NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Agenda
System Protection and Control Subcommittee

February 17, 2016 | 8:00 a.m. – 5:00 p.m. CT
February 18, 2016 | 8:00 a.m. – Noon CT

Oncor Electric Delivery
115 W 7th Street
Room 3156
Ft. Worth, TX 76102

Conference Dial-in Information: 1-866-740-1260 | Access Code: 5506033 | Security Code: 021716

Register for Webinar access here: ReadyTalk

Introduction and Chair's Remarks (Wednesday: 8:00 – 8:10 a.m.) **– Phil Winston**

Host Arrangements and Safety Briefing (Wednesday: 8:10 – 8:15 a.m.) – **Sam Francis**

NERC Antitrust Compliance Guidelines and Public Announcement* (Wednesday: 8:15 – 8:20 a.m.) **– Katherine Street**

Agenda Items

1. **Agenda (Approve)** (Wednesday: 8:20 – 8:25 a.m.) **– Phil Winston**
2. **Meeting Minutes* (Approve)** (Wednesday: 8:25 – 8:30 a.m.) **– Phil Winston**
3. **Unit Auxiliary Transformer Protection* (Review Comments and update report for submission to the PC in March for information)** (Wednesday 8:30 a.m. - 5:00 p.m.) **– SPCS**
4. **Review SPCS library of Documents for potential inclusion in NERC library and/or updating** (Thursday 8:00am-10:30a.m.) **– Bob Cummings to lead**
5. **Review of PRC Standards Under Development (Discuss)** (Thursday 10:45-11:30 a.m.)
   a. PRC-001-2 and PRC-027-1, System Protection Coordination
   b. PRC-002-2, Disturbance Monitoring
   c. PRC-004-3, Protection System Misoperations
   d. PRC-005-6, Protection System Maintenance and Testing
   e. PRC-006-2 and PRC-010-1; Underfrequency and Undervoltage Load Shedding
   f. PRC026-1; Protection System Response to Power Swings
6. **Protection philosophy for devices such as synchronous condensers, SVCs, STATCOMS, etc. (Discuss)** (Thursday 11:30-11:45 a.m.) **– David Till**

7. **Review of Actions/Assignments – Katherine Street**
8. **Future Meetings**
    a. TBD
9. **Adjourn**

*Background materials included.
**Note: 10- 15 minute breaks are scheduled for 9:30, 10:30, 2:00, and 3:30. Lunch on Wednesday 11:30-12:30

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Antitrust Compliance Guidelines

I. General

It is NERC's policy and practice to obey the antitrust laws and to avoid all conduct that unreasonably restrains competition. This policy requires the avoidance of any conduct that violates, or that might appear to violate, the antitrust laws. Among other things, the antitrust laws forbid any agreement between or among competitors regarding prices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that unreasonably restrains competition.

It is the responsibility of every NERC participant and employee who may in any way affect NERC's compliance with the antitrust laws to carry out this commitment.

Antitrust laws are complex and subject to court interpretation that can vary over time and from one court to another. The purpose of these guidelines is to alert NERC participants and employees to potential antitrust problems and to set forth policies to be followed with respect to activities that may involve antitrust considerations. In some instances, the NERC policy contained in these guidelines is stricter than the applicable antitrust laws. Any NERC participant or employee who is uncertain about the legal ramifications of a particular course of conduct or who has doubts or concerns about whether NERC's antitrust compliance policy is implicated in any situation should consult NERC's General Counsel immediately.

II. Prohibited Activities

Participants in NERC activities (including those of its committees and subgroups) should refrain from the following when acting in their capacity as participants in NERC activities (e.g., at NERC meetings, conference calls and in informal discussions):

- Discussions involving pricing information, especially margin (profit) and internal cost information and participants' expectations as to their future prices or internal costs.
- Discussions of a participant's marketing strategies.
- Discussions regarding how customers and geographical areas are to be divided among competitors.
- Discussions concerning the exclusion of competitors from markets.
- Discussions concerning boycotting or group refusals to deal with competitors, vendors or suppliers.

- Any other matters that do not clearly fall within these guidelines should be reviewed with NERC's General Counsel before being discussed.

III. Activities That Are Permitted

From time to time decisions or actions of NERC (including those of its committees and subgroups) may have a negative impact on particular entities and thus in that sense adversely impact competition. Decisions and actions by NERC (including its committees and subgroups) should only be undertaken for the purpose of promoting and maintaining the reliability and adequacy of the bulk power system. If you do not have a legitimate purpose consistent with this objective for discussing a matter, please refrain from discussing the matter during NERC meetings and in other NERC-related communications.

You should also ensure that NERC procedures, including those set forth in NERC's Certificate of Incorporation, Bylaws, and Rules of Procedure are followed in conducting NERC business.

In addition, all discussions in NERC meetings and other NERC-related communications should be within the scope of the mandate for or assignment to the particular NERC committee or subgroup, as well as within the scope of the published agenda for the meeting.

No decisions should be made nor any actions taken in NERC activities for the purpose of giving an industry participant or group of participants a competitive advantage over other participants. In particular, decisions with respect to setting, revising, or assessing compliance with NERC reliability standards should not be influenced by anti-competitive motivations.

Subject to the foregoing restrictions, participants in NERC activities may discuss:

- Reliability matters relating to the bulk power system, including operation and planning matters such as establishing or revising reliability standards, special operating procedures, operating transfer capabilities, and plans for new facilities.
- Matters relating to the impact of reliability standards for the bulk power system on electricity markets, and the impact of electricity market operations on the reliability of the bulk power system.
- Proposed filings or other communications with state or federal regulatory authorities or other governmental entities.

Matters relating to the internal governance, management and operation of NERC, such as nominations for vacant committee positions, budgeting and assessments, and employment matters; and procedural matters such as planning and scheduling meetings.

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Public Announcements

REMINDER FOR USE AT BEGINNING OF MEETINGS AND CONFERENCE CALLS THAT HAVE BEEN PUBLICLY NOTICED AND ARE OPEN TO THE PUBLIC

For face-to-face meeting, with dial-in capability:
Participants are reminded that this meeting is public. Notice of the meeting was posted on the NERC website and widely distributed. The notice included the number for dial-in participation. Participants should keep in mind that the audience may include members of the press and representatives of various governmental authorities, in addition to the expected participation by industry stakeholders.

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System Protection and Control Subcommittee

DRAFT Meeting Minutes

November 11-12, 2015
MRO Offices in St. Paul, Minnesota

1. Introduction

The meeting was brought to order by Phil Winston, chair, at 8:30 a.m. CT, Wednesday, November 11, 2015. He requested those in attendance introduce themselves. He also thanked Sam Francis who have served our great nation, and those who have given their lives in service to our country. Rich Quest provided a safety briefing and housekeeping. The attendees are as follows:

Name	Representing	Name	Representing
Amir Najafzadeh	NERC Staff	Jonathan Sykes	Pacific Gas & Electric
Bill Crossland	Reliability First	Mark Gutzmann	Xcel Energy
Brad Gordon	NERC Staff	Mathew Pacobit	Associated Electric Cooperative, Inc.
Dan Schoenecker	MRO Staff	Phil Winston	Southern Company
David Greene	SERC Staff	Rich Quest	MRO Staff
David Till	NERC Staff	[1]Sam Francis	Oncor
Jeffrey IIer	American Electric Power	[1]Sandeep Sadanandan	FERC
John Seidel	MRO Staff		

The attendees were apprised of the NERC Antitrust Compliance Guidelines and the public nature of the meeting.
The agenda (see appendix A) and meeting minutes of April 21-22, 2015 were reviewed, and approved.

2. Review of the UAT Report

Jonathan Sykes and Phil Winston had incorporated all comments from SPCS members into the UAT report. The focus of the report is to highlight the recommendations and to echo the purpose of the report. The low-side over current limits of generating unit auxiliary transformer was discussed in detail, with considerations for auxiliary load components (motor or resistive load) as well as other protection devices interference with UAT low-side settings. The SPCS will continue incorporating remaining comments with UAT report findings to be presented to the Planning Committee in December 2015, with final approval of the report in March 2015.

3. Misoperations and Collaboration with NERC Performance Analysis

Brad Gordon (Senior Engineer of Performance Analysis) and David Till (Manager of Performance Analysis) presented on preliminary findings of system protection misoperations, and asked the group the best manner to represent the data and draw conclusions.

4. Other Items

The SPCS work plan submitted to the Planning Committee was reviewed and amended.
The SPCS will be revisit, sunset, or revise published guidelines and references in 2016.
FERC Order 754 report was approved by the Planning Committee in September 2015, and a SAR drafting team will be formed to review the SAR in preparation for the Standard Drafting Team in order to implement the SPCS recommendations into the TPL standard.

[1] Participated via teleconference.

Appendix A – Meeting Agenda

System Protection and Control Subcommittee

Meeting Agenda

November 11, 2015 | 8:00am – 5:00pm (CDT)
November 12, 2015 | 8:00am – 12:00pm (CDT)

MRO Offices in St. Paul
380 St. Peter Street, Suite 800
St. Paul, MN 55102

Teleconference: (866)740-1260 | **Access Code:** 2415222 | **Security Code:** 2415
Webinar Link: http://www.readytalk.com/?ac=2415222

NERC On-Site Contact: Amir Najafzadeh (404) 330-4137

Wednesday, November 11*

8:00 – 8:30 am

5. Administrative

a. Welcome and introductions – *Phil Winston, SPCS Chair*
b. NERC Antitrust Compliance Guidelines – *Amir Najafzadeh, NERC RA Staff*
c. Facilities & Safety Briefing – *MRO Staff*
d. Review agenda – *Amir Najafzadeh, NERC RA Staff*
e. Review April Meeting Minutes – *Amir Najafzadeh, NERC RA Staff – Jonathan moved. Bill seconded.*

8:30 – 10:00 am

6. Review of the UAT report and comments

a. Based on FERC's recommendation/ questions for the low side and high side of transformer over current limits.
b. Review Assignment
c. Next Steps

10:00 – 10:15 am

BREAK

10:15 – 11:59 am

Review of the UAT report and comments (con't)

12:00 – 1:00 pm

LUNCH

1:00 – 3:00 pm

Review of the UAT report and comments (con't)

3:00 – 3:15 pm

BREAK

3:15 – 5:00 pm

Review of the UAT report and comments (con't)

5:00pm

ADJOURN

Thursday, November 12*

8:00 – 10:00 am

Review of the UAT report and comments (con't)

10:00 – 10:15 am

BREAK

10:15am – 12:00 am

7. **Other items as time permits:**
   a. Misoperations and collaboration with PA
      - 2014 Analysis of System Protection Misoperation Report Review
      - Discussion and next steps: Scope, outline, etc.
   b. FERC Order 754 SAR review and assign volunteers on the drafting team as recommended by the Planning Committee
   c. Review the previously published guidelines; Assign volunteers to review and recommend changes
   d. Review of Planning Committee Work Plan for SPCS in 2016
   e. Review action items
   f. Next meeting confirmation

12:00pm

ADJOURN

1:00 -3:00 pm

Note: room is available in case more time is needed.

*Agenda times are subject to change based on progress on primary task. (#2)

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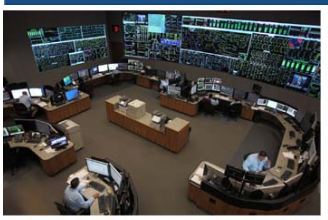
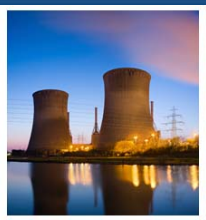
Unit Auxiliary Transformer Overcurrent Relay Loadability During a Transmission Depressed Voltage Condition

NERC System Protection and Control Subcommittee

December 2015

RELIABILITY | ACCOUNTABILITY

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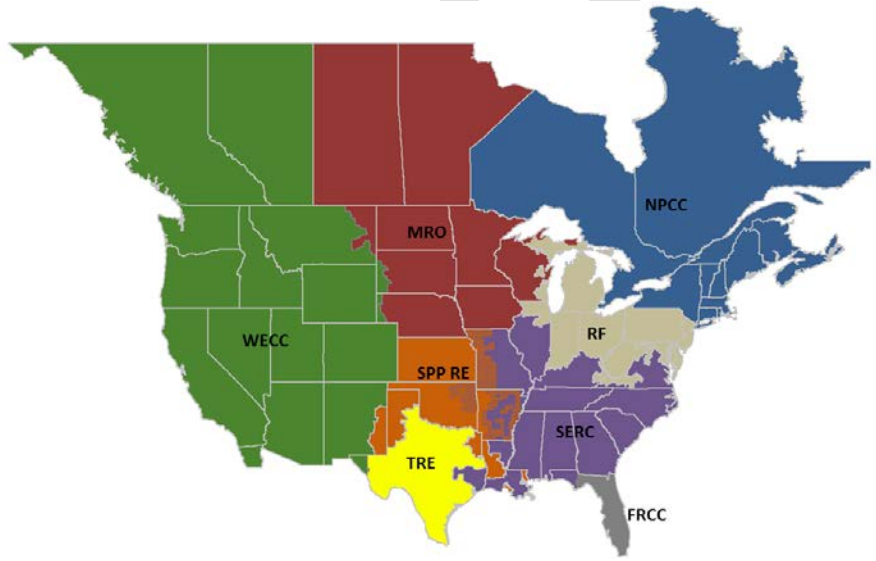
Preface

The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to assure the reliability of the bulk power system (BPS) in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the electric reliability organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

The North American BPS is divided into several assessment areas within the eight Regional Entity (RE) boundaries, as shown in the map and corresponding table below.



The Regional boundaries in this map are approximate. The highlighted area between SPP and SERC denotes overlap as some load-serving entities participate in one Region while associated transmission owners/operators participate in another.

FRCC	Florida Reliability Coordinating Council
MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
SPP-RE	Southwest Power Pool Regional Entity
TRE	Texas Reliability Entity
WECC	Western Electricity Coordinating Council

Executive Summary

TheTheTheThe NERC Board adopted proposed Reliability Standard PRC-025-1 – Generator Relay Loadability on August 15, 2013 and requested NERC staff and standard drafting team to investigate whether a potential gap in reliability exists for unit auxiliary transformer (UAT) protective relays not applicable in the proposed Reliability Standard. The standard drafting team recommended a three tiered approach to assessing and mitigating any risk not revealed in the study: monitoring, and if needed, a guideline or enhancement to the Reliability Standard(s). NERC staff determined that the GADS and TADS applications were not organized in a manner that would lead to meaningful conclusions in monitoring. Therefore, the NERC Planning Committee (PC) tasked the NERC System Protection and Control Subcommittee (SPCS) to study the application of the load-responsive unit auxiliary transformers (UAT) low-side protective relays to account for increased loading during depressed transmission voltages. This paper provides the technical basis for minimum guidelines for the relay in question. and determine whether a guideline or changes to the standard were necessary.

Depressed voltage will cause an increase in the load ofloading onf the UAT transformer. The relaying applied on the UAT transformer must not operate based on thisdue to the increased load. A depressed transmission system voltage of 85% is used assumed based on studies, and recommendations recommendation from the *Technical Analysis of the August 14, 2003, Blackout* report[1] and subsequent reliability requirements in various NERC standards (i.e. PRC-023[2] and PRC-024[3]). The relay must not operate for at least 3 seconds based on the low voltage ride through requirements derived in NERC Standard PRC-024. This provides the minimum requirements for the relay in question.

The SPCS has determined that a load- responsive relay applied on the low side of the UAT set with a minimum pickup value of 135% of the transformer nameplate is adequate to prevent the UAT protection relays from operating due to depressed voltage conditions. This includes a 20% conservative margin to account for higher percentages of motor loads, inaccuracies of current transformers, and inaccuracies of relays. The 135% pickup value also aligns with industry recommendations for the protection of transformers. Setting the protection for UAT per the guidelines in this paper supports the low voltage ride-through requirement of NERC PRC-024 standard.

In some situations it might be desirable to set this relay lower than 135% of the transformer nameplate. This could be to protect equipment or because the load of on the transformer can is be much less than the nameplate rating of the transformer. If this option approach is used, then it is recommended the settings must be 135% of the maximum load on the UAT.

…

As a result of the analysis conducted by the SPCS, we recommend that the Planning Committee adopt this paper as the technical basis for setting guidelines for the relay in question.

Commented [CT1]: Need a bit more background giving a more accurate understanding of where we are what we are trying to accomplish.

Commented [WPB2]: PBW ok with this

Commented [BGT3]: The paper uses a mix of "load-responsive" and "overcurrent" terms. I assume the use of "load-responsive" in the Executive Summary was intentional. So, it is not clear why "overcurrent" is used in other parts of the report, including in the overall title and a section title, but not here. It might improve the paper to use one terminology throughout.

Commented [WPB4]: Rich, ok to change to overcurrent?

Commented [WPB5]: PBW do not agree with this

Commented [CT6]: I see later on where you assumed the 85% propagated directly to the aux bus, but I think it is important here to highlight that it is the transmission system we are trying to support. In reality, I think 85% voltage on the aux bus is VERY conservative, even for a plant that has separate transmission voltage connections for its aux transformer(s) because in these configurations transformers are set-up boosting the MV bus voltage to compensate for internal voltage drop.

Commented [WPB7]: Ans to Carl: The report also covers the worst case of a t connected UAT

Commented [WPB8]: PBW ok with these changes

Commented [WPB9]: No to adding this

[1] Technical Analysis of the August 14, 2003, Blackout: What Happened, Why, and What Did We Learn?
[2] Standard PRC-023-2 — Transmission Relay Loadability
[3] Standard PRC-024-2 — Generator Frequency and Voltage Protective Relay Settings

Introduction and Background

The NERC Board adopted proposed Reliability Standard PRC-025-1 – Generator Relay Loadability on August 15, 2013 and requested NERC staff and the standard drafting team to investigate whether a potential gap in reliability exists for unit auxiliary transformer (UAT) protective relays not applicable in to the proposed Reliability Standard. The UAT, for the purposes of this report, supplies the overall auxiliary power necessary to keep the generating unit online. This study was in response to one unresolved minority issue raised by industry:

Problem Statement: "The application for UAT Facilities may not address all the load-responsive protective relays that potentially impact the operation of a generating unit or generating plant during the conditions anticipated by the proposed Reliability Standard."

The Reliability Standard PRC-025-1 (*Generator Relay Loadability*) did not include certain UAT protective relays; specifically, the low-voltage side load-responsive protective relay(s). In a study prepared in response to the Board's request, the standard drafting team determined that there is no adverse reliability impact resulting from excluding these UAT protective relays in the proposed Reliability Standard. However, based on the conservative study, the standard drafting team concluded acknowledged that the Protection System margins typically applied on these UAT protective relays by industry are an important consideration in the loadability of the UAT. Therefore, the standard drafting team recommended a three tiered approach to assessing and mitigating any risk not revealed in the study~~.~~: monitoring, and if needed, a guideline or enhancement to the Reliability Standard(s). The three steps tiers are:

1. Monitoring – Investigate the feasibility to revise or append the NERC GADS cause codes with greater granularity to facilitate the monitoring and tracking of the UAT, for both load-responsive high-side and low-side protective relay(s) that cause the loss of generation due to a depressed voltage as anticipated by the PRC-025-1 standard.
2. Guideline – Solicit industry input through the appropriate NERC committee for establishing a guideline for setting load-responsive UAT low-side overload protective relays to account for increased loading during depressed voltages. This guideline should be based on information revealed through monitoring that demonstrates a need for industry guidance and not a reliability standard. This option is next if monitoring is not feasible.
3. Standard – Revise the PRC-025-1 standard or create a new standard to address the loadability of the load-responsive UAT high-side and low-side protective relays if lessons learned through monitoring and/or developed guidance do not demonstrate the necessary reliability described in the standard.

NERC staff completed the first step in the tiered approach to start with monitoring generator outages that might involve UAT protective relays not included in the PRC-025-1 Reliability Standard through the NERC Generator Availability Data System (GADS) and/or Transmission Availability Data System (TADS) applications. The expectation was that reported occurrences identified through monitoring will would be assessed through NERC's risk analysis processes and matched appropriately with the next two recommended tiers of industry action, including the initiation of an industry guideline or revision to Reliability Standard PRC-025.

NERC staff determined that the GADS and TADS applications were not organized in a manner that would lead to meaningful conclusions about the risk that UAT low-side protective relays might have to tripping during a depressed voltage of 0.85 per unit event. Because of this, the NERC Planning Committee directed the NERC System Protection and Control Subcommittee to analyze the risk concerning the loadability of unit auxiliary transformers'~~transformers~~ (UAT) protective relays. ~~Based upon the analysis,~~ it appears ~~the PC would~~

Commented [CT10]: Note that the applicability section of the standard does not state high side or low side – it just says "at the terminals". Requirement R1 referred to Table 1 for the setting requirements, and Table 1 provides setting requirements for relays on the high side of the transformer. Nowhere is it explicitly written that low side relays are not applicable to the standard.

Commented [CT11]: Where is this study? Can it be referenced?

Commented [WPB12]: Add reference to study

Commented [CT13]: Is the SDT conclusion really "based on the conservative study"? Use of "conservative" is confusing in this context because it does not appear that the conservatism of the study had anything to do with the conclusion that further analysis was warranted. I have seen this statement written a few times, and worded differently each time. As a result, I am not 100% clear as to in what way the results of the study indicated there was not a gap but that the SDT felt this was not conclusive and warranted further analyses.

Commented [CT14]: It bothers me that we advocated this step in this way (I know the language pre-dates this report) – At what stage did we truly investigate the severity of the issue? We state that each tier is only implemented when the previous tier is unsuccessful – how would we know that the "guideline" was not successful? Furthermore, because we have no GADs data – we don't even really know if a guideline is necessary. How can we advocate these steps when we don't know if there is a problem?

Commented [WPB15]: This is a quote and therefor the comment is mute

Commented [WPB16]: n

Commented [WPB17]: o need to add this except to satisfy him. No problem adding.

Commented [CT18]: Throughout this report we use "loadability" in a wide array of contexts.

Commented [WPB19]: OK with this

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~~recommend~~ that development of a guideline or modification of the applicable Reliability Standard(s) be pursued~~, the appropriate action according to steps two and three above~~.

Commented [WPB20]: PBW I agree with deleting

Commented [BGT21]: Not sure what the original text was intended to propose or request. I edited it to make it clearer, based on my assumption of what was intended. However, it seems that the best approach would be to leave this sentence out of the paper and make the request to the PC when the paper is presented.

Commented [BE22]: First, it seems that the SPCS should be the one making the recommendation. Second, this statement seems to be in conflict with the recommendations in the report which seems to suggest the creation of a guideline, option 2. Third, there seems to be a leap of faith from the previous sentence to this sentence to be able to rationalize this statement. I would recommend that we delete this sentence. Lastly, it wouldn't appear to be either introductory or background.

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Discussion

During a~~a~~n event that causes transmission depressed transmission voltage event resulting in a transmission voltage of 85% of nominal, increased current draw by plant loads may cause unnecessary tripping of the UAT[4] low-side protective relays. The plant station service bus has a combination of relatively constant impedance resistive (non-motor) and inductive induction (motor) loads. The motor load portion of the plant will draw increased current as a consequence of a depressed voltage; resistive loads draw lower current in response to depressed voltage. The general consensus of the standards drafting team was the The aggregate current of these loads during a depressed transmission voltage event is generally not enough to cause operation of the overcurrent relay on the UAT. Nevertheless, a study is needed to verify if there are gaps in this conclusion and provide some consistency for the industry.

The following analysis will study the applications of overcurrent relays on UATs and the relay response during depressed system voltages. Other factors that are unique to the plant and the operation and protection of the transformer have also been considered within this paper and where significant they are discussed in detail. There are references provided for on other factors that were considered that had negligible impact on the loadability of the low side relays. This paper considers assumes that the low voltage event has will occurred while the generating plant is operating under normal conditions.

It is typically assumed that tThe UAT loads typically? consist of up to 90% or less induction motor or inductive loads with the remainder~~reminder~~ as resistive load. However, this paper will also examine the effect of various percentages of motor loads on the UAT (including 100%). The percentage of motor load on UATs varies based on the type of generating plant~~or~~. For example, ~~S~~steam~~generator. Steam~~ units will typically have more motor load than oil or gas units and the The lower the percentage of motor loads will reduce thewithin the plant, the lower the potential for any adverse impact on the loadability of the UAT protection ~~of~~ resulting from~~of~~ low voltages on loadability of the UAT.

The UAT can be connected in at least 3 different configurations. This paper considers the UAT to be connected to the same transmission bus as the GSU (shown in Figure 1 below). This configuration provides a more severe impact of~~to~~~~o~~ the loads on the UAT than the connection of the UAT to the generator bus.

Commented [CT23]: Any load with a lagging power factor is in some way "inductive". The term doesn't describe the way motor load current changes with voltage. For example, if the load was just a large inductor, it would behave line a constant impedance load.

Commented [CT24]: I completely agree with this statement.

Commented [WPB25]: No issue with all these changes. PBW

Commented [CT26]: I think we mean we will study the potential change in load current during depressed system voltages. The relay functions we are discussing are generally not sensitive to voltage.

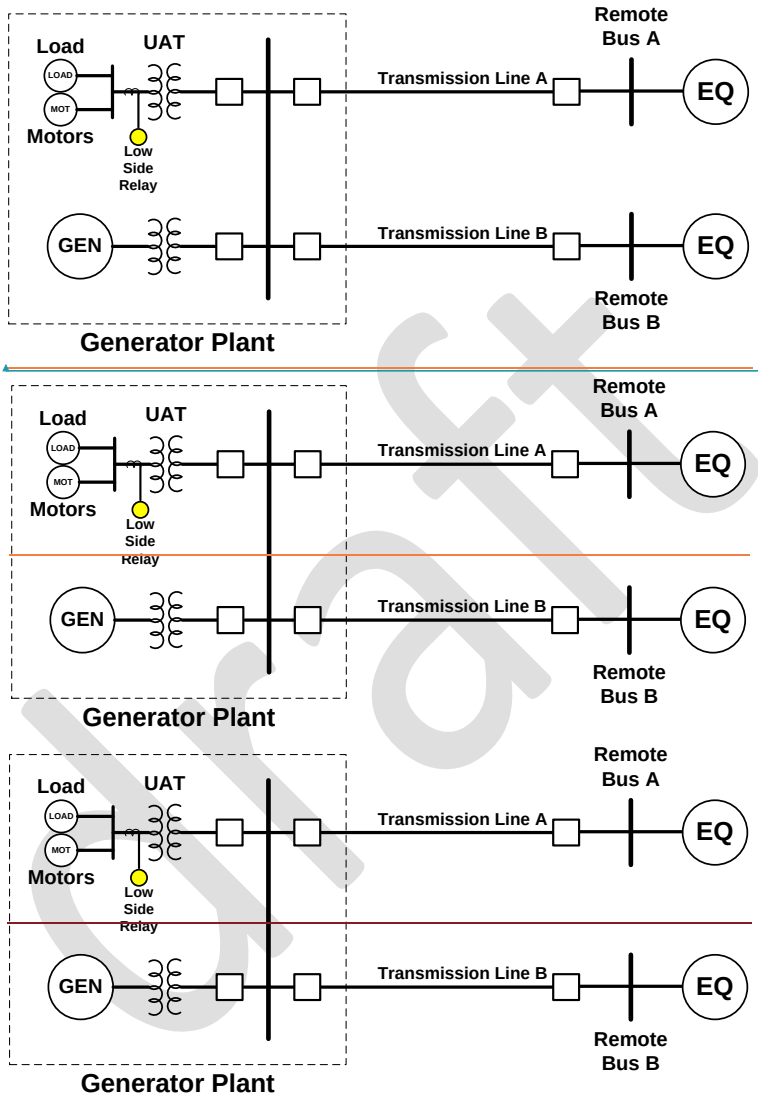
Commented [WPB27]: Ok with this pbw

Commented [CT28]: I believe we strictly mean induction motors. Furthermore, we probably need to differentiate between standard directly connected induction motors and those driven by adjustable frequency drives – these are becoming extremely common, often have their own voltage and frequency protection, and vary with voltage differently depending on the type.

Commented [WPB29]: Need help here pbw

[4] These transformers are referred to as station power, unit auxiliary transformer(s) (UAT), or station service transformer(s) used to provide overall auxiliary power to the generator station when the generator is running. Loss of these transformers will result in removing the generator from service. Refer to the PRC-025-1 Guidelines and Technical Basis for more detailed information concerning unit auxiliary transformers.

Field Code Changed



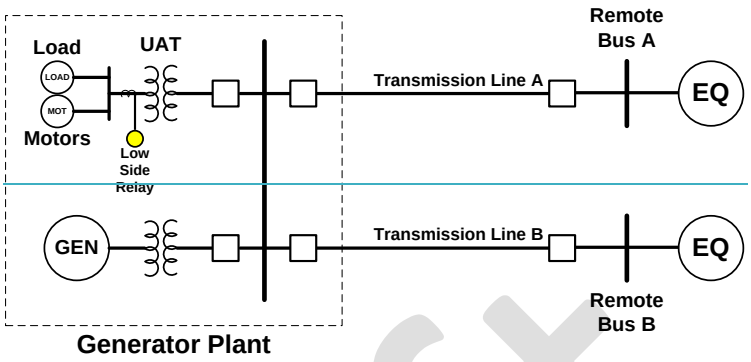


Figure 1: Station Service Transformer Connection

Impact of Motor loads

The following section addresses the impact of induction motor loads on setting over-current relays on the UAT. Motors operating at rated speed and normal voltage can be considered constant kVA devices which try to maintain load under low voltage conditions. The response of large induction motors to low voltage conditions depends on the design of the motor and the type of equipment the motor is driving. In most situations in electric power plants, Therefore, a decrease in voltage results in an increase in current. ConsequentlyConversely, ,non-motor loads are generally constant impedance devices where the current goes down in proportion to voltage. The *Electrical Apparatus Service Association* motor booklet indicates that at an 85% undervoltage condition, the motors would require 117-120% more current to maintain constant kVA.[5]

Each motor installed on the UAT must have individual protection of the motor. This protection must take into account motor starting time, locked rotor current, service factors, coordination with upstream relaying and other considerations. Motor protection can be reviewed in IEEE Std. C37.96-2012. These individual motor characteristics are taken into account when operating the generating unit and individually do not impact the loadability of the UAT.

This paper considers the impact to all the motors installed and operating on the low side of the UAT when subjected to a depressed voltage of 85% nominal. In conclusion, ~~i~~Individual~~individual~~ motor protection is not applicable to UAT low side over-current settings.

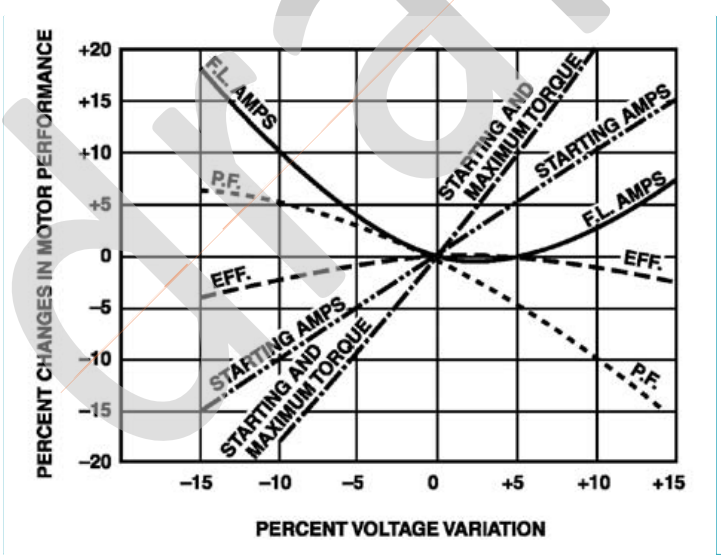


Figure 2: Effects of Voltage Variation on a Motor

[5] *Electrical Apparatus Service Association* motor booklet, page 28-29

Commented [WPB30]: Be consistent throughout

Commented [BGT31]: This was not hyphenated in the title, so should probably not be hyphenated here. Please do a search through the document and make all uses of this term consistent.

Commented [CT32]: Note related to the previous statement- do we mean Conversely?

Commented [CT33]: Is "Motor Booklet" the official title? Please identify and reference.

Commented [WPB34]: Need reference

Commented [CT35]: kVA is only constant over a small band. While the current does go up, the kVA is not a constant at 0.85 pu (power factor is at plus 6% and efficiency is at minus 4%). Constant kVA is a convenient assumption for powerflow studies but is not strictly true, as shown by the curve in this chart.

Commented [CT36]: This statement doesn't sense to me. I think we mean to say that we are not evaluating individual motor protection in this document.

Commented [WPB37]: Need help here

Commented [CT38]: This assumes a specific motor type- B? I don't have this reference document. I agree the curves are generally a good representation of what "typically" occurs, but we are attempting to bound the majority of possibilities…do we need to consider the variations due to differences in motor designs? A type D for example will behave quite differently, to my understanding.

UAT Low-side Overcurrent Relay

The plant load on medium and low voltage transformers is typically in the range of 80% motors and 20% non-motor load. For situations outside of this range the following table provides guidance.

. The non-motor load is usually made up of constant impedance devices that have a characteristic of drawing less current at a lower voltage, so that a 15% drop in voltage would also result in a 15% drop in current. This characteristic reduces the effect of increased current drawn by motor loads. It is the aggregate of the current from all the loads that must be considered. T and this is shown in Figure 3 below in which the overload on a fully loaded transformer would be approximately 111% of FLA. The figure below also includes a chart to describe the FLA for various percentages of motor loads.

$$FLA = (\%\ non-motor\ load) \times (voltage\ pu)\ + (\%\ motor\ loads) \times \frac{1}{(voltage\ pu)}$$

$$Sample\ Calculation:\ \ FLA = (0.2) \times (0.85\ pu)\ + (0.80) \times \left(\frac{1}{0.85\ pu}\right) = 1.11 times$$

% Resistive Load	% Motor Load	FLA on Transformer (% of Nameplate)
20%	80%	111%
10%	90%	114%
None	100%	118%

Figure 3: FLA on UAT Due to Depressed Voltage

Operating Differences between UAT and Transmission Transformers

The loading considerations are different for generation step upggenerating betweengenerating transformerstransformers installed at generating plants (UAT and GSU)transformers and transmission transformers. It is valuable for TtransmissionTransmission transformers must to have the ability to be loaded above the nameplate of the transformer to account for short term contingencies that occur on the grid. These contingencies may require emergency loading of the transmission transformers to allow operators to reconfigure the grid and reduce the loading on lines and transformers. Transmission operators owners are willing to potentially reduce transformer life to maintain reliability. Generating Generatorplant transformers are typically planned andsized and operated (even for emergencies) below the nameplate rating of the transformer. Generating Generator operators do NOT overload the UAT and the maximum load is known and not exceeded. The settings of relays on the transmission transformers must be set based on PRC-023 to allow emergency over load based on PRC-023.. The settings of relays on the UAT should be set based on the effect of the load whento voltage isto depressed voltage.

Phase Overcurrent Settings:

Various industry standards indicate an overcurrent pickup range of 125% to 200%, of the maximum transformer rating or cable ampacity, whichever is lower. Based on the discussion above, the minimum high vVoltageVoltage voltage and low voltage current pick should consist of the following; the calculated full load amps (FLA) plus an additional margin. The margin is needed to cover inaccuracies in the CT and relays, and percentage of motor load. To make thisFor simplicity-is it simple for the industry, we recommendhave chosen a setting of 135%.% is recommended. For the situation where 100% of the load is motor load the margin would be 17% (135% minus118% from Figure 3).%.

Therefore, the minimum pick-up should be 135% or greater to prevent the overcurrent element from picking up during a depressed transmission voltage event (.(0.85PU Under Voltage). If the load is defined and lower than

Commented [WPB39]: I need help with this whole section

Commented [CT40]: From what source? Earlier in the document we said up to 90%. I presume this is an "assumption" and should be identified as such.

Commented [CT41]: I don't see anywhere where we discuss the different applications where a low side versus a high side relay are used (or where both are used). To me, this is an important piece for the audience to understand, since the standard covers high-side relays, and does so with different percentages.

Commented [CT42]: What did we assume the rating of the transformer was? I don't see it anywhere, and this can differ widely. Did we assume worst-case that the transformer is rated for 100% of the total plant load? Also note, in many plants the transformer is designed to carry more than one bus as an "alternate".

Commented [CT43]: Owner is responsible for the rating and takes the risk of damage. I realize you weren't using the strict NERC registrations, but I still think this is more accurate.

Commented [CT44]: Of the lowest continuous rating of any of the equipment in the protected zone – could be transformer, could be cable, could be a switch, a breaker, switchgear/bus etc.

Commented [CT45]: This statement doesn't make sense to me. The current pickup is just a current pickup. On the other hand, the calculated current is different under high voltage and low voltage conditions. So I assume we mean that we are setting the pickup based on the highest current that occurs under either high voltage or low voltage conditions, plus a margin.

Commented [CT46]: The margin covers a lot of things. Not just the percentage of the motor load. More commonly, the estimates of the total actual plant load are not particularly accurate, since some plant loads are not continuously operating and many loads are too small to be worth preparing a detailed calculation. The amount of large motor load, in particular, is usually one of the most accurately known numbers.

Commented [CT47]: Not necessary since we said minimum.

the UAT capacity[6] then the settings relay would becan be set ~~as~~at~~s~~~~as~~as the minimum pickup can be established as 135% of the maximum load.

Note: On an MVA basis, the current that passes through the UAT high-side overcurrent relay is theessentially the same as the current that passes through the low-side bus and associated overcurrent relays.

Commented [BGT48]: I think losses in the transformer would make the "MVA" slightly different. This entire "note" could be eliminated, perhaps.

Commented [WPB49]: Ok to delete?

Commented [CT50]: Where do we refer to this note? It relates to the comment I made above but I saw no mention of comparing high and low side current nor relay settings….

[6] UATs with multiple secondary windings; the capacity refers to individual windings.

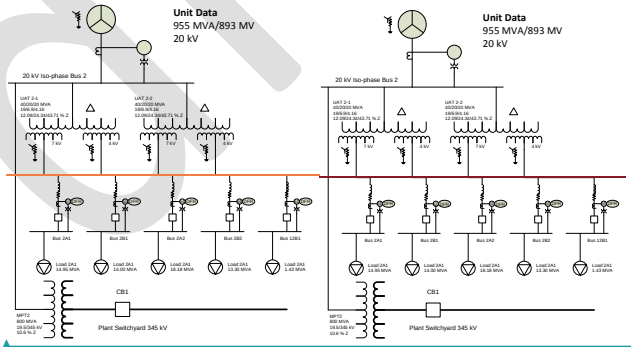
Impact of Generator Exciter

The generator exciter will attempt to hold the voltage at the generator terminals to 100% of the set-point for the unit voltage. As the voltage of the transmission system goes down the generator will try to ~~bring~~bringincreases its reactive power output to attempt to hold its terminal the voltage back up ~~to~~toat 100%.that level. Voltage on the high-side of a A UAT that is connected directly to the generator bus is supported by the actions of the generator exciter, which can react rapidly (less than a second) to hold voltage up as the system voltage drops. Therefore, for this type of UAT connection it is likely that the generator bus and the UAT voltage would be higher than the system voltage when the system is experiencing a depressed voltage event (.85 PU). The higher the voltage, the less the motors will draw, and therefore result inthere will bethere is less of a loadability concern.

When the generator auxiliary transformer is connected to the transmission system (sometimes called an SAT) therethe exciter output has less impact on the voltage at the transformer high side terminalsthere is little little usually (but not always) nearby voltage support and the exciter cannot effectively hold the voltage up for the transformer. Under theseWith this~~e~~ configurations the voltage on the low side of the SAT generator auxiliary transformer would decrease as the transmission system voltage decreased. This paper studies this configuration and the impact of the loads on the low side of UAT for a depressed voltage of 85% nominal.

The PRC-025-1 standard drafting team conducted a study to investigate the impact of load on~~to~~to a~~to~~ low voltage events.event on the system. The study developed a model for an actual event that presented a depressed voltage to the plant's auxiliary systems and validated that model using recorded data from that event. The study data was used to determine the expected relay loadability response on the low-voltage side of the UAT under the stressed system conditions. The study results indicated that for that event the increase in load was significantly below 135 % of the capacity of the UAT. This further supports the use of a minimum setting of 135% pickup for the low side relays.[7]

Unit Auxiliary Transformer (UAT)



Commented [WPB51]: Most of these seem OK

Commented [CT52]: Not really – it will hold the voltage to whatever its setpoint is, which we can assume is relatively close to 100% but in practice is likely somewhere between 97% and 104%.

Commented [CT53]: The setting

Commented [CT54]: "React" implies completion of the action, and some exciters are faster than others. Nonetheless, the point is valid – that the exciter mitigates a large portion of the voltage changes observed and acts to raise local voltage.

Commented [BGT55]: This term is not used in the rest of the paper. Seems better to not mention it here.

Commented [HS56]: What if there is a cap bank, Statcom nearby on the transmission system

Commented [CT57]: Is this "study" referring to the Guidelines and Technical Basis that were posted with PRC-025-1 during the development process?

Commented [CT58]: Not sure about the use of this term in this context. The loadability does not change – what changes are the conditions that might cause the actual load to approach the loadability limit.

Field Code Changed

[7] Placeholder for the report- If not on NERC website, add report to SPCS webpage.

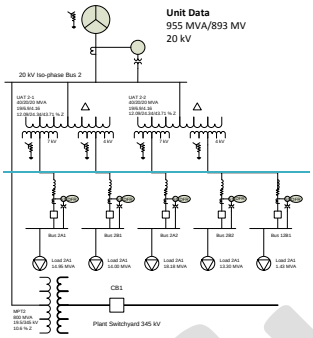


Figure 4: UAT Connection used in PRC-025 Standard Drafting Team Study

Conclusion

As discussed in this report, the setting for a low-side load-response relay on a generator unit auxiliary transformer minimum low voltage current pickup of the relay in question should be no lower than 135% of UAT the nameplate rating of the transformer to prevent the relay from operating during capacity to prevent the overcurrent element from picking up during a depressed transmission voltage event (0.85PU Under Voltage). If the load is defined and lower than the rating of the generator unit auxiliary transformerUAT capacity[8] then the settings can be set as 135% of the maximum load.

The 135% criteria will provide enough margin to account for worst case situations and also provide the recommended protection for the transformer. This will also complimentcompleiment the requirements of low voltage generator ride through as required in PRC-024.

Based upon the information contained within this report, the SPCS recommends to the Planning Committee to take the appropriate action according to step two above.

Commented [CT59]: I think if this were a guideline we would need a lot more detail.
Did we confirm whether this is achievable without relay replacements at certain plants? They are not likely to follow the guideline if they can't. For example, I've seen plants that have main bus relays that are standard-inverse and if we tinker with the pickup, they may not properly protect the transformer itself. Did we consider these types of things?

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Commented [WPB60]: Recommending a guideline brings into play a whole new process of surveys industry input, etc. Not sure we should do this. Just let this be a report to the Planning Committee and then let them debate.

[8] UATs with multiple secondary windings; the capacity refers to individual windings.

Comments from Brian's Email:

1. There is no cohesiveness to the report in the Executive Summary, Introduction and Background, and Conclusions sections of the report. I don't see them working together in trying to communicate the background, analysis, and recommendations. I have offered some suggested language changes to unify their message.

2. If I read both the report and the presentation, I come away with belief that the SPCS is advocating for Option 2 Guideline; but I am not certain given the vagueness of the report and presentation.

3. If 2 is correct above, what form and who would create the guideline for the PC's consideration? Shouldn't that Guideline be included in the action to the PC?

Comments from Carl's Email:
First, I am going to attempt to write the background as I understand it. I believe most of the important information is in the "Introduction and Background" section but some condensed version should be in the executive summary (and I don't see it there). Here goes:

- The NERC Board of Trustees requested NERC Staff and the PRC-025-1 Standard Drafting Team (SDT) to address a concern as quoted from the Background section "The application for UAT Facilities may not address all the load-responsive protective relays that potentially impact the operation of a generating unit or generating plant during the conditions anticipated by the proposed Reliability Standard." Incidentally, it seems unusual for the Board to make a comment or voice a concern coincident with adopting a standard (at least to me and to our compliance staff –maybe that is more common than I am aware) – I could not actually find the original source of the quote, though I would not call my search exhaustive. In any case, I note that the summary language asks specifically "whether a potential gap in reliability exists."
- As a result of this, the SDT conducted a "study" which I have not seen. This "study" may or may not be referenced in the report – it is hard for me to tell. In some fashion, the SDT evaluated the potential change in auxiliary load current that might result from a depressed bus voltage (note the vagueness in my statements here) and compared this potential change with common overcurrent relay setting practices for UAT transformers to determine whether there was any risk of a UAT overcurrent relay tripping due to increased load current drawn by auxiliary loads during the "event". Based on the language in this report, and the language from Phil Tatro's presentation to the PC in June of 2014, I can conclude that the SDT determined the evidence appeared to indicate there was not a reliability gap, but that the SDT in some fashion felt that additional analysis was needed. It is not clear to me exactly what basis the SDT had in their minds for this, but I can make some pretty good guesses since I myself would have been wary of this conclusion.
- The SDT recommended the three-tiered approach of monitoring using GADS/TADS, preparing an industry guideline, or standard changes as necessary as follow-on to provide the "additional analysis" that was needed. The plan proposed by the SDT (in what document, by the way??? I would like to actually read what the SDT wrote) was to only progress with the next tier when the prior tier's investigation was exhausted.
- NERC staff investigated the use of GADS data and found it infeasible.
- At the June 2014 NERC PC Meeting, Phil Tatro presented the status of this effort, including the fact that Staff had found the use of GADs data to be infeasible (although the meeting minutes do state that Staff reviewed some GADs data…), and asked the PC to endorse moving ahead with Tier 2 (preparing a guideline). **Here is where I begin to get confused as to where we are**. Part of this concern is that I note Tiers 2 and three of the "plan" never actually address whether or not there is a reliability gap. At the June 2014 meeting we discussed this, and admittedly it is too long ago for me to remember precisely. However, I do recall voicing explicit concern that we should investigate whether the reliability

gap exists in coordination with NAGF. In reviewing the meeting minutes from the June 2014 meeting, I see that I endorsed the efforts to "gather more information, collaborate with NAGF and draft a report to be presented to PC in December 2014." **Thus, I believe that effectively we (the PC) were asking for a report from SPCS regarding whether there was a reliability gap.** The report that we are reviewing appears to me to be somewhere in-between a guideline document and the report we wanted to see. I don't find any discussion on whether or not the reliability gap exists, but I also don't see anywhere where the report refers to itself as a guideline, and as I read the content, I don't find enough content for it to be considered one.

Based on the above backdrop, I can offer the following comments (more details in the attached Word document).

1. I believe we need a better summary of the background in the Executive Summary. It does not need to be long, but we are missing some key pieces of information, some of which are in the Background section.
2. We need to have a discussion at the PC as to what this report is and give the SPCS better direction as to what we are looking for. It is not presently a guideline, and it presently does not answer the questions I have about risks, if any, associated with UAT low side overcurrent relay settings. In my opinion, which admittedly others may not share, I believe the report should be a report to the PC that adds further information and analysis to what was already conducted, and explains the risks versus benefits that SPCS truly believes may or may not be out there. I can provide you with some of the details I am wondering about (some of which you'll see in my detailed comments in the word document), but at the end of the day, I don't believe we should be writing a guideline unless we feel strongly there is a need for a guideline, and this is why the PC asked SPCS to bring us a report. I have not seen anyone present an argument for the need of a guideline. To be frank, I almost lean towards just telling people they need to make sure that their aux system protection will allow their plant to meet the ride-through requirements of PRC-024, and explain (as if they don't already know) that we are concerned about the increase in current during voltage transients. We could issue that as some sort of advisory or alert – but that's just my quick opinion and it's the kind of discussion I was hoping for from SPCS – e.g. how much variation are there in the setting practices, how much variation in load types, etc – what is the risk? What are the chances of us preparing a guideline with a single percentage setting recommendation that actually has any value for Generator Owners, given the variations in practices?
3. What happened to collaborating with NAGF? Was this done?
4. I would like to see us be a lot more rigorous in how we deal with
    a. Electrical terms
    b. References
    c. Assumptions – we need to acknowledge where information is based on an assumption, or based on average data, typical data, etc, and explain how these assumptions may constrain the conclusions drawn.
5. I have attached a version with comments in it. However, because of my comment above- item 2 – I don't feel you should spend a lot of time incorporating these comments until we have question 2 answered. If you feel you already know the answer as to what type of document this is, then perhaps lets proceed, but I would caution that at present it will take a lot of changes for me to feel comfortable with this report

Comments from Gary's Email:
None
Comments from Herb's Email:
None