Innovative Design Approach to Plant Power Distribution

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Background

Electrical power distribution is the backbone for efficient and continuous operation of any water/ wastewater treatment plant. At a wastewater treatment plant the power system is subjected to corrosive gasses, which can effects the operation of the electrical equipment. The failure in electrical service directly effects the plant operation.

At Trinity River Authority of Texas Central Regional Wastewater System (CRWS) the power is distributed at 15 kV to various unit substations which provides power to the process areas. The existing Main 15 kV Switchgear was installed in 1970's and has been severely affected by corrosive gases such as hydrogen sulfide. Corrosion has caused CRWS to spend valuable resources to maintain the equipment.

In order to provide reliable treatment for its customers Central Regional Wastewater System decided to replace the aging Main 15 kV Switchgear.

The design included review of switchgear technology in today's market place, keeping in mind the corrosive nature of the plant. The goal was to design a system which will provide a maintenance free service for years to come.

The team work between the owner and engineer led to the use of an innovative cost effective approach to manage the corrosion effect on the electrical equipment. The final design included use of SF6 gas submerged switches along with breakers for power distribution at 15 kV to the plant process. The existing 15 kV underground feeders will also be replaced. The electrical design considered factors to minimize downtime and keep the plant fully operational during construction.

Existing Electrical Distribution System- Overview

Electrical power to the TRA CRWS plant is provided by TXU Electric Delivery (TXUED) from a substation located at the plant. Two 138 kilovolt (kV) transmission lines feed the substation consisting of two 15/20/25 MVA transformers that convert the power to 13.2 kV. The secondary busses in the substation are arranged to provide redundant power.

Picture-1

Picture-2

Power from the TXUED transformers is supplied to following switchgear lineups:

- Main Plant Switchgear No. 1 (MSG-1)
- Main Plant Switchgear No.2 (MSG-2)

The main switchgear (MSG-1) and its associated feeders were constructed in the mid-1970. Power from the switchgear is distributed at 13.2 kV to the North Plant, one of two wastewater treatment trains at the plant.

The main switchgear (MSG-2) and its associated feeders were constructed in the mid-1990. Power from the switchgear is distributed 13.2 kV power to the South Plant.

Following is a summary of the features of the existing main switchgear (MSG-1) and its associated power distribution system:

- The switchgear is manufactured by General Electric (GE) vertical lift metal clad switchgear Type M-36.
- The enclosure is painted steel NEMA 3R rain-tight covered aisle construction.
- The switchgear has two separate sections (left and right) to avoid paralleling from the two TXUED substation transformers and to provide redundant service to the plant.
- Circuit breakers in the existing switchgear are air-break design, which is an old technology.
- Protective relays are an electro-mechanical design manufactured by GE.
- Concrete-encased PVC ductbanks carry 13.2 kV wire throughout the North Plant
- Feeders from Switchgear No. 1 provide 13.2 kV power to eight primary unit substations. Transformers at these substations provide lower voltage power for the North Plant facilities.

Existing Switchgear MSG-1 Condition Evaluation

The main switchgear MSG-1 at the Trinity River Authority Central Regional Wastewater System facility was installed in as part of the Central Regional Wastewater System Phase I project.

The metal clad switchgear by inherent design does not have protection against high levels of corrosive atmospheric exposure. Typically for this type of switchgear there is a mild steel structure that receives a

painted coating. Without any long term exposure to corrosive conditions this would be an acceptable method of protection for the steel frame work and covers. However, inside a wastewater facility there are frequently high levels of exposure to atmospheric conditions that are deleterious to mild steel with only a painted coating. (See pictures 3, 4, 5 & 6)

Picture 3

Picture 4

Picture 5

Picture 6

Typically the exposure to H2S gases is quite common inside of a wastewater facility. This exposure will tend to accelerate the corrosion rate of unprotected equipment. At the TRACRWS facility the exposure to H2S gases over a period of time has accelerated the corrosion of the steel framework, covers and internal equipment such as the contactors and especially the metering equipment for the ground fault protection of the feeders. (Picture 5)

The sensitive nature of the metering equipment (Pictures 7 & 8) is critical to the operation of the equipment and the protection of the feeders that are served. Upon annual testing of the fault protection relays it was determined that the reliability and functionality was becoming very subjective. The reliability of the relays are crucial to the safety of the 15 KV feeders and equipment This feeder protection also protects the equipment that the feeders are serving which is critical to plant operations.

Picture 7

Picture 8

Proposed Improvements Challenges

Design criteria included minimum downtime for switching power; minimize exposure to corrosion gases to improve maintenance and reliability and fit in the space available.

Minimize downtime

In order to minimize downtime the proposed switchgear will be constructed next to the existing switchgear and power company substation. New conductors will be installed from the switchgear to the various secondary unit substations through out the plant. Feeders will be switched out one at a time to reduce the impact on the plant.

Corrosive Gases Consideration

During the preliminary design phase following options were considered:

- Option-1: Conventional metal clad switchgear installed in a metal housing
- Option-2: Conventional metal clad switchgear installed in 316 stainless steel housing
- Option-3: Conventional metal clad switchgear installed inside a block building
- Option-4: Use of encapsulated switchgear for power distribution

Option-4 was selected as it provides switchgear which is fully encapsulated and hence is not affected by the corrosive gases. Pad Mounted low profile switchgear as manufactured by S&C Electric was selected for this application as it is encapsulated and provided a smaller foot print to fit in the space available.

Refer to Figure -1 for the location and layout of the switchgear.

Proposed Improvements

This new switchgear is sized for both existing and planned future electrical loads. The new switchgear will also be expandable to accommodate electrical loads proposed in future expansion phases up to the switchgear capacity of 2,000 amps.

The 2000A bus capacity was not available in the fully encapsulated design. Various options were considered.

The proposed switchgear main sections will be housed in an outdoor walk-in power house building. These main sections will be manufactured by General Electric. The distribution sections will be low profile, externally operated, pad-mounted switchgear manufactured by S&C Electric. S&C Electric manufacturer is responsible for furnishing the complete package including the main sections, outdoor walk-in power house building, ventilation, receptacles, and lights, as well as the pad-mounted distribution switchgear.

The following are design features for the switchgear:

- The switchgear design for the two 2,000 amp (A) main sections is metal clad, which has complete barrier construction that isolates low voltage, high voltage, and main bus compartment areas to prevent a fault in one area from involving an adjacent area. The barrier construction also provides greater safety for electrical personnel.
- All busses including ground bus are tin-plated copper.
- The main bus bracing will withstand 31.5 kA (three-phase symmetrical) and 82 kA (peak).
- The main sections of the switchgear are two-high construction.
- The main sections of the switchgear have rear access with either bolt-on, hinged and bolted, or hinged and three-point latched doors.
- Surge arrestors are provided on the output of every breaker as extra insurance against an unwanted switching voltage spike leaving the switchgear.
- The switchgear will use capacitance for tripping the main breakers.
- The distribution sections are joined to the main sections via a metering section.
- The distribution sections are utilize an SF6 gas-insulated sealed stainless steel tank that contains five 600 A load interrupter/ fault interrupters. This construction provides a corrosion resistant environment and the SF6 gas insulation in the tank allows a smaller profile and footprint.
- The metering sections will allow connection to the 2,000 A bussing from the main sections and provide space for the relays.
- Feeder cables will be connected with dead front, load break, elbow type medium voltage terminations which are airtight and waterproof. This is reducing the possibility of corrosion.
- The main breakers for SW-1 will be vacuum interrupter breakers with lockout relays. New solid state relays such as GE Multilin 750 will be used for feeder protection
- The switchgear will be labeled for arc flash safety.

The elevation and plan of the new Main Switchgear is shown on the Figure-2

Protective Relays and Remote Monitoring

Protective relays are the backbone for safety and proper operation of the power distribution system. Use of sensitive equipment is on the rise in all facilities. Also use of switching devices such as power supplies, variable frequency drives etc are on the rise.

Being able to record the condition of power will help determine the source of problems in the future. The solid state relays GE Multilin 750 are connected as described below:

- The relays will be connected to the plant supervisory control and data acquisition system (SCADA) via a new local programmable logic controller (PLC).
- The PLC will be connected to the plant fiber optic network.
- The PLC will in turn communicate via Ethernet protocol.

- The information from the relays will be monitored, recorded, and displayed at a stand-alone personnel computer using manufacturer software.

The relays can also provide four analog outputs and two alarms. Thus, in addition to the relays being on the network, the following points are hardwired to the plant PLC for monitoring by the plant operations staff.

- Voltage
- Current
- Power factor
- Kilowatt hours
- Breaker open
- Breaker closed.

The PLC will be housed in the switchgear housing. Power to the PLC will be provided with an uninterruptible power system (UPS) sized to handle the load.

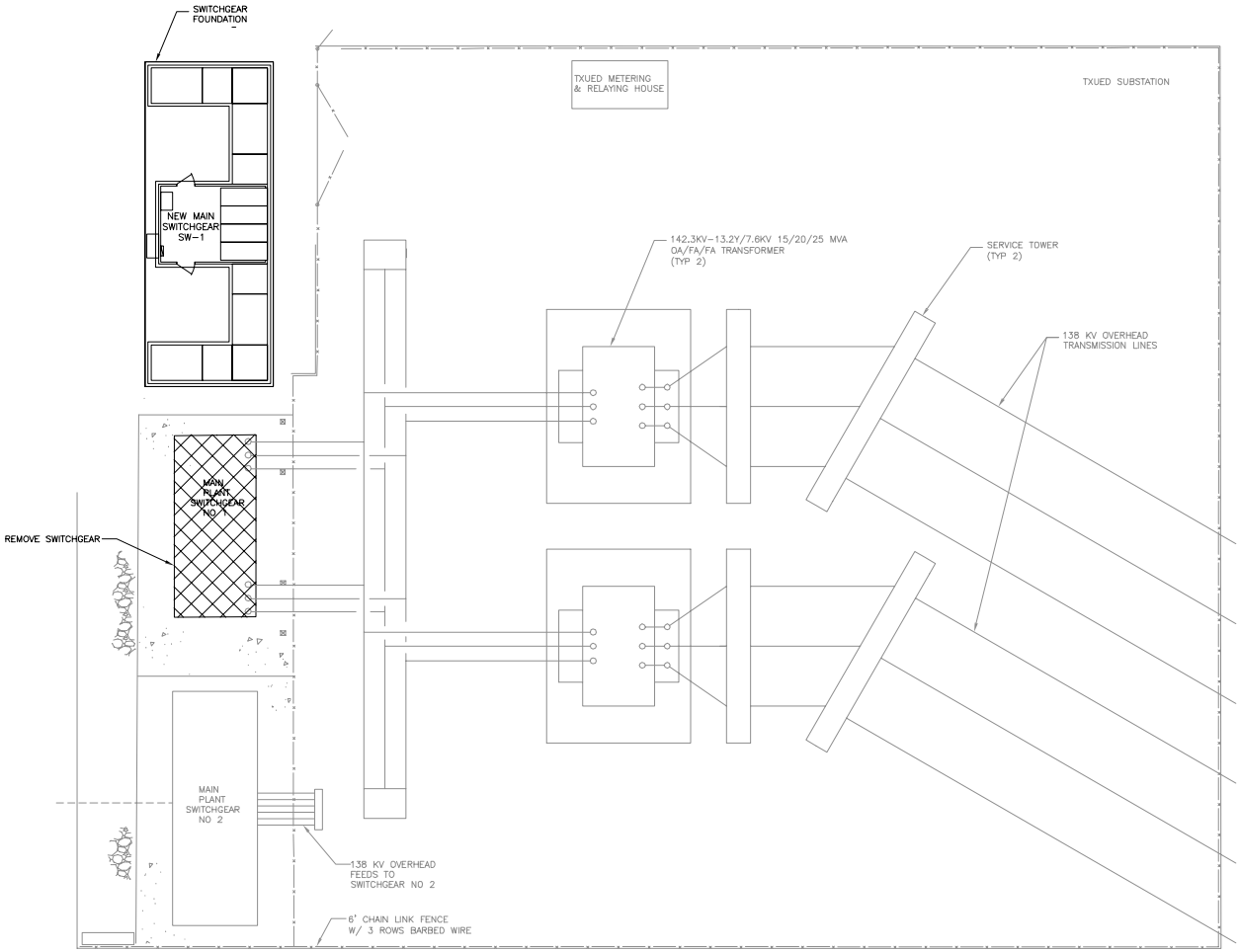
Conclusion

Trinity River Authority has been very progressive in their approach to replace the existing aging switchgear. The goal was to select a system which will provide safety and minimize corrosion hazards.

The S&C Vista System VI switchgear was chosen for several reasons.

- The Vista switchgear utilizes sealed stainless steel tanks that resist the corrosive environment often associated with waste water treatment plants
- The Vista switch provides enhanced safety features for operators - allowing for all normal procedures including opening, closing and grounding the cables without exposure to medium voltage
- Low profile flexible arrangement fit within the space constraints
- The lineup costs less than a comparable metal-clad switchgear lineup

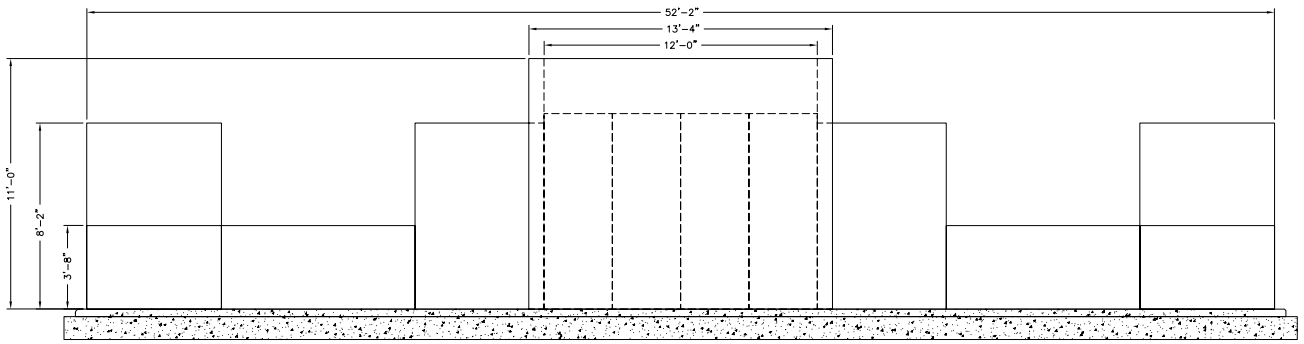
The overall benefit to plant is a safer, more reliable switchgear lineup at a lower cost



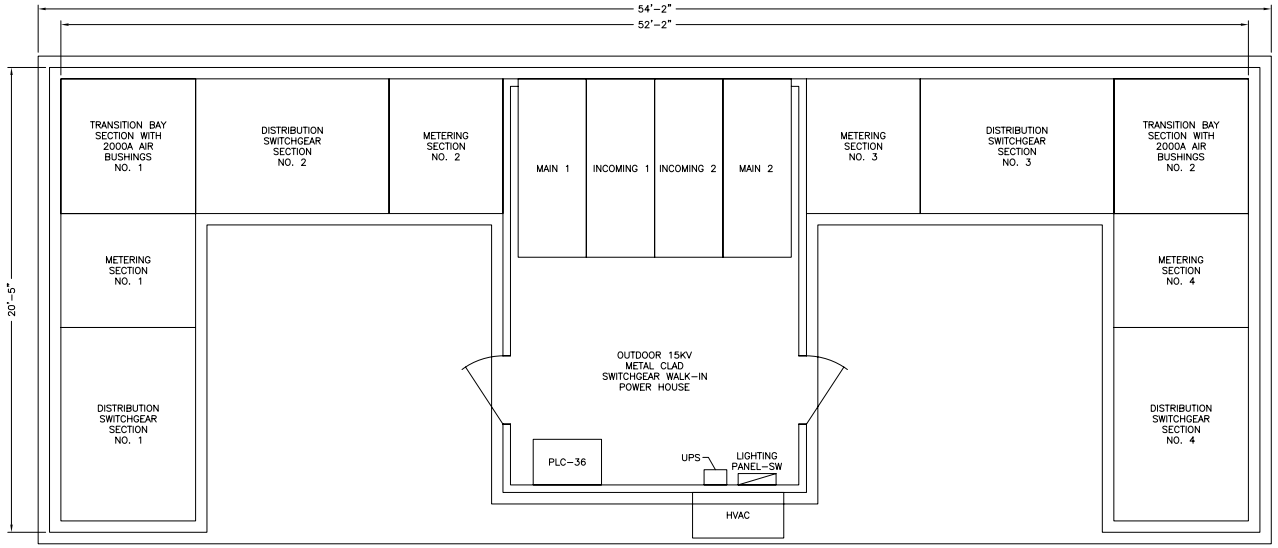
SWITCHGEAR SITE PLAN

INNOVATIVE DESIGN APPROACH TO PLANT POWER DISTRIBUTION

FIGURE NO.1



ELEVATION



PLAN

ELEVATION AND PLAN OF MAIN SWITCHGREAR

INNOVATIVE DESIGN APPROACH TO PLANT POWER DISTRIBUTION

FIGURE NO.2