BANGLADESH RURAL ELECTRIFICATION BOARD

PBS INSTRUCTION: 100-61

GUIDELINE FOR ENGINEERING ASSESSMENT OF TAKEN-OVER FACILITIES FROM OTHER UTILITIES/ COMPANIES/ ORGANIZATIONS

RURAL ELECTRIFICATION BOARD
PBS INSTRUCTION 100-61

Approval Date: 14/06/2005
Revision Date : 19/02/2020

SUBJECT: GUIDELINE FOR ENGINEERING ASSESSMENT OF TAKEN-OVER FACILITIES FROM OTHER UTILITIES/ COMPANIES/ ORGANIZATIONS

1. GENERAL

1.1. Scope

To develop a set of guidelines that identify and prioritize the work needed to renovate power lines and substations taken over by the Palli Bidyut Samity's (PBSs) from other electrical entities in Bangladesh. This PBS Instruction 100-61 will supplement PBS Instruction 100-37 (BREB Instruction 500-09), "Electrical System Take Over Policy and Procedure".

1.2. Purpose

Power lines and substations are being taken over by the PBS systems in rural, municipal and metropolitan areas. The purpose of this instruction is to document the best practices being done at PBS systems now and to develop new procedures that will improve the process so that the takeover of Bangladesh Power Development Board (BPDB) and other entities/ utilities' facilities will go as smoothly and consistently as possible from one PBS to another.

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1.3. Background

The facilities transferred over are often in very poor condition after many years of substandard or deferred maintenance. In addition, the taken-over electric network systems are European standard three-phase systems with three-phase delta-wye (Δ-Y) transformers feeding large secondary sections. The secondary is usually three-phase 230/400 voltage, though the extreme ends commonly reduce to single phase. Substations are also European style, with two 3-Phase 33/11 kV transformers, typically of 10 MVA each, feeding 11 kV switchgear located in a separate control building.

It is desirable to eventually convert most of the taken-over systems to the PBS standard four-wire system.

2. ELECTRIC NETWORK SYSTEM RENOVATION PROCEDURES

2.1. General

While some PBS systems have been renovating taken-over systems for several years and there is some consistency in the process from one PBS to another, the documentation of the procedure needs to be improved. It is desirable to have a consistent, documented procedure so that evaluations can be made by the Bangladesh Rural Electrification Board (BREB) and others in a uniform manner from one takeover section to another.

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2.2. Field Inventory

The first step in the process is a field inventory. An accurate field inventory is essential to evaluate the renovation that may be needed. The following items should be recorded for each structure during this initial process:

- Pole dimensions (height/class), type, and condition of material;
- Primary (HT) construction units and condition of materials;
- Secondary (LT) construction units and condition of materials;
- Number, direction, length, and wire size of service drops, including condition of materials;
- Location and names of existing and potential customers if known (load included for three-phase customers);
- Secondary wire designation, sketch, span length, number of jumper, twist, splices, and condition;
- Primary wire designation, sketch, span length, number of splices, jumper, twist, and condition;
- Transformer units, phase connection, rating, serial number, and other available important nameplate data and condition.

See section 3 for guidance and criteria in determining whether to reuse or retire equipment and material when renovating a takeover area. This first assessment of the taken-over system and condition is important in determining the renovations needed and priority of making required changes.

2.3. Inventory Sheet

The inventory should be documented on a form similar to that of a staking sheet that organizes the units in a logical manner so that the makeup of the structure can easily be determined (Figure-1). Since construction of taken-over lines is different from new BREB construction, taken-over construction unit designations should be used and referenced in all taken-over documents. A uniform list of typical taken-over construction units and unit designations, along with appropriate drawings, is in a separate publication titled, "Taken-Over Design Unit Drawings" as approved by the Chief Engineer (Project). Inventory sheets should be grouped by area that encompasses a lateral or small section of the main feeder so that renovation priority decisions can be made for the entire group. A sketch of the inventory section group should be included for geographical reference. On the cover page a tabular summary of the types of line should be noted in a format shown in Table-1.

In addition, tabulation of total legal and illegal consumer counts should be included in the format shown in Table 2 on the cover sheet to the inventory staking sheet group.

Tabulations of totals for conductor sizes and lengths for LT, HT, service wire and non-standard conductors should be included in a format shown in Table-3.

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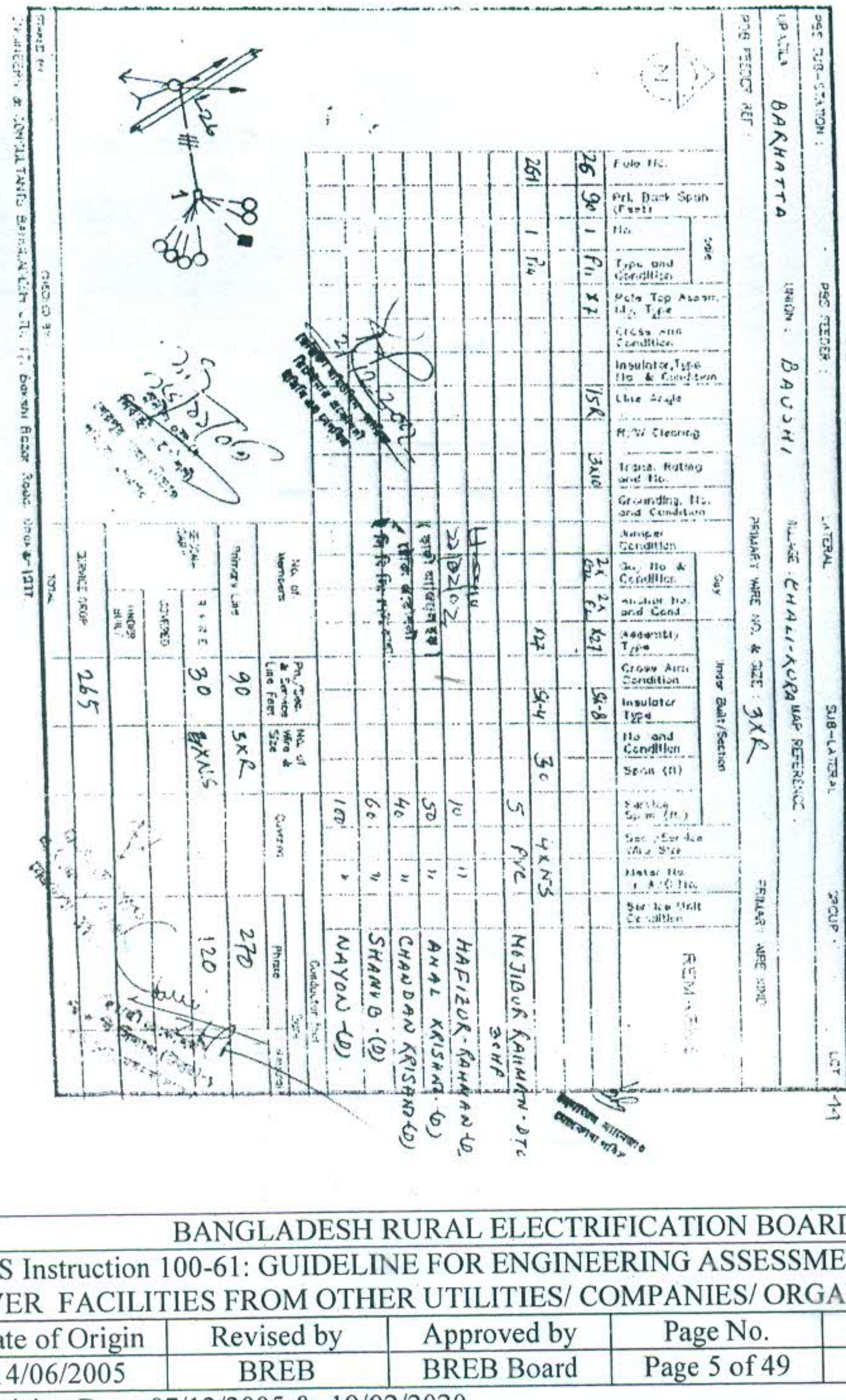

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Figure-1: Example of an Inventory Sheet

Line Summary		
Description	Unit	Quantity
3-phase HT, 33 kV	Km	
3-phase HT, 11 kV	Km	
1 phase HT, 6.35 kV	Km	
3-phase HT With Under-build (3-Ø LT)	Km	
3-phase HT With Under-build (1-Ø LT)	Km	
3-phase LT	Km	
1-phase LT	Km	
Non-Standard LT	Km	
TOTAL	Km	

Table-1: Line Type Summary

Customer Summary				
Customer Type	Number with Meter	Number without Meter		Total Existing Customers
		Authorized	Unauthorized	

Table-2: Customer Summary

Conductor Summary			
Primary/ Secondary Conductor Size	Length of Reusable Conductor (Km)	Length of Damaged/ Unusable Conductor (Km)	Total conductor length (Km)

Table-3: Conductor Type Summary

The inventory should include a tabular listing of all existing materials by construction units, including standard and non-standard poles, primary units, secondary units, and transformers with rating and serial number in format shown in Table-4.

Inventory of Materials (Other Than Conductor)				
Unit Designation or Description	Number of Reusable Units	Number of Damaged Units	Total Number of Units	Remarks
(1)	(2)	(3)	(4)	(5)

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Table-4: Inventory of Materials

2.4. Work Plan Drawing

When the field inventory sheet is completed, an overall work plan drawing should be prepared. One of the purposes of this drawing is to show a geographic representation of the entire taken-over section. Each pole, each existing and potential service location, each existing transformer and other equipment with rating, and all standard and nonstandard lines should be shown on the drawing. This document also will show new and renovated HT and LT lines, along with new transformer and other equipment locations. It is desirable to have the drawing to scale. If the drawing is not to scale, it should give an indication of the general direction and distance for HT and LT lines in the takeover area shown and noted NTS (Not to Scale). A legend with symbols as in Figure 2 should be shown on each work plan drawing.

Color-coding for electric lines shown in this drawing will be:
Black for existing, Green for new construction and Red for conversion
Removed facilities should be shown in black with an X periodically marked through it. Calculated values of existing secondary voltage drop as well as the secondary voltage drop of the proposed system should be shown on the work plan drawing.

LEGEND

ITEM	SYMBOL	ITEM	SYMBOL
Pole to be removed and re-installed	◑	Existing consumer, DOM/COM, Black	○
PDB existing pole, STEEL	○	Existing consumer, SI, Black	□
Takeover existing pole, RCC	□	Proposed consumer, DOM/COM, Green	○
Takeover pole to be removed, STEEL	(R)	Proposed consumer, SI, Green	□
Takeover pole to be removed, RCC	[R]	Takeover 3-ph transformer	⊕
REB new pole	●	Takeover 3-ph transformer to be removed	●
Non-standard pole	◪	Takeover 1-ph transformer	△
Takeover existing line, HT	———	REB 1-ph transformer	△
Takeover existing line. LT	- - - - -	REB 3x1-ph transformer bank	⊛
REB proposed line, HT	———	Service drop to be removed	—⊗
REB proposed line, LT	- - - - -	Service drop to be installed	—○
Line to be removed, HT	—×—×—×—	Proposed transformer zone boundary	—·—·—·
Line to be removed, LT	-×-×-×-×-		

Note: Use color code to identify status of a symbol as under-

Existing to continue - Black; Proposed/new - Green; Conversion - Red;

Figure-2: Work Plan Drawing Legend

The reason for showing the existing secondary voltage drop is to verify that transformers do indeed need to be added and to indicate the voltage improvement that customers will experience. See Appendix 2 for an explanation of the methodology to calculate secondary voltage drop. Note that this calculation is a single-phase calculation. For existing and new three-phase transformers, it should be assumed that the load is balanced between the three phases and that one-third of the three phase load is to be included on each phase.

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2.4.1. Determine new transformer locations

When found technically justified, existing three-phase transformers will be replaced with several smaller single-phase transformers in residential areas, although the existing transformer voltage drop should be calculated to verify that replacing the existing transformer is necessary. In commercial areas, there may be existing three-phase load. Therefore, existing or refurbished three-phase transformers can be used or a three single-phase transformer bank can be installed. The purpose of this part of the renovation is not just to replace transformers, but to reduce secondary voltage drop. Reducing the length of secondary line not only leads to reduced losses, it also improves the quality and reliability of the service. First, the existing secondary voltage drop will be calculated, after which new transformer locations will be determined. Maximum allowable voltage drop as per Instruction 100-21 is shown in Table 5.

Name of Electrical Equipment/ Apparatus	Maximum allowable voltage drop	
	In Volt age	In %
1. Primary Line	6.9	3.0
2. Distribution Transformer	3.5	1.5
3. All Secondary line including Service	9.2	4.0
Total:	19.6	8.5

Table-5: Voltage Drop Limits

(As per PBS 100-21-1-2) Based on 230-Volt Secondary

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For this calculation, the secondary all the way to the meter should be considered. Therefore, the maximum calculated voltage drop is 9.2 volts, or 4%. It is not necessary to calculate primary line or distribution transformer voltage drop for this purpose. See Appendix-A for a discussion of the voltage drop calculation method.

Existing and new voltage drop figures should be shown on the work plan in the tabular format illustrated in Table-6. All meters served by a particular transformer constitutes the transformer zone and will be designated by the transformer pole number.

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Transformer Loading Information				
Transformer Zone	Number of Customers in this zone	Connected Load in this zone	Total Demand in this zone	Maximum Secondary Voltage Drop

Table-6: Transformer Load Summary

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2.4.2. Work Plan Approval

The concern Executive Engineer of BREB has approval authority, but the PBS staff including the Senior General Manager/ General Manager, AGM(O&M), AGM(E&C) and RE should have input on the decision-making. The PBS Senior General Manager/ General Manager, BREB Assistant Engineer and RE will sign the work plan drawing before approval. The concerned Executive Engineer of BREB will approve the Work Plan

2.5. Staking Sheet

After the conceptual design is completed on the work plan drawing, a staking sheet should be prepared. This may require an additional field trip if a significant time period has elapsed, because additional consumers may have been added or other changes may have been made since the original inventory. This is especially relevant in faster-growing urban and semi-urban areas. Staking sheets should be grouped with the same inventory sheet groups for work to be done in the same area. The staking sheet will show the existing structure units on one row, items to be removed on another row, and items to be added on a third row. The customer's name with existing meter number or account number should be indicated on the staking sheet.

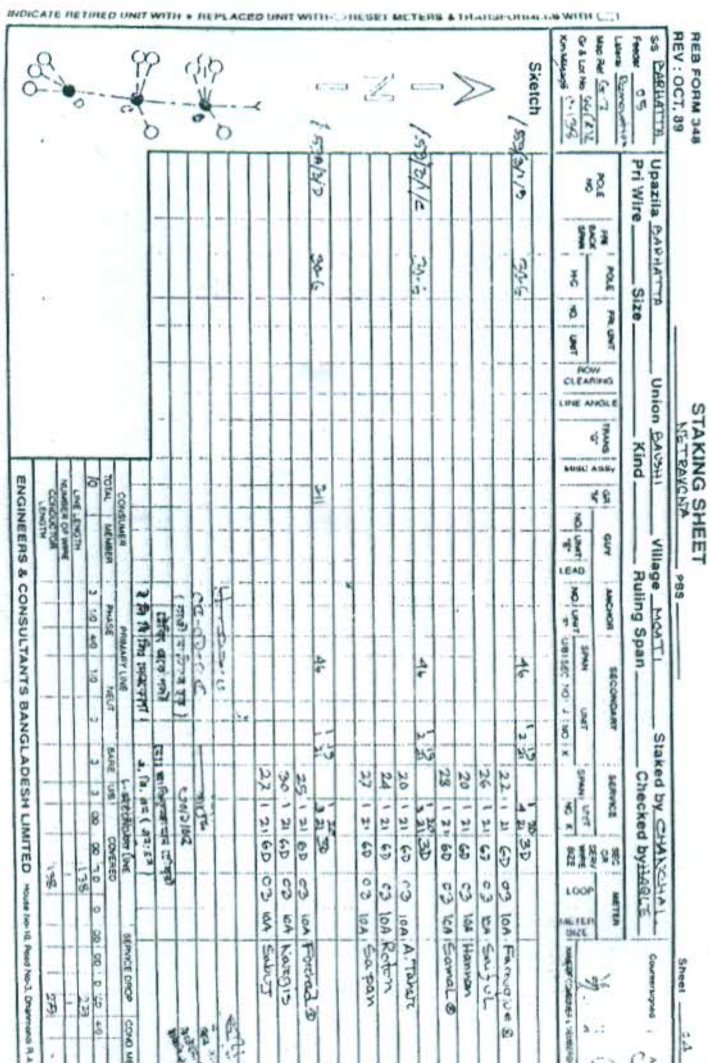

Figure-3: Example of a Staking Sheet

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An inventory list page should be included in staking sheet package. This construction inventory summary has much of the same information as the one on the inventory sheet, except that a list of the items relocated within the same area is included. All construction units should be noted on the construction inventory summary form, including conductors, transformers and others equipment (Table-7). Staking Sheets will be approved by the concerned Executive Engineer of BREB after being signed by the PBS Senior General Manager/ General Manager.

Staking Sheet Summary			
Unit Designation	Number of Removed Units	Number of New Units	Number of Re-Used Units

Table-7: Construction Inventory Summary

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2.6. Construction/Rehabilitation

Decisions as to which areas to construct should be based on the priority established in Section 4. The concerned Executive Engineer, BREB makes the decision with input from the PBS Senior General Manager/ General Manager, AGM (O&M), and RE. The concern Executive Engineer of BREB will request to the zonal Superintending Engineer of BREB to engage required number of contractors. The Superintending Engineer, BREB then chooses required number of contractors based on a previously established "Tender Document for Construction/ Rehabilitation of taken over electric system" Contractor will be engaged by zonal Superintending Engineer of BREB, when the renovation work is under BREB project, otherwise by PBS Senior General Manager/ General Manager, when renovation work will be done under PBS fund. However PBS Senior General Manager/ General Manager have option to request BREB to do the renovation work by PBS fund, specially, when the work is complicated.

2.6.1. Construction Inspection

The RE of PBS Electrical Consulting Farm is responsible for on-site inspection during the construction process. In addition to assuring that the contractor does the renovation as described on the staking sheet, the Inspector, SAE and AE of BREB should also coordinate the construction activities with the residential and commercial customers in the area to minimize any inconvenience to the customers. In case of change of construction from the design shown on the staking sheet, prior to approval from HOPE is needed as variation/ additional work.

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2.7. As-Built Staking Sheet

The RE is responsible for creating a set of as-built staking sheets. The as-built staking sheets should show the actual construction units reused/retired and actual construction units added. In addition, customer names and meter numbers should be verified for accuracy. The data from the as-built staking sheets will be incorporated in the PBS system maps. The on-site inspector should establish and mark pole numbers on both the pole itself and on the as-built staking sheet, consistent with the requirements of the PBS pole numbering system in use.

3. LINE MATERIALS AND EQUIPMENT USAGE

3.1. General

It cannot be over emphasized that existing materials should be used as much as possible. This will save money and allow for more renovation areas to be completed within the same budget cycle. In addition, using existing materials saves construction time so that improvements to safety and service can occur sooner, however, damaged or defective materials should not be used. Rebuilding an entire structure merely to establish an BREB standard design is not acceptable. If an entire new structure needs to be replaced, a BREB standard structure type can be installed, if it is better suited to the situation. In more urban locations, different construction units need to be established to properly complete the renovation. The following are some suggested new construction units:

- "Stay" pole (push brace)
- Spacer cable

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- "Alley" arm
- Double pole structure of various pole separation distances.
- Double circuit.

3.2. Poles

Poles are the most critical item to evaluate when renovating takeover systems. Many types of standard and non-standard poles are being used. There are a number of reasons to replace or relocate poles.

- Pole damage or deterioration
- Inadequate ground clearance (PBS Instruction 100-28, 100-45, 100-70)
- Addition of HT: poles that are of adequate height for LT may not be of adequate height for HT
- Inadequate clearance/ strength over roadways, railroads, rivers, etc. (PBS Instruction 100-28, 100-45, 100-70)
- Inadequate clearance because of built-up land.

In general, poles replaced only for clearance reasons should be re-used.

3.2.1. Steel Poles

Steel poles, although not standard for PBS system, should be replaced only if necessary because of damage or clearance problems. Damaged steel poles will be repaired and reused as service poles when feasible. If the damage or deterioration is at either at the top or at the bottom, the damaged or deteriorated section can be cut off, repainted and reused. ***All unused steel poles should be returned to the warehouse, regardless of their condition, unless they will be reused in the area from which they are removed.***

3.2.2. Reinforced Concrete (RCC) Poles

RCC poles that are only used for LT, generally are not tall enough to install HT; however, they can be difficult to remove. RCC poles should be re-used if feasible. Unused RCC Poles should not be left at the work site. The contractor should be required to dispose of RCC poles. If necessary, concrete can be broken and left at the site and the rebar removed from the site.

3.2.3. Spun Pre-stressed Concrete (SPC) Poles

SPC poles are commonly used on PBS systems and therefore all SPC poles should be reused or relocated unless damaged or of inferior quality. Most new poles set in takeover areas will be SPC poles. Taken-over SPC poles are difficult to climb because there are no step bolts. There is a technique to climbing them. Training in that technique would be helpful for PBS line crews not familiar with climbing RCC poles or SPC poles without steps.

3.2.4. Wood Poles

Wood poles are preferred by contractors as well as PBS construction and maintenance crews because of their light weight, ease of climbing and ease of making attachments. Wood is lighter and, therefore, easier to install, especially in remote areas where the pole must be carried in. However, there are some disadvantages to wood poles, such as durability and availability. Current REB directives, along with good engineering judgment, should be used in determining which type of pole to use for replacements. A pole inspection and maintenance program will help extend the life of wood poles. If a wood pole is reused, it should be properly treated and ensured of the adequate strength for the application.

3.2.5. Nonstandard Poles

Use of nonstandard poles such as bamboo, pipe' and trees are common in rural takeover areas. These types of structures should not be reused. Often the use of nonstandard poles is a safety hazard and should have a very high priority for renovation.

3.2.6. Pole Grounds

Pole grounds, particularly at transformer locations, are very important, especially in rural locations where the neutral conductor may be missing or stolen. A driven ground rod (as per PBS instruction 100-22) is required at all transformer and other equipment locations. For locations where an existing structure and existing pole ground is being used, the condition of the ground rod should be checked and replaced if necessary.

3.3. Conductor

Conductor that is out of sag should be re-sagged as required. If the conductor is damaged by excessive heat and losses it's ductile quality, the strength may be reduced and re-sagging may not be possible. If there is more than an average of one splice per phase in a single span, then the conductor in that section of line should be replaced instead of being reused.

3.3.1(a). HT (33 kV and above) Conductor:

Conductor should be reused if it is not damaged or if there is not more than one splice per phase per span. But in most of the cases, conductors of 33 kV and above voltage lines are very old with lower ductile quality and comparatively high resistance. Apparently they look good but it may contribute more system loss, if re-used. So with proper judgment may be the best solution.

3.3.1(b). HT (11 kV) Conductor

Conductor should be reused if it is not damaged or if there is not more than one splice per phase per span. ***Insulation covered conductors should be treated as if they were bare conductor for clearance and safety considerations.*** In certain locations where there are major clearance problems, the use of bundled or spacer cable may be desirable. It should be noted that the use of this type of construction is applicable in very limited situations and that, like the covered conductor, bundled or spacer cable should be treated as if it were bare conductor for safety and ground clearance considerations.

3.3.2. LT (230 Volt) Conductor

WASP AAC and ANT AAC with PVC insulation are commonly used conductors in taken-over facilities for LT. WASP is nearly equivalent to 4/0 ACC in size and current-carrying capabilities. ANT is nearly equivalent to 1/0 ACC in size and current-carrying capabilities. Long spans and the use of mid-span secondary spacers are common practices. Like the HT covered conductors, this conductor can be re-used if it is not damaged and if there is not more than one splice per span per phase. Open wire type LT designs using either covered or bare

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(Kamrul Ahsan Mollik) Asst. Secy. (Board), BREB, conductor can be used where they are under-built on an HT structure or an extension of an HT line for a few spans. However, duplex cable should be used for secondaries not as under-built on the HT structure.

3.3.3. Neutral Conductor

In many cases, there is no neutral conductor for the HT in the taken-over design because only three-phase, delta connected transformers are installed. In other cases, the neutral conductor is missing because it has been stolen. In either case, a neutral conductor should be installed. The neutral conductor can be either the same size as the HT conductor or the open wire LT conductor and should be sagged the same.

3.3.4. Underground Cable

There may be an occasion to use either 11 kV or 230 volt underground cable in rare occurrences. In very congested, high-density urban areas where there are many shops and residences with multistory buildings and narrow roadways, underground primary or secondary may be the best solution. For the primary installations especially, careful workmanship must be maintained. A damaged or incorrectly installed cable or terminations may not be apparent and may not fail immediately, but the life of the installation will be significantly reduced. Inspection of every splice and termination during installation is essential to maintain a quality installation. Failures in the underground system are much harder to find and repair than they are in overhead installations. In highly congested areas where there are many other underground facilities, such as telephone, water, and sewer, "dig-ins" after the installation is complete can be a

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problem. Note that underground is rarely used in PBS systems and underground materials are not standard for most warehouses. When underground materials are stored, care must be given to assure that they are properly handled and stored. End caps should be installed on the cable to prevent moisture migration.

3.3.5. Connections

Compression or quick splices should be used for splices on all tension lines, because hand-wrapped splices and twisting have a high resistance and are subject to failure and increase losses. Compression connectors should be used for jumpers and transformer/ equipment connections. Compression tools should be inspected and calibrated periodically to assure they make high quality connections. The correct "die" must be used.

3.3.6. Transformers

Taken-over systems extensively use three phase distribution transformers with delta connected HT windings. Many of these transformers are leaking oil and/or have damaged HT and LT bushings. Damaged and leaking transformers should be removed and taken to the PBS store for inspection and replacement or repair of damaged parts. The oil level and quality should be checked and the oil should be centrifuged or replaced as required. If the winding is good, then bad LT and HT bushings can be replaced and the transformer placed back in service. Three-phase transformers should be reused whenever possible. Where a three-phase transformer is replaced with another three-phase transformer, all connections and jumpers should be tight and compression connections used wherever possible. Where only single-phase loads are being served, single-phase, BREB standard transformer installations should be used. The BREB standard system design criteria according to PBS Instruction 100-21, will dictate that many new transformer installations will be required to reduce the voltage drop, reduce technical losses and improve the power quality to levels acceptable to BREB.

3.4. Insulators

All insulators should be inspected for damage and replaced if necessary, even on structures that otherwise don't need any renovation.

3.4.1 11 kV Insulators

Generally, HT insulators on takeover structures are not reusable on PBS designed structures because of a difference in thread size. However, good insulators of taken over electrical lines should be used to replace the bad insulators on non-renovated structures.

3.4.2. Secondary Insulators

LT insulators are more standardized, and are more likely to be able to be reused. LT insulator racks should be reused if not rusted or otherwise damaged.

3.5. Guys and Anchors

Guys and anchors seem to suffer the most damage and neglect as a result of poor maintenance practices.

3.5.1 Guys

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Because many of the taken-over facilities are in the more urban areas, there are many short guy leads and broken guy wires. If there is space, guy leads should conform to the standard 1:1 ratio, that is, the lead length being the same as its attachment height on the pole. If there is not sufficient space, the guy lead can be left as it is. Rusted or otherwise damaged guy wire should be replaced. In cases of absolute necessity, a push brace or "stay" pole can be used, but these should be used only in unavoidable circumstances.

3.5.2. Anchors

Anchors should be checked for rust and deterioration. If the anchor strength is questionable, anchors should be replaced with BREB standard log anchors. If anchors appear to be in good shape and there is adequate lead length, they can be reused. If good anchors are retired, they should be dug up and used again.

3.6. Arrestors

Properly used surge arrestors protect transformers and other equipment from damage resulting from voltage surges caused by lightning and other things, such as switching. If an arrestor appears to be damaged, it should be replaced. Damaged arrestors should never be reused. Arrestors should be installed at all transformer locations and on all phases at the end of HT lines. Care should be taken to keep the lead length between the bottom of the surge arrestor and the connection to the protected equipment as short as possible, and the connection to the pole ground should be with a compression connector. The ground rod should be checked and replaced if found defective.

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3.7. Cutouts

Fused cutouts are used to protect transformers and other equipment from severe damage such as extreme overload or faults within or near the device. In addition, and probably more importantly, properly sized fused cutouts will isolate the overloaded or damaged equipment from the rest of the distribution system. It is important for the size of the fuses to be correct so that proper operation and coordination can occur. In addition, the jumpers and connections to the cutout and the cutout itself should be checked for damage and replaced if defective.

3.8. Service Drops and Meters

Service drops and meters are where the connection to the customer's premises occurs. This Instruction supplements PBS Instruction 300-44, "Renovation of Service/ Meters of Taken-Over Consumers. Consumer of some utility supply and maintain Service drop and meters, whereas the practice for RE system the PBS is to own and maintain service drops and meters. When an area is taken over by the PBS, the ownership of the service drops and meters will be transferred to the PBS. In certain areas, because of very long LT lines and several illegal connections, a temporary check meter could be installed to verify that all the power from the transformer is being metered at the customer premises. This is especially applicable when the entire length of secondary is not visible or accessible from the transformer location.

3.8.2. Individual single-phase meters

Because the accuracy and quality of existing customer-owned meters is questionable, all meters should be replaced with the standard PBS meter

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assembly. Grounding on all meters should be verified and, if necessary, a ground wire and ground rod should be installed at the meter location. For locations that have service, but no meter, a standard PBS meter assembly including ground rod, should be installed as soon as possible. This should be done before any other renovation work is done (see section 4- Distribution Line Renovation Priority). Takeover meters that meet the BREB standard can be cleaned, tested, and calibrated by the PBS. As is the general practice, all new installed meters should be tested by the PBS before placed in service.

3.8.3. Bazaar Areas and Apartment Building Single-Phase Meters

(a) Multiple service drops are not suitable for multistoried apartment building. One meter for each flat/unit of a multistoried apartment building may be connected from single service drop of adequate size. Primary with CT/PT connection shall be provided in multistoried apartment building, if the total load exceeds 50 KW

(b) To protect revenue in Bazaar area multiple meter connection from single service drop should be avoided. Under unavoidable situation maximum 3 meters can be connected from single service drop instead of more than 3.

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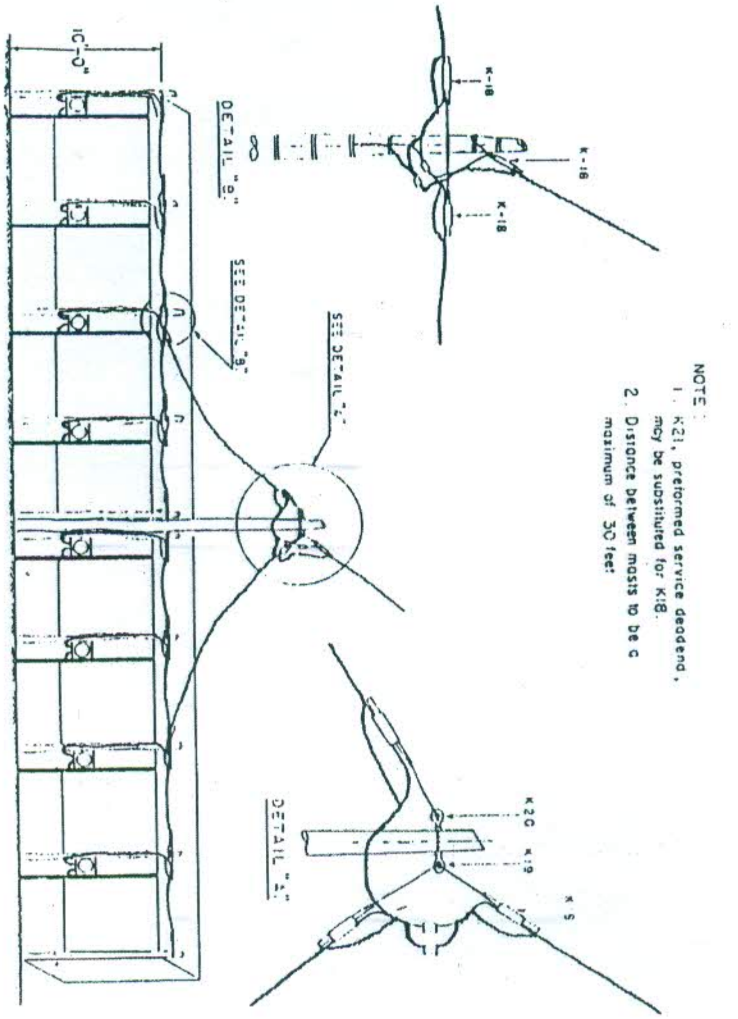

Figure-4: Bazaar Area Secondary (LT) Example

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3.8.4. Three-Phase Meters

Three-phase services in taken-over areas are more common than in PBS systems. Because three-phase service has been available in most taken-over areas, three-phase motors are being used more frequently than in the rest of the PBS system. If the PBS has no facilities to test three-phase meters, all three-phase meters must be tested and sealed by BREB. If the PBS does have facilities to test three-phase meters, all three-phase meters must be sealed by BREB. Three phase meters are usually S-base meters are used in PBS system, while single phase meters are usually A-base type meters but for irrigation purpose single phase meters may be S-base meters.

3.8.5. Service Drops

In other utility systems, the service drop is supplied and maintained by the customer. This type of service drop is PVC insulated conductor, which is inferior standard in comparison with BREB standard. Therefore, depending on load, XLPE (Cross Link Poly Ethylene) insulated 6 or 3 duplex LT wires are installed by the PBS in most cases. In some cases, removed covered aluminum wire could be re-used for LT wire only.

3.9. Industrial Areas and Extremely High Density Urban Areas

In more urban areas, complete renovation may not be feasible, because of established industry and the fact that outages can't be tolerated. Service may be adequate for some industrial customers and no renovation may be needed. Very high density areas with narrow roadways will present problems that are not possible to solve using conventional BREB rural designs, especially where

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multistory buildings are present, and access to both HT and LT facilities is possible via windows or balconies. Non-BREB standard construction may be necessary for clearance and safety--alley arms, vertical construction, double-pole construction, etc. Right-of-way is a problem because of the high price of land. Even pole replacements can become a problem because land owners want the poles relocated off their property. Renovation in very dense areas may need to be underground. Underground has its own unique set of problems. Space on the ground for transformers may not be available and submersible transformers are not generally an option because of flooding. Other present and future underground utilities use the same space. Dig-ins that damages the underground cable can be a big problem to repair. Underground faults are much more difficult to locate and repair than the more traditional overhead construction. If underground is used, on-site inspection is essential. Quality of workmanship is essential to assure adequate life of cable and other underground materials.

4. ELECTRICAL NETWORK RENOVATION PRIORITY

4.1 General

Renovating all taken-over facilities in a short time frame is desirable but, in most cases, may not be possible because of time, manpower and budgetary restraints. Therefore, a system of prioritizing the most important renovation items needs to be established. While circumstances can vary, a consistent method of determining the priority from one PBS to another is highly desirable. The PBS has the primary responsibility for determining priority, taking into consideration issues such as safety and revenue generated.

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4.2 Meter Changes

The first step in the renovation process should be to change out or add meters where service exists. This starts the revenue stream flowing and establishes new customers for the PBS in the taken-over areas. Even very long, non-standard LT lines where illegal connections exist should have the standard meter assembly installed, including grounding with meter. This should occur even before or during the initial inventory of taken-over facilities. This establishes the habit among customers to pay the PBS for power received from the very beginning of the takeover.

4.3 Safety

The next highest priority in the renovation process should be safety considerations. Safety encompasses several aspects as described below. In general, a whole staking sheet area should be renovated at the same time. However, temporary renovation may be necessary for extreme danger situations. Such cases should be determined during the initial inventory for design of temporary renovation. Permanent renovation should be designed and scheduled in the normal fashion.

4.3.1 Clearance above Ground

Clearance of HT and LT conductors above ground and especially over roadways and pathways is the greatest cause for concern with regard to safety. There are a variety of causes and remedies for ground clearance problems. Use of nonstandard poles, such as bamboo for long distances of LT line, is probably the most common cause of ground clearance violations. Roadway crossings are the areas of greatest concern; however, other areas, such as pathways, waterways, and cultivated fields are problem areas that should be addressed immediately; low hanging secondary in areas that are relatively inaccessible is an area of lesser concern. HT and LT lines that are out of sag because of guying problems or overheating of the wire (specially where AAAC conductor is used) are other causes of ground clearance problems that should be addressed.

4.3.2 Clearance to Structures

HT and LT lines that are over or near buildings and other structures are a concern also. The greatest concerns are locations where the conductor is readily accessible via windows, balconies, rooftops and other situations where human contact with the live line is possible. Insulated secondary voltage is not as great a concern as bare conductor or the HT lines, but should be addressed as well. For HT applications, spacer cable may be an option.

4.3.3 Danger Poles

Poles that are badly deteriorated because of severe wood decay or severe rust near or just below the ground line are considered danger poles. Deterioration at the top of the pole is possible also, although less common. These poles should be changed out as soon as possible. A regular pole inspection and maintenance program can prolong the life of poles and prevent some dangerous situations from occurring.

4.3.4 Dangerous Conductors

Conductors that have excessive splices or otherwise damaged beyond repair are considered dangerous and should be replaced. If the conductor is not replaced, it could break and cause a serious hazard, create a clearance problem, or cause a structure to become overloaded or unbalanced and fail.

4.4 High-Density and High Loss Areas

High-density and high loss areas represent areas of greatest return with regard to improvements in service, revenue, and loss. After the more critical situations indicated above are addressed, renovation should start with the areas with the highest load, highest customer density, and highest losses. The renovation may be more difficult and more disruptive to the activities of people in these areas, but the most long-term benefit for the PBS will occur in the areas of highest density of load and consumers.

4.5 Low-Density Areas

Rural and remote areas that don't contain an excessive number of clearance problems have the lowest priority for renovation. While it is certain that voltage, power quality and losses will be improved, because of the low number of customers, the relative benefit is less than in areas of higher density.

4.6 HT Voltage Improvement

After all renovation has brought taken-over facilities up to adequate condition and the reduction of secondary voltage drop has occurred, some voltage and power quality improvements may still be necessary to improve the voltage drop on the 11 kV primary line. Line voltage regulators and/or capacitors can help to improve the HT line voltage. It should be noted that the best long-term solution to the low

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primary voltages being experienced is to have adequate incoming voltage at the substation and properly sized conductor on the primary. However, a short-term, less expensive, and easier to accomplish method of improving HT voltage is with the use of line voltage regulation.

5. SUBSTATION RENOVATION PROCEDURES

5.1. General

A separate but parallel activity in the takeover area renovation process is the inspection and renovation of taken-over substations. In some cases, the takeover area does not include substations. In such cases there is little the PBS can do to improve the operation and reliability of the substation. However, in other takeover areas, the substation is included and the ownership, operation, and maintenance of the substation become the PBS responsibility. In some cases, the PBS takes over just part of the substation, while the BPDB or other entities like the Power Grid Company of Bangladesh retain ownership of the remainder of the 33 kV and higher voltage equipment with in the same substation yard.

5.2. Inventory

Knowing exactly what has been taken over is the first and most essential step in the process.

5.2.1. Single-line Diagram

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Even if a single line diagram exists for the substation, it should be verified in the field to reflect the current configuration and status of equipment within the substation.

5.2.2. Equipment List

A detailed list of equipment within the substation should be obtained. This list should include all equipment, even if it is currently not in service. The manufacturers' brochure/operating instructions and drawings, including wiring diagrams, should be located and checked. If manufacturer drawings are not available, an attempt should be made to obtain them from the manufacturer. In addition, other substation wiring and schematic drawings should be located and checked. If these drawings are not available, the design engineer or previous owner of the substation should be asked for a set of drawings. Maintenance records and substation logbooks should be obtained and reviewed. The date/time of last inspection and date/time of last maintenance of each item of equipment should be noted in the log book.

5.2.2.1. Operational Status

Once the list of equipment is completed, the operational status should be determined. If possible, the equipment should be taken out of service and operated several times to see if it is operating properly. Minor maintenance to correct a small problem should be done at this time if possible. However, the purpose of this step is to determine the operational condition of the equipment and determine what needs to be done to bring it up to an acceptable operational level, not to fix all the problems.

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5.2.3. Determine Work To Be Done

The next step is to prepare a list of the work that needs to be done to repair or replace defective equipment. This list should not include periodic maintenance for equipment that is in service and functioning, but should include major overhauls, repairs, or replacements needed to make the defective equipment operate properly. Included in this list are major repairs to the ground grid, fences, buildings, and other structures, as well as the work needed on the electrical equipment. This is the point at which a determination is made as to whether a particular piece of equipment can be repaired, or if it should be replaced with a new piece of equipment that can be more easily operated and maintained. In extreme cases, the whole substation may need to be rebuilt. It should be noted that equipment should not be replaced only because it is not a standard PBS material/item. Healthy equipment should be retained and maintained in proper operating condition as much as possible. After the work list is prepared, it should be prioritized as outlined in Section 7.

5.2.3.1. Drawing

Before construction begins, a complete set of construction drawings, including material lists, manufacturer drawings and wiring diagrams should be collected and prepared. The material list should be used to assure that necessary material, parts, and equipment are available before beginning work by allocating and procuring the items according to applicable BREB/PBS guidelines. It is not necessary to have a complete set of drawings for lower priority work done before high priority work is started, but the drawings should be available well before any construction work is started.

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5.2.3.2. Substation Construction Approval

Several types of substations are designed by a committee of BREB and they are approved by the concern authority of BREB. These are generally 5 MVA (Extendable to 10 MVA), 10 MVA (Extendable to 20 MVA), and 20 MVA (Extendable to 40 MVA). Sub-stations are constructed as per pre-design and pre-approval. The Chief Engineer (Project) and Chief Engineer (Planning & Operation), BREB jointly has approval authority, but the concerned Executive Engineer, BREB and the PBS staff including the Senior General Manager/ General Manager, AGM(O&M), AGM(E&C) and RE should have input on the decision-making, specially MVA capacity, Load center and site selection. The Executive Engineer, BREB and PBS Senior General Manager/ General Manager and RE will sign the construction drawings and proposal before approval by BREB.

5.2.4. Construction

Decisions as to which areas to construct should be based on the priority established in Section-7. The Concern BREB Executive Engineer makes the decision with input from the PBS Senior General Manager/ General Manager, AGM (O&M), AGM (E&C) and RE.

5.2.4.1. On-site Inspection

The RE is responsible for on-site inspection during the construction process. In addition to assuring that the contractor does the work as described on the drawings, the inspector should coordinate the construction activities with the

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customers in the area to minimize any inconvenience to the customers. Minor deviations in construction from the design shown on the construction drawings should be executed by the on-site inspector with the concurrence of the RE and concern BREB Executive Engineers. Major discrepancies from the construction drawings should be approved by the BREB Executive Engineer before work execution.

5.2.5. As-built Drawings

The RE is responsible for creating a set of as-built construction drawings. When the work and the as-built drawings are completed, the new drawings will be included in the set of substation drawings. Originals of the drawings should be kept in the RE's office at the PBS, with a copy being retained at the substation. Copies of as built drawing will be distributed to PBS Senior General Manager/ General Manager, AGM(E&C), AGM(O&M) and concerned Executive Engineer of BREB.

6. SUBSTATION EQUIPMENT AND MATERIALS USAGE

6.1. General

Many substations of other entities are suffering from years of inadequate maintenance. Many of the taken-over substations have leaking transformers, nonfunctioning or no voltage regulation, very old and non-operating high- and low-side protection schemes, and the substations themselves are in general disrepair. Most of the taken-over substations are manned, but even some of the manned substations are in disarray, with a lack of simple housecleaning and

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simple building and yard maintenance. Few drawings are available and the ones that are available are typically the switchgear manufacturers' wiring diagrams and possibly a few schematics. A typical design for a taken-over substation is two, 10 MVA transformers with indoor switchgear on the 11 kV. Taken-over substations are quite different from the PBS standard, so PBS personnel may not be familiar with the indoor switchgear and other equipment and how to operate it. Because of increasing loads at these and other PBS substations, a PBS standard design for 20 MVA or higher capacity substations would be very helpful. Other taken-over substations are small, with no protection on the high side of the transformer. Generally speaking, the 33 kV side of the substation varies between 25 kV and 28 kV during times of heavy load and the 11 kV side varies between 8 kV and 9 kV during times of heavy load. This is the main cause for low voltage at consumer meters. As stated before, adding voltage regulation on the line will help the voltage on the line, but a major contributor to the low voltages being experienced by consumers is low incoming voltage on the 33 kV bus, which is beyond the control of the PBS. Load shedding is common because the power demand is more than the power available. At some locations, staggered load shedding is occurring 24 hours a day. At some locations SCADA monitoring and control, including load shedding, is being performed by NLDC (National Load Dispatch Center).

6.2. 33 kV Protection

Where 33 kV breakers are outdoor style, they are very old and often not functional; 33 kV switchgear located inside the control buildings in general seem to be functioning. Replacing old, non-functional indoor switchgear and outdoor

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breakers with outdoor re-closers with adequate fault handling capacity voltage rating should be considered in many cases. If there is insufficient space outside, retrofitting indoor 33 kV switchgear may be necessary. The high side protection relays often are old, but generally seem to be functional. Lack of routine maintenance seems to be the biggest problem. Panel indicating meters and revenue meters are of questionable accuracy.

6.3. 11 kV Protection

Most taken-over substations have indoor switchgear for the 11 kV. Drawings often are not available. Even when indoor switchgear has been replaced over the years, the old panels may still be in place. It is sometimes difficult to determine which of the panels are obsolete and which are functioning. Most equipment seems old, dirty, and in need of maintenance.

6.4. Transformers

Substation power transformers are generally old and in need of maintenance. Some have major oil leaks that are in various stages of repair. Some look as though they have been overloaded at one time or another. Some On Load Tap Changers (OLTCs) are working and others can only be changed manually. For more information on the OLTC operation, see the section 6.5 on voltage regulation.

6.4.1. Grounding

Several taken-over substation transformers are not solidly grounded. Grounding is through a resister or the use of a ground-fault neutralizer (Petersen coil). For distribution systems such as the BPDB design, where transformers are delta connected on the high side, this is fine and reduces the number of ground faults. However, in the PBS distribution systems, where transformers are connected line-to-ground, this is not acceptable and the power transformers at the substations should be solidly connected to the substation ground grid. This may cause what may seem to be increased nuisance breaker trips; however, this is an indication that there is a ground fault condition that needs to be located and repaired. Cracked insulators, bad lightning arresters, and other conditions leading to a temporary or permanent ground fault will cause the breaker to trip on a solidly grounded system, while these problems may remain undetected on a system that is not solidly grounded. If a large number of breaker operations occur when the ground resister is removed, do not re-install the grounding resistor. Find the ground fault problem and fix it and the nuisance trips will go away.

6.4.2. Oil Testing

Testing substation transformer oil for moisture and dissolved gases provides very valuable information. The moisture content is directly related to the insulation level of the transformer oil. If there is too much moisture, the insulation will not be adequate and the transformer will fail. The dissolved gases test gives information on the condition of the transformer core and coil and its insulation. This test will detect hot spots, winding insulation defects, and other conditions that will reduce the life of a transformer. The trend of values for dissolved gases in the oil is sometimes a better indication of the condition of the transformer than the actual value itself. Therefore, it is recommended that a moisture and dissolved gases test be performed annually on older and heavily used transformers.

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6.5. Voltage Regulation

There are very few voltage regulators in taken-over substations. OLTC transformers are more common. Many taken-over substations don't have any voltage regulation at all. Usually, if not all the time, the station operator controls the OLTCs manually. Automatic operation would be much more desirable. If the OLTC is functioning properly, it should be placed in automatic operation. ***Some OLTCs are restricted from operating to the last step, both raise and lower. There is no valid reason for this restriction. Tap changers should be allowed to operate over their full range as designed.*** Because of the low 33 kV voltage, even if the OLTC is on the highest tap, the voltage is still not adequate most of the time. Installing more voltage regulation on the line will bring the voltage to a more acceptable level for some of the time. But, as stated earlier, it will be necessary to have adequate incoming voltage on the 33 kV bus before the PBSs can provide proper voltage levels, according to BREB consumer standards. Even if the 33 kV voltage level is adequate, some form of voltage regulation should be installed in every substation. If there is not enough space within the substation or on adjacent property, line regulators should be installed near the substation on each distribution circuit. A standard design for a voltage regulator bank with underground cable feeds in and out should be the best solution in such case.

6.6. Ground Grid or Mesh

A visual check of substation grounds should be made to assure that all metal parts within the substation area, including the fence, are directly tied to the substation ground grid. In addition, the underground portion of the ground grid should be

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tested. Not only the value of the resistance between the ground grid and the earth should be measured, but continuity of the ground mat should be verified also. The ground mat and most of the connections to it are composed of copper wire or a copper strap. While this makes a very good ground, it also is subject to theft. Therefore, periodic inspection of ground connections should be made to assure that there is an adequate grounding system. An adequate ground grid within the substation assures that ground faults will be cleared. Also, proper ground connections and the grid itself prevent hazardous step and touch potential from occurring during faults.

6.7. Batteries

Batteries provide the DC voltage for control circuits and protection circuits. Battery systems should be checked, cleaned, tested, and maintained on a periodic basis. For lead-acid batteries, the water level should be checked periodically and more distilled water added when necessary. All such activities should be noted in the log book.

6.8. Surface of Substation Yard

Most taken over substation surfaces are brick or earth with a grass surface. Rarely is substation surfaces composed of crushed rock or gravel. The surface should be cleaned and well maintained, with the grass or other vegetation neatly trimmed. Spare parts or other items should not the stored within a substation area unless they are in a separate designated area.

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6.9. Fence

The fence around the substation area should be of adequate height and construction to deter people and large animals from entering the substation. This not only keeps people from stealing or otherwise damaging equipment within the substation, but it prevents accidental contact and electrocution as a result of the general public coming in contact with energized equipment. If all or part of the fence is metal, the metal parts should be grounded to the substation ground grid to prevent hazardous step and touch potential for those outside the substation fence.

6.10. Building

The building should be kept neat, clean, and freshly painted inside and out. ***For manned substations, especially, there is no excuse to have clutter and dirt on equipment inside the substation building.*** The addition of air conditioning in the control room is recommended. The purpose of air conditioning in control buildings is not for the comfort of personnel. Excessive heat affects the operation of relays and other control systems. In addition, air conditioning allows the building to be kept cleaner by preventing dirt and excessive dust from entering the building.

7. SUBSTATION RENOVATION PRIORITY

7.1. General

Determining the priorities when renovating takeover substations is a critical step. Substation renovations can be complex and costly. Substation outages cause interruption of service to large numbers of customers, can be lengthy, and can require large number of man-hours to repair.

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7.2. Safety and Clearance

As always, safety is the highest priority. Adequate clearance of energized electrical parts to the ground should be achieved. If any piece of electrical equipment does not have adequate ground clearance, this situation should be rectified immediately. The equipment should either be guarded, insulated, or have its structure height raised. Care should be taken not to cause other clearance problems, such as phase-to-phase clearance, or phase-to-structure clearance when remedying ground clearance problems. In addition, equipment too close to the substation perimeter fence should be addressed, especially if the fence is metal.

7.3. Neutral Grounding

Providing a solidly grounded transformer neutral is the next priority. Grounding transformers should be taken out of service and removed from the substation.

7.4. High Tension Side Protection

The HT side including 33 kV transformer protections has the next highest priority level. All breakers along with 33 kV including the relays and control devices should be operating properly or replaced, if found defective.

7.5. Low Tension Side Protection

The 11 kV line breakers or re-closers have the next level of priority. Installation of outdoor re-closers with adequate fault handling capacity may be considered if the indoor switchgear in the substation building is beyond repair, and if there is adequate space within the substation yard.

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7.6. Transformer

Repair of transformer oil leaks and other faulty items within the transformer, including the OLTC, has the next priority level.

7.6.1. Oil Test

Testing the oil for moisture and dissolved gases is a part of this priority level. Repairs, further tests, or inspections may be required based on these test results. This may require extensive measures, such as removing and filtering or replacing the oil.

7.7. Ground Grid or Mat

The ground grid should be inspected, tested, and repaired to make sure that there is an adequate ground mat for the safety and integrity of the grounding system, next.

7.8. Voltage Regulation

Unless the transformer has an OLTC (On Load Tap Changer) that was repaired earlier, voltage regulation should be addressed next. If there is no voltage regulation in the substation, voltage regulators may be installed within the substation or on each circuit a short distance outside the substation. Care should be taken to assure public safety if the voltage regulators are installed outside the substation fence. Special attention should be given to assure proper fencing and adequate clearances are achieved.

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Appendix-A

1. SECONDARY (LT) VOLTAGE DROP CALCULATION

1.1. Determination of Load (in kW or Amps)

Determining the load on the secondary side of a distribution transformer for each customer can be approximated by using the average system usage in kWh per month for a particular customer. A load factor of 30% is assumed for residential and small commercial customers. The following is the formula for determining the non-diversified load per residential customer:

Load in kW = (average kWh per month) / (730 hours per month x 0.30 load factor)

Therefore, assuming an average kWh per month of 100, the peak load for each residential customer is:

100 / (730 x .30) = 0.457 kW

or

0.457 kW / .230 kV = 2 Amps

If the area has an uncharacteristically low average kWh usage for a takeover area, the value calculated with the equation above may be multiplied by 0.5. Likewise, if the area has uncharacteristically high average kWh usage for a takeover area, the value calculated with the equation above may be multiplied by 1.5. If the above methods do not produce sufficiently accurate results, a higher or lower kWh value that better represents the average loading for the area, can be used in place of the average system usage for this calculation. For voltage drop calculation, all houses should be considered, including existing legal connections, existing illegal connections, and those consumers presently without electricity.

1.2. Maximum Voltage Drop

According to Engineering Manual PBS 100-21, the allowable voltage drop on a 230 volt basis for all secondaries and service is 9.2 volts, or 4%. For this calculation, the span into the meter location (or service drop) will be considered in the calculation. If there is a likelihood of more customers being added to the secondary, a more conservative approach should be taken.

1.3. Determine Ampere-Feet or Ampere-Meter

Starting at the load end of the secondary, a calculation should be made of ampere-feet or ampere-meter for each section. This is done by multiplying the number of amperes times the number of feet or meters in the section.

1.4. Conductor Sizes

Use of existing covered secondary conductor is preferred if its condition is adequate. The following table shows the voltage drop factor for secondary wire sizes most commonly used:

Single-Phase Voltage Drop Factors		
Wire Size	Ampere-Foot	Ampere-Meter
6 Duplex	1,180	360
3 Duplex	1,990	607
3 AA	2,040	622
1/0 AA (equivalent to ANT)	3,110	948
4/0AA (equivalent to WASP)	4,680	1,426

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1.5. Voltage Drop Calculation

Using the calculated ampere-feet or ampere-meter values and the factors above, the secondary voltage drop for each section can be calculated as follows:

Voltage drop = ((amps) (feet)) / (ampere-foot factor)

or

Voltage drop = ((amps) (meters)) / (ampere-meter factor)

Voltage drop values for each section are added together to determine the entire secondary voltage drop.

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