Banner Health®

Community Hospital
Torrington, Wyoming

Essential Electrical System
Power Quality Issues

PREPARED BY: PowerQuality Specialists **CHEYENNE, WYOMING**

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Overview

Findings contained herein were identified while conducting metering at the essential electrical system automatic transfer switches and 480Y/277V main distribution switchboard in support of the engineering design effort for Community Hospital's **CT & RF Replacement Project.** Our inspection and analysis was limited to that effort. This report does not reflect findings and recommendations that would have been forthcoming from a comprehensive investigation of the essential electrical system.

Refer to the "Findings & Recommendations Commentary" section for more detailed information on each of the identified power quality issues.

Extensive changes have been made to the hospital electrical system in the ten (10) years since power quality metering was last performed at Community Hospital for the purpose of upgrading portions of the electrical system. The findings in this report serve as a small representative sample of the types of issues that likely exist throughout this facility.

Contact Glen Coffman at (307) 638-6911 with questions related to this report.

Findings Summary

(1) The standby generator has 325 kW, 402 kVA of additional power capacity available. No sizing of generator service conductors or equipment feeder conductors was performed to determine if they match normal and generator power systems.

(2) Normal power supplied by the City of Torrington Utilities Department is well-regulated with respect to voltage phase imbalance for both the 480Y/277V service and the 208Y/120V service.

(3) Normal power supplied by the City of Torrington Utilities Department is well-regulated with respect to voltage range for the 480Y/277V service. However, the 208Y/120V service voltage is at the top of the required ±5% range.

(4) "Equipment #3" automatic transfer switch failed to transfer during the scheduled monthly load transfer test of 08/12/2015.

(5) "Equipment #3" automatic transfer switch has a "normal" power supply of 480Y/277V, yet measures 120V phase-to-neutral. There may be a correlation between this "mysterious" voltage and the connection to the generator control panel.

(6) "Life Safety #2" automatic transfer switch experienced abnormally high voltage events during the scheduled monthly load transfer test conducted 8/12/2015. This problem occurred during both transfers; normal-to-generator and generator-to-normal.

(7) Installation of the facility-wide cascaded surge protection system commenced in 2005 was never completed, although the complementary lightning protection system was installed. Emergency systems switchboards and panelboards are not equipped with surge protective devices, as required by Article 700.8, National Electrical Code.

(8) Objectionable ground currents are present, with those recorded at the 208Y/120V "Critical #2" automatic transfer switch particularly significant.

(9) The lack of environmental protection for the 500 kVA, 480V:208Y/120V ventilated dry-type transformer supplying standby generator power to 60% of the hospital's essential electrical system (EES) loads constitutes a risk to the reliability of this system.

(10) A 120V contactor is fed by a single conductor from a 208Y/120V Life Safety panelboard. The required grounded conductor (neutral) is supplied from another source or phase-to-ground is producing the required 120V; both are *Code* violations.

(11) Receptacles in the space housing the 480Y/120V main distribution switchboard and all automatic transfer switches are not connected to the essential electrical system. The receptacle faceplates are not marked with the panelboard and branch-circuit number supplying them.

Recommendations Summary

Determine ampacity of standby generator service conductors and essential electrical system equipment feeder conductors.

(Reference Finding #1)

Approach the City of Torrington Utilities Department about bucking (lowering) the 208Y/120V voltage.

(Reference Finding #3)

Investigate the cause for the 480V Equipment #3 automatic transfer switch failure – and the "mysterious" 120V phase-to-neutral voltage on "normal" feeders. Resolution of this problem may require combined efforts from multiple parties.

(Reference Findings #4 & #5)

Investigate and mitigate the high voltage events occurring during "Life Safety #2" load transfers.

(Reference Finding #6)

Install a cascaded surge protection system following a comprehensive deployment plan. Commence with emergency systems switchboards and panelboards not equipped with surge protective devices, as required by Article 700.8, National Electrical Code.

(Reference Finding #7)

Investigate and mitigate the causes for objectionable ground currents, particularly those present at the 208Y/120V "Critical #2" automatic transfer switch.

(Reference Finding #8)

Evaluate and implement environmental protection for the 500 kVA, 480V:208Y/120V ventilated dry-type transformer supplying standby generator power to 60% of the hospital's essential electrical system.

(Reference Finding #9)

Correct the improper wiring for the 120V contactor located adjacent to the 208Y/120V Life Safety panelboard in the room housing the automatic transfer switches.

(Reference Finding #10)

Install a 20A, 120V essential electrical system circuit with a duplex receptacle in the space housing the 480Y/120V main distribution switchboard and a 20A, 120V essential electrical system circuit with a 4-plex receptacle in the space housing the automatic transfer switches. Attach a machine-printed label to each receptacle faceplate listing the panelboard and branch-circuit number supplying the receptacles.

(Reference Finding #11)

Findings & Recommendations Commentary

Standby Generator (Reference Finding #1)

The Standby Engine Generator is a Generac Type MD0750-K36120D23GPSYC, Model 6996780500, S/N 2090575.

Generator Power Rating: 750 kW, 938 kVA

- Two (2) paralleled 375 kW generators [legacy *Gemini* Twin Pack, with 12L Mitsubishi engines] in a single enclosure. These engines are no longer used because they could not meet stricter emissions standards.

Total Generator Power [Adjusted]: 736 kW, 921 kVA

- Temperature derating: None. The generator is rated for 104^0F
- Elevation derating: 2.5%/1000 feet above 3500 feet. Elevation of 4215 feet used to calculate generator power multiplier (0.982125).

Additional Generator Power Available: 325 kW, 402 kVA

Generator capacity may be increased by adding single unit rated at 300/400/500/600 kW.

Existing Standby Generator was supplied by Rocky Mountain Power Generation. Contact Dave Coxon, (303) 428-2517 for additional information.

No sizing of generator service conductors or equipment feeder conductors was performed.

Recommendation:

Determine ampacity of standby generator service conductors and essential electrical system equipment feeder conductors. During the installation of the generator and original four (4) automatic transfer switches in 2006, the electrical contractor was required to replace the generator service conductors after it was determined that these conductors had been incorrectly specified by the design engineer.

Determine ampacity of essential electrical system equipment feeder conductors. Failure to consider the effects of ambient temperature, non-linear load characteristics, and stringent medical equipment (particularly imaging systems) requirements when sizing conductors is an all too common occurrence.

Utility Voltage (Reference Findings #2 & #3)

Normal power supplied by the City of Torrington Utilities Department is well-regulated with respect to voltage phase imbalance for both the 480Y/277V service and the 208Y/120V service.

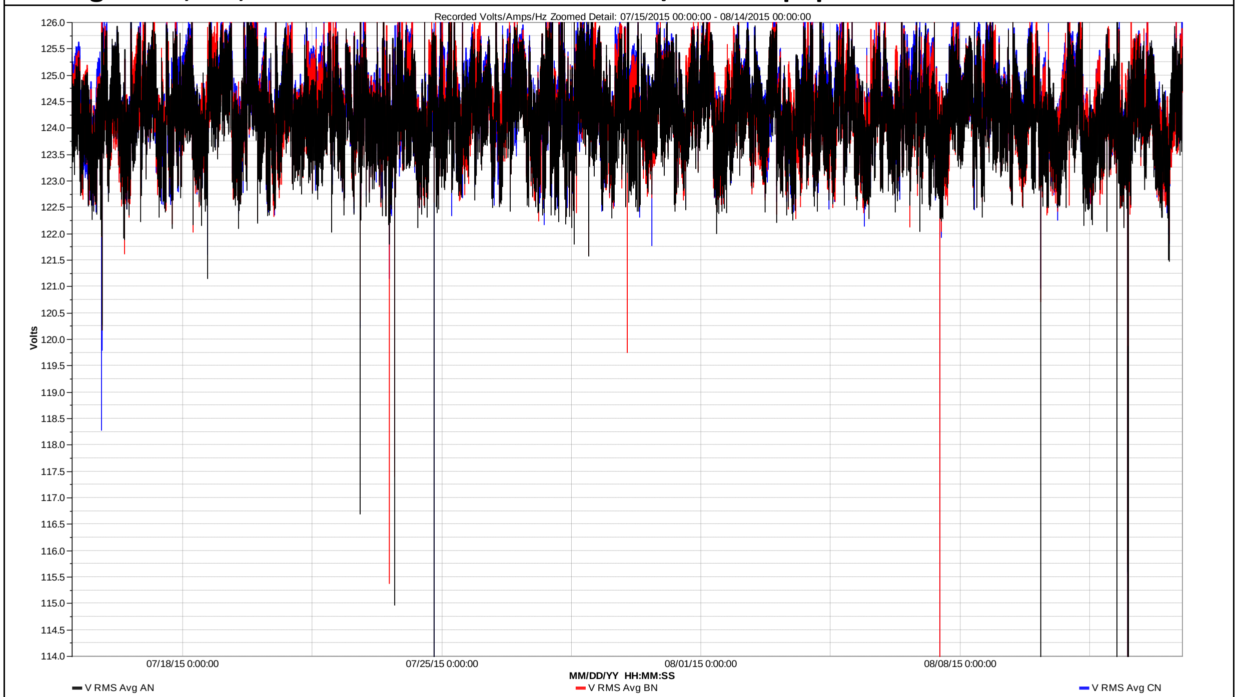
Normal power supplied by the City of Torrington Utilities Department is well-regulated with respect to voltage range for the 480Y/277V service. However, the 208Y/120V service voltage is at the top of the required ±5% range. Refer to data graphs on next page.

Sustained overvoltage – even when sustained at +5% – contributes to premature failure of sensitive electronic equipment components, lighting ballasts, and lamps. The additional benefit to lowering the normal 208Y/120V voltage is that it will more closely match the output voltage of the 500 kVA, 480V:208Y/120V transformer supplying standby generator power to essential electrical system loads, making for smoother load transfers.

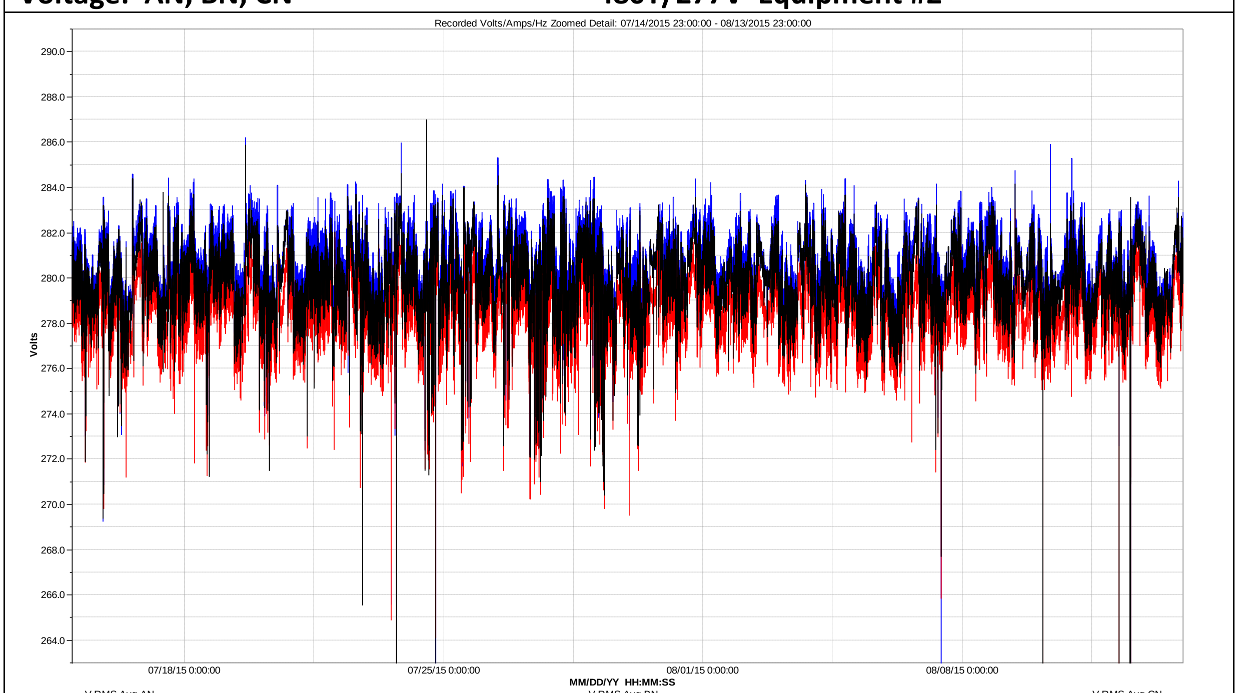
Approach the City of Torrington Utilities Department about "bucking" (lowering) the 208Y/120V voltage. The voltage regulators located at the SE corner of Community Hospital allow for small adjustment increments; however, these regulators probably effect change in both the 480Y/277V service and the 208Y/120V service. Since no change is recommended for the 480Y/277V service voltage, a tap-change to "buck" the 208Y/120V utility service transformer voltage is the more likely avenue for lowering the normal voltage so that it is more centered in the 120V ±5% window. Refer to data graph on the next page.

The two graphs that follow provide a representative sample of the two utility services, each within its respective phase-to-neutral voltage displayed in a ±5% window.

Voltage: AN, BN, CN 208Y/120V Equipment #1



Voltage: AN, BN, CN 480Y/277V Equipment #2



“Equipment #3” Automatic Transfer Switch (Reference Findings #4 & #5)

“Equipment #3” automatic transfer switch failed to transfer during the normally scheduled test, 8/12/2015. This is an Emerson ASCO 400A/4-pole automatic transfer switch; model E00300C0400N10C, S/N 661171 RE.

“Equipment #3” automatic transfer switch has a “normal” power supply of 480Y/277V, yet measures 120V phase-to-neutral.

“Equipment #3” automatic transfer switch is supplied with a grounded conductor (neutral), from both normal and generator power, but does not supply the load with a grounded conductor (neutral). While this configuration differs from the other six (6) automatic transfer switches at this installation, this is offered as an information note only. This is a proper installation method for loads not requiring a grounded conductor (neutral).

Recommendation:

Have *Pittman Electric* work with *Rocky Mountain Power Generation* to connect this ATS to the Generac control panel and configure it to exercise during the monthly scheduled load transfer test. Contact Dave Coxon at *Rocky Mountain Power Generation* (303) 428-2517.

Investigate the “mysterious” 120V phase-to-neutral voltage on “normal” feeders, particularly if this issue is not resolved while *Pittman Electric* and *Rocky Mountain Power Generation* work together to make the ATS-to-Generac control panel connection.

Another resource “might be” *Grounded Technologies*, whose labels are applied to transfer switches, indicating that this company has provided ATS testing or maintenance; although it is unknown if service has been limited to the four (4) GE Zenith Controls transfer switches.

"Life Safety #2" Automatic Transfer Switch (Reference Finding #6)

"Life Safety #2" automatic transfer switch experienced abnormally high voltage events during the scheduled monthly load transfer test conducted 8/12/2015. This problem occurred during both transfers; normal-to-generator and generator-to-normal.
This is an Eaton Cutler-Hammer 100A/4P ATS; model ATHIFDA40100XSU.

Date/Time	Type	Duration (d-h:mm:ss)	% of Nominal	Absolute	Phase
08/12/2015 12:31:55.533.123	**Impulse**	**0 - 00:00:00.000750000**	**435.49%**	**-1.206 kV**	**AN, BN, CN**
08/12/2015 12:31:55.533.160	**Impulse**	**0 - 00:00:00.000257000**	**267.43%**	**740.79 V**	**NG**
08/12/2015 12:31:55.533.354	**Swell**	**0 - 00:00:00.149745600**	**36.44%**	**100.93 V**	**NG**
08/12/2015 12:31:55.533.354	Dip	0 - 00:00:00.279624100	0.03%	0.090 V	AN, BN, CN
08/12/2015 12:31:55.549.965	**Interruption**	0 - 00:00:00.238537500	0.03%	0.090 V	AN, BN, CN
08/12/2015 12:31:55.788.503	**Swell**	**0 - 00:00:00.016141500**	**15.74%**	**43.590 V**	**NG**
08/12/2015 12:31:55.798.535	**Impulse**	**0 - 00:00:00.000283000**	**221.23%**	**-612.81 V**	**AN**
08/12/2015 13:08:18.459.240	**Swell**	**0 - 00:00:00.199481600**	**122.45%**	**339.19 V**	**NG**
08/12/2015 13:08:18.459.240	Dip	0 - 00:00:00.199481600	0.03%	0.077 V	AN, BN, CN
08/12/2015 13:08:18.484.148	**Interruption**	0 - 00:00:00.158134200	0.03%	0.077 V	AN, BN, CN

Power Quality Specialists provided the above table to Eaton ATS Technical Support. We requested information as to the possible cause for the impulses and asked if there are ATS adjustments that might prevent this condition from occurring. Eaton's Doug Frantz replied *"There is no kind of adjustment of the style ATS you have as far as transfer. There are timers associated to the transfer length and acceptable voltages… The duration of the event is so small I have no idea what could have caused the sensing"*. Doug consulted Eaton's Power Quality Metering Group and they asked all the same questions – which I answered. I also provided voltage, amperage, and event waveform graphs. No further feedback has been forthcoming from Eaton as to the possible cause for the impulses.

Doug Frantz
Application Engineer - Automatic Transfer Switch
EATON
221 Heywood Rd
Arden, NC 28704
1-800-809-2772 option 4, option 3
mailto:atstechsupport@eaton.com
http://www.eaton.com

Recommendation:

See the next section on "Surge Protection" for additional commentary and our recommendation specific to mitigating the voltage impulses recorded at "Life Safety #2" automatic transfer switch.

Surge Protection (Reference Finding #7)

Installation of the facility-wide cascaded power surge protection system commenced in 2005 was never completed – although the building exterior portion of a lightning protection system was installed. While a surge protection system may be installed as a standalone system – a lightning protection system is incomplete without surge protective device installation. The minimum SPD requirement is stipulated in NFPA 780 Standard for Installation of Lightning Protection Systems.

Section 4.20 of NFPA 780 provides the **minimum** surge protection requirements for a lightning protection system.

- 4.20.2.1 SPDs shall be installed at all power service entrances (Mains)
- 4.20.2.2 SPDs shall be installed at entrances of conductive communications systems (including but not limited to CATV, alarm, and data) and antenna systems
- 4.20.2.3 SPDs shall be installed at all points where an electrical or electronic system leaves a structure to supply another structure if the conductors or cables are run over 100 feet
- 4.20.2.4 Surge protection shall be permitted for installation at subpanels or branch panels and the point of utilization (outlet or signal termination)

The 2014 National Electrical Code, Article 700.8, states: ***"A listed SPD shall be installed in or on all emergency systems switchboards and panelboards."***

Prudent application of surge protective devices is no longer limited *to the service entrance equipment, downstream electrical switchboards and panelboards, and panelboards on the secondary of separately derived systems if they support communications, ITE, signaling, television, or other form of electronic load equipment* – locations stipulated in the outdated ***emerald*** *Book*, IEEE's Standard 1100, Recommended Practice for Powering and Grounding Electronic Equipment. Improved equipment reliability has long been associated with cascaded deployment of high-end surge protective devices. Studies have shown a short payback period for installation of SPDs on every switchboard and panelboard in hospitals.

"Life Safety #2" automatic transfer switch experienced abnormally high voltage events during the scheduled monthly load transfer test conducted 8/12/2015. This problem occurred during both transfers; normal-to-generator and generator-to-normal.

Given that each facility is unique, there is no "silver bullet" when it comes to mitigating power problems and improving electrical system reliability. However, the cascaded distribution of high-quality surge protective devices [most equipped with component level fusing and enhanced transient filter] will be a common component in "almost all" solutions.

Recommendation:

Install *Total Protection Solutions* model TK-LP120-3Y480-FL on the 480Y/277V Life Safety #2 automatic transfer switch and on Panel "H1XA" to protect medical equipment from the transitory voltage swells occurring during essential electrical system load transfers.

Have *Power Quality Specialists* prepare a comprehensive cascaded power system surge protective device deployment plan that features *Total Protection Solutions* devices; the same TVSS/SPD product line that was initially deployed within Community Hospital in 2004.

Embark on phased deployment of power system surge protective devices using the comprehensive deployment plan. Phase I of deployment will include SPDs required by *Codes*; e.g.,

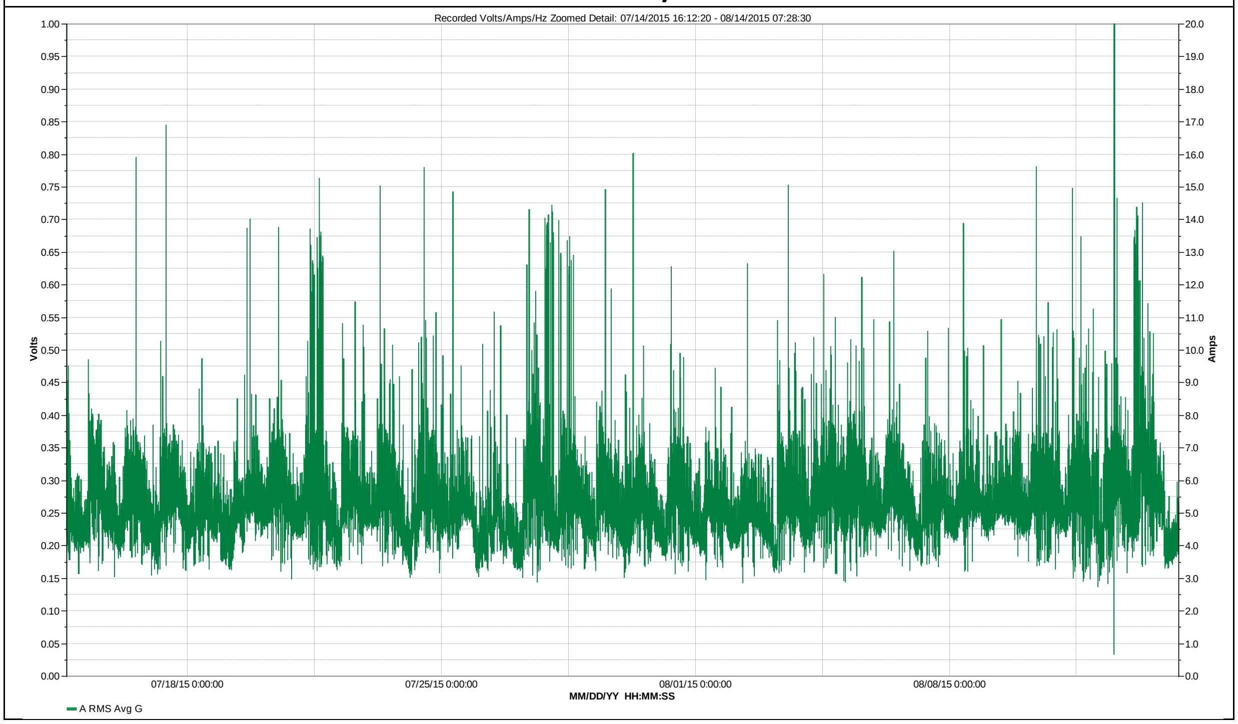
- all emergency systems switchboards and panelboards
- all power service entrances (Mains)
- all points where an electrical system leaves a structure to supply another structure if the conductors or cables are run over 100 feet

Have *Power Quality Specialists* work with Community Hospital staffs to prepare a comprehensive SPD deployment plan for communications systems.

Ground Currents (Reference Finding #8)

Objectionable ground currents are present, with those recorded at the 208Y/120V "Critical #2" ATS particularly significant.

Ground Current **208Y/120V Critical #2 ATS**



Large amounts of current flow on ground can adversely affect equipment and trigger ground fault circuitry. The ground current level indicates the likelihood of wiring errors in the distribution network supplied by the "Critical #2" ATS. Two common wiring errors are:

1. Improper connection of neutral conductor to ground conductor permits neutral currents to flow in the grounding system.
2. Improper use of the ground in cases where a neutral is required, but not readily available. Example: It is an all too common practice for mechanical systems tradesmen to use phase-to-ground when installing a 120V receptacle alongside 3-phase 208V mechanical equipment.

Recommendation:

Have *Power Quality Specialists* inspect the "Critical #2" switchboard and eleven (11) branch circuit panelboards that it feeds to identify potential sources for ground currents. Have *Pittman Electric* provide inspection support as needed, as well as perform the necessary work to correct identified wiring errors.

EES Step-Down Transformer (Reference Finding #9)

The lack of environmental protection for the 500 kVA, 480V:208Y/120V ventilated dry-type transformer supplying standby generator power to 60% of the hospital's essential electrical system (EES) loads constitutes a risk to the reliability of this system.

Power Quality Specialists submitted a memo to Banner Health representatives on August 27, 2015 in which we outlined our concerns specific to this step-down transformer.

Recommendation:

Service the essential electrical system transformer prior to winter of 2015-2016.

Develop a plan to relocate the transformer indoors or otherwise provide shelter from the harsh outdoor environment. Bear in mind that free circulation of ambient air is essential for the proper operation of FAC (fan-assisted cooling) dry-type transformers. FAC dry-type transformers are cooled both by free circulation of surrounding air and by forced circulation of air. They depend on air to enter at the bottom, flow upward over the core and coil surfaces and exit through the openings near the top.

Improper Wiring (Reference Finding #10)

A contactor housed in an enclosure located on the north wall of the transfer switches room is fed from a 120V, 20A/1P circuit breaker in the adjacent 208Y/120V Life Safety panelboard. Either the required neutral conductor originates from a different panelboard or phase-to-ground is supplying the required 120V. This circuit miswiring is both a *Code* violation and a power quality issue that compromises the 208V EES Life Safety system.

Recommendation:

Have *Pittman Electric* investigate and correct the wiring for this contactor.

Lack of EES Receptacles in EES Equipment Room (Reference Finding #11)

In the event of a utility power outage, there is no receptacle power available in the EES electrical equipment space to power instruments, equipment, or tools that may be required during a time of emergency.

Two receptacles installed in the space housing the 480Y/120V main distribution switchboard and all automatic transfer switches are not connected to the essential electrical system. The receptacle faceplates are not marked with the panelboard and branch-circuit number supplying them.

We may have "dodged the bullet" while performing the 30-day EES metering project. I arrived onsite to perform the 7-day data download to find mechanical systems personnel with a metal chop-saw plugged into the same 4-plex receptacle that was powering seven (7) of the eight (8) power quality analyzers. Chop saws typically draw 13 amps and can easily trip the branch-circuit breaker if the blade binds. The receptacle being used has no marking to identify the panelboard and branch-circuit feeding it. Had the breaker tripped, the seven (7) PQ Analyzers would have stopped within five (5) minutes after losing power. It is unknown how long it would have taken to restore circuit power. Had I not shown up at the jobsite when I did; there are some worse-case scenarios that may have resulted. Pittman Electric directed the mechanical systems employees to an outside receptacle and then installed a temporary 4-plex receptacle powered from a Life Safety panelboard to minimize the chances that the metering project would be compromised.

Recommendation:

Install a 20A, 120V essential electrical system circuit with a duplex receptacle in the space housing the 480Y/120V main distribution switchboard and a 20A, 120V essential electrical system circuit with 4-plex receptacle in the space housing the automatic transfer switches. Attach a machine-printed label to each receptacle faceplate listing the panelboard and branch-circuit number supplying the receptacles.