and oil circuit breaker brands as well as being the original manufacturer of a line of Transformer Health Products®. Additionally, we offer a variety of LTC services, including maintenance training, failure analysis reporting and complete overhauls at this location while also continuing to build our reputation as an industry leader in reverse-engineering and design enhancement.

SPX CORPORATION

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