LOI SUPPORTING DOCUMENTATION FOR WC-1039

EXCERPT FROM WY-0002/SY-0003 REPORT

ARC FLASH SUMMARY & FIELD INVESTIGATION EVALUATION

4.1 Source Data

The Arc Flash Hazard Analysis builds upon the results of the Short Circuit Study and the Protective Device Coordination Study in order to calculate the incident energy. Consequently, the Arc Flash Hazard Analysis is completely dependent on the results of these two studies. When the Short Circuit Study or Protective Device Coordination Study is updated due to changes in the electrical distribution system, a revised Arc Flash Hazard Analysis must be performed to ensure that the incident energy, PPE level, and arc flash boundary at each piece of equipment are correctly calculated. NFPA 70E 130.5 (2) 2015 Edition also states that the arc flash risk assessment shall be performed/reviewed periodically at intervals not to exceed 5 years. The standard IEEE arcing current variation of 15 percent is incorporated to these scenarios representing utility fault current variation as well as other factors that affect arcing fault current. Reduced fault current levels result in long clearing times for protective devices. Because the arc flash incident energy is the result of both fault current and clearing time, reduced fault current can result in higher incident energy.

4.2 Arc Flash Summary

The Arc Flash Summary Table uses the Arc Flash Evaluation Module of ETAP. Appendix D1 and D2 contain the worst-case results from all of the operating scenarios as defined in Table 3. This summary shows both the inputs to and results of the incident energy calculations. Columns in the summary are as follows:

Bus - The location of the arcing fault.

kV - Bus voltage in kV.

Configuration - The name of the scenario which resulted in the worst case incident energy results.

Total Energy (cal/cm^2) - The energy produced by the arcing fault experienced at the working distance of 18 inches.

Arc Flash Boundary (ft) - The distance from the arcing fault that results in an incident energy of 1.2 cal/cm^2.

Energy Level - The level of PPE required based on the calculated incident energy.

Final FCT (sec) - The amount of time it takes for a breaker to open once the trip has been initiated. Note that protective devices with an opening time of zero are those devices whose opening time is included in their characteristic curves on the TCC (e.g. thermal-magnetic molded-case circuit breakers).

Ia at FCT (kA) - Total symmetrical arcing fault current at the fault location for an arcing fault.

Source Protective Device Name - The name of the first protective device to clear the arcing fault.

% Ia Variation - Whether or not the worst case was caused when 15 percent IEEE 1584 current variation was used.

Normal Operation - Indication of whether the equipment meets the five criteria for Normal Operation per 2015 Edition of NFPA 70E 130.2(A)(4).

Table 6 includes a list of the busses in the study that experience an incident energy level greater than 12 cal/cm^2.

Many of the busses listed below are fed directly from the secondary of a transformer without any protective device between. In these instances, there is no method for decreasing the available incident energy without modifying the electrical system.

Table 6 Arc Flash Hazards
WY-0002/SY-0003 Electric Arc Flash Study, Short Circuit Analysis, and Power Availability Study
City of Oklahoma City - Booster Pump Stations

Bus/Breaker	Energy Level	Recommendation
10-MNS-MCC PRI	LEVEL C	Note 1
10-PRI-MTS-U	LEVEL C	Note 1
11-DC FIRE BOOSTER PUMP 1	LEVEL C	Note 1
11-DC FIRE BOOSTER PUMP 2	LEVEL C	Note 1
11-DC FIRE BOOSTER PUMP 3	LEVEL C	Note 1
11-MAIN DISCONNECT PRI	>C	Note 1
12-DC FIRE BOOST PUMP #1	LEVEL C	Note 1
12-DC FIRE BOOST PUMP #2	LEVEL C	Note 1
12-PP1	LEVEL C	No changes recommended.
15-DC-PUMP 3	>C	Note 1
15-PRI MCC 15	>C	Note 1
15-PRI-MTS-MCC	>C	Note 1
15-PRI-MTS-PUMP 3	>C	Note 1
15-PUMP 3 VFD	LEVEL C	No changes recommended.
18-PANELBOARD	>C	Note 1
18-PRI-MTS	>C	Note 1
19-PRI MCC 19	LEVEL C	Note 1
19-PRI-MTS	LEVEL C	Note 1

Table 6 Arc Flash Hazards
WY-0002/SY-0003 Electric Arc Flash Study, Short Circuit Analysis, and Power Availability Study
City of Oklahoma City - Booster Pump Stations

Bus/Breaker	Energy Level	Recommendation
20-CT CABINET	LEVEL C	Note 1
20-PRI-MCC 20	LEVEL C	Note 1
20-PRI-MTS	LEVEL C	Note 1
21- CT CABINET	LEVEL C	Note 1
21-PRI-MCC 21	LEVEL C	Note 1
21-PRI-MTS	LEVEL C	Note 1
22-CT CAB OKC	>C	Note 1
22-CT CAB YUKON	>C	Note 1
22-PRI-MTS	>C	Note 1
22-PRI-MTS YUKON	>C	Note 1
22-PRI-SWBD-1	>C	Note 1
22-PRI-SWBD-2	>C	Note 1
23-MAIN DISCONNECT	>C	Note 1
25-HVAC STARTER	LEVEL C	Note 1
25-PRI MCC A	LEVEL C	Note 1
25-SEC-TRANSFORMER #3	LEVEL C	Nothing can be done as this is a transformer's secondary terminals.
25-SEC-XFMR #1	LEVEL C	Nothing can be done as this is a transformer's secondary terminals.
25-SEC-XFMR #2	LEVEL C	Nothing can be done as this is a transformer's secondary terminals.
7-MCC 7	LEVEL C	OCPDs were not modeled. See assumptions in Section 2.2.
7-PRI-MTS	LEVEL C	Note 1
7-VFD 60-HP-PUMP #1	LEVEL C	OCPDs were not modeled. See assumptions in Section 2.2.
7-VFD 60-HP-PUMP #2	LEVEL C	OCPDs were not modeled. See assumptions in Section 2.2.
8-MCC 8 PRI	>C	Note 1
8-OGE METERING	>C	Note 1
8-PRI-MTS-U	>C	Note 1

Notes:

(1) As this equipment is fed directly from the secondary of a transformer, additional equipment would need to be installed in order to mitigate the arc flash hazard at this equipment.

4.3 Arc Flash Hazard Mitigation Techniques

As shown in Appendix D1 and D2, there are many pieces of equipment throughout these facilities that can potentially experience an Arc Flash Hazard involving incident energy in excess of 12 cal/cm^2. A common method for mitigating some of these hazards would be to install an overcurrent protection device, such as a circuit breaker, as the main service disconnect. This is not only recommended for arc flash mitigation, but also to meet the ASCO switch manufacturer's recommendation for proper installation and to comply with NEC 230.91. In addition to this method, there is a variety of methods available to reduce arc flash hazards at specific pieces of equipment. Some potential mitigation methods are outlined below.

4.3.1 Zone Selective Interlocking

Zone Selective Interlocking (ZSI) is a coordination and protection strategy typically employed in low voltage switchgear. The goal of a well-coordinated electrical system is for the breaker closest to the fault, to clear the fault (usually with intentional delay), minimizing interruption to other parts of the facility. The goal of using ZSI is to reduce trip time without compromising the coordination between main and feeder circuit breakers.

To understand how this is used, consider an example of a ZSI system where there is a main circuit breaker and feeder circuit breaker. During a fault downstream of the feeder breaker, the feeder breaker restrains or inhibits the main breaker thereby allowing the feeder breaker to clear the fault first. During a fault between the main and the feeder breaker, the feeder breaker does not provide a restraint signal to the main breaker. As a result, the main breaker operates instantaneously instead of following the normal trip curve, which may reduce arc flash hazard in the equipment itself.

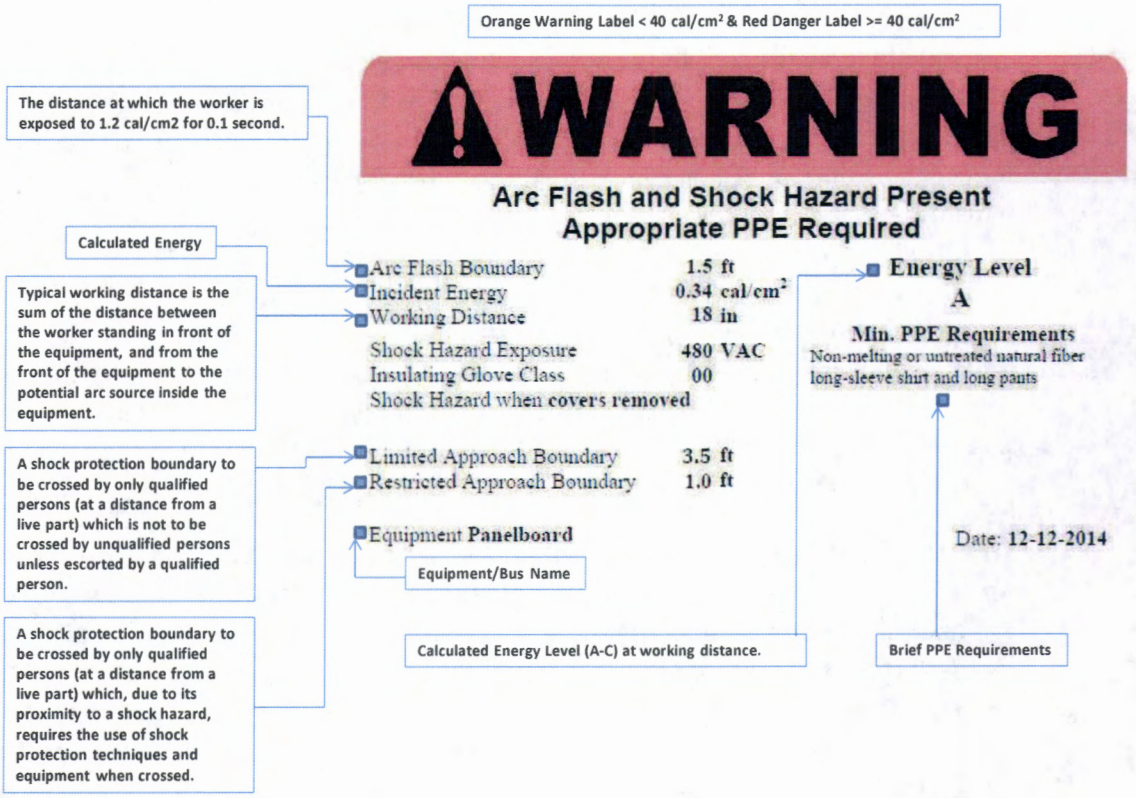
4.3.2 Maintenance Mode

Some breakers and relays have the ability to store multiple settings for the same breaker. This functionality can be used for implementing a “maintenance mode” that can enable instantaneous and altering other settings to allow breakers to trip faster, reducing incident energy levels in equipment for personnel. Use of this “maintenance mode” may help to reduce Arc Flash hazards by up to 75 percent in some cases.

4.4 Arc Flash Hazard Labels

A sample arc flash label follows for review. A complete set of labels suitable for direct application to equipment is provided as part of the final study for installation on the appropriate electrical equipment.

The arc flash hazard labels produced for this report are based on the assumption that the recommendations in the coordination study section of the report have been implemented.



5.0 FIELD INVESTIGATION EVALUATION

During the field investigation of the Booster Pump Stations, each piece of equipment in the electrical distribution system was opened for data collection. The following concerns and code violations that were observed are listed below.

As described in Section 4.0, it is critical to consider the condition of the equipment when performing normal operation, maintenance, etc. When we consider the five criteria that must be satisfied for normal operation without PPE (*(1) The equipment is properly installed, (2) The equipment is properly maintained, (3) The equipment doors are closed and secured, (4) All equipment covers are in place and secured, (5) There is no evidence of impending failure)* the Booster Pump Stations pose significant concerns and should be considered when planning for equipment replacement and maintenance.

- The majority of these pump stations have a manual transfer switch (MTS) that acts as a service-entrance disconnect switch. Each MTS has a nameplate that indicates a short circuit current rating based on an upstream overcurrent protection device. However, most of the facilities do not have an overcurrent protective device upstream of the MTS. Therefore, it is unclear how to assign a short circuit current rating for the MTS.

Photo 1 - MTS Nameplate

- At Pump Station #7, the electrical distribution gear is very old and is scheduled to be replaced within 1 year. The General Electric MCC was installed around 1957. The circuit breakers were not modeled as a part of this study. When the existing equipment is replaced, an updated study will need to be performed.

NO PROJECTS NEEDED, BOOSTER PUMP STATION SCHEDULED FOR DEMOLITION

Photo 2 - PS #7 Electrical Gear

- At Pump Station #8, the utility service enters the facility through a MTS. This switch does not have any overcurrent protection. Additionally, the incoming neutral conductor is not bonded to ground at this MTS. To comply with NEC 230.91, it is recommended that a service-entrance rated overcurrent protective device be installed between the utility transformer and the MTS. Adding overcurrent protection between the secondary of the transformer and the major electrical equipment in the pump station could reduce arc flash energy at the downstream equipment and improve safety at the facility.

NO PROJECTS NEEDED, BOOSTER PUMP STATION NOT IN SERVICE

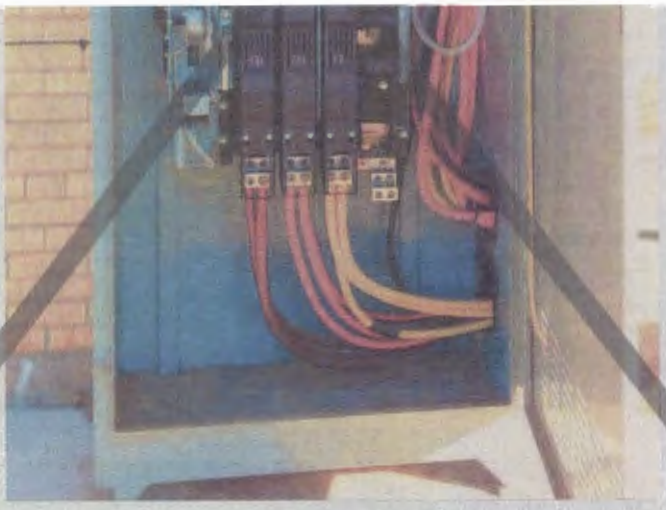


Photo 3 - PS #8 MTS

- At Pump Station #8, the newest Square D PowerLogic power meter is not functioning properly. We recommend the manufacturer inspect this meter so that the City can have accurate metering information.

- At Pump Station #8, there are two variable frequency drives (VFDs) that control the 150 hp and 250 hp motors. These VFDs have a tendency to shut down in summer months from overheating. Electrical equipment that frequently overheats can experience reduced operational life, which creates reduced liability of the pump station. Carollo recommends the City consider Heating, Ventilation, and Air Conditioning (HVAC) modifications to this pump station to improve reliability and increase the life of the electrical equipment.

NO PROJECTS NEEDED, BOOSTER PUMP STATION NOT IN SERVICE

Photo 4 - PS #8 MCC

- At Pump Station #10, the utility service enters the facility through a MTS. This switch does not have any overcurrent protection. To comply with NEC 230.91, it is recommended that a service-entrance rated overcurrent protective device is installed between the utility transformer and the MTS. Furthermore, the control wiring in this switch enclosure shows burn marks, and there is evidence of water damage in the bottom of the enclosure. The wiring should be tested and repaired to ensure proper operation of the equipment and reduce safety concerns.

NO PROJECTS NEEDED, BOOSTER PUMP STATION NOT IN SERVICE

Photo 5 - PS #10 MTS Control Wiring

- At Pump Station #11, the fire pump motor starters are very old and have not been serviced in a long time. The breakers would not close under normal operation, and had to be forced closed. These starters should be replaced immediately to increase reliability and reduce safety concerns.

Photo 6 - PS #11 Fire Pump Starters

- At Pump Station #12, the main disconnect was opened for inspection and would not close. The disconnect was then forced closed and deemed a significant safety hazard. This disconnect switch should be replaced immediately to increase reliability and reduce safety concerns. The fire pump motor starters are also very old, have not been serviced in a long time, and should be replaced.

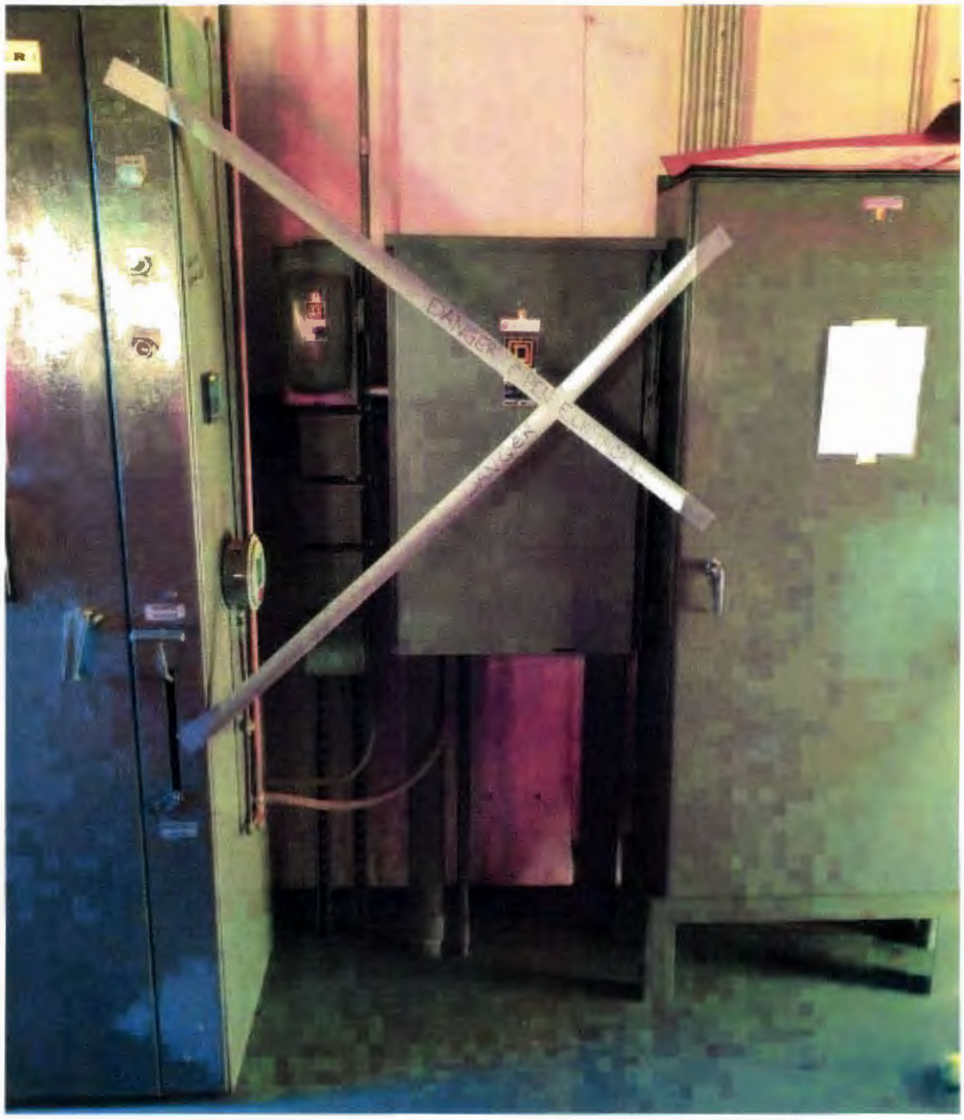


Photo 7 - PS #12 Main Disconnect

- At Pump Station #12, the lighting panel had a "burnt" odor and has likely been on fire in the past. This represents reliability and safety concerns. Carollo recommends replacement as soon as possible.

Photo 8 - PS #12 Lighting Panel

- At Pump Station #12, the utility transformer is on a concrete pad that appears to be settling into the soil. It is recommended that the foundation be repaired so that damage does not occur to the transformer or electrical infrastructure of the service entrance conductors. As this transformer is OG&E's equipment, we recommend that the City contact OG&E and inform them of this condition.

Photo 9 - PS #12 Utility Transformer

- At Pump Station #15, the utility service enters the facility and is brought to two MTSs. These switches do not have any overcurrent protection. Additionally, there are no incoming neutral conductors from the service transformer. To comply with NEC 230.91, it is recommended that a service-entrance rated overcurrent protective device be installed between the utility transformer and the MTSs.

Photo 10 - PS #15 Service-Entrance Equipment

- At Pump Station #15, the utility transformer is on a concrete pad that appears to be sinking into the soil. It is recommended that the foundation be repaired so that damage does not occur to the transformer or electrical infrastructure of the service entrance conductors. As this transformer is OG&E's equipment, we recommend that the City contact OG&E and inform them of this condition.

Photo 11 - PS #15 Utility Transformer

- At Pump Station #18, the utility service enters the facility through a MTS. This switch does not have any overcurrent protection. To comply with NEC 230.91, it is recommended that a service-entrance rated overcurrent protective device be installed between the utility transformer and the MTS.

At Pump Station #18, the utility service transformer appears to be very old and rusted. Carollo recommends determining if the transformer should be replaced, or repainted depending on the age of the equipment.

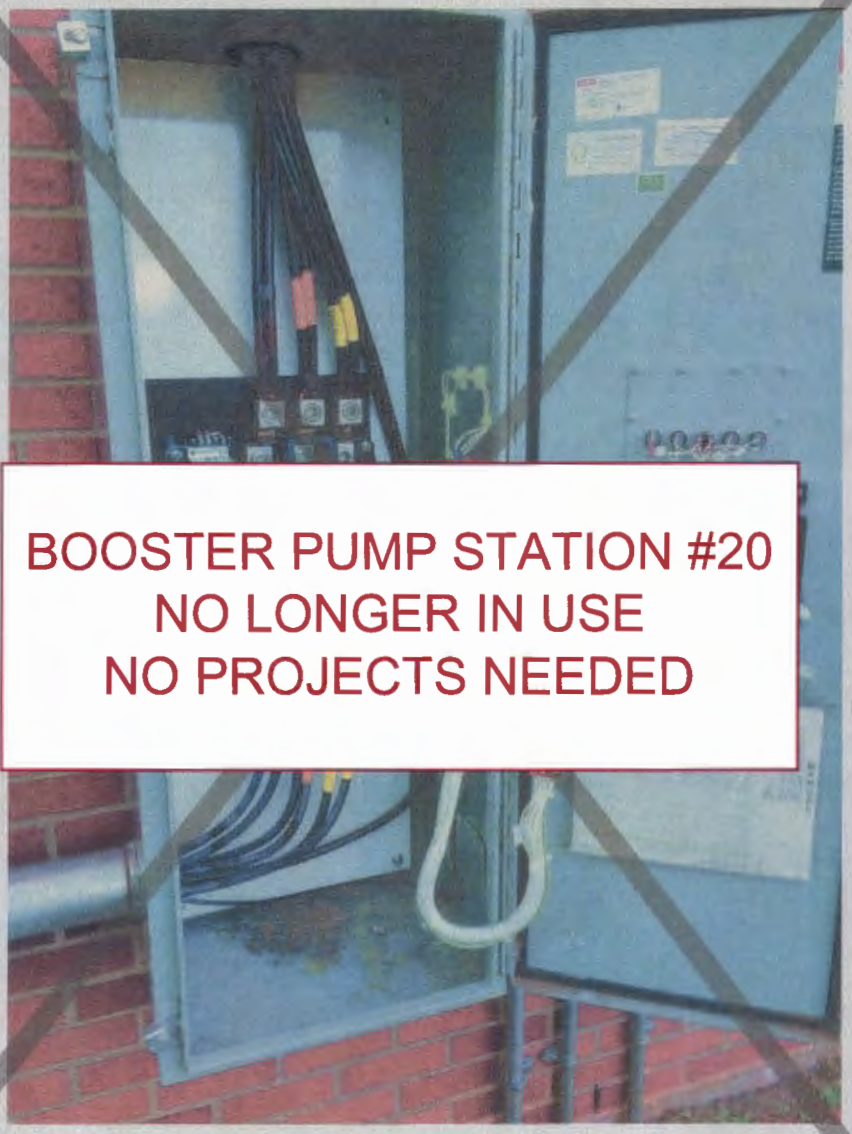
TRANSFORMER HAS BEEN REPLACED

Photo 12 - PS #18 Utility Transformer

- At Pump Station #19, the utility service enters the facility through a MTS. This switch does not have any overcurrent protection. To comply with NEC 230.91, it is recommended that a service-entrance rated overcurrent protective device be installed between the utility transformer and the MTS.

Photo 13 - PS #19 MTS

- At Pump Station #20, the utility service enters the facility through a MTS. This switch does not have any overcurrent protection. To comply with NEC 230.91, it is recommended that a service-entrance rated overcurrent protective device be installed between the utility transformer and the MTS.



BOOSTER PUMP STATION #20
NO LONGER IN USE
NO PROJECTS NEEDED

Photo 14 - PS #20 MTS

- At Pump Station #20, the Square D PowerLogic power meter is not functioning properly. We recommend the manufacturer inspect this meter so that the City can have accurate metering information.

- At Pump Station #21, the utility service enters the facility through a MTS. This switch does not have any overcurrent protection. Additionally, there is no neutral bonding jumper. To comply with NEC 230.91, it is recommended that a service-entrance rated overcurrent protective device be installed between the utility transformer and the MTS.

Photo 15 - PS #21 MTS

- At Pump Station #21, the MCC is in overall good condition. However, one of the buckets has burn marks on the inside of the door, indicating a fire at some point. Carollo recommends a thorough inspection of the equipment to ensure that it has been repaired accordingly to prevent further issues from arising.

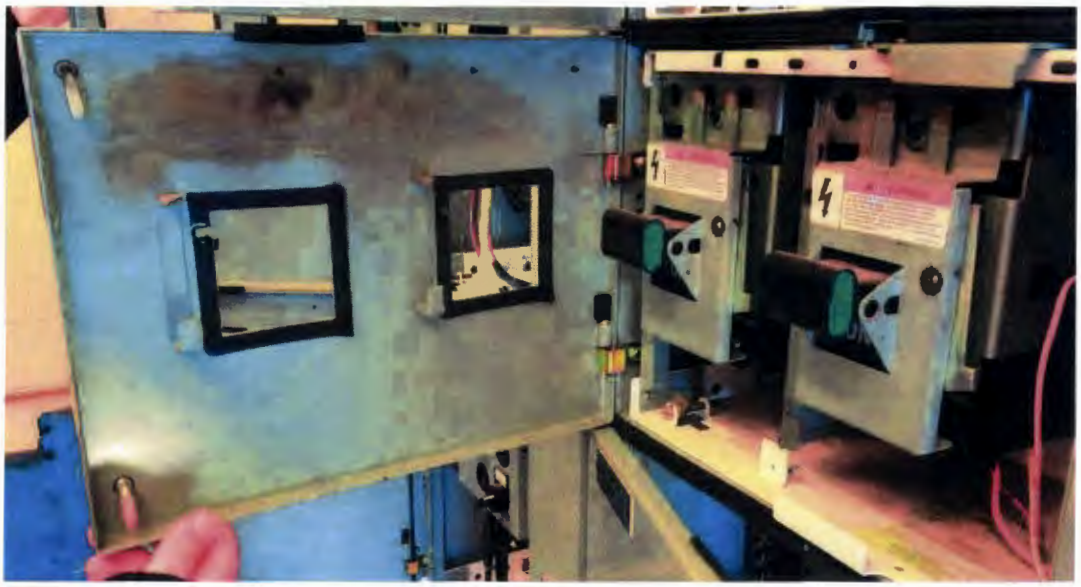


Photo 16 - PS #21 MCC Bucket with Burn Marks

- At Pump Station #21, the Square D PowerLogic power meter is not functioning properly. We recommend the manufacturer inspect this meter so that the City can have accurate metering information.

- At Pump Station #22, the utility service enters the facility through a MTS. This switch does not have any overcurrent protection. To comply with NEC 230.91, it is recommended that a service-entrance rated overcurrent protective device be installed between the utility transformer and the MTS.

- At Pump Station #23, the MTS has some burn marks inside the enclosure and the control wiring is damaged. This control wiring has been capped with wire nuts, so it is no longer in use. If the City would like the ability to use controls with this switch, the wiring will need to be replaced.

Photo 17 - PS #23 MTS with Damaged Control Wiring