BANGLADESH RURAL ELECTRIFICATION BOARD

PBS INSTRUCTION 100-30

DISTRIBUTION OPERATION, INSPECTION AND MAINTENANCE

BANGLADESH RURAL ELECTRIFICATION BOARD
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SUBJECT: DISTRIBUTION OPERATION, INSPECTION AND MAINTENANCE

1.0: INTRODUCTION

These introductions recommend a systematic program of inspection, record keeping and follow-up to provide reliable information of the condition of electric lines and equipment and maintenance that is needed. Experience has shown that such information leads to orderly planning, good maintenance and lower costs of maintenance and replacement.

Each PBS should have a systematic, complete line inspection program, including records such as those described in these instructions.

In reporting results, it is recommended that a summary of line inspection progress, inspection results and maintenance progress be included in regular reports of the General Manager to the board of directors.

These instructions are divided into three parts:

(1) Distribution Operation;

(2) Distribution Inspection and Maintenance;

(3) References.

2.0: DISTRIBUTION OPERATIONS

2.1 SCOPE

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This section will set forth some operating guidelines for:

- Safe work procedures.
- Equipment operations.
- Inspection and maintenance of equipment.
- Distribution records.
- Emergency procedures and disaster management.

As the system grows, additional management tools will be required and these tools must be developed as required in the future.

2.2 OPERATING RESPONSIBILITIES.

Responsibility for operation of the distribution system will be assigned to the Senior General Manager/ General Manager of each PBS. Some of this responsibility can be delegated to the DGM (HQ Tech./Respective Zonal Office) and AGM (Operation and Maintenance), but the overall responsibility must be maintained by the Senior General Manager/General Manager.

2.3 OPERATION PLANNING.

Careful planning is necessary to develop a good operating plan for varied conditions that must be dealt with. Procedures must be developed and records maintained to assure that those responsible for the system are informed at all times what is happening on the distribution system. Each Zonal/Area office must be maintained the same record keeping procedure. Each Zonal/Area office will send it to the DGM (Tech-HQ) of PBS. Summarize of the detailed records and procedures that must be maintained in each PBS are:

Re-closer records	Emergency plans
Meter records	Distribution feeder loads

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Regulator records

Inspections reports and records

Transformer records

ACR/ OCR/ Breaker records

Voltage recorder records

Line patrol records

Maintenance records

2.3.0 SAFE WORK PROCEDURES

2.3.1 GENERAL

Each employee must accept responsibility for his own safety as well as safety to fellow-workers and the pubic. Safe operating conditions shall be maintained at all times. Poor "housekeeping" cannot be tolerated since it generally leads to accidents. The rules set forth in the BREB Safety Manual shall be observed.

2.3.2 TOOLS AND CONSTRUCTION EQUIPMENT

All tools and construction equipment shall be kept in good working order. Tools or construction equipment found to be broken or damaged shall be reported immediately and replaced or repaired to good working condition before they are again used. Workmen's climbing tools and equipment that will be issued to individuals must be maintained in good condition. An office order shall be issued for distribution of tools for individuals. The person to whom the equipment or tool is assigned shall be responsible for proper care of such tools or equipment. Damaged or broken tools and construction equipment can cause serious accidents. These accidents can be prevented by a "common sense" approach to safety in using tools and construction equipment. Tools and construction equipment shall be used only for the function for which they were designed. Do not use tools or equipment those are unfamiliar. Before using an unfamiliar tools one must know how to use the tools or equipment. PBS must retain adequate tools and equipment for operation and maintenance of its Electrical Distribution System. The functionality and capacity of each tool and equipment must be checked before

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2.3.3 PERSONAL SAFETY

Working in the vicinity of electric facilities can be performed safely if good judgement is used. Linemen, when properly trained, can work safely on a pole. Short cuts, however, cause accidents. No one's personal safety shall be jeopardized to allow for short cuts or unsafe acts. Personal protective equipment shall be used at all times, hard hats, gloves, safety belts, long sleeved shirts, long pants and safety glasses.

2.3.3.1 When line personnel are working above ground, special hazards are introduced, not only to the men on the pole, but also to the men working on the ground. Falling tools or other objects constitute such hazards. Hand lines shall be used for raising or lowering material from the pole. Do not throw material up (or down) the pole. Hard hats shall be worn when working in the area of activity.

2.3.3.2 The tagging and clearance procedure as described in the Substation Operation and Maintenance Manual (PBS Instruction 100-29) shall be used on distribution lines to enhance safety.

2.3.4 TRANSPORTATION EQUIPMENT

Transportation equipment presents some special hazards when operated in congested areas or on rough roads or terrain. Every effort shall be made to keep the equipment properly maintained and in good working order. The person assigned to operate the equipment shall be responsible for its safe operation. Speeding, rough handling, or other abuse of equipment shall not be allowed. Any equipment defect shall be promptly reported and repaired. To operate mechanical vehicle/transport, license from BRTA (Bangladesh Road Transport Authority)

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must be obtained, when required and should be updated timely.

Unsafe, improperly maintained equipment shall not be used on the PBS systems.

2.4.0 DISTRIBUTION EQUIPMENT OPERATION

2.4.1 GENERAL

There are varied types of equipment installed on the PBS network systems and it is necessary that all persons that are required to operate this equipment be instructed in its function and operation. Some of the less familiar equipment will be discussed in this section together with points to remember in its operation.

2.4.2 DISTRIBUTION EQUIPMENT.

The distribution equipment items to be discussed are as follows :

1. Transformers
2. Voltage Regulators
3. Switches and fused cutouts
4. Oil circuit re-closers (OCR)
5. Automatic circuit re-closers (ACR)
6. Breaker
7. Meters
8. Street lights
9. Distribution line equipment.
10. Lightning Arrester
11. Capacitor
12. CT & PT

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2.4.2.1 Distribution Transformers

Mainly single phase pole mounted distribution transformers are used in the PBS systems. It is the Conventional type transformers. In course of time load in rural Hat Bazar, growth center has been increased rapidly. As a result now a day Three phase Transformers are also being used in PBS system.

A) Conventional Type Single phase Transformers:

This transformer has the following features

- A single high voltage bushing
- Two low voltage bushings
- Tank mounted ground lug
- Pressure Relief device

Conventional type single phase transformers are used in three phase power bank installation (3 transformers). These transformers do not have the protecting features like the modified protected transformer. Externally mounted surge arresters and fused cutouts must be installed for three-phase power bank installation.

CAUTION: Do not remove the tank ground when the transformer is energized. It will cause death for line crew.

B) Three phase Transformers: Normally 3-phase distribution transformers are not purchased in RE system but BREB had taken-over huge amount of electric lines along with 3-phase distribution transformers. To replace and rehabilitate taken-over 3-phase distribution transformers and to connect densely loaded area, BREB has recently purchased 100 KVA and 200 KVA 3-phase distribution transformers under UREDS project. Very recently BREB has started to use 3-phase distribution transformers to connect densely loaded Hat- Bazar area. But RE people are not habituated of using

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them. Installation of three phase distribution transformer is little bit different from single phase. But for concentrated loaded area, comparatively three phase distribution transformer is more advantageous in various aspects.

2.4.2.2 Voltage Regulators

Single phase step-type voltage regulators are to be used on the distribution system. These regulators have an on-load tap-changer to raise (or lower) the voltage up to 10 percent. The regulator has 16x5/8% steps to raise the voltage and 16x5/8% steps to lower the voltage, thus a total of 32 steps to lower/raise the voltage. Most regulators also have travel stops to permit setting the steps at less than the maximum. This permits an increase in current rating at reduced voltage regulation as described in the manufacturer's instruction book/manual. The current rating for line regulator is 100A.

The application and function of voltage regulators are described in more detail in the Engineering and Staking Instructions. See Reference 8 under part III.

A. Operating Single-Phase Step-Type Voltage Regulators

To place a regulator in service, several initial tests and settings are often required. Before installing the regulator:

(1) Perform the initial tests as outlined by the manufacturer and PBS Instruction Series100-29.

(2) If the regulator(s) has been stored for an extended period of time, perform a dielectric strength test on the oil. Check proper oil level.

(3) Make the necessary control settings (voltage level, band-width, compensation, time delay, tap-changer steps of travel, etc.)

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(4) After the regulator is in place, check to see that all connections, including the tank ground connection, are correct.

(5) Check regulator position on neutral.

(6) Check to see if regulator is by-passed.

NOTE: Most combined function regulator by-pass switches are in the open position to isolate the regulator and shunt the load circuit past the regulator when the regulator is by-passed. Check to make sure the switch installed is built this way.

(7) Check the control power circuit breaker in the control cabinet open.

(8) Check the control switch on "off" position.

(9) Check the power supply switch on internal.

(10) Visually check the voltage level, band width, time-delay and line drop compensation settings, tap-changer travel stops and reset if necessary.

(11) Close the control power circuit breaker.

(12) Place the control switch on automatic.

B. Removing Single- Phase Step-type Regulators from service

The following procedure is to be used:

(1) Operate the regulator tap changer mechanism to neutral position (position "O"). This is accomplished by adjusting the control switch to raise or lower the regulator position. The neutral position lamp will light on the control panel. Return the control switch to the "off" position.

(2) Open the control circuit breaker.

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(3) Open the combined operation disconnect switch to by-pass the regulator.

2.4.2.3 Switches and Fused Cutouts

There are three types of switches to be used on distribution lines. The operation of these switches is described below.

(1) Gang/Group Operated Air Break Switch

This switch is designed with the switch handle located at ground level. Refer to reference 14 for adjustment and mounting details. The switch is opened (or closed) by moving this operating handle. Before operating this switch, check that the switch handle and operating mechanism is properly grounded. Use rubber gloves when operating this switch. This is an "Off Load Switch".

(2) Single Blade Disconnect Switches

These switches are to be used at sectionalizing points and as by-pass switches at recloser installations. These switches are designed to be operated with a hook stick. This is also an "Off Load Switch". The key points in operating this type of switch are:

(a)Do not attempt to interrupt load with this type of switch unless the switch is equipped with a load buster tool adapter hook. Then a load buster tool can

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be connected to the switch to interrupt the load.

(b) Check adjustment of the contacts of this type of switch before installing. Looseness or improper adjustment of the contacts is not acceptable.

(c) When operating this type of switch with a hook stick, perform the opening or closing operation with a positive and continuous motion. Ascertain that the switch reaches a completely open or closed position to prevent arcing of the contacts and to ensure proper and safe operating conditions.

(3) Regulator By-pass Switch

This combined operation by-pass switch is designed to perform the switching operations of three switches. It serves as two disconnects and one by-pass disconnect. When the switch is closed, the disconnect switches are closed and the by-pass feature of the switch is open. When the switch is in the open position, the two disconnect blades are open and the by-pass is closed. The key points in operating this type switch are:

(a) Check the adjustment of the switch to ensure proper sequence operation of the switch. Refer to Exhibit 3.1. When opening the switch, the by-pass "a" switch must close before the contacts open on the "b" and then the "c" disconnect blades. When the switch is being closed both the "b" and "c" disconnect blades must make contact before the "a" by-pass opens.

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(b) When operating this type of switch with a hook stick, perform the closing or opening operation with a positive and continuous motion. Ascertain that the switch reaches a completely open or closed position to prevent arcing of the contacts and to ensure proper and safe operating conditions.

(4) Fused Cutouts

The fused cutout will be used at sectionalizing points and for fusing transformers. This device serves a dual function of a fuse and a disconnect switch. The key points in operating a fused cutout are :

(a) Check the adjustment of the fused cutout before installing. The main contacts must make good contact when the switch is closed.

(b) If the switch has been used previously, check the arcing tube to see that it is not unduly burned.

(c) When installing a fuse in the cutout, make sure that the mechanism at the bottom of the arcing barrel is properly adjusted to ensure that-

(i) The contacts will line up properly when the fuse is installed in the mounting and

(ii) The arcing tube will drop open when the fuse is blown.

(iii) Ensure fuse link is placed in the center of the fuse barrel.

(d) When operating a fused cutout with a hook stick, perform the closing or opening operation with a continuous and positive motion. Ascertain that the fused cutout is completely in the closed position to ensure against

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arcing at the contacts.

2.4.2.4 Oil Circuit Re-closers

Single-phase oil circuit re-closers (OCR) shall be checked thoroughly before installing on the system. Some of the key points to check are:

(a) Check evidence of oil leaks.

(b) Check damaged tank, operating mechanism or bushings.

(c) Check the nameplate for proper voltage and current ratings and reclosing sequence.

(d) This device shall be operated with a hook stick by pulling the operating lever down to open, and pushing up to close.

(e) When working on the distribution line on the load side of OCR's, always obtain a visual line opening by: (1) opening a jumper; (2) opening a disconnect switch; or (3) opening a fused cutout.

2.4.2.5 Automatic Circuit Re-closer (ACR)

2.4.2.5.1. Function of ACR

(a) The re-closer with the microprocessor-based digital control technology is designed to provide automatic distribution reclosing system for maximum continuity of electric service.

(b) Ensure that all programmable setting of the microcontroller meet the system requirements. Check that the re-closer is properly installed and all electrical connections are made. Check that any external wiring connections for control are placed normal.

(c) ACR recloses to restore service if the fault is temporary and resets for another cycle of operations. It locks itself after one, two, three or four operations according to the predetermined setting, if the fault is permanent.

(d) Opening sequences of the re-closer can be all fast, all delayed or a combination of fast and delayed. When the combination sequence is used, fast operation always precede delayed

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operations.

(e) After one, two or possibly three such fast sequences, the re-closer automatically changes to a delayed trip operation. This delayed trip allows more time to clear more persistent faults.

(f) The combination of fast operations followed by delayed operations permits effective coordination with other protective devices on the system.

(g) Another intelligence feature is automatic reset. If a re-closer is adjusted to lockout after the fourth tripping operation but the fault has been cleared after the first, second or third operation, the re-closer will automatically reset itself a short time later to its original status, capable of performing another complete four- operation sequence.

(h) If the recloser has been subjected to a permanent fault and goes through a complete sequence to lockout, it must then be manually closed.

(i) On coordinated systems, fast re-closer operations are used to clear temporary faults before branch-line fuses are damaged. Subsequent time-delayed openings allow fault currents to flow long enough to clear by branch-line fuses. Therefore, outages caused by permanent faults are confined to shorter sections of line.

2.4.2.5.2 Different components of ACR

Components vary with the type of control and interruption of the ACR. A diagram showing major components of ACR is given below:

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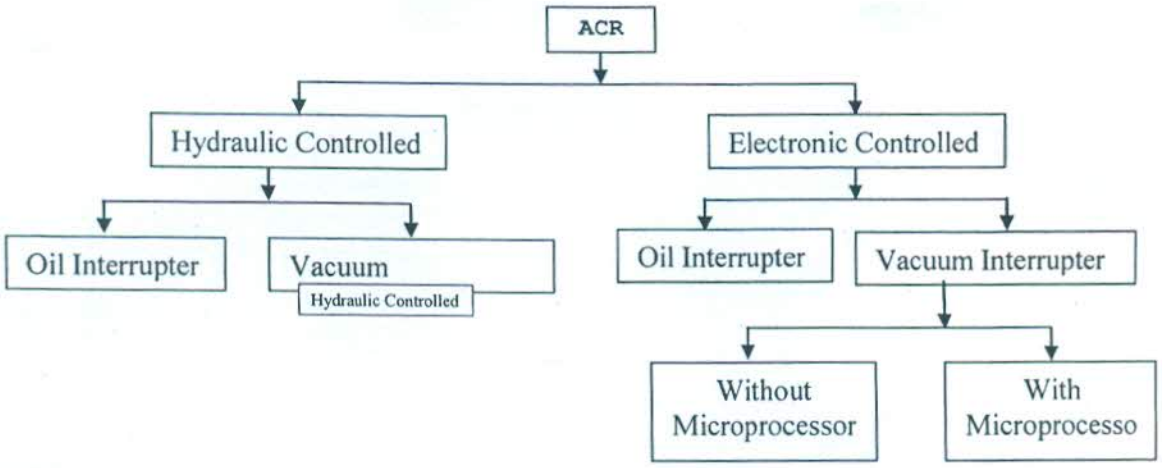

2.4.2.5.3 Factors for Operating ACR

(1) **Automatic circuit re-closers** are used on the distribution feeder and substation. The basic function of the re-closer is to protect the substation equipment (transformers, regulators, bus work) and the distribution conductors, from thermal damage due to fault current.

(2) **To achieve this**, it is necessary to determine the rating of the re-closer maximum fault current, maximum load current and minimum fault current at each sectionalizing device location on the distribution feeder. It is also necessary to determine the minimum fault current at the ends of all circuits and branch lines.

(3) **Six major factors must be considered for operation application of ACR-**

(a) **System Voltage:**

(i) Re-closer must have a voltage rating equal to or greater than the system voltage. For three phase line it is phase to phase voltage and for single phase line it is phase to neutral voltage.

(ii) It is important for bushing & core spacing, turn of solenoid coil for developing

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magnetizing force.

(b) **Maximum fault current:**

(i) The re-closer interrupting rating must be equal to or greater than the maximum available fault current. Some margin should be allowed above this value because the trend is toward higher fault currents in the future as changes are made and additional capacity is added to the power supply system.

(ii) The maximum faults current will be known or can be calculated at the point of re-closer location.

(c) **Maximum load current**:

Load growth should be considered in selecting the re-closer size. A practical growth limit might be that which would require changes in either the conductor or substation transformers.

(i) The maximum continuous current rating of the re-closer must be equal to or greater than the maximum load current anticipated for the circuit. Idealy the load current should be at 70 percent or less of the re-closer rating.

(ii) In hydraulically controlled re-closers, the continuous current rating of the series oil coil selected may be equal to greater than the anticipated circuit load.

(iii) Some circuits may have high air conditioning loads or electric heating loads, so difficulties may be experienced when attempting to re-energize the circuit after an extended outage (cold load pickup). For these applications, a trip current setting of 250 percent or higher of the peak load current may be required.

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(d) Minimum fault current:

(i) The minimum fault current that might occur at the end of the line section to be protected must permit the re-closer to sense fault current throughout the desired protection zone and interrupt the section.

(ii) The minimum trip rating, also a property of the series coil, normally is twice the coil's continuous rating and should be at least twice the expected peak load current. In some re-closer, there is provision of setting minimum trip current in some predetermined current which is less than twice of the continuous rating.

(iii) In electronically controlled re-closers, the minimum trip current is selected independently of the re-closer's maximum continuous current rating, although it normally does not exceed twice the value.

(iv) The "minimum fault current" values used in applying re-closers and other over current protection devices are arbitrary values based on the particular utility's determination as to the level of protection needs for the zone in question. Obviously the true minimum fault level at any point on any system is zero. If 40 ohms fault resistance is used for fault current calculation, the minimum fault current will be less than 180 amperes. Therefore, a 70 ampere series coil re-closer will be the maximum size, which will detect a calculated minimum line-to-ground fault.

(e) **Coordination with Other Protective Device:**

Coordination with other protective devices, both source-side and load-side, becomes important after the above factors are satisfied.

(i) Generally the time-current characteristics and operating sequence of a re-closer are selected to coordinate with source-side devices. Load side device must clear a

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permanent or temporary fault before the source side device interrupts the circuit. And outage must be restricted to the smallest section of the system.

(ii) After a specific re-closer size and sequence are determined, protective equipment further down the line is then selected to coordinate with it.

(iii) The first operations are as fast as possible in order to clear temporary faults before any down line fuse operation. If the fault is permanent, the time-delay operation allows a down line device either another re-closer or fuse nearer the fault to interrupt the over current, thereby limiting the outage to a smaller portion of the system.

(iv) **To coordinate re-closer with a down line fuse--**

(1) The fuse link size should be selected to coordinate with the re-closer fast and time delay curves.

(2) A re-closer operating on its first curve should clean a temporary fault before the fuse link can be damaged.

(3) When on its time delay curve, a re-closer operation should be more retarded than the fuse-link clearing time, allowing the fuse to clear permanent faults without tripping the re-closer.

(f) **Ground-Fault Sensing**

The majority of faults on the typical utility system (wye connected) involve either the neutral or the ground and are commonly referred to as 'ground' faults-

(i) These faults are commonly revealed through the detection of over-current, which is accomplished by sensing the residual current of three-phase current

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transformers. The residual current measured the zero-sequence current of the circuit, is comprised of both the line-to-ground (or neutral) fault current plus the unbalance current of the three-phase feeder.

(ii) The standard phase-current sensing of re-closers will detect ground-fault currents when the total current through any phase (load plus ground fault) exceeds the minimum phase-trip setting. This setting is relatively high (two to two-and- a-half times peak load current), so many ground faults may not be detected.

(iii) Many of the ground faults occur at some distance from the substation, so the magnitude is limited by the line impedance, ground resistance and arc resistance.

(iv) When ground-fault sensing is used with a three-phase re-closer, the ground-fault settings (Minimum trip and timing) must be coordinated with the phase-trip settings of the down line single-phase re-closer. That is the ground-fault minimum trip and timings must be greater than those of the down line re-closer. This will ensure trip and lockout of the down line re-closer on any fault beyond it without causing lockout of the up-line three-phase re-closer.

2.4.2.6 METERS

Single phase and three phase kilowatt-hour meters are to be installed on the PBS distribution system. The following are key points in installing and removing meters:

(1) Inspect the meter for damage before installing. Care must be taken in transporting all types of meters to prevent damage.

(2) Before installing a meter, check whether it is a bottom connected type or socket type meter Always check for grounds on the customer side of the meter. An improperly installed ground can cause serious damage to the meter and may cause injury to the person installing the meter.

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(3) Always install the meter with the customer's switch open and always make the meter connections while the secondary service is de-energized.

(4) Always remove the meter with the customer's switch open. De-energize the service to remove bottom connected meters.

(5) When any meter is damaged (such as broken glass, etc.) always de-energize the meter and open the customer's switch before replacing the meter.

2.4.2.7 STREET LIGHTS

Street lights shall be inspected and cleaned annually. At these times, glassware should be cleaned and inspected and the light tested to determine if it is operating satisfactorily. The light can be turned on by covering the photo-electric control to simulate darkness.

- The date of installation of each luminaire should be clearly marked on the luminaire. It is recommended that during the inspection the mercury vapor bulb should be replaced if it has been in service for four or more years. All maintenance that can be accomplished during this inspection should be performed to eliminate additional trips.

2.4.2.8 Distribution line Equipment

The distribution line equipment include the poles timber/concrete/steel, cross-arms, insulators, wire, structural components and hardware, all the material that supports the preceding items that is required to get the power to the customer. It is an essential part of the system and can not be ignored or undermined in the overall reliability of the distribution system.

2.4.2.9 GENERAL

Physical Inspection & Test before installation of Distribution Equipment.

(1) Following physical inspection shall be carried out before installing distribution equipment to the service.

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(a) Check for damage, change in color.

(b) Check for loose connection, loose screws & nuts.

(2) Following test shall be carried out before installation of Distribution Equipment to the service.

(a) Test di-electric strength of oil.

(b) Continuity Test.

(c) Insulation resistance Test (Distribution Transformer)

(d) Gas Leakage Test (Pressure release test)

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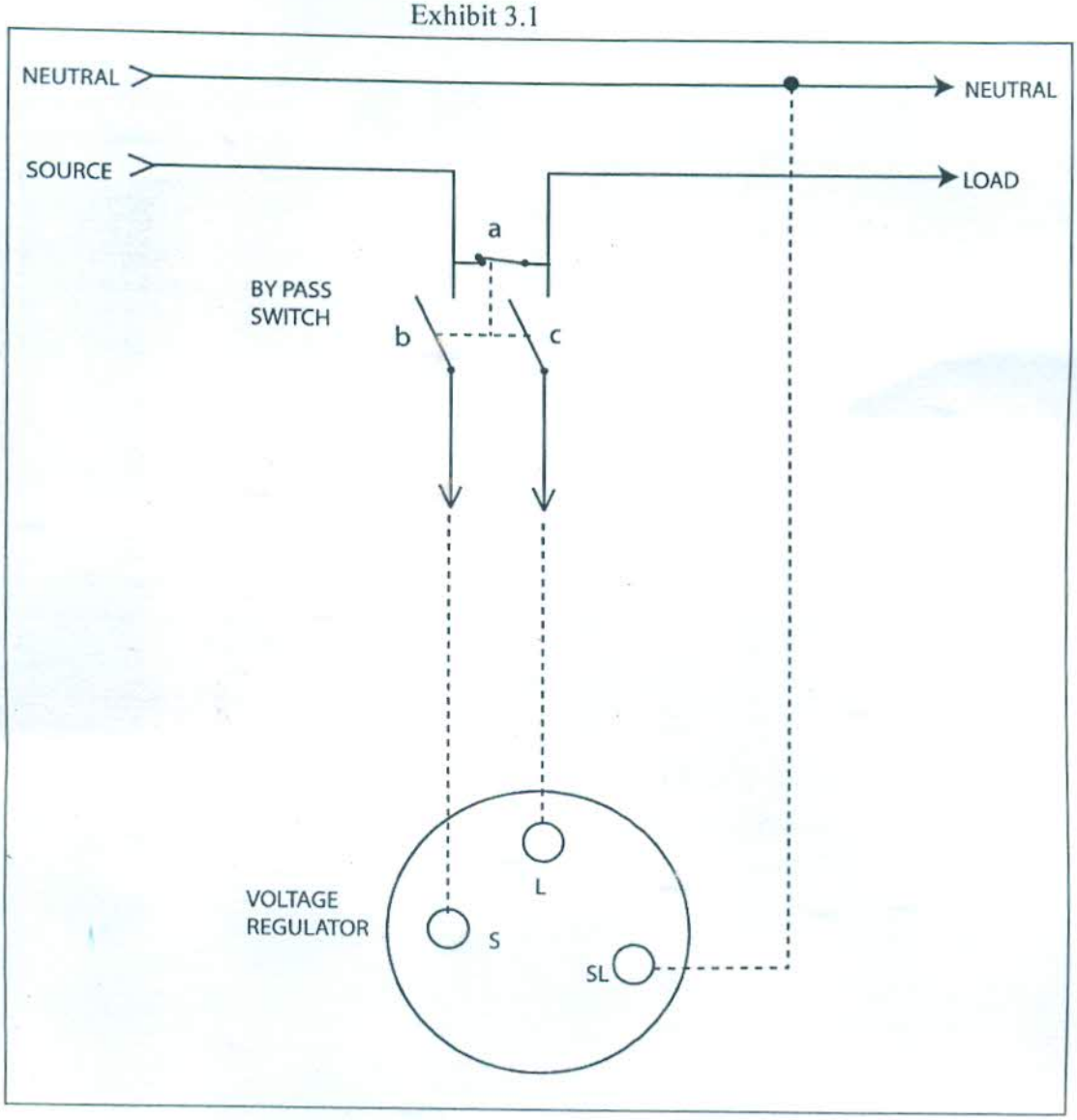
Exhibit 3.1



COMBINED OPERATION REGULATOR BYPASS SWITCH

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2.5.0 VOLTAGE INQUIRES

2.5.1 GENERAL

An inquiry may be received occasionally from a customer regarding the voltage being supplied to his/her residence or business other than normal. Voltage conditions can be caused by an overloaded transformer, loose connection, long secondary or other reasons. There are several steps to remember in making an investigation brought about by this inquiry. They are as follows:

(1) Is the problem created by a low primary voltage serving in the area. If so, the following steps are to be taken to check and rectify the faults.

(a) Check Grid supply voltage. If the voltage level is not normal, notify BPDB/ PGCB to take corrective measures.

(b) De-energize the transformer and reset the transformer no load tap changer to correct over/under voltage or change OLTC tap as required.

(c) Check phase voltage and if not found normal, carry out phase balancing.

(d) Adjust voltage regulator setting. In case of OLTC facilities, no voltage regulator is necessary.

(2) Question the customer to determine the specific problem. Typical questions are:

(a) Is the problem isolated to one area or does it exist on the entire electric installation on the premises?

(b) When is the problem experienced ? Is it continuous or only at certain times of the day?

(c) Has new load been added recently to the customer's service or other services served from the same transformer?

(d) Has the customer experienced an excessive number of blown fuse recently?

(3) Make a voltage check at the customer's switch with a portable volt meter. Is there evidence of loose connections? The voltage will show extreme fluctuation if there is a load applied while checking the voltage.

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(4) If there is any evidence of loose connections, check all connections from the customer's switch back to the transformer terminals. This is a common occurrence on electric network facilities. Tightening of loose connection may solve the problem at this point. If this is not the problem, proceed with additional checks.

(5) Check the transformer load. Counting the connected customers and observing any recent, new load additions may indicate an overloaded transformer. Check transformer load current with a tong type or clamp-on type ammeter.

(6) Calculate the expected secondary service voltage drop.

(7) If none of the above circumstances appear to be the cause of the voltage problems, install a recording voltmeter. The recording voltmeter should be installed for a minimum of 48 hours to obtain a reasonable indication of voltage variations.

(8) The data obtained from this investigation and the action taken shall be properly recorded and kept on file in the appropriate PBS headquarters. Prompt action should be taken to correct an abnormal condition on the electric system in order to avoid damage to system or customer owned equipment.

3.0: DISTRIBUTION INSPECTION AND MAINTENANCE
3.1 INSPECTIONS

3.1.1 GENERAL

Quality electric system inspection and maintenance are major factors in providing reliable and safe system operation. To determine maintenance that may by required, periodic inspections of the system must by made. The persons assigned to perform

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these inspections must be qualified and well trained in order to obtain meaningful inspection data. Inspection and maintenance records must be maintained to systematically and regularly determine work required to keep the distribution system in good operating condition.

The key objectives in providing a good inspection program are to:

(1) Promote safety for work personnel and the public.
(2) Provide satisfactory service to consumers.

(3) Lower costs through improved efficiency in planning and work scheduling. Preventive maintenance for system equipment and other components may avoid costly replacements.

(4) Protect large investments in distribution plant/system.

(5) Provide satisfaction and pride in good workmanship.

A program of inspection and maintenance requires a considerable financial appropriation. These funds must be expended effectively in carrying out the program.

3.1.2 SELECTING AND TRAINING INSPECTORS

Qualifications of those selected for training as inspectors should include:

(1) Competence and fairness that will be respected by others who should use the inspection reports.

(2) Familiarity with BREB construction standards and codes.

(3) Training in inspection of timber products, SPC and steel products/materials if responsibilities are to include pole and cross arm inspection.

(4) Training and experience in recognizing deficiencies which could create hazards or cause service interruptions.

(5) Familiarity with BREB/PBS maintenance practices and procedures.

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3.1.3 INSPECTIONS

All distribution lines {with the exception of equipment such as oil circuit re-closers (OCR), /Automatic circuit re-closer (ACR)/ Breakers, voltage regulators and capacitors} shall be inspected on a four-year cycle except where more frequent inspections are found necessary (example: when tree problems are evident and adequate clearances from trees cannot be maintained, these areas should be properly identified for six monthly inspections or as required).

3.1.3.1. Electrical network

The electrical line will have following items inspected on the four-year cycle. An infrared inspection will be part of the inspection and will be done on the same inspection cycle. The items to be inspected are defined by the following:

(1) SHIELDWIRE and HARDWARE- Includes all the overhead ground wire (shield wires) and hardware, including but not limited to shield wire shoes, rods and attachment bolts and hardware.

(2) REPAIR GROUNDWIRE- If required the INSPECTOR shall repair broken ground wire found in the ground-line area and must utilize accepted safe practices. The ground wire shall be the same material as on the existing pole. Burndy HYLINK connector or equal shall be used.

(3) INSULATORS and HARDWARE- All of the insulators associated with a distribution/transmission structure including but not limited to the attachment bolts, hardware and the insulators themselves.

(4) CONDUCTOR and HARDWARE- All conductors and related hardware including conductor shoes, connected to the distribution/transmission structure.

(5) HARDWARE- All non-wood products related to a distribution/transmission

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structure, including the cross arms, X-braces, cross arm braces, pole ground wire, conductor, insulators, shield wire and all associated hardware.

(6) Connections and other equipment inspected includes surge arresters, sectionalizing switches and any miscellaneous equipment installed in the system. Connections are inspected visually and with infrared devices. All connections to equipment and line taps are inspected to see that they are tight and that there is no evidence of arcing, burning or melted conductor. Surge arresters are inspected to ensure that they have not failed. Arresters are inspected for excessive surface contamination.

(7) SOUNDING- Is the inspection procedure of sounding a pole with a hammer from the ground line to eight (8) feet above, in order to locate internal decay pockets; this procedure is used on all wood poles. This is a safety procedure requirement before climbing a wooden structure, sound it to ensure that the pole in safe enough to climb.

(8) NEEDS FURTHER ACTION- This is a structure requiring further review as to the acceptability of the wood products, hardware, conductor, shield wire or maintenance related to the above.

It is recommended that one quarter of the PBS electrical facilities be inspected yearly. With this plan, all of the electrical system will receive an inspection every four years. However the inspection plan may include more frequent inspection for lines having following conditions:

(a) Older lines - starting from sub-station.

(b) Over-loaded line.

(c) Lines having sensitive load like Hospital, TV/Radio Station, Airport, University, large Industrial loads, etc.

(d) Numerous operations as reported on the monthly sub-station inspection report for OCR/ACR/ Breakers.

(9) Control of vegetation is a never-ending problem

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All electrical lines shall be inspected on a one year cycle i.e. one half of the PBS electrical facilities shall be inspected every six months to ensure adequate clearance from tree, creepers, etc. When trees growing under the line are within 5 feet from the line they are to be trimmed back. If possible they will be cut completely down. It is within the rights of the landowner to decide whether or not to completely cut down or just trim the danger tree.

A common cause of outages is contact of the line to vegetation such as tall trees. Due to high winds during cyclones, tree branches and flying debris can contact lines and cause fuses to blow, circuit breakers to trip and lines, insulators & cross arms to break. Encroachments on rights-of-way can introduce serious clearance and safety problems.

Right-of-way inspection is performed visually. The inspectors observes and notes trees that require trimming areas where undergrowth young tree's and vines need to be cleared; and any other unusual conditions that might affect the reliability and service of the line. Easement and access roads are inspected for erosion and other degradation. Occasionally temporary or permanent obstacles may be erected under a line that could seriously jeopardize the clearances from a conductor to that obstacle, i.e. hay stack, pile of trees and branches that have been cut down, a new building or shed erected, old unused equipment permanently piled there. The landowner is to be contacted and arrangements made to remove or move the obstacle to a safe location or relocate the line at the owner's expense.

BREB Form No. 100-30-02 is the recommended inspection form to use for the line inspections. Since this form can be used for four inspections, the notes shall include a date when the deficiency was found. Adequate explanation of the problem shall also be noted. Attach a detail map point to each inspection form for ready reference. A maintenance order should be written to correct the conditions

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found on the inspection. After the maintenance work is completed, an entry should be made on the inspection form. Make sure that all items are noted on the form and prompt action is taken to correct the conditions found during the inspection.

(10)Priorities shall be established for the maintenance work found on the routine inspections.

TABLE- 1

Priority	Condition	Examples
1	Requires Immediate Attention	1. Floating Primary 2. Equipment loaded too close to line 3. Broken pole or conductor support 4. Tree in primary line
2	Requires attention within one week	1. Tree condition 2. Broken guy/ anchor pole is stable 3. Partially damaged conductor
3	Requires attention within one month	1. Tree clearing required 2. Damaged pole 3. Damaged guy/ anchor

(11) Good judgement must be exercised in determining the priority assignment for a maintenance item. Remember - the condition will not correct itself. Action must be taken.

(12) Infrared Scanning

The majority of all electrical failures are preceded by an abnormal temperature rise. The use of thermography for detecting potential failures in electrical equipment has proved invaluable. There is no other maintenance procedure available today that can give an evaluation of an operating electrical system as efficiently and effectively as

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thermography. A routine inspection every four years using thermographic inspection can substantially reduce the frequency of equipment failures and unplanned power interruptions.

Overheating due to high resistance connections causes the majority of electrical failures. Some of the factors contributing to the development of these high resistance connections are, poor equipment application, improper installation, vibration, expansion and contraction of circuit parts due to load cycling and oxidation of conducting material surfaces. The overheating of electrical equipment is a self-compounding problem. As the temperature rises, so does the resistance.

This rise is heat and resistance leads to mechanical and insulation breakdown with eventual failure of the electrical equipment. This failure can result in injury to personnel, lost production time and expensive labor and material costs for equipment repair or replacement. An added advantage to an infrared inspection is that it is performed under normal loaded conditions with no interruption to the electrical system.

Scan all equipment and connections, looking for any abnormal variances in temperature

All electrical contact points and welded or mechanical connections on switches are thermally scanned. Infrared anomalies are then classified and acted upon according to the following system.

Classification of Heat Rise and action to be taken:

Grade 1: If any connection exceeds 60° C ΔT above local ambient, equipment should be removed from service immediately to determine the cause and effect repair. Extent of damage at this point may require replacement of parts.

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Grade 2: If any connection exceeds 40° C ΔT above local ambient, equipment should be removed from service as soon possible (as scheduling permits) to determine the cause and effect repair. The problem can normally be corrected with minimal or no damage having occurred to the component.

Grade 3: If any connection exceeds 10° C ΔT as compared to the remaining corresponding phases, or if any connection is more than 20° C ΔT above local ambient, measures are taken to determine the cause and effect repair. These are problems that should be looked at under normal maintenance schedules or under routine equipment outages

The weather conditions on the day of an inspection may result in a lower temperature rise on the electrical equipment. Following the thermographer's analysis, this equipment may be assigned a higher priority rating.

Items to focus on when conducting an infrared scan

Switches and parts

Bolted connections

Pressed-on connections

Welded connections

3.1.3.2 Equipment Inspection:

Automatic circuit re-closers (ACR), Oil circuit re-closers (OCR), Breakers, Voltage regulators and capacitors require more frequent inspections than do other electrical line equipment.

A schedule for inspecting this equipment shall be established as outlined below to ensure that these equipment is operating properly.

3.1.3.2.1 Voltage Regulators.

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Voltage regulators require inspection and maintenance on a regular schedule since they have numerous moving parts, perform tap-change switching in oil and have a complex electronic control system with settings and adjustments that may change (drift) with age.

(1) Monthly inspections, both visual and functional, should cover the following items as a minimum. Manufacturer's recommendations should also be reviewed in conjunction with inspection. See reference 9. (Keep in mind that most voltage regulators will be energized and dangerous during inspections. Also, treat all neutral and ground conductors as if they are energized.)

(a) Look for loose, broken or contaminated bushings, oil leakage from bushings and evidence of heating at terminals.

(b) Record oil level indicated by the level gauge.

(c) Record oil temperature (if regulator has a thermometer).

(d) Inspect general condition including tightness of connections, tightness of cover fasteners, oil leaks at gaskets, valves and welds, tank and accessory paint finish, rust formation, and breakage of glass covers in position indicator and instruments. Inspection of dryness, dust & insect freeness of control cabinet and controls, proper operation of heaters, wiring condition, etc.

CAUTION: No inspection above edge of top cover should be performed while regulator is energized.

(e) Check against previous record of settings to verify proper settings of voltage sensor, line-drop compensator, band width, position indicator travel stops and time delay.

(f) Record tap-changer operation counter reading.

(g) Check regulator operation (energized).

-Record voltages (regulated) and drag-hand positions.

-Switch to "manual" position.

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-Run to neutral position.

-Record voltages again (unregulated).

-Switch back to "automatic" position. After time delay setting of control has expired, regulator will return to normal raise or lower top position.

- Repeat the operation such that the regulator will operate in the opposite direction i.e. if it lowered then manually lower the taps and then return the control to "AUTO" and verify that it will raise the taps.

-Reset drag-hands.

(h) Static Control

- Check all indicating lamps using test switch procedures given in manufacture's instruction book. See Reference 9.
- Take all the readings required on the monthly inspection form
- Overall test of controls is not considered necessary on monthly schedule unless utilized for training purposes. Otherwise, it should be performed on annual schedule.

(2) Annual Inspection

Annual inspections should be performed to cover important items not included in the monthly inspections, but they could by performed to coincide with one of the monthly inspection. Reference can be made from manufacturer's recommendations should be reviewed before each inspection. See the following guideline:

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INSULATING OIL TEST SCHEDULE

ACTION	SCHEDULE					
	INITIAL			ROUTINE		
	Upon Receipt or Installation	After Energization				
		24 hours	1 month	Monthly	Yearly	3 Years
Dissolved Gas Analysis (DGA)		X	X		X	
Oil Water	X				X	X
Oil-Acid		X				X
Oil-IFT		X				X
Oil-Color		X				X
Dew Point	X		X			X
Inspection	X			X	X	X
Minor Maintenance					X	X
Major Maintenance	X					X

IFT = Inter Facial Tension, DGA = Dissolve Gas Analysis

(3) The first major maintenance should be performed at three (3) years. If minor test and maintenance indicates the Voltage Regulator to be in normal condition, routine major test and maintenance can be delayed an additional year or follow manufacturer's recommendations.

(4) Oil Physical Guidelines

The following is a list of ASTM tests that can be performed on the oil samples taken from the electrical equipment. The accepted levels of the oil being tested and the

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meaning of those results are also listed with each test are also given as a guideline.

Limits of **O**il Dielectric **S**trength Test**

Apparatus	138KV and below ASTM D 877 (KV)	230KV and above ASTM D877 (KV
New Transformers, Regulators and Reactors - main tank	30	35
In-Service Transformers, Regulators and Reactors - main lank	26	30
New Vacuum Tap Changers	30	35
In-Service Vacuum Tap Changers	26	30
New interrupting devices - Breakers and Load Tap Changers	30	35
In-Service interrupting devices - Breakers and Load l ap Changers	26	30

(a) Collect an oil sample from the bottom drain valve. Use a clean, dry standard oil sampling bottle for the dielectric/physical tests and clean lint free rags. For DGA samples follow the outline below:

Proper oil sampling is critical for accurate test results. The method outlined is to be

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used for the sampling of oil from power transformers, and regulators. The sample will be used in performing fault gas analysis, dissolved water content and any such test that requires the sample not come in contact with the atmosphere.

The important considerations to observe when obtaining samples are as follows:

(1) Oil readily absorbs air and water.

(2) The apparatus being sampled must not be under negative pressure.

(3) The valve and plumbing through which the oil is sampled must be cleaned and thoroughly flushed with oil.

(4) The oil sample should be taken from the bottom of the tank.

(5) The filled sampling container should contain no air and be protected from extreme heat and sunlight.

(6) Sampling identification paperwork must be completed and accompany the sample.

(b) Sampling Equipment

(1) Stainless steel sampling cylinder (bomb) or glass syringe.

(2) New tubing and fittings for connection between the apparatus and the sampling cylinder.

(3) Bucket for collecting flushed oil.

(4) Sealable container for waste oil.

(5) Rags and solvent for spills.

(6) Funnel.

(7) Wrenches.

(8) Insulating Oil-Lab Analysis data sheet.

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(c) **Sampling Procedure DGA SAMPLING**

(1) Remove the valve plug and flush at least one (1) liter of oil through the valve into the bucket.

(2) Attach the appropriate bushing adaptor to the valve or re-install the valve plug and use the sampling port.

(3) Connect the sampling hose to the valve and flush with at least one (1) liter of oil in order to insure a good sample. Flush until there is no sign of air bubbles, sludge or free water.

(4) Close drain or sampling valve.

(5) Connect the sampling hose to the bottom serrated brass fitting of the oil-sampling cylinder.

(6) Follow the directions for the type of sample container.

(7) Record the pertinent data on the Insulating Oil-Lab Analysis data sheet: Note the presence of water, sludge, etc. in the comment section.

(8) Pour the spent oil used for flushing into the waste oil container. The waste oil will be collected in bulk containers (55 gallon drums) and disposed at a later time.

(9) Clean any spilled oil and return the site back to a clean condition.

(10) Send sample and data sheet to lab for analysis.

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3.1.3.2.2 SEQUENCE FOR OBTAINING TRANSFORMER OIL SAMPLES FOR DISSOLVED GAS ANALYSIS USING GLASS SYRINGES

1) Connect tubing to sampling valve on transformer and allow approximately 4 liters of oil to drain into a waste-oil container. Close transformer valve

2) Connect free end of tubing to end nipple of glass syringe. Open transformer valve. Turn syringe valve so that arm is pointing toward side nipple. Draw approximately 10 mils of oil into syringe. Close transformer valve.

3) Hold the syringe in a vertical position with the end nipple pointing up. Turn the syringe valve so that the arm is pointing toward the end nipple. Expel the oil out of the side nipple into a waste oil container. Try to remove all bubbles when performing this step so that only oil fills the "dead space" between the end of the plunger and the base of the syringe barrel.

4) Turn the syringe valve so that the arm is again turned toward the side nipple. Open transformer valve. Slowly draw in oil from the transformer. Any "air" bubbles that form are from degassing of the oil. Do not try to remove these from the syringe.

5) After drawing in toward the glass barrel of the syringe approximately 55mls. Close the system by turning the syringe valve.

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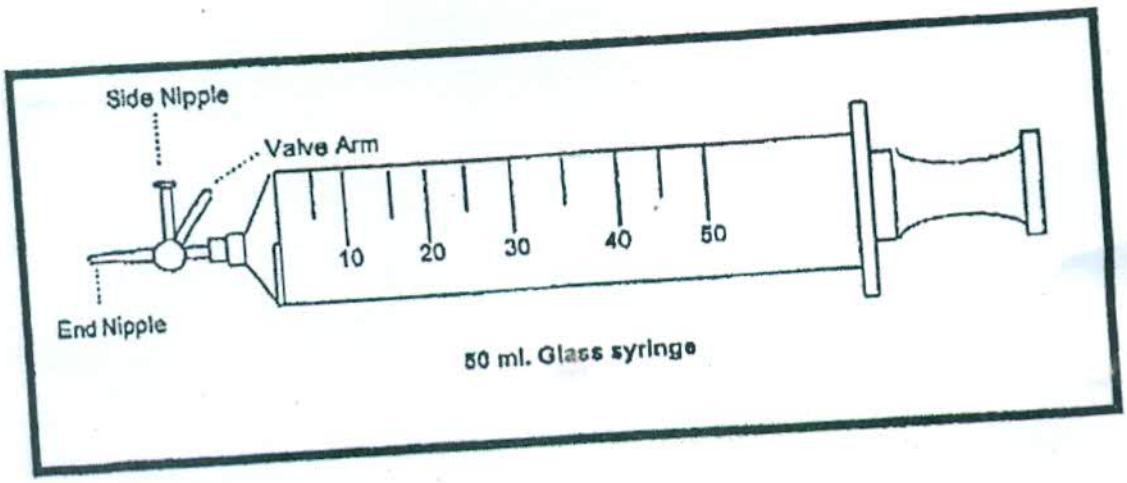

50 ml. Glass syringe

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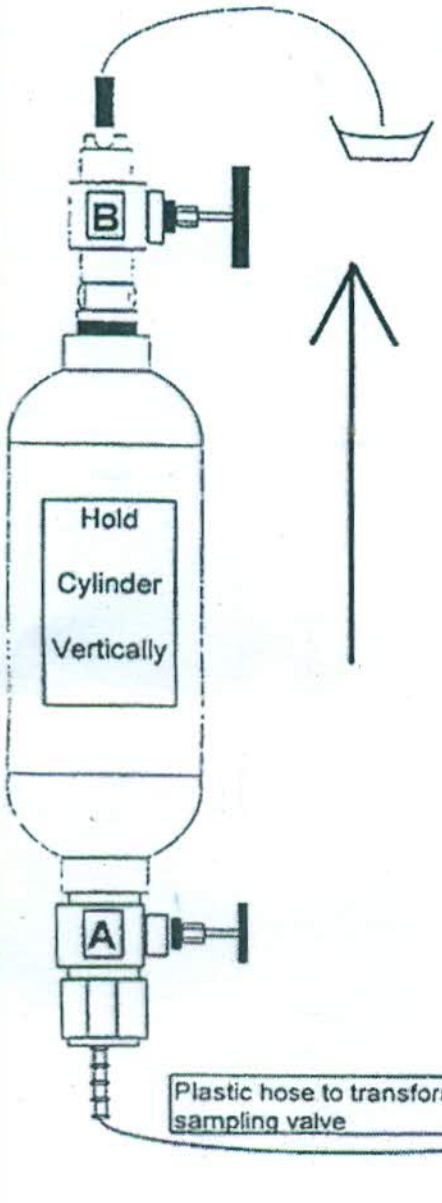

FILLING SEQUENCE

1. Run 1 gallon of oil from the transformer into the oil waste container. Drain until oil is clean and clear.
2. Connect the cylinder with plastic hose as shown.
3. Open valve A.
4. Open valve B.
5. Allow about 1 quart of oil to flow through the cylinder into the oil waste container. Rap sides of cylinder with tool to dislodge air bubbles. Oil running through tubing should be free of bubbles.
6. Shut valve B.
7. Shut valve A.
8. Shake cylinder and listen/feel for signs of incomplete filling. If present, redo from Step #2.
9. Complete paperwork and ship cylinder.

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(b) Test oil sample per ASTM D877 for the following:

- Dielectric strength using ASTM D877 standard test cup (minimum acceptable breakdown is 26 KV)
- Moisture content (maximum acceptable content is 25 ppm).
- Acidity (maximum acceptable is 0.25 Mg. KOH/g).
- Inter Facial Tension (IFT) 25 dynes/cm or less
- Absorbed gas content (in the order of 5% to acceptable)
- Viscosity at 40^0C New oil limit max: 11Centistokes
- Color 3.0 or better
- Arc products (principally carbon particles formed during tap-changer operation).
- Perform additional tests, if any of above test results show unsatisfactory oil condition, according to appropriate standards and manufacture's recommendation.

(c) Collect an oil sample in a DGA sampling device after draining a liter of oil out. Use new tubing to take the sample. If using a glass syringe immediately put back in the unit's protective shipping container. An oil sample in a glass container that is exposed to the suns UV rays will give erroneous test results.

(d) The test DGA oil sample results are read for the following gases only for a regulator. Methane, Ethane, Ethylene, Carbon Monoxide and Carbon Dioxide. These are the useful gases in determining the condition of the regulator. The exception is for the units that have vacuum bottles as the interruption device.

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(e) Check accumulated tap-changer operations against manufacturer's recommendation for contact replacement. (See Reference-9).

(f) Perform all tests required in the monthly inspections.

(g) Check all controls and control components for proper settings, calibration, operation and condition. Follow procedures given in manufacture's instruction book.

3.1.3.2.3ACR, OCR and Breaker

Automatic Circuit Reclosers (ACR), Oil Circuit Re-closers (OCR) and Breakers are installed on the electric network system to protect equipment. To ensure efficient and trouble-free service, it is essential to carry out inspection on a regular schedule as described below. A record of these inspections shall be maintained in each PBS headquarters.

CAUTION: PROPER SAFETY PRECAUTIONS MUST BE TAKEN DURING VISUAL INSPECTION OF ENERGIZED RECLOSER.

(a) Monthly inspections. Monthly inspections must cover the following items in addition to manufacturer's recommendations. (See Reference 10).

(1) Look for loose, broken or contaminated bushings.

(2) Check for loose or corroded connections.

(3) Check oil tank for damage or leaks.

(4) Record the reading of operations counter.

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(5) De-energize the re-closer, if possible, through the bypass switch and disconnection switch. Test operate by hook stick

(6) to check freedom of operation and proper functioning of the counter.

(b) Periodic Inspections

Perform periodic inspections every three years or at 100 interrupting operations, whichever occurs first. However, operating experience with different types of re-closers is the best basis for establishment of schedule ELECTRICAL NETWORK INSPECTION AND MAINTENANCE SECTION 4, (See Maintenance Section 4.1.2).

3.1.3.2.4 CAPACITORS

Capacitor banks shall be inspected two times each year. Some of the key items to cover in the inspection are:

(1) Check for blown fuses and damaged arresters.

(2) Check for evidence of damage to capacitor banks, bushings and accessories.

(3) Check for evidence of connector heating

(4) For switched capacitor banks :

(a) Check oil switches for leaks or damage to bushings or tank.

(b) Check for heated connections.

(c) Check control switch for proper setting.

(5) Check that all ground connections are in good condition.

A record of the capacitor inspection shall be maintained in each PBS Headquarters.

3.1.3.2.5 POLE INSPECTIONS

After the PBS system has been operating for about forty years, a continuous pole

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inspection' program shall be initiated. The program recommended is outlined in Reference 6. In this instruction has a good detailed program and explains the method to inspect and maintain the poles. All pole inspection activity shall be properly recorded and these records shall be kept at each PBS Headquarters. Necessary maintenance to be done based on this inspection records.

3.1.3.2.6 Voltage and Current Surveys.

Annual voltage and current surveys shall be made to determine feeder voltages and loads. It is recommended that these studies be conducted during system peak loading conditions. By utilizing the data obtained from these voltage and current surveys, plans for future feeder reinforcement and/or additional substation capacity can be made.

The suggested voltage and current measurements for each feeder:

(1) Voltage Survey

(a) Output voltage chart at substation (on distribution feeder circuits).

(b) Voltage on source side of distribution feeder regulators.

(c) Voltage chart of voltage at end of feeder.

(2) Load Current Survey

(a) Circuit maximum demand amperes per phase at substation (on distribution feeder circuits).

(b) Additional maximum demand ammeter charts along the feeder as required (on branch circuits, etc.).

3.1.3.3 Non-scheduled Inspection:

PBS personnel, specially Meter Readers and PCMs shall be encouraged to carry out this kind of inspection. Meter Readers and PCMs are visiting their designated area of responsibility every month and with little effort they are able to identify maintenance requirement if they are trained and their mind is set to the issue. The Meter Readers and PCMs may identify the following problems in the lines while

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visiting a particular area and report back to AGM (O&M) in a simple format developed for the purpose. The BREB Officers should also be involved in this program. A recommended format is enclosed as BREB Form No. 100-30-01.

(a) Snapped service drop/loose service connection, etc.

(b) Right of way clearance/tree trimming.

(c) Loose conductor/snapped conductor/missing conductor.

(d) Pole tilted.

(e) Cross arm tilted.

(f) Broken guys.

(g) Right of Way Problem.

(h) Side connection.

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BANGLADESH RURAL ELECTRIFICATION BOARD
BREB Form No. 100-30-01 (Version-1)

Non-Scheduled Inspection Report

Name of Reporting Person : _____
Date of Inspection: _____
Location: _____ Union: _____ Walking Order: _____
Name of the Consumer: _____
A/C No.: _____ Phase: _____ Type of Connection: Dom/Com/Indus

Type of Defect/Deviation		Remarks
(a) Snapped service drop/loose service connection, etc.	☐	
(b) Right of way clearance/tree trimming.	☐	
(c) Loose conductor/snapped conductor/missing conductor	☐	
(d) Pole tilted	☐	
(e) Cross arm tilted	☐	
(f) Broken guys	☐	
(g) Right of Way Problems	☐	
Others: (Please specify)	☐	

Signature : _____
Submitted to: _____

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3.2.0 ELECTRICAL NETWORK RECORDS

3.2.1 GENERAL

The following is a listing of records that should be maintained in each PBS headquarters. Other records may be developed as the need arises.

3.2.2 RESPONSIBILITY FOR RECORDS

The responsibility for maintaining distribution operation and maintenance records will be assigned to the AGM(O&M) in each PBS area. It will be necessary to delegate some of this responsibility but the AGM(O&M) will maintain the overall responsibility of the maintenance of adequate records.

3.2.3 TYPES OF RECORDS.

This listing will include most of the operating and maintenance records that will be maintained in each PBS headquarters for proper operation and maintenance of the distribution system. Other records will be added as needed:

- ❖ Electrical Line inspection and maintenance records;
- ❖ Voltage Regulator inspection and maintenance records;
- ❖ ACR/OCR/Breaker inspection and maintenance records;
- ❖ Capacitor inspection and maintenance records;
- ❖ Voltage and current survey records;
- ❖ Meter records;
- ❖ Transformer records;
- ❖ Operational Diagram.

3.3.0 MAINTENANCE

3.3.1 GENERAL

The electrical network system represents a major capital investment and replacement of any

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portion of the system is very expensive. Therefore, it is necessary to perform maintenance on the electrical network system in order to-

(1) prolong the system life;

(2) provide quality service to the customers and

(3) protect the public and PBS personnel from unsafe conditions.

Each PBS shall allocate funds to perform the maintenance work required to keep the electrical network system in good condition.

The inspection program as outlined in the Electrical Network Operation part of this manual will detect any problems on the system. A dedicated effort is required to perform the maintenance program requirements on a regular and continuing schedule.

3.3.2 DISTRIBUTION MAINTENANCE RESPONSIBILITY

The responsibility for electrical network system maintenance will be assigned to the AGM(O&M) in each PBS area. Some of this responsibility can be delegated, but the overall responsibility must be maintained by the AGM(O&M).

3.4.0 EQUIPMENT MAINTENANCE

3. 4.1 SCHEDULE EQUIPMENT MAINTENANCE

Schedule shall be established to perform shop maintenance on the following distribution equipment.

3.4.1.1 Voltage Regulators:

The maintenance required (if any) for single phase step-type Voltage regulators will be generally determined from the annual inspection. The manufacturer's manual, reference 9, shall be used as a guide for the maintenance required. The shop maintenance will not normally be required until after 1,000,000 operations of the regulator occurs. The typical maintenance required after this number of operations is (1) filter or replace oil, (2) replace contacts, and (3) check all mechanisms for excessive wear and proper operation.

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If major maintenance work is found necessary, proceed as follows:

(1) Oil Filtering

a. Perform only when voltage regulator is initially installed and subsequently only when tests on oil or DGA samples show conditions and characteristics to be less than acceptable.

b. Perform only with voltage regulator de-energized.

c. Use vacuum process and heated oil.

d. Follow voltage regulator manufacturer's recommendations and oil filter equipment manufacturer's recommendations and instructions. See References 2.A and 2.E in Substation Maintenance Manual.

e. Ground all winding line and neutral terminals, oil filtering equipment, oil containers, etc. solidly to a common ground and to the substation ground. This procedure will eliminate development of hazardous static voltage charge. Leave all winding terminals grounded as long as possible after oil filtering is completed to ensure drainage of static charge on the windings to a safe value.

f. Perform an insulation power factor test. Double test or other established methods may be used. This test will determine bushing and winding insulation condition.

g. If power factor test equipment is not available, a megger test to measure insulation resistance can be substituted. (**Note:** Terminal grounds must be removed for insulation power factor and megger tests, thus requiring appropriate safety precautions to be observed).

h. Moisture content of insulation and oil may remain too high through filtering process. This will require continued filtering with heated oil and may require application of external heat, circulation of heated air through gas space or by other approved methods. In severe cases of wetness or free, suspended water, reconditioning of the voltage regulator at a service and

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repair facility may be necessary.

(2) Opening Tank

a. Voltage regulator tank should only be opened for a definite or specific purpose such as bushing replacement, abnormal operation, malfunction, failure, etc. Whenever the tank is to be opened, external electric clearances must be verified for safety, any pressure or vacuum should be relieved and the gas space above the oil should be purged with air to remove nitrogen, oil vapor and any other gases, thus minimizing the possibility of asphyxiation (suffocation) of personnel working inside tank or near tank openings. All hand tools should be attached to workman or firm object on voltage regulator cover by a rope or cord to prevent falling or being dropped into tank. Workman should also remove all pencils, coins, and other loose objects from his clothing before opening the tank. Hand hole, manhole or other covers should be removed carefully and in accordance with manufacturer's recommendations. Note should be made of gasket compression or seating and the need to reuse or replace gasket. Lower the oil level to a sufficient distance to permit access to bottom bushing connection, tap changer, core ground connection etc. Protection should be provided to prevent entrance of rain and other contaminants into voltage regulator tank. Tank should not be left open for more than 2 (two) hours unless complete filtering of the oil is planned. See reference 9.

b. With tank open and properly prepared for safe work conditions, the following work items may be performed and certain observations made

   i. Bushing found broken or leaking oil can be repaired or replaced as determined appropriate. All bushing connections can be checked for tightness and evidence of heating.

   ii. Tap changer condition and correct operation can be observed. Connection can be checked and tightened. Contact resistance can and should be measured if evidence of heating, wear, erosion or misalignment is observed.

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iii. Core ground connection can be checked for tightness or disconnected for measurement of core resistance to ground.

iv. Causes for high oil and high gas pressure can be investigated. Smoke or bubble rising through the oil indicate an internal disturbance such as winding deformation during a through fault, internal arc, insulation deterioration etc. In most cases, smoke indicates definite damage, whereas a bubble may indicate a non-damaging disturbance. Further verification of voltage regulator condition can be made performing ratio, resistance and power factor tests and analyzing oil and gas samples.

v. Causes for unusual noises and vibration can be investigated by checking for loose core iron and clamps, winding clamps, missing wedges and bracing, tap changer gear and contact alignment, etc.

vi. General condition of winding and lead insulation and CT and PT wiring can be observed.

vii. After all internal inspection, adjustment and repairs have been completed, anything that has been opened up for inspection or testing should be closed. Gasket seats must be clean, smooth and either dry or painted with manufacturer's recommended sealant or comment where applicable. See reference 9.

(3) Finishing Work and Inspection

a. Repair any paint damage or rust found on top, sides and auxiliary equipment.

b. Wipe clean all bushings

c. Wipe clean any oil residue, dust or other debris.

d. Check all bolted items for tightness such as bushing flanges and connections, junction box cover, etc.

e. Set tap changer on neutral tap position and give all controls a final check for proper setting and adjustments.

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f. Review electrical clearance, tagging and grounding jumper instructions. In accordance with these instructions, remove grounding jumpers in preparation for returning voltage regulator to energized service.

3.4.1.2 Re-closer/Breaker:

Single phase Oil Circuit Re-closer/ Breaker shall be replaced by a spare re-closer/breaker and returned to the repair shop for maintenance after 100 operations, or every 3 years, whichever comes first.

The manufacturer's recommended re-closer/ breaker maintenance procedure is to be followed. See Reference 10.

BREB Form 100-29-02 will be used to record all maintenance activity for each recloser/ breaker.

(1) Perform detailed inspection to check the following items as a minimum:

(a) Proper operation of recloser/ breaker and operation counter.

(b) Moisture present in oil or indicated by soft spots in tank liner.

(c) Warping or blistering of tank liner.

(d) Alignment of arcing contacts.

(e) Oil level in tank.

(f) Dielectric strength of oil (Minimum acceptable strength is 26 KV).

(g) Condition of gaskets.

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(h) Smooth or sticky operation of re-closer.

(i) Any other item or abnormal condition requiring attention.

(2) **Routine Maintenance**. Monthly inspections may determine minor maintenance work, such as cleaning the bushings, tightening connections, counter repair, etc. The re-closer/breaker MUST BE DE-ENERGIZED before performing any maintenance work. The maintenance must be performed in accordance with the procedures prescribed by the manufacturer. See reference 10.

(3) **Periodic Maintenance of Re-closers/Breaker**.

(i) **OIL FILLED RECLOSERS/BREAKERS** (Lever operated & Electronically operated) When a re-closer/breaker removed from service every three years or after 100 operations (as manufacturer's instructions) or after a malfunction, perform shop inspection and maintenance that includes the following as a minimum: ^

(a) By-pass, de-energize and remove the re-closer/breaker from service. Disconnect the control cable from the re-closer/breaker.

(b) Clean and inspect external components, whether there is broken or cracked bushings. Check for paint scratches and other mechanical damage; paint to inhibit corrosion. Note counter reading and enter in the record log in the control.

(c) Perform a dielectric withstand test to check the insulation level of the recloser and the vacuum integrity of the interrupters.

(d) Remove head bolts and carefully lower the tank to expose the internal components.

CAUTION: Be sure the re-closer/breaker is open (yellow operating handle under the sleet hood is down) before lowering the tank, so that the mechanism will not be tripped accidentally while the mechanism is out of oil.

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(e) Dismantle re-closer/breaker mechanism.

(f)Inspect and clean all parts.

(g) Replace worn contacts and deteriorated parts.

(h) Test tank oil and replace if results are not satisfactory.

(i) Clean and remove all traces of carbon by wiping with a clean, lint-free cloth from the internal components. Flush the mechanism with clean transformer oil.

NOTE: Although current interruption takes place in a sealed vacuum chamber, the closing solenoid contactor operates in oil and will produce some carbon deposits.

CAUTION: Never use volatile solutions, detergents, or water-soluble cleaners.

(j) Check the contact erosion of the vacuum interrupters. Locate the scribe mark on the moving contact rod at the top of the interrupter, If the scribe mark falls below the top of the phenolic guide when the interrupter is closed, the interrupter has reached the end of its useful life and must be replaced.

(k) Check circuit components attached to the re-closer/breaker head, frame and operating mechanism.

Check condition of the wiring to the terminal strip and ensure all connections are tight.

Make sure that the rotary solenoid and the trip solenoid is firmly attached to the rccloser/breaker frame.

Check that the two mercury switches are securely held in place by the nylon mounting straps.

Check conditions of micro switch mounted above main shaft.

Check condition of the bushing current transformers and the associated wiring.

Check the control cable receptacle, if circuit component malfunction is suspected.

(l) Check the dielectric strength of the insulating oil. An oil sample taken near bottom of the tank should have a dielectric strength of not less than 26 kv. Low dielectric strength indicates the presence of water or carbon deposits. Replace

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the oil as necessary.

(m) If oil is deteriorated, it must be replaced, Drain the tank, and clean out all sludge and carbon deposits. Fill with new, clean insulating oil up to specified level below the top of the tank flange.

(n) Clean and examine the head gasket. Replace if it is cracked, cut, or otherwise damaged, or if it has been permanently deformed.

(o) Clean the head gasket seat and re-tank the re-closer/breaker. Move the yellow operating handle under the sleet hood to the up position to avoid any possible binding while raising the tank. Replace the head bolts. Apply clamping force gradually and equally, in rotation, to each bolt to achieve an evenly distributed gasket sealing pressure.

(p) Check the oil level with the dipstick in the head and adjust the level to the upper line on the dipstick.

NOTE: If the re-closer/breaker is equipped with an oil-sight gage, the oil level should be above the sight gage. If the oil surface line is visible in the window, add oil to raise the level to the upper line on the dipstick.

(q) Repeat the high voltage dielectric withstand test to make sure the dielectric strength within the tank have not been compromised.

(r) Manual Operation of the Re-closer/Breaker. 'The re-closer/breaker may be closed and opened manually while the mechanism is either in or out of oil.

(s) Check the proper functioning of re-closer/Breaker after re-assembly as follows :

(i) Determine if the re-closer/breaker trips at the proper current value by conducting minimum tripping current test according to manufacturer's instructions.

(ii) Verify time-current characteristics as required by manufacturer.

(iii) Check by operating through the sequence to lockout.

(iv) Check resetting time during sequence test.

NOTE: If the re-closer/breakers are electronically operated steps to be taken those were appropriate as manufacturer's instructions and procedures should be followed according to the manufacturer's

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instructions.

(ii) GAS FILLED RECLOSERS/BREAKERS (Electronically operated)

(1) General

These type of re-closers/breakers have been designed as a low maintenance unit and using single moving part as adopting magnetic actuator mechanism does not require major maintenance. For the maintenance of the control and relay, each equipment of the re-closer/breaker manufacturer's instruction should be followed. A general inspection of the re-closer/breaker should be made giving attention for clean and normal condition of each equipment.

(2) Warnings Events (shown in the control panel)

In control panel warning LED if is lighted up inspects and steps to be taken according to the manufacturer's instructions of the ACRs/Breakers.

(3) Malfunction Events

In the manufacturer's instructions describes the malfunction events available from the control
and what they indicate. It also suggest steps to follow to assist in determining why the event was
generated. Necessary or appropriate steps to be taken according to the manufacturer's instructions of the ACR/Breaker.

(4) Removing/Dismounting of re-closer/breaker

(a) Ensure that the HV system is grounded for safety.

(b) Dismantle high voltage connections and prepare the slinging wire to lift rccloser/Breaker. / /

(c) Before lifting of the re-closer/breaker on the pole with the lifting arm fitted and to support the weight of the re-closer/breaker with the lifting arm engaged.

(d) Remove the multi-core connectors on the re-closer/breaker.

(e) Dismantle the lower hanger band fixing bolts and consequently the upper hanger band fixing bolls.

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(f) Lift the re-closer/ breaker and move to the ground level.

(g) Dismantle the control cubicle mounting bolts.

(h) Lift the control cubicle and move into the ground level.

(5) Contact life of vacuum interrupter

The life of the vacuum interrupter is normally over 20 years or 10,000 operations with light load operations staling by manufacturer. However, it can vary depending on the magnitude of fault currents and number of operations under loaded condition.

The remaining life of the vacuum interrupter is displayed on LCD with percentage of wear-out at contact point based on calculating from magnitude of fault currents and number of trip operations. The vacuum interrupter is recommended to replace if the remaining life becomes lower than 20%. Be sure to consult with the manufacturer for replacement in details.

Actually since most faults are considerably lower than the maximum fault current and number of faults are considerably fewer than the guaranteed number of faults. The service life is expected to be much longer than the contact life of vacuum interrupter calculated by the amount of contact wear. Thus it keeps the operation of re-closer/breaker to be satisfactory.

Note: Maintenance should be made according to the manufacturer's instructions.

Oil Change. Replace tank oil as follows:

(a) At least once every three years.

(b) Following 100 fault operations (manufacturer's recommendation).

(c) If dielectric strength falls below 26 KV.

(d) If excessive carbon or moisture contamination is detected.

(e) In accordance with manufacture's recommended procedure.

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3.4.1.3 Oil Switches

The oil switches that will be installed on switched capacitor banks shall be replaced every 2(two) years and returned to the repair shop for maintenance. Replace the oil, check the contacts and replace if necessary. Check all moving parts for excessive wear. BREB Form 266 shall be used to record the maintenance activity for all oil switches.

3.4.1.4 Distribution Transformers.

Distribution transformers require minimum maintenance if the transformers are not overloaded excessively. The transformers should be replaced after 15(fifteen) years service for shop maintenance. Replace the oil, paint the tank and check all internal connections. BREB Form 100-29-05 will be used to record the maintenance activity for each transformer.

3.4.1.5 Watt-hour Meters.

All watt-hour meters should be tested for accuracy before they are installed. Since these meters are a power usage recorder used directly for determining revenue charges (customer billing) their accuracy must be maintained. It is recommended that (1) single phase meters be replaced and shop tested every 6(six) years, and (2) three phase meters be replaced and shop tested every 5(five) years. The necessary maintenance shall be preformed after testing.

BREB Form 100-29-01 will be used to record the maintenance activity on each meter.

- Before performing meter testing, the manufacture's recommendation for operating the meter test facilities shall be thoroughly understood and all personnel required to operate the test facilities shall be given training in the use of this equipment.

3.4.1.6 Switches and Fused Cutouts.

Since an interruption to service is required to perform maintenance on this type equipment, it is recommended such maintenance only be performed when required as indicated by an infrared, visual or climbing pole by pole inspection.

Every four years, a close inspection of the switch shall be made by the pole climbing

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inspection preferably during a planned outage. The lineman should maintain adequate clearance from all energized equipment before inspecting the cutouts and switches. Assure that the ground connections are in place on air break switch handles.

Ascertain that the ground connections are in place on air break switch handles.

3.4.2 NON-SCHEDULED MAINTENANCE

Frequently, minor maintenance is required on electrical lines and equipment to reduce the possibility of failure in the future. Each employee should remain alert to check for necessary maintenance when he is in the vicinity of PBS lines. These minor maintenance items can result in outages if they are not corrected. The inspections will point out such necessary maintenance.

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3.5.0 ELECTRICAL LINE MAINTENANCE

3.5.1 LINE MAINTENANCE PROGRAM.

The two main elements of a distribution/transmission maintenances program are.

(1) A routine line patrol inspection program and record system as outlined in the inspection section of this PBS Instruction 100-30.

(2) The pole to pole maintenance inspection is the basic maintenance practice for a reliable system. Twenty five (25) percent of the distribution/transmission system should have the pole to pole maintenance inspection every year. If this maintenance cannot be coordinated with planned line outages then not every item can be maintained or inspected. **Caution and strict adherence to the safety manual has to be observed. The safe working distance must be observed as listed in Table 6-4 of Instruction 100-29.**

3,501 to 10,000 volts : 60 cm

10,000 to 50,000 volts: 1.0 meter

This maintenance is accomplished by the following:

Climbing Inspection-Detailed "hands on" (in contrast to routine observation) inspections are identified as "Climbing Inspections" and are used to inspect and repair conductor, as well as all aerial components and ground line conditions of the distribution/ transmission structure,

All safety guidelines, personal protection equipment, and safe working distances must be observed and used. There will be some hardware and equipment that will not be accessible when the line is energized. Whenever possible the climbing inspections should be done during a scheduled outage on the line(s) to be inspected.

A very detailed rigorous climbing and ground maintenance inspection with each structure being climbed. All wood, concrete, steel, hardware, and conductor will receive a thorough hands on maintenance inspection (the exception being the hands on for the

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conductor and energized hardware which will be done only when de-energized!)

Guy Wires: Observe for loose wire, bad guy grips, three-bolt clamps, damaged strands, rust, and bad hardware.

Wood Poles: Observe for broken, leaning, deflected, burned, split, or cracked pole, and mechanical damage. Observe for termite tunnels, nests, or any other damage caused by any other insects or animals

Concrete: Observe for leaning, deflected, cracked, flaked, corroded steel strands, Poles and mechanical damage.

Steel Poles: Observe for leaning, deflected, dents, rust, corrosion, and mechanical damage.

Braces: Observe X-braces, cross arm braces for cracks, lightning damage, broken bolts, and decay.

Cross Arms: Observe for broken x arms, lightning damage, loose bolts, and termite tunnels, nests, or any other damage caused by any other varmints.

Hardware: Observe tightness of bolts, worn or deformed attachment points, burn marks, rust and missing parts.

Insulators: Observe for cracked/hair cracked or chipped skirts, and flash marks. Look for evidence Porcelain of rust or corrosion on ball and socket, clevis connection, or head of each bell. Observe the condition of pins and cotter keys. Look for contamination, flashed spots, tracking, and dirty areas. Observe for cuts or splits on the skirts, (silicone deposits), UV Composite degradation, and contamination.

Suspension Insulators: Observe for bent, deformed, damaged clamps or attachment hardware that can reduce the mechanical strength of wire attachment points.

OHGW: Observe for lightning damage, broken strands and rust on the wire or on the hardware. Look for uneven tension and improperly installed splices.

Conductor: Observe for broken spacers, broken strands, condition of sleeves, phase

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to ground and phase to phase clearances, damaged dead-ends, and general conductor damage.

Right-of-Way: Observe for trees that may be within 5 feet from the bottom of conductor or leaning towards the line in danger of falling. Check for erosion and washouts that may be endangering the stability of structures, and any encroachments that may be natural or man made

3.5.2 CONDUCTOR, GUYS, ANCHORS AND GROUND WIRE MAINTENANCE.

Most of the maintenance required for conductors installed on primary or secondary lines or circuits results from tree contacts. Lightning will occasionally cause conductor damage.

Damaged or frayed conductors must be repaired by either (1) splicing in a new piece of conductor or (2) cover the damaged area with repair sleeve, provided internal steel must be in good condition. Any guy wire that is damaged in any manner, will be replaced in its entirety

For conductors, the following table shall be followed:

Maintenance activity for Torn/ Broken Conductor Strands	Allowable Number of Torn / Broken Conductor Strands		
Repair by repair sleeve	6/1	26/7	45/7
Armor Rods can be used	2	8	10
Conductor Splice	4	9-23	11-42
Full Tension	5	24	43

If any strand of the steel core is torn/broken or injured even for hair crack, a full tension splice is required.

Torn/ Broken strands on shield wire with one broken strand, a repair splice should be installed, for two or more broken strands, a full tension splice shall be installed. Splice shall be at least 50 feet from the attachment hardware.

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When damaged Anchor rods are found, they shall be replaced or repaired. If the anchor rod is damaged from electrolysis, all anchor rods at that structure location shall be replaced. Until a standard is developed the process will be to replace all anchors at a structure when there is one broken anchor, and it is caused by electrolysis.
Broken or unattached ground wires shall be repaired. When needed, ground resistance measurements will be taken and when greater than 15 ohms, corrective actions will be taken to reduce ground resistance for the structure. To lower the ground resistance, first try adding more ground rods. Next try attaching a counterpoise as corrective action but this requires engineering support for the prescribed fix.

Insulator strings with one or more damaged insulators shall be replaced by the unit as needed. Porcelain insulator strings that have 30% or more defective units broken shall be changed as soon as possible .Damaged Glass insulator strings shall be replaced by the unit as needed. Glass insulator strings that have 25% or more defective units broken shall be changed as soon as possible.

Composite insulators are made in complete units and shall be changed if any defect is found.

When broken or damaged structural components such as cross-arms or cross arm braces are found, they will be repaired or changed out as required.

3.5.3 SECONDARY AND SERVICE DUPLEX CABLE MAINTENANCE.

The duplex cable used for secondary and service circuits has a tough, cross-linked polyethylene (XLPE) covering on the energized conductor. However, if this cable is allowed to rub against trees or other obstructions for an extended period of time, this XLPE covering can be damaged and it may fail. If the covering is damaged, it must be taped with a good grade electrical insulation tape to prevent shorting out to the bare neutral messenger conductor. If it is necessary to splice or tap into a duplex cable, the joints must be taped with two layers (half-lapped) of a good grade electrical *insulation* tape.

A. Since duplex service cable is used from the pole to the meter, it is mandatory that no

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exposed, energized splices or damaged conductors be allowed to exist. The personnel that are reading meters should be especially alert to his potential hazard and they should report any hazard of this nature immediately.

B. The PBS maintenance responsibility stops at the meter. No. internal wiring beyond the meter will be maintained by the PBS personnel.

2.5.4 POLE MAINTENANCE.

This maintenance work will be minimal for the first 15 to 20 years after the lines are installed. After the first 10 years of service the pole to pole maintenance should be started. The maintenance work that can be expected is to straighten poles, repair or replace poles damaged by lightning, accidents, insects, fungus, burning from leaking insulators, accelerated aging due to poor wood treatment or manufacturing of the concrete pole. A wood pole inspection and treatment program needs to be implemented after the first ten years of service. This is covered in Procedure of PBS Instruction 100-54.

Frequently, minor damage to poles can be repaired and this should be done if adequate pole strength can be maintained. Repairs such as a split top, can frequently be repaired by bolting at the pole top. Partial damage to poles near the ground line can be reinforced by the installation of a stub pole adjacent to the damaged pole. Alternate plans shall be considered before replacing a partially damaged pole.

3.5.5 CROSS ARM AND HARDWARE.

The cross arm and hardware maintenance should follow the same 10 year maintenance schedule that the pole maintenance does as they are an integral part of the pole.. The tops of the cross arms wood or steel are frequently ignored since it is not always easy to inspect, especially if there is no aerial patrol. They are still important as there is decay from moisture and pollution. If left without the proper maintenance or treatment they will require replacement sooner than they should. If maintenance is required then the decay or corrosion will be cleaned away and a coating of copper naptha or equal for the wood products and galvanizing for the steel should be applied.

This maintenance should only be done while the line is out of service (de-energized).

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Any loose hardware should be tightened and replaced if it is found defective or missing. If the safe working clearances are such that the hardware can not be reached then the work will be scheduled during a planned outage.

3.5.6 INSULATORS AND ARRESTERS

The insulator and arrester maintenance should follow the same 10 year cycle as the poles.

The climbing maintenance/inspection of the insulators and their associated hardware should be done during planned power outages when possible. During the planned outage the insulators, arresters, and hardware can be tightened or replaced as needed. If the climbing maintenance/inspection cannot be done during a planned power outage, the visual inspection and/or work can only be done if safe working distances can be maintained.

3.5.7 TREE CLEARING

Tree interference with electrical lines presents a major problem in maintaining good service. To provide for adequate clearances, the initial minimum clearing should be maintained according to voltage level of electrical lines. For 11 KV primary lines should provide a minimum of 10 feet to each side of the centerline. At some locations, this clearing cannot be accomplished. However, this clearance is highly desirable for reliable service and safety, and it should be obtained wherever possible. Secondary extensions require a minimum of 6 feet to each side of the centerline.

A. The minimum tree clearances allowed from primary conductors is 5 feet. The minimum tree clearances allowed form secondary conductors is 2 feet.

B. The inspection form, previously described in the distribution inspection manual, will serve as the communication tool to point out where trimming is necessary. Normally, all distribution lines should be inspected each four yours. However six monthly inspection to be carried out to ensure clearance from tree interference.

C. In some areas it may be desirable to use sprays or other herbicides to control undergrowth. Care should be used in applying these controls to prevent damage to adjoining crops, contamination of water systems, etc.

D. A map of the distribution system should be maintained in each PBS area. The problem tree areas should be noted on this map so that the proper trimming cycle can

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be maintained. It may be necessary to trim each year in some areas if adequate initial tree clearing rights were not obtained when the line was initially built.

E. The PBS shall also maintain an Operational Diagram. The Operational Diagram shall identify problems area as outlined below and provide an important tool to plan maintenance program effective for the purpose.

(1) Right of way

(2) Over-loaded line section/feeder

(3) High interruption area/line section/feeders

(4) Pilferage area

(5) Disaster prone area

(6) Multi line crossing

(7) Road/River/Level crossing

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BREB Form No.100-30-02 (Version-1)

Line Inspection and Maintenance Form

Line Inspection and Maintenance Log Sheet																Substation Feeder PBS Detail Map No.												
Pole No.	Pole					Guy Anchor			Ground Rod		Pole Top Assembly					Tree Trimm-ing			Conductor				Miscellaneous					Notes
											X-Arm		Insulators						Resag		Other							
	Length Class	Date Installed	Straighten	Reset	Replace	Repair Guy	Replace Guy	Replace Anchor	Install	Repair	Straighten	Replace	RP. Pin Type	RP. Susp. Type	RP. Sec. Service	Clear or Trim	Danger Tree	Other	Primary	Sec. Service	Repair	Ratio	Transformer	Clearance	Other	Long Secondary		
Inspector																												
Date																												
Date Work																												

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LINE INSPECTION AND LOG SHEET – INSTRUCTIONS

Additional Notes:

	LINE INSPECTION AND LOG SHEET- INSTRUCTIONS This form is designed to provide a permanent record of distribution pole line inspection and maintenance. This form lists the work to be accomplished as well as work to be done. It is to be used in the field to record the result of the line inspection and then return to the office for preparation of maintenance orders and will remain in the office for record of the inspection and maintenance activity. **APPLICATION** 1. Record all poles so that the same sheet may be used for subsequent inspections. 2. To record a maintenance item to be done mark the appropriate block. First Inspection ☐ Second Inspection ☐ Third Inspection ☐ Fourth Inspection ☐ 3. When the work is completed, mark the same block thus - ☐ 4. If it is necessary to make a note concerning an item mark thus- ☐ ☐ then enter the comment in the note column.
Date to Inspect	

APPENDIX-B

OIL PHYSICAL TESTS

Introduction

Oil is used both as an electrical insulator and as a coolant. The ability of the oil to properly perform these two functions can be measured by the following set of physical and chemical tests. The tests are specified by the ASTM(American Society of Testing and Materials) and are based on both field experience and technical understanding of those properties which are important to the insulating oil.

1. Aniline Point

Method: ASTM D611

New Oil Limit: 78°C max.

Significance: This test relates to the solvency of the oil for materials which are in contact with it. The lower the aniline point, the more solvent the oil is.

2. Color

Method: ASTM D1500

New Oil Limit: 0.5 max.

Significance: The color generally indicates the degree of refinement for new oil and the amount of aging for old oil. Clear new oil is given a color index value of 0.0, while black oil has a color of 8.0. For in-service oils, an increasing or high color (3.0 or greater) indicates significant contamination or deterioration.

3. Corrosive Sulfur

Method: ASTM D1275

New Oil Limit: Non corrosive

Significance: This test detects the presence of corrosive, sulfur-bearing compounds that can cause the corrosion of such metals as copper and silver.

4. Dielectric Breakdown-D.E. Cell

Method: ASTM D877

New Oil Limit: 30 KV min.

Significance: The Dielectric Breakdown is the minimum voltage at which electrical flashover occurs between two flat electrodes 2.54mm apart. It is a

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measure of the ability of the oil to withstand electrical stress at power frequencies without breakdown. A low breakdown value is generally the result of contamination either by water, carbon or conducting particulates. The minimum breakdown voltage for in-service transformer oil is 26 KV.

5. **Dielectric Breakdown-V.D.E. Cell**

Method: ASTM D1816

New Oil Limit 28 KV min.

Significance: Similar to the above test, but uses spherical electrodes 0.04 inches (1mm) apart with the oil being stirred constantly during the test. This method is more sensitive in the detection of contamination products found in the oil. The minimum breakdown voltage for in-service transformer oils is 26 KV.

6. **Dissolved Gas Content**

Method: ASTM 831

New Oil Limit: 0.25% max.

Significance: The dissolved gas content is significant only for degassed oils. Oils not degassed and in contact with the air will have approximately a 10% by volume gas content. Dissolved gas results in a lowering of the dielectric strength of the oil which may be critical for high voltage conservator type transformers.

7. **Flash Point**

Method: ASTM D 92

New Oil Limit: 146°C min.

Significance: The flash point is the minimum temperature at which heated oil gives off a sufficient amount of vapor to form a flammable mixture with air. The test is a good detector of fuel oil contamination that may be encountered during shipping.

8. **Interfacial Tension**

Method: ASTM D971

New Oil Limit 40dynes/cm minimum

Significance: The interfacial tension is a measure of the surface tension of the oil at an oil-water interface. Contaminates like soap, paints, varnishes and oxidation

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products like sludge reduce the interfacial tension of the oil. For in-service oils, an interfacial tension value below 20 dynes/cm is an indication of sludge formation.

The interfacial tension can be improved through reclamation, a filtering process that removes the oxidation products of the oil

9. Neutralization Number

Method: ASTM D 974

New Oil Limit: 0.025 mg KOH/gram of oil

Significance: The neutralization number or acid number is a measure of the amount of acids in the oil. The number is found by measuring the amount of potassium hydroxide (KOH), a base, it takes to neutralize the acid in the oil. As oils age, the acidity and therefore the neutralization number increases as a result of oxidation. This acid acts on the cellulose insulation resulting in a reduction in its mechanical and dielectric strength.

For in-service oils, a neutralization number of greater than 0.25 mg KOH/gram of oil indicates that severe aging of the oil and insulation have taken place.

The neutralization number can be reduced by reclamation, a filtering process that removes the oxidation products of the oil.

10. Oxidation Inhibitor Content

Method: ASTM D1473 or D2668

New Oil Limit: 0.3% by weight Maximum

Significance: Oxidation inhibitor, normally D.B.P.C. (2, 6-ditertiary butyl-paracresol) is added to oil to help it resist oxidation. The oil is called "inhibited oil", and the test determines the amount of D.B.P.C. added to the oil.

Due to changes in the availability of certain types of crude oil stocks, the natural oxidation inhibitors found in much of today's insulating oils is not as effective as in previous types. The addition of D.B.P.C. is becoming a common option to make up for this deficiency

11. Oxidation Stability

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Method: ASTM D2440

A. New uninhibited oil limit 72 hrs. max. sludge - 0.15% by mass
Max. neutralization number 0.5

B. New inhibited oil limits,72 hrs. max. sludge - 0.1% by mass
Max. neutralization number 0.3

Significance: This test assesses the oxidation resistance of the oil by measuring the amount of sludge and acid formed when the oil is subjected to a high temperature and exposed to large quantities of oxygen. Oils which meet or exceed the requirements tend to preserve the oil-cellulose insulation systems and exhibit good heat transfer characteristics.

12. Pour Point

Method: ASTM D97

New Oil Limit: (-40°C) max.

Significance: The pour point is the temperature at which the oil will just flow (like honey). A low pour point ensures that the oil will circulate and provide proper cooling and insulation in cold climates.

13. Power Factor

Method: ASTM D924

New Oil Limit@25°C: 0.01% max. @100^0 C: 2.99%.

Significance: A high power factor can indicate the presence of water, carbon, metallic soaps and other conducting materials in the oil.

14. Specific Gravity

Method: ASTM 01288

New Oil Limit: 0.910 max.

Significance: The specific gravity is the relative density of oil to water. In cold climates a high specific gravity (0.95 or more) can result in the floating of ice on the oil leading to possible flashover.

15. Viscosity at 40°C

Method: ASTM D445, D2161, D88 or D2161

New Oil Limit Max: 11 Centistokes

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Significance: The viscosity is a measure of the oils resistance to flow and is an important factor in the transfer of heat

16. **Water Content**

Method: ASTM D1533

New Oil Limit: No free water

25 ppm after vacuum drying

Significance: Oil can absorb small amounts of water. This water reduces the dielectric strength of the oil. A low water content is necessary for good dielectric strength and may be obtained by vacuum treatment.

The test procedure requires a good deal of sampling care in order to prevent inadvertent water contamination. Sample retrieval during high humidity may also affect the integrity of your sample. Extreme care and cleanliness is a must.

DISTRIBUTION OPERATION AND MAINTENANCE

REFERENCES
RUS Bulletins

Sl No.	RUS Bulletins	Bulletin No.
1	Inspection & maintenance of Distribution Lines	161-3
2	Maintenance of Oil Circuit Re-closers and Sectionlizers	161-14
3	Operation and Maintenance Records	161-11
4	Electric System Review and Evaluation	161-5
5	Engineering and Operation Manual for Rural Electric Systems	160-1 & 160-2
6	Pole Inspection and Maintenance	161-4
7	Repair and Conversion of small Distribution	161-6

MANUFACTURES BULLETINS

Sl No.	Manufacturers Bulletins	Bulletin No.
8	GE Type ML 32 Single Phase Step Voltage Regulator	GEH4239A
9	McGraw Edison Single Phase Re-closers	280-10
10	Ronk Electric Add-A-Phase (Static Convertor)	472-1
11	Multi-Amp General Purpose Test Table Type FA	DSI-HA
12	Multi-Amp Watt-hour Meter Test Table Types HABL	DSI-FA

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13	Siemens-Allis Outdoor, Air-break Switch Equipment	99X5447-01
14	S & C Load buster Disconnect	721-30
15	Cooper Power System Regulator VR 32	225-10-2
16	Siemens Regulator JFR	PR4018-05
17	Toshiba Regulator Type B	2437
18	Cooper Regulator Control CL-5	225-10-10
19	Siemens Regulator Control MJ-X	21-115527-010-04
20	Nu Lec N12, N24, N36 SF6 Vacuum breaker	N00-453
21	Schlumberger Quantum Q 1000 Electronic Meter	

DISTRIBUTION OPERATION AND MAINTENANCE

REFERENCES

REA Bulletins

Sl No.	REA Bulletins	Bulletin No.
1	Inspection & maintenance of Distribution Lines	161-3
2	Maintenance of Oil Circuit Re-closers and Sectionlizers	161-14
3	Operation and Maintenance Records	161-11
4	Electric System Review and Evaluation	161-5
5	Engineering and Operation Manual for Rural Electric Systems	160-1 & 2
6	Pole Inspection and Maintenance	161-4
7	Repair and Conversion of small Distribution Transformers	161-6

MANUFACTURES BULLETINS

Sl No.	Manufacturers Bulletins	Bulletin No.

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8	GE Type ML 32 Single Phase Step Voltage Regulator	GEH-4239A
9	McGraw Edison Single Phase Re-closers	280-10
10	Ronk Electric Add-A-Phase (Static Convertor)	472-1
11	Multi-Amp General Purpose Test Table Type FA	DSI-HA
12	Multi-Amp Watt-hour Meter Test Table Types HABL	DSI-FA
13	Siemens-Allis Outdoor, Air-break Switch Equipment	99X5447-01
14	S & C Load buster Disconnect	721-30

Note:

Inspection, maintenance and repair of distribution lines are needed after any disaster, specially, cyclone, storm, earthquake, fire, over flood, tidal wave etc. In such cases, to minimize the damage of life, asset and electric system, emergency procedure and disaster management are required to follow. There are three phases/steps that need to be undertaken to combat emergency procedure and disaster management for any type of disaster. They are Alert phase, Disaster phase, and Recovery phase. Emergency procedure and disaster management are described in detail in PBS Instruction 100-75.

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