HOOSIER ENERGY REC, INC

Requirements for Connection of Non-Generation Facilities

to the HE Transmission System

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1.0 Introduction

Hoosier Energy REC, Inc., has prepared this document which outlines the minimum requirements for all Transmission Interconnection or Transmission End-User facilities connecting to the HE Transmission System, or to transmission owned by others connected to the HE Transmission System. **Transmission Interconnections** refer to transmission connections between HE and other utilities. All other facility connections, except generation facilities, are considered **Transmission End-Users**[1].

1.1 Background

In the present electric utility environment characterized by deregulation, open access to the transmission network, wholesale and retail competition, etc., there is wide recognition that electric system reliability, safety and quality of service are to be maintained. Maintaining reliability, safety and quality of service in this changing environment places additional challenges in the planning and operation of electric systems.

As a result of this new environment, there are an increasing number of requests to connect to and use the HE Transmission System. The purpose of this document is to facilitate meeting the demands of this competitive environment. Each request is reviewed to identify the impacts and necessary system improvements on the HE system. These reviews ensure that comparable treatment is given to all users, and that reliability, safety, and quality of service are maintained.

The Hoosier Energy transmission system is, in effect, managed by the Midwest Independent System Operator (MISO). Any requests for a transmission connection to the Hoosier Energy system must be submitted to and approved by MISO, per MISO procedures.

1.2 Scope

This document informs entities seeking facility connections to the HE Transmission System of the transmission connection requirements. The requirements are applicable to all facilities connecting to the HE Transmission System, both those owned by HE as well as facilities owned by other parties. These requirements are not a substitute for specific Interconnection Agreements between HE and entities connecting to the HE Transmission System.

[1] **Transmission End-User** is hereinafter referred to as **End-User**.

The scope of this document satisfies the NERC Planning Standards by identifying requirements for connections to the bulk transmission system at voltages generally 100 kV and above. This document also applies to connections to those systems designated as transmission facilities that are rated at lower voltages, which include 69 kV. Requirements applicable for all types of **Transmission Interconnection** and **End-User** facilities are covered.

The minimum requirements pertaining to connected facilities are contained herein. Reliability concerns in particular are such that additional facility and operational requirements may need to be imposed on connecting facilities based on their location within the system, facility power level and the associated impacts on HE's system performance. The need for additional requirements can only be evaluated once certain details of a proposed facility are made known and system impact studies have been conducted.

The requirements for initial facility connection apply equally to any upgrades, additions, enhancements, or changes of any kind to an existing connected facility.

The scope of this document is limited to the technical requirements for connected facility design and operation. **Transmission Interconnection** and **End-Users** requiring transmission service are also referred to the appropriate Midwest ISO Tariff documents.

1.3 Objectives

HE, in its role as a transmission provider, has prepared this document based on the following objectives:

a) Maintain system reliability, personnel and equipment safety, and quality of service as load and new facilities are added to the transmission network.

b) Ensure comparability in the requirements imposed upon the various entities seeking to connect facilities to the transmission network.

c) Satisfy compliance with NERC Standards FAC-001 and FAC-002 pertaining to documentation of facility connection requirements by those entities responsible for system reliability.

d) Inform those entities that seek facility connections to the HE Transmission System of the various requirements for system reliability, safety of personnel and equipment, and quality of service.

e) Facilitate uniform and compatible equipment specification, design, engineering, and installation practices to promote safety and uniformity of service.

1.4 Rough Plan of Service

To facilitate a system impact study (discussed in the following step), the entity proposing the interconnection, with approval of Hoosier Energy, will prepare a "rough" plan of service to provide information on proposed transformer and line loading and other high level information needed for the system impact study. This rough plan will be used later for the detailed plan, upon approval of the project by MISO following analysis of system impact.

1.5 System Impact Studies

In order to assess the impact of a proposed facility connection on system reliability, system impact studies need to be conducted. These system impact studies, as a minimum, examine the transmission line and transformer loading, voltage profiles and schedules, and power quality impacts of the proposed facility for a range of expected seasonal loading and power transfer conditions. The effect of the proposed facility on short circuit duties is examined for all proposed transmission connections. A multi-step approach to the proposed facility may be considered where the impact of each step is assessed separately. Alternative plans of service may be considered.

All requesters of transmission service must petition Midwest Independent System Operator (MISO) for approval of the connection. MISO then performs any system impact studies needed for the interconnections at the owner's cost. All transmission connections above 100kV and selected interconnections (at MISO discretion) at 69kV will be evaluated by MISO. See MISO Procedures for details.

1.5.1 Power Flow Analyses

Power flow analyses are conducted to examine the impact of the proposed facility on transmission lines and transformers, and voltage profiles. These analyses may typically determine the maximum load demand in the case of End-User facilities or through flow in the case of a Transmission Interconnection that can be accommodated with minimal or no upgrades to the transmission system. Contingencies consisting of single or multiple outages of lines and/or transformers are considered in these analyses. Where the analyses indicate that transmission upgrades are necessary, alternative reinforcement plans may be devised and evaluated for their capability to accommodate the proposed facility. These analyses may also indicate a need to perform system dynamic studies.

1.5.2 Short Circuit Analyses

Short circuit analyses are conducted to examine the impact of the proposed facility on equipment duties. These analyses are primarily concerned with **Transmission Interconnection** facilities. Increased fault duties may require upgrading existing circuit breakers and other equipment.

The criteria HE uses to determine what constitutes acceptable performance in the above system impact studies is readily available from HE's FERC Form 715 filing.

1.5.3 Additional Analyses

Other analyses may be required as part of system impact studies based on power flow analysis and depending on the nature of the proposed connected facility and its location within the transmission network:

a) Power quality analyses are undertaken for all **End-User** load that could potentially cause harmonic current or voltage, voltage flicker, and/or telephone interference.

b) The possibility of adverse subsynchronous torsional interaction is investigated wherever the end-user's equipment such as arc-furnaces and/or cycloconverters is to be located in close electrical proximity to existing generation.

Criteria for harmonic interference, voltage flicker, and telephone interference are included in the document appendices. As for adverse torsional interaction, the criteria are wholly dependent on the specifics of any nearby generation.

The scope of all the above system impact studies will be determined by HE based on the type, location, and power level of the proposed facility. Normally, MISO will perform the system impact studies. The cost of these studies will be chargeable to the **Transmission Interconnection** or **End-User** in accordance with the applicable tariff. A report documenting the assumptions, results, and conclusions of the system impact studies is made available to the **Transmission Interconnectio**n or **End-User**.

HE and MISO must be notified of new facilities, upgrades, or additions such as an increase in load or generating capability of existing facilities connected to the transmission system within the HE Control Area. System impact studies are to be conducted to determine the need for any upgrades of transmission equipment or transmission reinforcements to the HE system to accommodate the changes in the connected facility.

1.6 Detailed Plan of Service

A plan of service is developed to provide for the physical connection between the transmission system and a proposed connected facility. The electrical configuration of the connection equipment including transformers, switchgear and other station equipment, and required transmission line sections are determined. Appendix A illustrates some of the more typical configurations for plans of service, but other possibilities exist depending on the particular situation. The physical layout of equipment and right-of-way needs are determined in the plan of service as well. Typically, more than one alternative is considered in developing a plan of service depending upon the accessibility of the local area transmission facilities and the needs of the proposed connected facility. A multi-step approach may be considered in the plan of service to accommodate a multi-step increase in load for the connected facility.

1.7 Initiating a Facility Connection or Facility Change

The following table outlines the HE personnel to be contacted with regard to any request for a new facility connection or significant change to an existing connected facility. Requests for transmission service to MISO should be made simultaneously with a connection request.

The following table summarizes the interface needed with HE by the entities seeking to connect their **Transmission Interconnection** or **End-User** facilities to the HE Transmission System.

Type of Customer To be Connected	Service or Activity Required From HE	HE Contact
Transmission Interconnection	Joint Transmission Planning Studies	Manager – Technical Assets
Transmission End-User Wholesale	Initial Contact to Request a Connection or Study	Manager – Corporate Planning
Transmission End-User Retail	Initial Contact to Request a Connection or Study	Manager – Corporate Planning

Following the initial contact regarding a proposed Transmission Interconnection or End-User facility connection, when the proposed location and power level are established, a rough plan of service is prepared by HE and system impact studies are undertaken by MISO (in most cases) as needed. The information needed to develop a plan of service and to conduct the system impact studies should be provided to HE or MISO at this point. The system impact studies may, as noted above, identify additional requirements for reliability beyond the minimum requirements covered by this document.

HE approval of a proposed facility or facility change is contingent upon a design review of the proposed connected facility. Operation of a connected facility is also subject to continuing compliance with all applicable construction, maintenance, testing, protection, monitoring, and documentation requirements described herein, as well as the applicable NERC Planning Standards and RFC Documents noted herein.

HE's facility connection requirements are organized into two separate documents titled "Requirements for Connection of Non-Generation Facilities to the HE Transmission System" covering **End-User** and **Transmission Interconnection** facilities, and" Requirements for Connection of Generation Facilities to the HE Transmission System" for generation. This is because many requirements applicable to generation do not apply to end-user or transmission interconnection facilities. Likewise, requirements applicable to **End-User** facilities and **Transmission Interconnections** do not always pertain to generation. However, when a proposed facility includes both generation and **End-User** or **Transmission Interconnection** facilities, proposing entities will need to consult both documents.

1.8 Responsibilities

Transmission Interconnection and **End-Users** is generally responsible for the costs associated with connecting to the HE Transmission System in accordance with the applicable tariff. The information contained herein is subject to change and may be revised at any time.

2.0 Tap Connection Definition and Requirements

Any connection to the HE transmission system that results in only the **End-User** load to pass through the connecting facilities under any condition is considered a tap connection.

For facilities below 230 kV, Figure 1 in Appendix A illustrates typical tapped line supply configurations and some of the basic connection requirements. As indicated, line switches are typically the minimum requirements at the tap location point. The in-line air break switches allow for sectionalizing the line without supply interruption to the **End-User** and the tap line air break switch can disconnect the **End-User** without outaging the supply line. Optionally, motor operated mechanisms (with or without supervisory control) can be added to in-line air break switches to minimize the time required for restoration following a failure on the HE supply line.

Figure 2 in Appendix A illustrates a typical tap supply configuration for the HE Extra High Voltage (EHV) transmission system (345kV) and some of the basic requirements. The two in-line air break switches at the tap location allow for sectionalizing the line without interrupting supply to the **End-User**. The tap line air break switch can disconnect the **End-User** without outaging the supply line. Due to concerns with the practical ability to reliably operate EHV line switches, HE recommends these switches only be utilized in a substation environment at this time. Optionally, motor operated mechanisms (with or without supervisory control) can be added to the air break switches to minimize the time required for restoration for a failure of the HE supply line.

In general, an **End-User** connecting to an HE substation bus would use transformer switching arrangements similar to that required for tapped line supply configurations. The substation bus connections will be reviewed on a case-by-case basis.

For tap supply configurations, either a delta or ungrounded-wye high side transformer winding configuration is preferred. The installation of a grounded-wye high side transformer could require additional protection facilities and costs to be borne by the **End User**.

3.0 Looped Connection Definition and Requirements

Any connection to the HE Transmission System that provides two line extensions to supply the **End-User** is considered a looped connection. In general, the two line extensions are installed to facilitate **End-Users** obtaining looped service, not to enable HE to provide adequate electrical service to any location other than the **End-User**.

Since some looped connections have the potential to significantly affect the reliability and loadability of the HE Transmission System, specific design and operational requirements are imposed which may not be required for a tapped connection.

Figure 3 in Appendix A illustrates typical looped supply configurations for below 230 kV and some of the basic connection requirements. For looped supply configurations, either a delta or ungrounded-wye high side transformer winding configuration is preferred for connecting substation transformers. The installation of a grounded-wye high side transformer winding configuration may be acceptable but could require additional protection facilities and costs to be borne by the **End-User**.

Figure 4 in Appendix A illustrates a typical looped supply configuration for End-User's connecting to the HE EHV System (345 kV) and some of the basic requirements. The line air break switches permit restoring service from both End-User transformers for an outage of one of the supply lines. These line air break switches would be in the HE supply station and motor operated mechanisms (with or without supervisory control) can be added to minimize the time required for returning a transformer to service for a failure of the associated HE supply line.

4.0 Network Connection Definition and Requirements

Any connection to the HE Transmission System that allows bi-directional energy and/or fault current flow between otherwise independent transmission systems is considered a network connection. This is considered a special circumstance, which requires a detailed system impact study to determine the acceptability of the proposed transmission interconnection and the specific interconnection requirements. Transmission interconnection requests on the HE Transmission System will be considered on a case- by-case basis. The **Transmission Interconnection Requester**[2] will be responsible for reimbursement of the cost for these studies (generally done by MISO). In addition, the cost of facilities to establish and reliably integrate the new network connection will be at the expense of the **Transmission Interconnection Requester** to the extent allowed by the appropriate Midwest ISO Tariff documents.

5.0 Voltage Levels

The **Transmission Requester's**[3] facility will be supplied from HE's Transmission System, which generally under system normal conditions and single transmission element outage conditions can range between 92% and 105% of nominal. If the **Requester's** supply voltage requirements are more restrictive than the 92% to 105% range, HE recommends that the **Requester** consider the addition of voltage regulation equipment in their facility. Nominal transmission system voltages presently on the HE system are: 345 kV, 161 kV, 138 kV and 69 kV.

Under certain emergency conditions, the HE Transmission System may operate for a period of time outside of the 92% to 105% range. The **Requester** is responsible for providing any voltage sensing equipment required to protect their equipment during abnormal voltage operation.

6.0 Power Factor Requirements

The NERC Planning Standards state that distribution entities and customers connected directly to the transmission systems should plan and design their systems to operate at close to unity power factor to minimize the reactive power burden on the transmission systems. The HE interpretation of “close to unity power factor” is that the power factor of the connected load should be within the range of approximately 0.98 lagging to 0.98 leading.

Unless otherwise restricted by Retail Tariffs, the maximum hourly reactive power (kV Ar) demand, both leading and lagging, will be identified each month at the delivery point(s). An **End-User** will incur no charges for power factor if the maximum leading and lagging kVAr demands do not exceed 20% of the real power (kW) demand in the same hour(s). If the maximum hourly leading and/or lagging kV Ar demands exceed 20% of the corresponding kW demand, charges will be assessed.

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[2] **Transmission Interconnection Requester** -refers to the entity requesting a network transmission interconnection to the HE transmission system.

[3] **Transmission Requester** - can refer to either a **Transmission Interconnection Requester** or a **Transmission End-User Requester** and hereinafter is referred to as a **Requester**.

The charge will be one rate per kV Ar for all leading and/or lagging kV Ar demand in excess of 20% of the corresponding kW demand. When the leading and/or lagging kV Ar demand exceeds 50% of the corresponding kW demand, the charge will be a higher rate per kV Ar, for all kV Ar in excess of 20% of the kW demand. The cost of reactive demands for HE full requirements customers will be based on the applicable state or FERC filed tariff.

Capacitors generally provide an effective means of controlling the power factor of a **Requester's** facility. However, there are several factors that should be addressed in applying capacitors. These factors can include, but are not limited to, transient voltages due to capacitor switching and voltage amplification due to resonance conditions. The services of a qualified consultant should be obtained to review the specific application and provide recommendations in regard to control of these phenomena.

7.0 Frequency Range

The HE transmission system typically operates at a nominal 60 Hz with a variation of +0.05 Hz to -0.05 Hz. Under certain emergency conditions, the transmission system may operate for a period of time outside of this range. The **Requester** is responsible for providing any frequency sensing equipment required to protect their facility during abnormal frequency operation.

8.0 Power Quality

8.1 Harmonics and Flicker

Certain electrical equipment located at the **End-User's** facility (arc furnaces, cycloconverters, etc.) will generate voltage flicker[4] and harmonic distortion which can negatively impact other **End-Users**. Should this be the case, the **End User** shall take responsibility, initially or in the future, for limiting interfering levels of harmonic voltage and current distortion and/or voltage flicker. Limits for harmonic distortion (including inductive telephone influence factors) are as published in the latest issues of ANSI/IEEE 519, “Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.”

Specific HE harmonics and flicker criteria are given in Appendix B. HE criteria requires that flicker occurring at the point of compliance shall remain below the Border Line of Visibility curve on the IEEE/GE curve for fluctuations less than 1 per second or greater than 10 per second. However, in the range of 1 to 10 fluctuations per second, voltage flicker shall remain below 0.4% (see Appendix B, Exhibit 1). HE may, initially or in the future, require the installation of a monitoring system to permit ongoing assessment of compliance with these

[4] Flicker is an objectionable, low frequency, voltage fluctuation which can be observed through changes in intensity or color of illumination

criteria. The monitoring system, if required, will be installed at the **End-User's** expense.

Situations where high harmonic voltages and/or currents originate from the transmission system are to be addressed in the Connection Agreement.

8.2 Sensitive Electrical Equipment

Certain electrical equipment in the **Requester's** facility may be sensitive to normally occurring electric interference from nearby connected loads in the **Requester's** facility, from other **End-Users** connected to the power system, from natural causes, and system switching, etc. If sensitive electrical equipment is to be supplied directly from the electric power system, it is recommended that the equipment grounding requirements and power supply requirements be examined by the **Requester** or the **Requester's** consultant prior to installation. Attention should be given to equipment tolerance to various forms of electric interference, including voltage sags and surges, momentary outages, transients, current and voltage harmonic distortion, or other electrical and electromechanical noise. When electrical disturbances to sensitive electrical equipment such as computers, electronics, controls, and communication equipment cannot be tolerated, the **End-User** shall install additional equipment as may be necessary to prevent equipment malfunctions and protect against equipment failure. The **End-User** should consult the supplier of such sensitive electrical equipment regarding the power supply requirements or the remedial measures to be taken to alleviate potential mis-operation or failure of the equipment. The **End-User** may need to hire a power quality consultant to also perform a site survey of the electric power supply environment and furnish recommendations to provide the acceptable levels of reliability and quality of service.

8.3 Transformer Protective Devices

In the last few years, HE has typically installed circuit switchers on the high side of transmission/step-down transformers. Prior to that time, HE generally installed motor-operated-air-break (MOAB) ground switches on these transformers.

The MOAB ground switch combination is designed to place a solid phase-to-ground fault on the system and isolate a fault in the transmission/step-down transformer as follows. The ground switch closes for a fault on the transformer to ensure tripping of the remote line terminal circuit breakers. This is followed by opening of the transformer MOAB switch to isolate the transformer and permit the remote terminal circuit breakers to reclose and return the transmission line to service.

In cases where other HE **End-Users** in an area have (or install) sensitive electrical equipment, a MOAB/ground switch operation may cause objectionable voltage sags and momentary interruptions. If this occurs, HE may require the noncompliant **End-User** to pay for the cost to replace the MOAB/ground switch with a suitable circuit switcher or circuit breaker. **End-**

User's facilities using MOAB/ground switches should take this possibility into account when planning the initial installation as well as future costs.

8.4 Unbalanced Electric Conditions

8.4.1 Voltage Balance

Voltage unbalance attributable to the **End-User** facilities shall not exceed 1.0% measured at the point-of-service. Voltage unbalance is defined as the maximum phase deviation from average as specified in ANSI C84.1, "American National Standard for Electric Power Systems and Equipment Voltage Ratings, 60 Hertz."

8.4.2 Current Balance

Phase current unbalance attributable to the **End-User** facility shall not exceed that which would exist with balanced equipment in service, measured at the point-of-common coupling.

Situations where high unbalance in voltage and/or current originate from the transmission system are to be addressed in the Connection Agreement.

8.5 Subsynchronous Torsional Interaction

Certain **End-User** equipment, in particular electric arc furnaces and cycloconverters, may cause adverse interactions and possible damage to existing turbine-generators located in close electrical proximity. These situations will be analyzed by HE, or HE's consultant, and appropriate corrective or preventive measures identified as needed. Corrective and preventive measures may consist of torsional current monitoring at a defined point of compliance, special protective relaying on the turbine-generator shaft(s), or constrained operation of the **End-User** equipment under certain system configurations. Costs of studies and the design and installation of protective and/or monitoring equipment shall be the responsibility of the **Requester**.

9.0 Generation

Generation connected to and operated in synchronism with the HE transmission system in conjunction with **End-User** load is subject to additional requirements beyond those specified in this document. Information concerning these requirements is contained in "Requirements for Connection of Generation to the HE Transmission System." The **Generation Facility Owner** should contact the local HE Industrial/Commercial Service Representative for this document.

10.0 Information Required

As soon as available, the **Requester** shall provide two copies of the following information for review and comment by both the Technical Assets and the Design Services groups at HE, as well as to MISO.

a. **Requester's** Information -company name, mailing address, contact representative and phone number.

b. Project Design/Engineering Information -company name, mailing address, contact representative and phone number.

c. Requested in-service date for the transmission connection, and a date for temporary service to test facilities prior to formal in-service.

d. Plot plan or description showing exact location and orientation of Requester's proposed facilities and point of electric service delivery.

e. One-line, schematic diagrams, plan and elevation drawings of the proposed facilities showing dimensions, clearances and grounding layout.

f. Information on characteristics of load, including initial load build-up, 5 and 10 year load projections, and power factor of such loads.

g. Information concerning the **Requester's** power factor correction equipment. This information should include size and amount of fixed or switched capacitors, or other power factor correction equipment and methods used for operation.

At least three months before starting electrical construction of the **Requester's** facility, the following additional information must be sent to HE's Manager – Technical Assets and also to HE's Manager, Design, or their designee(s). Failure to provide this information in a timely manner may delay the facility in-service date.

h. Data on equipment to be installed.

   i. High side interrupting and sectionalizing devices - Manufacturer, type, voltage rating, and current ratings.
   ii. High side relaying equipment -Complete manufacturer's data.
   iii. Power transformers -Complete nameplate and test report data, including manufacturer, serial number, high and low side voltage taps, kVA ratings, high and low side connections, low side grounding (if used), load loss watts and positive and zero-sequence impedances between the high-low, high-tertiary, and low-tertiary transformer windings (as applicable) at each tap.

i. Data on **Requester's** low voltage protection equipment, including fuses, breakers, relays, and relay settings.

The information in subsections h and i is required to perform coordination selectivity studies in a timely manner. Any disagreement in this regard must be resolved prior to energization.

Depending upon the nature of the **End-User** equipment to be installed, the following data may be required to complete the portion of the system impact studies addressing power quality and/or subsynchronous torsional interactions.

j. Data on the harmonic and sub-harmonic current/voltage spectra of the end-user equipment to be installed under three phase balanced and unbalanced conditions.

k. Maximum magnitudes (MW and MV Ar) of sudden load swings at the point of connection and the number of such fluctuations per second, minute or hour.

l. Data on SVC equipment and harmonic filters if applicable.

m. Maximum expected MW and MV Ar demand at the point of connection.

11.0 Requester's Facility Equipment

11.1 Size and Take-Off Tension of Line Conductors and Overhead Ground Wires

The **Requester's** structure shall be designed for (# of) incoming (size and type of) phase conductors and (# of) incoming (size and type of) overhead ground wire(s). The approximate take-off or dead-end tension will be (#) lbs. for each phase conductor and (#) lbs. for each overhead ground wire in accordance with Rule 250 of the National Electric Safety Code (NESC). The exact take-off tensions will be determined after the facility plans are finalized.

The line terminal connectors furnished by the **Requester** should be (copper or aluminum) wire-and-pad connector to bolt to and be materially compatible with the air switch terminal pad. The overhead ground wire shall be grounded using aluminum compression wire and a pad type connector furnished by the **Requester**.

If the incoming high voltage lines will cross road ways or railroad tracks, such as a siding or main line, to reach the **Requester's** facility, it may be necessary to increase the above tensions or provide additional height on the structure to meet appropriate crossing requirements.

The point of attachment of the line entrance conductors shall be of sufficient height to provide the basic vertical clearance requirements for lines crossing over public streets, alleys, or roads in urban or rural districts, as outlined in the NESC.

11.2 Short Circuit Data & Interrupting Device Ratings

The following estimated short circuit levels will be provided by HE at the point of common coupling.

Estimated Initial Short Circuit Levels (Year)

3 Phase Fault	= ______ MVA	ANSI X/R Ratio = _____
Phase-to-Ground Fault*	= ______ MVA	ANSI X/R Ratio = _____

Estimated Future Short Circuit Levels (Year)

3 Phase Fault	= ______	MVA	ANSI X/R Ratio = _____
Phase-to-Ground Fault*	= ______	MVA	ANSI X/R Ratio = _____

*Note: Phase-to-ground fault values are calculated assuming the **Requester's** transformers have either a wye-ungrounded or delta connected high side. For wye-grounded transformers, the transformer contribution to the total fault current will have to be taken into account and the fault values recalculated.

Transmission Interconnection and **End-Users** equipment should have adequate interrupting and momentary ratings for the future short circuit conditions listed above.

While HE will endeavor, where possible, to anticipate system changes which may affect these values, it does not assume responsibility or liability with respect to such protective devices, nor guarantee their continuing adequacy against increased interrupting capacity requirements resulting from system changes. **Transmission Interconnection** and **End-Users** who use this information should periodically review existing and future fault conditions and equipment ratings for adequacy. Any equipment replacements or upgrades to maintain adequacy of the **Transmission Interconnection** or **End-Users'** facilities will be at the **Transmission Interconnection** or **End-Users'** expense.

All gas insulated protective devices within the **Requester's** facility having a direct connection to an HE transmission line shall be equipped with a low gas pressure alarming/tripping/lockout scheme as appropriate for the particular device.

11.3 Other Design Criteria

11.3.1 Equipment Basic Insulation Levels

The minimum required Basic Insulation Levels (BIL) for stations are listed in Table 1 of Appendix C. Facilities in areas with significant airborne pollution may require a higher insulation level.

11.3.2 Transformer Surge Protection (Lightning Arresters)

Lightning arresters protecting transformers are generally porcelain design and mounted on the transformer. However, since lightning arresters can adequately protect equipment some distance from the arresters, the overall number of lightning arresters required in each design can be reduced. Lightning arrester allowable separation distance from the equipment being protected is based on Table 4 of IEEE Std. C62.22.

The **Requester** should consult the manufacturer's catalog for details concerning arrester protective characteristics, ratings, and application.

11.3.3 Ratings of Current Carrying Equipment

For tap and looped connections, the **Requester's** high voltage bus and associated equipment, such as switches, connectors, and other conductors shall have minimum continuous current and momentary asymmetrical current ratings which: (1) do not limit the HE transmission system network capability and (2) have adequate capability for the initial and future system conditions identified by HE.

11.3.4 Electrical Clearances (Outdoor)

Electrical facility design clearances are listed in the table in Appendix C. These design clearances should be used for electrical facilities up to and including any interrupting device connected directly to an HE transmission line and for all facilities that are part of the HE transmission system.

The minimum vertical clearance of the conductors above ground and the vertical and horizontal clearance of conductors passing by but not attached to a building or wall shall be in accordance with the NESC or applicable state and local codes.

11.3.5 Insulators for Station

The required station post insulator types are listed in the table in Appendix C. Facilities in areas with significant airborne pollution may require a higher insulation level. Higher strength insulators are available and should be used if needed to meet bus momentary short circuit withstand values.

11.3.6 Air Break Switch(es) and Disconnect Switch(es)

A group operated switch shall be installed on each transmission line supply entrance to the **Requester's** facility and accessible to HE personnel at all times. The switch shall be mechanically lockable in the open position with an HE padlock in order to provide for a visible electric isolation of the **Requester's** facility and shall be identified with an HE designated equipment number.

All air break switches shall be three phase, single throw, group operated. Disconnect switches shall be a three pole, single throw device. Characteristics for all air break switches and disconnect switches including voltage and BIL ratings, clearances and pole spacing shall meet the requirements shown in the table in Appendix C. Facilities in areas with significant airborne pollution may require a higher BIL level. There shall be no braids in the current carrying parts of the switch. Group operated switches shall be complete with a horizontal, rotating-type operating handle. A grounding device is to be furnished for the operating shaft and shall consist of a tin coated, flexible copper braid, located as close as possible to the operating handle. The braid shall have a cross-sectional area equivalent to 4/0 copper cable, or greater. The braid shall be secured to the shaft by means of a galvanized steel V-bolt clamp and associated cradle-type galvanized steel hardware. The opposite end of the braid shall have two (2) 9/16 inch holes at 1-3/4 inch spacing. Both ends of the braid shall be stiffened and protected by a ferrule or additional tinning.

As a minimum, a protective grounding loop shall be provided around all group operated switches as illustrated in Appendix D. This table applies to areas where native soil resistivity does not exceed 500 Ohm-meters. When the above condition is exceeded a detailed engineering assessment study must be undertaken by HE.

All workers, who are using the operating handles on air break switches and disconnects on energized lines and equipment shall use protective headgear, insulating gloves and approved protective footwear. Before operating, the switch and ground arrangement shall be visually checked.

All switches are to be manufactured and tested in accordance with the latest revision of ANSI C37.30, ANSI C37.32, and ANSI C37.34.

11.3.7 Facility Fence Safety Clearances

The fence safety clearances in the **Requester's** facility shall comply with Section 11 of ANSI C2-1997, “National Electrical Safety Code.”

11.3.8 Ground System Resistance

The grounding system should be designed in accordance with IEEE Standard 80 -latest revision, “IEEE Guide for Safety in AC Substation Grounding.” In evaluating the step and touch potential the target body weight value should be set to 50 kg. If a reasonable grounding design is unobtainable using the 50 kgs, then consider a body weight of 70 kg as the absolute minimum allowable.

Ground fault levels from HE sources are listed in Section 11.2, Short Circuit Data & Interrupting Device Ratings. **Requester** equipment ground sources can contribute significant fault current independent of the ground fault values in Section 11.2. These **Requester** ground sources should be considered in the design of the grounding system.

If the facility structure is to be wood-pole type construction, the transmission line overhead ground wire, all switch bases, fuse bases, and other noncurrent-carrying metal parts shall be grounded to the station grid.

12.0 System Protection

12.1 Transmission Protection

HE will provide functional specifications and relay settings for all protective relays at the **Requester's** facility that have a potential impact on the reliability of the HE transmission system. The criteria for these functional specifications and settings will be based on existing HE protection practices. HE reserves the right to specify the type and manufacturer for these protective relays to ensure compatibility with existing relays. The specific recommendations and requirements for protection will be made by HE based on the individual substation location, voltage and configuration.

12.2 Requester Protection

It is the **Requester's** responsibility to assure protection, coordination and equipment adequacy within their facility for conditions including but not limited to:

1. single phasing of supply,
2. system faults,
3. equipment failures,
4. deviations from nominal voltage or frequency,
5. lightning and switching surges,
6. harmonic voltages,
7. negative sequence voltages,
8. separation from HE supply,
9. synchronizing generation.

12.3 Automatic Under-frequency Load Shedding

HE may require automatic under-frequency load shedding relaying on connected loads to comply with NERC EOP-003 “Load Shedding Plans” and ECAR Document No.3, “Emergency Operations"[5] (note that ECAR has been superseded by RFC, but this standard remains in place until a new RFC

[5] Available on RFC web site www.rfirst.org.

standard PRC-006-RFC is approved) or other system stability considerations. This document requires RFC control areas to shed at least

13.0 Remote Relay Access

13.1 Tap Connected Facilities

Remote relay access is not normally required at tap connected facilities.

13.2 Loop or Network Connected Facilities

All digital relays which have the capability of recording system disturbance information and are used for protection of HE transmission facilities shall be provided with the equipment necessary to allow HE to remotely retrieve this data via **Requester** supplied access to the public phone system.

14.0 Revenue Metering and Telemetry Requirements

14.1 Revenue Metering

HE approved revenue class metering equipment shall be installed at the delivery point to meter the aggregated load of the connected facility consisting of instantaneous bi-directional real and reactive power and integrated hourly real and reactive energy metering.

25% of their connected load in successive steps during system under-frequency emergencies.

HE, being in the RFC footprint, is obligated to have an automatic under-frequency load shedding plan in effect which meets ECAR Document No. 3 requirements. Connecting parties without an automatic under-frequency load shedding plan meeting ECAR Document No. 3 requirements may need to install under-frequency relaying at the request of HE. The amount of load to be shed and the frequency set points will be specified by HE as required to achieve RFC under-frequency load shedding compliance.

The metering equipment will include potential and current transformers, meters and test switches. The accuracy of the instrument transformers and meters will be 0.3 percent or better. The secondary wiring and burdens of the instrument transformers will be configured so that they do not degrade the total accuracy by more than 0.3 percent. The metering equipment will be tested periodically as defined in the service agreement and the test results will be available to all involved parties. The meters, test switches and wiring termination equipment will be sealed and the seal may be broken only when the meters are to be tested, adjusted or repaired. Proper authorities from both parties will be notified when seals are broken.

At least (N-1) metering elements will be used to measure all real and reactive power crossing the metering point, where N is the number of wires in service including the ground wire. Bi-directional energy flows including watt-hour and var-hour will be separately measured on an hourly basis.

Depending on the tariffs to be applied, appropriate demand quantities will be metered in terms of kilowatts, kilovars or kilovolt-amperes. If required, voltage measurements will be provided.

The instrument transformers used for revenue metering shall be installed on the high voltage side of the **Requester's** step-down transformer. Under special circumstances and with written approval granted by HE, revenue metering may be performed on the low voltage side of the step-down transformer. Written approval shall only be given if the **Requester** can demonstrate that accurate transformer loss compensation will be programmed into the revenue metering when instrument transformers are installed on the low voltage side of the step-down transformer.

14.2 Telemetry

Suitable telemetry equipment will be installed at the metering point to provide real-time telemetry data to HE and to all other participating parties.

Telemetry equipment will include transducers, remote terminal units, modems, telecommunication lines, and any other equipment of the same or better function. The remote terminal unit, or equivalent device, must have multiple communication ports to allow simultaneous communications with all participating parties. That device will accommodate data communication requirements specified by each participating parties control center, including communication protocol, rate and mode (either synchronous or asynchronous). All metered values provided to the telemetry equipment will originate from common metering equipment. All transducers used for telemetry will have at least 0.2 percent accuracy. As part of real-time data to be provided, HE has the right to require the status and remote control of switching devices at the Receipt and/or Delivery Points.

A continuous, accumulating record of megawatt-hours and megavar-hours will be provided by means of the registers on 'the meter. Freezing accumulation data for transmission will be taken every clock hour. The freezing signals synchronized to within 2 seconds of Universal Coordinated Time must be provided by only one of the agreed-upon participating parties. If the freeze signal is not received within a predefined time window, the remote terminal unit, or equivalent device, will be capable of freezing data with its own internal clock.

The metering, if external power supply is required, and telemetry equipment will be powered from a reliable power source, such as a station control battery, in order to allow the equipment to be continuously operational under any abnormal power supply situations. Proper surge protection will be provided for each communication link to protect communication hardware from ground-potential-rise due to any fault conditions. A separate communication media shall be provided to allow HE to remotely retrieve billing quantities from the meters. When real-time telemetry is required, a back-up data link must be provided in case of the outage of the primary telemetry line. The back-up link can be a data communication link between involved control centers; the party requesting service is responsible for furnishing the back-up link.

15.0 Communications

15.1 Voice Communications

A. Normal - At HE's request, the **Requester** shall provide a dedicated voice communication circuit to the HE System Control Center (SCC). Such a dedicated voice communication circuit would originate from the **Requester's** office staffed 4 hours a day and would be typically required for connected transmission facilities that significantly affect the HE transmission network capacity and operations.

All other normal voice communication concerning facility operations shall be conducted through the public telephone network to the SCC phone number(s) issued by HE.

B. Emergency - Voice communications in the event of a transmission facility emergency shall use the dedicated voice circuits, if available, or public telephone network and phone number(s) designated for emergency use.

It is the **Requester's** responsibility to take prudent steps when an area or system wide capacity emergency is declared. Load reductions shall be implemented by reducing non-essential loads. This type of reduction is usually conveyed through the local media. Interruptible customer load reductions may already be in effect depending on the nature of the emergency. The **End-User's** HE representative is responsible for providing the respective HE Transmission Dispatch Center (TDC) a "customer contact list." This listing contains the **End-User's** HE representative and backup person as well as their business, home and pager numbers.

These **End-Users** shall be provided an unlisted phone number to be used for emergency or routine operations. Operational emergencies (equipment) warrant a direct call either way. The TDC will advise the HE representative of problems that they should handle directly with the **End-Users**.

15.2 Interruptible Contracts

Owners of transmission facilities that have an HE interruptible contract shall install communication facilities with the HE TDC specified in the contract.

15.3 Emergency Operating Conditions

End-User's facilities may be subject to HE's Emergency Operating Plan (EOP) and other applicable plans which can require interruption of load to deal with generation deficiencies and/or transmission system emergencies.

It is noted that interrupting of load will only be done in extreme conditions that would result in a more serious degradation of system performance than if the load were not shed.

System emergencies are communicated through the local media. Interruptible customers are also notified electronically in the event of an "Emergency Interruption."

16.0 Turnover Inspection Requirements

Before a **Requester** owned facility can be energized, it must pass a final turnover inspection by HE personnel. HE will inspect all substation equipment from the point of interconnection to the first protective fault interrupting device and the ground system. This may include circuit breakers, circuit switchers, power fuses, instrument transformers, switches, surge arresters, bushings, and relays and associated equipment (including battery and battery chargers). The inspection will consist of a visual inspection of all major equipment as well as review of required test results.

The ground system must be checked by using the resistance measurement procedures in accordance with IEEE Standard 81 "Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth."

The inspection will be performed by HE personnel who will document the inspection by completing a site specific form supplied by Transmission System Analysis and Planning, or Transmission System Engineering at HE. An example of the form, showing the types of information required is shown in Appendix E.

17.0 Maintenance Requirements

All **Requester** owned equipment up to and including the first protective fault interrupting device is to be maintained to HE standards. This may include circuit breakers, circuit switchers, power fuses, instrument transformers, switches, surge arresters, bushings, relays, and associated equipment (including battery and battery charger). Maintenance procedures are detailed in the HE "Maintenance Strategy – Power Delivery xx" (where xx is the year of issue).

The **Requester** shall have an organization approved by HE test and maintain all devices and control schemes provided by the **Requester** for the protection of the HE system. Included in the testing and maintenance will be any initial set up, calibration, and check out of the required protective devices, periodic routine testing and maintenance, and any testing and maintenance caused by a **Requester** or HE change to the protective devices.

If the **Requester's** testing and maintenance program is not performed in accordance with HE's "Maintenance Strategy – Power Delivery xx". HE reserves the right to inspect, test, or maintain the protective devices required for the protection of the HE System.

All costs associated with the testing and maintenance of devices provided by the **Requester** for the protection of the HE system, including costs incurred by HE in performing any necessary tests or inspections, shall be the responsibility of the **Requester**.

HE reserves the right to approve the testing and maintenance practices of a **Requester** when the **End-User's** system is operated as a network with the HE transmission system.

18.0 Coordination with Other Codes, Standards, and Agencies

The information contained in this document is supplementary to and does not intentionally conflict with or supersede the National Electric Code (NEC) as approved by the American National Standards Institute (ANSI) or such federal, state and municipal laws, ordinances, rules or regulations as may be in force within the cities, towns or communities in which HE furnishes electric service. It is the responsibility of the **Transmission Interconnection** or **End-User** to conform to all applicable national, state and local laws, ordinances, rules, regulations, codes, etc.

19.0 Indemnification

The use and reliance upon the information contained in this document shall in no way relieve the **Transmission Interconnection** or **End-User** from the responsibility to meet NEC and NESC requirements governing their design, construction, operation, and materials.

The **Requester**, for itself, its successors, assigns and subcontractors will be required to pay, indemnify and save HE, its successors and assigns, harmless from and against any and all court costs and litigation expenses, including legal fees, incurred or related to the defense of any action asserted by any person or persons for bodily injuries, death or property damage arising or in any manner growing out of the use and reliance upon the information provided by HE. Reliance upon the information in this document shall not relieve the **Transmission Interconnection** or **End-User** from responsibility for the protection and safety of the general public.

APPENDIX A

Typical Transmission Tap Line Supply Configurations

Figure 1 -- (for below 230 kV)

Figure 2 -- (for 345 kV)

Typical Transmission Looped Supply Configurations

Figure 3 -- (for below 230 kV)

Figure 4 -- (for 345 kV)

FIGURE 1 Typical Transmission Tap Line Supply Configurations (for below 230 kV)

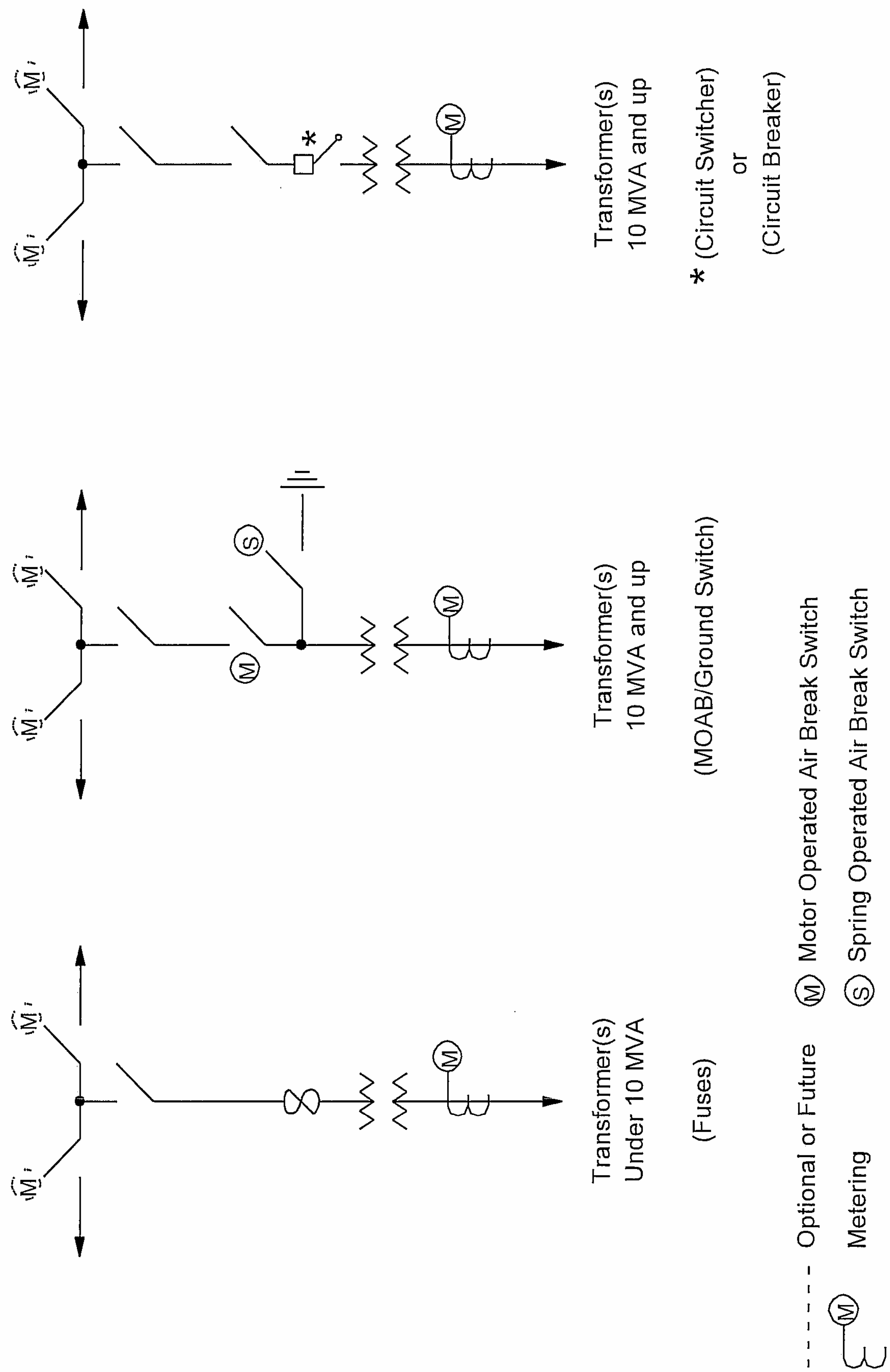
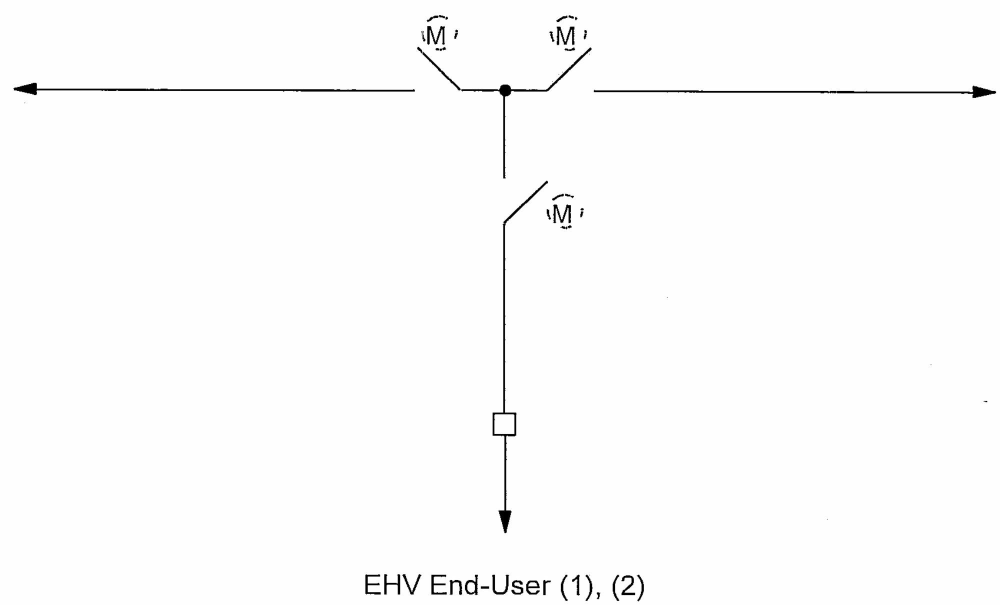


FIGURE 2 Typical Transmission Tap Line Supply Configurations (for 230 kV through 345 kV)



- - - - - - Optional or Future

(M) Motor Operated Air Break Switch

(1) EHV End-User generally owns the step-down transformer

(2) EHV End-User Metering is typically installed on the low-side of the step-down transformer and compensated to the high-side to cover losses.

FIGURE 3 Typical Transmission Looped Supply Configurations (for below 230 kV)

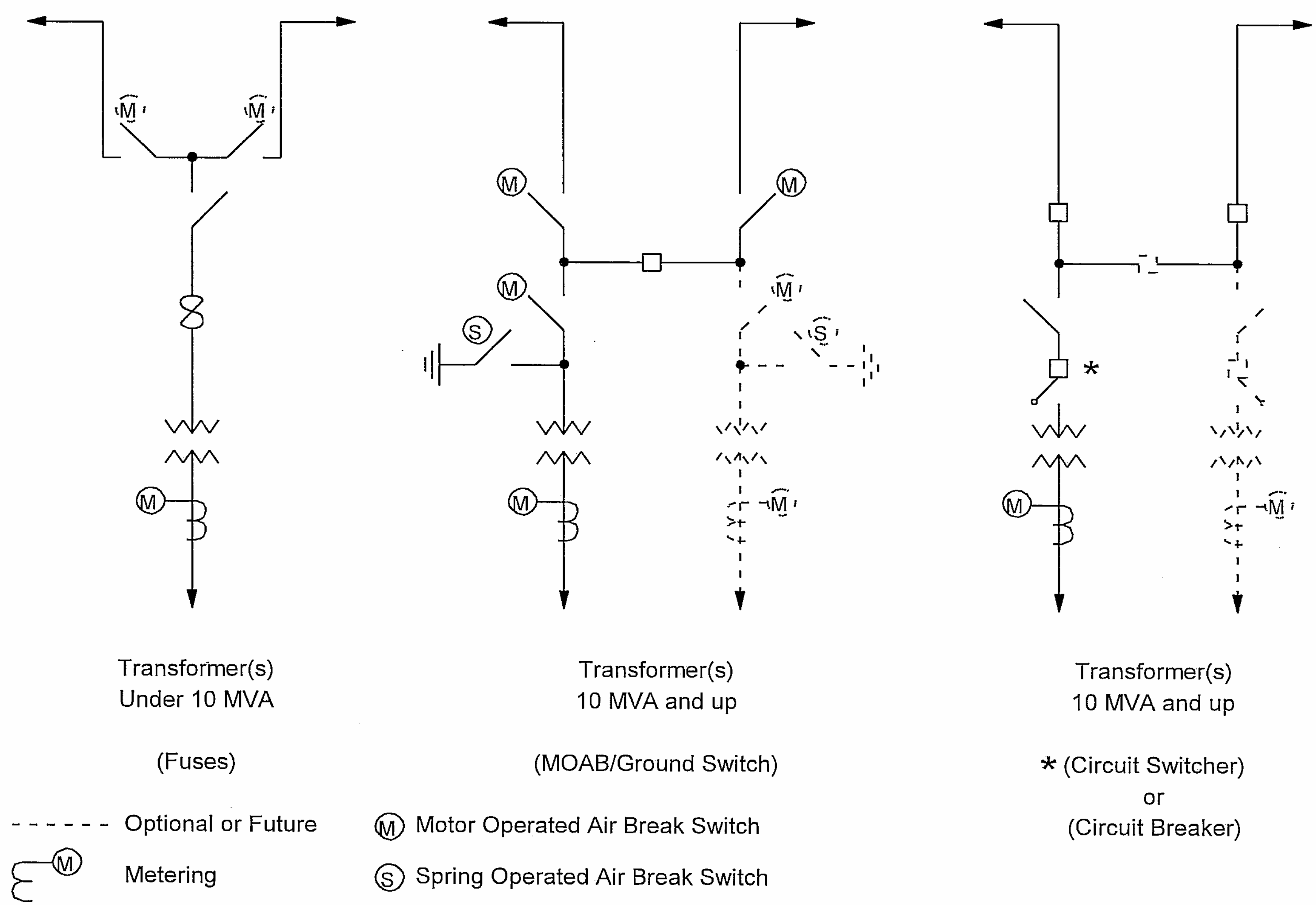
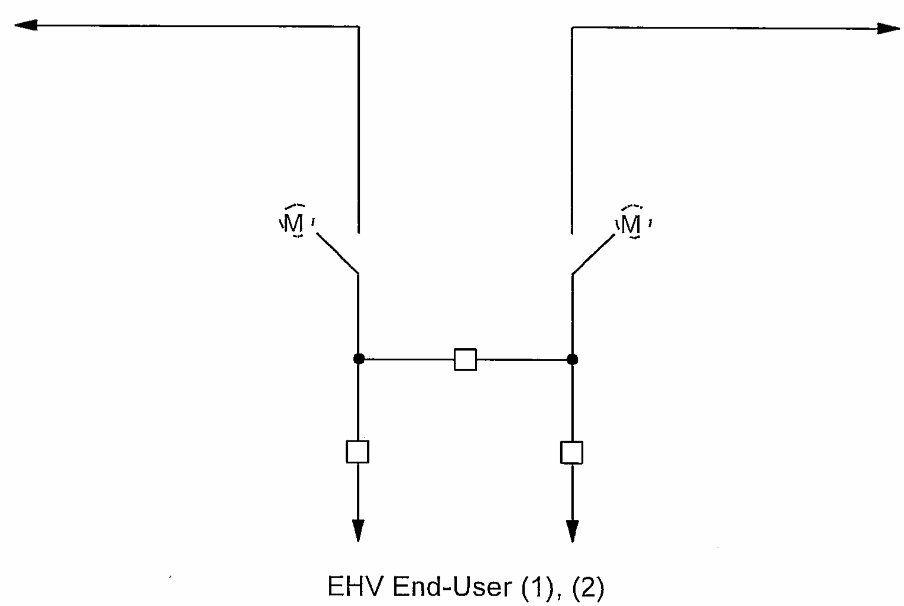


FIGURE4 Typical Transmission Looped Supply Configurations (for 230 kV through 345 kV)



- - - - - - Optional or Future

(M) Motor Operated Air Break Switch

(1) EHV End-User generally owns the step-down transformer

(2) EHV End-User Metering is typically installed on the low-side of the step-down transformer and compensated to the high-side to cover losses.

APPENDIX B

HE Voltage Flicker Criteria and Harmonic Distortion Criteria

HE Voltage Flicker Criteria and Harmonic Distortion Criteria

This document summarizes HE's policy on voltage flicker and harmonic distortion for customers connected to the electrical system via a Company dedicated transformer or a Customer owned transformer. The term Company is defined as Hoosier Energy REC, Inc. (HE). The term Customer is defined as the party connected to the HE System.

I. POINT OF COMPLIANCE -The point where the Company dedicated transformer or Customer owned transformer connects to the Company system will be the point where compliance with the voltage flicker and harmonic distortion requirements are evaluated.

II. VOLTAGE FLICKER CRITERIA -The Company requires that the voltage flicker occurring at the point of compliance shall remain below the Border Line of Visibility curve on the IEEE/GE curve for fluctuations less than I per second or greater than 10 per second (see Exhibit 1). In the range of 1 to 10 fluctuations per second, the voltage flicker shall remain below 0.4%.

The Customer agrees that under no circumstances will it permit the voltage flicker to exceed the Company criteria, whether or not complaints are received or service/operational problems are experienced on the Company subtransmission or transmission system. Should complaints be received by the Company or other operating problems arise, or should the Customer flicker exceed the borderline of visibility curve, the Customer agrees to take immediate action to reduce its flicker to a level at which flicker complaints and service/operational problems are eliminated.

Corrective measures could include, but are not limited to, modifying production methods/ materials or installing, at the Customer's expense, voltage flicker mitigation equipment such as a static var compensator. The Company will work collaboratively with the Customer to assess problems, identify solutions and implement mutually agreed to corrective measures.

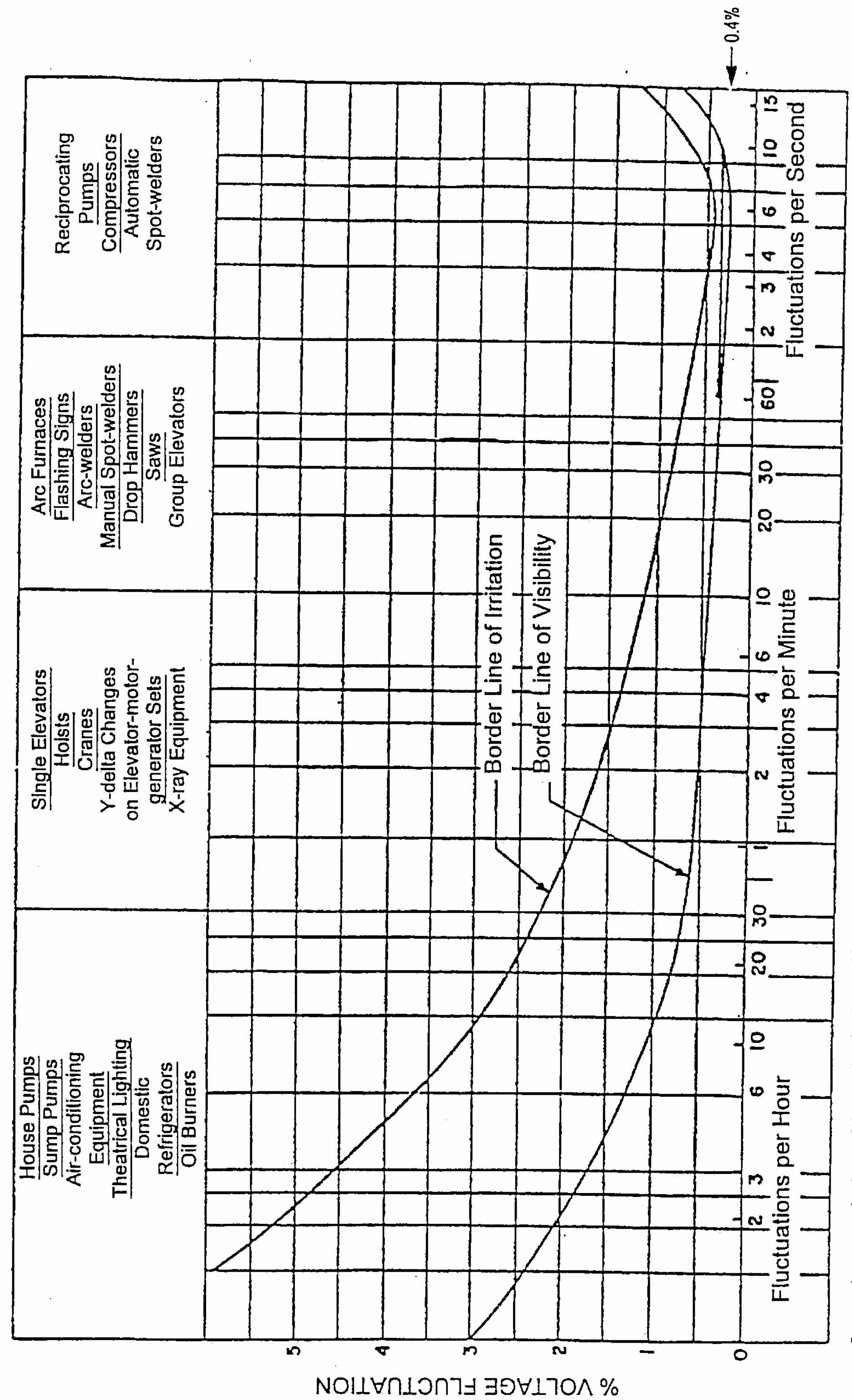
If the Customer fails to take corrective action after notice by the Company, the Company shall have such rights as currently provided for under its tariffs, which may include discontinuing service, until such time as the problem is corrected.

III. HARMONIC DISTORTION CRITERIA -The Company also requires that the Customer's operation be in compliance with the Company's Harmonic Distortion Guidelines (see Exhibit 2). These requirements are based on IEEE Standard 519, “IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems”.

The Customer agrees that the operation of motors, appliances, devices or apparatus served by its system and resulting in harmonic distortions in excess of the Company's Requirements will be the Customer's responsibility to take immediate action, at the Customer's expense, to comply with the Company's Harmonic Distortion Requirements. The Company will work collaboratively with the Customer to assess problems, identify solutions and implement mutually agreed to corrective measures.

If the Customer fails to take corrective action after notice by the Company, the Company shall have such rights as currently provided for under its tariffs, which may include discontinuing service, until such time as the problem is corrected.

Exhibit 1



Composite curve of voltage flicker studies by General Electric Company, *General Electric Review*, August 1925; Kansas City Power & Light Company, *Electrical World*, May 19, 1934; T&D Committee, EEI, October 24, 1934, Chicago; Detroit Edison Company; West Pennsylvania Power Company; Public Service Company of Northern Illinois.

Relations of Voltage Fluctuations to Frequency of Their Occurrence (Incandescent Lamps)

EXHIBIT 2

HE HARMONIC DISTORTION REQUIREMENTS

The HE Harmonic Distortion Requirements shown below are based on the information I_L presented in the IEEE Standard 519, approved in 1992 and titled, "IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems." The voltage limits are intended to be used to gauge the acceptability of harmonic magnitudes on the transmission systems, while the current limits are applicable to individual customers injecting harmonic currents at the point of common coupling (FCC).

HARMONIC VOLTAGE DISTORTION (THD_v) LIMITS

Bus Voltage at PCC	Individual Harmonic Voltage Distortion (%)	Total Voltage Distortion THD_v (%)
≤69kV	3.0	5.0
69kV<v≤161kV	1.5	2.5
Above 161 kV	1.0	1.5

HARMONIC CURRENT DEMAND DISTORTION (TDD) LIMITS

MAXIMUM HARMONIC CURRENT DISTORTION IN % OF BASE QUANTITY Harmonic Order (Odd Harmonics)						
v ≤ 69 kV						
I_{SC} / I_L	< 11	11 ≤ h < 17	17 ≤ h < 23	23≤ h<35	35 ≤ h	TDD
<20	4.0	2.0	1.5	0.5	0.3	5.0
20-50	7.0	3.5	2.5	1.0	0.5	8.0
50-100	10.0	4.5	4.0	1.5	0.7	12.0
100-1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0
69 kV < v ≤ 161 kV						
< 20*	2.0	1.0	0.75	0.3	0.15	2.5
20-50	3.5	1.75	1.25	0.5	0.25	4.0
50-100	5.0	2.25	2.0	0.75	0.35	6.0
100-1000	6.0	2.75	2.5	1.0	0.5	7.5
>1000	7.5	3.5	3.0	1.25	0.7	10.0
161 kV<v						
<50	2.0	1.0	0.75	0.3	0.15	2.5
≥50	3.0	1.5	1.15	0.45	0.22	3.75

Where I_{SC} = Maximum short circuit at PCC
I_L = Load current at the time of the maximum metered amount

*All power generation equipment is limited to these values of current distortion, regardless of actual I_{SC} / I_L.

Even harmonics are limited to 25% of the odd harmonic limits above.

EXHIBIT 3

Definitions

o **Harmonic Voltage Distortion** is to be normalized to the nominal system voltage and calculated using Equation 1.

TOTAL VOLTAGE HARMONIC DISTORTION (THD_v) in percent:

$$THD_v = \frac{\sqrt{\sum_{n=2}^{\infty} V_n^2}}{V_s} \times 100\% \qquad (Eq.1)$$

Where:

V_n = Magnitude at Individual Harmonics (RMS)
V_s = Nominal System Voltage (RMS)
n = Number of Harmonic Order

o **Harmonic Current Distortion** is to be normalized to the customer's load current at the time of the maximum metered demand which occurred over the preceding twelve months for existing customers and the customers anticipated peak demand for new customers. For existing customers who are increasing their load, the projected demand should be used. The harmonic current demand distortion (TDD) should be calculated using Equation 2.

TOTAL CURRENT DEMAND DISTORTION (TDD) in percent:

$$TDD = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_L} \times 100\% \qquad (Eq.2)$$

Where:

I_n = magnitude of Individual Harmonic (RMS)
I_L = Load Current at the Time of the Maximum Metered Demand
n = Harmonic Order

o **PCC - Point of Common Coupling.** The location where the customer accepts delivery of electrical energy from the utility.

Field Measurements

To gauge the acceptability of field measured harmonic distortion, a statistical evaluation of the data is to be performed. Measurements should be taken at live minute intervals or less over a minimum of 24 hours. For the measured data to be considered acceptable, two criteria must be met: 1) 95% of the measured data must fall below the limits stated; 2) no measured data shall exceed the limits specified by more than 50% of the absolute upper limit value.

Communication Interference Limits l*T

EXHIBIT 4

As stated n IEEE Standard 519, it is difficult to place specific limits on the telephone influence which the harmonic components of current and voltage can inflict. Hence, IEEE Standard 519 outlines a range of values where problems could our (refer 10 the table below). The actual interference to voice communication systems in proximity to the power system is dependent upon a number of factors not under the control of the utility or customer, These factors will vary from location to location and from time to time as the state-of-the-art of inductive coordination progresses.

IEEE Standard 519 - Balanced I*T Guidelines		
Category	**Description**	**I*T**
I	Levels most unlikely to cause interference	<10,000
II	Levels that might cause interference	10,000 to 25,000
II	Levels that probably will cause interference	> 50,000

The limit applicable to HE is the upper bound limit of the I*T levels that might cause interference on telephone systems. Thus, the customer induced harmonics shall not result in an I*T product to exceed 25,000 weighted amperes per phase, applicable to both the transmission and distribution systems. Residual I*T should also be minimized. Residual I*T is I_G*T, where I_G is the earth return current and is defined as the difference between the phasor sum of phase currents and neutral current. The I*T calculation is to be performed using Equation 3. The weighting of harmonic currents should conform to the 1960 TIF curve shown below.

$$I^*T = I^*TIF = \sqrt{\sum_{n=1}^{K} (I_n * W_n)^2} \quad \textit{weighted amperes} \qquad (Eq.3)$$

Where:

I = Current of individual harmonics, amperes, RMS
T = Telephone Influence Factor (TIF)
W_n = Single frequency TIF weighting at frequency n (refer to table and chart below)
K < 42, Maximum harmonic order

FREQ	TIF (W)	FREQ	TIF (W)	FREQ	TIF (W)	FREQ	TIF (W)
60	0.5	1020	5100	1860	7820	3000	9670
180	30	1080	5400	1980	8330	3180	8740
300	225	1140	5630	2100	8830	3300	8090
360	400	1260	6050	2160	9080	3540	6730
420	650	1380	6370	2220	9330	3660	6130
540	1320	1440	5650	2340	9840	3900	4400
660	2260	1500	6680	2460	10340	4020	3700
720•	2760	1620	6970	2580	10600	4260	2750
780	3360	1740	7320	2820	10210	4380	2190
900	4350	1800	7570	2940	9820	5000	840
1000	5000						

APPENDIX C

Electrical Clearances and Equipment Ratings

APPENDIX C

ELECTRICAL CLEARANCES

Nominal System Voltage (kV)	Basic Impulse Insulation Level (BIL) (KV crest) (2) Bus & Transformer Winding	Transformer Bushing	Outdoor Design Clearance (in.) Centerline-Ground Rigid Bus	Centerline-Ground Strain Bus	Centerline-Centerline Rigid Bus	Centerline-Centerline Strain Bus	Air Insulated Switch Design Clearance (in.) Air Break Phase Spacing	Disconnect Phase Spacing	Station Post Insulators Technical Reference Number(1)(2)
765	2050	2050	195	240	390	480	480	390	n/a
500	1550	1550	147	180	270	300	300	270	379
345	1050	1050	99	132	150	180	216	150	316
230	900	900	84	120	124	164	192	124	304,308
161	750	750	63	86	86	116	168	86	291,295
138	550	650	46	60	72	84	144	72	286,287
88	450	550	37	44	54	60	108	54	286,287
69	350	350	29	36	42	48	84	42	216
46	250	250	21	24	36	42	72	36	214
34.5	200	200	16	21	30	36	60	30	210
23	150	200	13	18	24	30	60	30	208

(1) The technical reference numbers shown are a widely used identification series for post type insulators and are the HE standard for the voltage class. Refer to ANSI Standard C29.9-1983, Table 1, for dimensions and characteristics for each insulator. Higher strength insulators with different technical reference numbers are available and should be used if required. The ANSI Technical Reference (T.R.) numbers refer to insulators with specific mechanical ratings. Higher ratings may be required or may be adequate according to the duty of the specific application.

(2) Substations in heavily contaminated areas may require a higher insulation level than indicated.

APPENDIX D

Protective Loop Installation

Figure 1 -- Ground Protection Loop with Static Wire

Figure 2 -- Ground Protection Loop without Static Wire

APPENDIX D

PROTECTIVE LOOP INSTALLATION
for various line conditions

Air Break Switch on a Line	**Wood Pole Line** **Direct Embedded Steel Pole** **Self Supported Steel Pole**
1. With shield wires grounded at every structure and extending for at least ½ mile in both directions from the air break switch location.	Grounding Protection Loop Fig. 1
2. With ungrounded shield wires extending for at least ½ mile in both directions from the air break switch location.	Grounding Protection Loop Fig. 2
3. With air break switch ground bonded to multi-grounded neutral or to nearby station ground grid.	Grounding Protection Loop Fig. 1
4. With no shield wire or shield wire extending less than ½ mile in both directions, with no multi-grounded neutral and with air break switch not bonded to nearby station ground grid.	Grounding Protection Loop Fig. 2

Design Limits:

$\mathbf{I}_{\Phi\text{-Gnd}} =$ 8000A Max.
Soil Resistivity = 500 Ω-Meter Max.
(If exceeded further analysis is required)
Spread 3/4 " crushed stone with 10-15% binding material,
4 " deep over entire area extending 1'-0" beyond grounding

NOTES FOR FIGURE 1 & 2

A.) For wood pole structures, a minimum 8 foot length of wood or plastic protective molding should be installed to completely cover the 4/0 AWG copper ground wire.

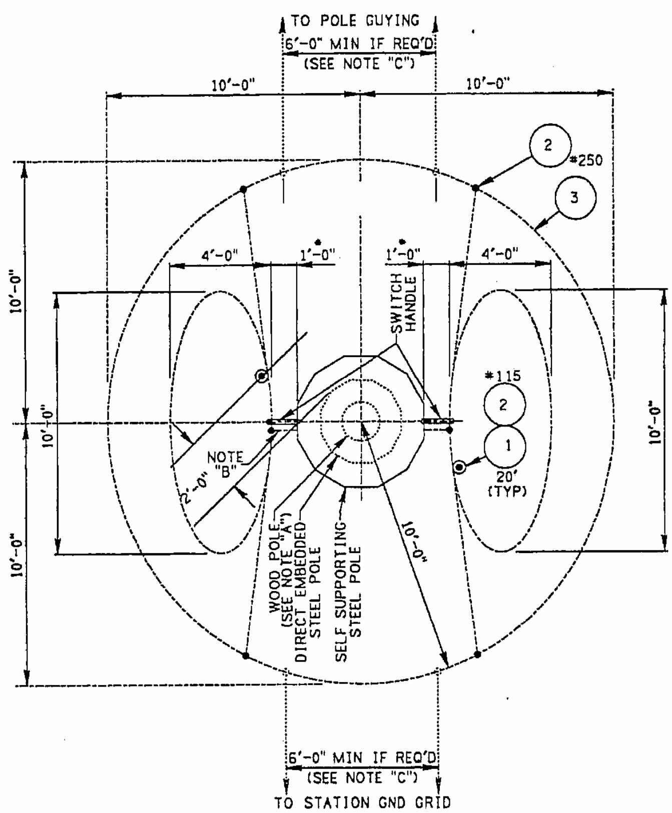
B.) Tie protective grounding loop to 4/0 AWG copper ground wire (Wood Pole) or structure ground pad (Steel Pole). In either case, the switch handle ground must be terminated to this 4/0 AWG copper ground wire.

C.) If switch structure is 100 feet or less from existing station ground grid, guy wire anchor grounding is recommended. Also, connect protective ground loop to existing station ground grid as noted.

FIGURE 1

GROUNDING PROTECTIVE LOOP WITH STATIC WIRE

(MANUAL OPERATION ONLY)



*= MAINTAIN 1'-0" BETWEEN POLE EDGE AND GROUND LOOP REGARDLESS OF POLE TYPE OR DIAMETER

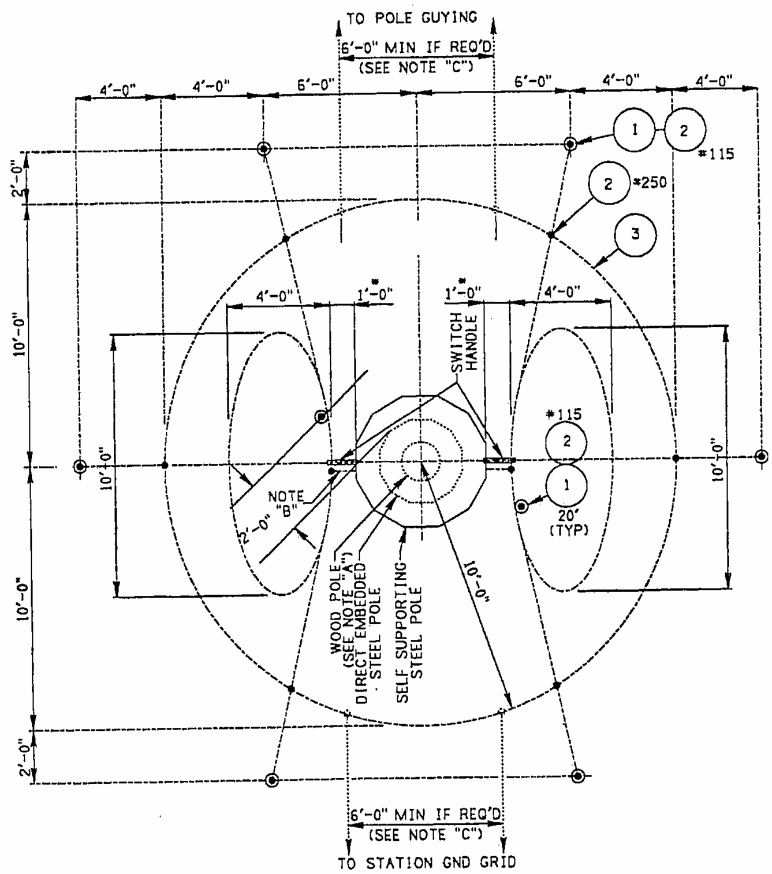
LEGEND

1. ¾" GROUND ROD (LENGTH AS NOTED)
2. EXOTHERMIC CONNECTION (CART SIZE AS NOTED)
3. 4/0 AWG CU-SOLID SOFT DRAWN

FIGURE 2

GROUNDING PROTECTIVE LOOP WITHOUT STATIC WIRE

(MANUAL OPERATION ONLY)



*= MAINTAIN 1'-0" BETWEEN POLE EDGE AND GROUND LOOP REGARDLESS OF POLE TYPE OR DIAMETER

LEGEND

1. ¾" GROUND ROD (LENGTH AS NOTED)
2. EXOTHERMIC CONNECTION (CART SIZE AS NOTED)
3. 4/0 AWG CU-SOLID SOFT DRAWN

APPENDIX E

Turnover Inspection Requirements Form

Appendix E

CONNECTING FACILITY
Electrical Facility Checkout Guide (Turnover Inspection)

ITEM	ACTION/INFORMATION	BY	DATE
1. Facility Ground Resistance	Review Test Results	________	________
2. Air break and Disconnect Switch Alignment			
a. *Switch Device Number* ____________	Visual Inspection	________	________
b. *Switch Device Number* ____________	Visual Inspection	________	________
c. *Switch Device Number* ____________	Visual Inspection	________	________
d. *Switch Device Number* ____________	Visual Inspection	________	________
e. *Switch Device Number* ____________	Visual Inspection	________	________
f. *Switch Device Number* ____________	Visual Inspection	________	________
3. Circuit Breakers			
a. kV Circuit Breaker *Device Number*			
1. Gas Filled	Visual Inspection	________	________
2. Timing Tests	Review Test Results	________	________
3. Digital Low R Ohmmeter	Review Test Results	________	________
4. Doble Test	Review Test Results	________	________
5. CT Ratio & Polarity	Review Test Results	________	________
6. Breaker Alarms	Detailed Inspection	________	________
4. Circuit Switcher			
a. _____kV Circuit Breaker *Device Number*			
1. Hipot Test	Review Test Results	________	________
2. Timing Test	Review Test Results	________	________
3. Digital Low R Ohmmeter	Review Test Results	________	________
5. Fuses			
a. _____kV Fuses *Device Number*			
1. Rating/Type	Visual Inspection	________	________
2. Air Flow Test	Review Test Results	________	________
6. Power Transformer			
a. _____kV Transformer *Device Number*			
1. CT Ratio & Polarity	Review Test Results	________	________

7. CCVT/VT

a. _____kV *Circuit/Line Name* CCVT/VT *Device Number*

1. Doble Test	Review Test Results	________	________
2. Potential Polarizing Test	Review Test Results	________	________
3. Ratio & Polarity Test	Review Test Results	________	________

b. _____kV CCVT/VT *Device Number*

1. Doble Test	Review Test Results	________	________
2. Potential Polarizing Test	Review Test Results	________	________
3. Ratio & Polarity Test	Review Test Results	________	________

8. Phasing

a. _____kV BUS *Number*	Detailed Inspection	________	________

9. Batteries and Charger

a. _____V DC Battery and Charger

1. Battery Acceptable	Review Test Results	________	________
2. Intercell Resistance Test	Review Test Results	________	________
3. Charger Settings	Visual Inspection	________	________
4. Ground Detector	Detailed Inspection	________	________

10. SCADA

a. Function Test with SCC

1. Control	Detailed Inspection	________	________
2. Indication	Detailed Inspection	________	________
3. Alarms	Detailed Inspection	________	________

b. Metering	Detailed Inspection	________	________

11. Relay and Control Schematics

a. _____kV Circuit Breaker *Device Number*

1. Correct Settings Applied	Review Test Results	________	________
2. Calibration Test	Review Test Results	________	________
3. Trip Test	Detailed Inspection	________	________
4. In-Service Load Angles	Detailed Inspection	________	________
5. Remote Relay Communication	Detailed Inspection	________	________

b. _____Annunicators and Alarms

1. Set Undervoltage & Time Delay Relays	Review Test Results	________	________
2. Function Tested	Review Test Results	________	________

12. Miscellaneous

a. Arrestors

1. Sized Correctly	Visual Inspection	_______	_______
2. Located Properly	Visual Inspection	_______	_______

b. Clearance

1. Bus to Ground	Visual Inspection	_______	_______
2. Bus to Bus	Visual Inspection	_______	_______
3. Bus to Steel	Visual Inspection	_______	_______