Introduction

San Antonio Water System (SAWS) requires the assistance of consultant electrical engineering companies to provide a complete design of the electrical system in newly constructed primary pumping stations and additions. It is the responsibility of the consultant to know and understand the theory of pump station operation, preferred equipment and associated applications, and the latest technology of electrical equipment. The consultant shall be responsible for any electrical applications associated with: incoming 5kV services, 5kV switchgear, 5kV motor controllers, transformers, low voltage panels and wiring, capacitor application, SCADA, cathodic protection, and protective devices. Previous pump station applications should be considered when designing the electrical for a new station. SAWS has adopted a standard production operating philosophies and the electrical controls of the pumping equipment incorporate these philosophies. SAWS has also developed preferences of equipment supplied, such as the Rosemount pressure switch or the Panametrics Flow Meter. Included in this Design Standard Handbook is the theory of operation, preferred equipment, typical drawings, and overall needs required by SAWS to design a complete primary pumping station.

Drawing E01 – One Line Diagram

The electrical one line diagram shows the layout for power side of the electric system from the incoming utility throughout the incoming switchgear and to the two (2) motor control centers. From the motor control centers the one line diagram indicates the relaying, feeder, capacitor, and motor for each well pump. Also fed from the motor control centers are two (2) station service transformers that provide low voltage power needs throughout the station. The one line diagram is an excellent reference to determine what the pumping station contains electrically. Close coordination with CPS' latest standard, shall be achieved such as easement, transformer slab design, etc. shall be achieved.

Marker 1 - A SAWS primary pumping station requires a three-phase, four-wire, wye-connected, 4.16kV electrical service. The kVA rating of the incoming electrical service shall be determined by calculating connected load and any consideration for future additions. SAWS production will determine the criticality of the pumping station in order to design for an additional incoming service. In situations that do not warrant a second incoming service, a single transformer shall be installed capable of supplying the pumping station. Although one incoming service is supplied, a split bus with two incoming sections should be considered for isolation purposes. A main-tie-main configuration is a preferred method of utility connection to the station whether a single service or two separate services are used. In situations that do warrant a second incoming service; SAWS Production Department shall determine whether the transformers shall be full redundant. The sizing of the transformer(s), configuration of the transformer(s), and the installation of transformer(s) shall be coordinated with the local utility company and SAWS Production Department. When two transformers are required, the transformers shall be on separate utility circuits. Separate circuits will allow for station operation if there is a utility outage on one of the two circuits. Incoming service switchgear is to be provided with MOV intermediate class surge arrestors connected to incoming main bus on each phase.

Marker 2 - An automatic throw-over of control power in the incoming gear is necessary to insure the control power is available regardless of utility configuration.

Marker 3 - Potential transformers shall be installed on the line-side of the main-tie-main switches. The installation will allow voltmeter operation when main switch is open, showing utility availability. Voltmeter shall be Bitronics – Model VTAIE2.

Marker 4 - Mechanical key interlocking shall be installed on the main-tie-main switches to prevent the closing of switches, tying the A and B side busses together. The keys shall allow both mains to be closed while the tie is open, or one main and tie closed while the other main is open. Manufacturer shall be ABB – Kirk Key interlock system.

Marker 5 - The incoming switchgear shall be sized for the continuous station load. The switchgear shall be a main-tie-main configuration with a Kirk Key Interlock (KKI) to prevent connection of two incoming utility electrical services. Each main, as well as the tie, shall be sized to carry the system independently. The switches shall be vacuum power circuits interrupters. Switchgear manufacturer shall be General Electric, Cutler-Hammer, Siemens, Square D, ABB or approved equal.

Marker 6 - Multi-ratio current transformers shall be installed to allow for future additional loading. Mechanical rating shall be equal to short-time current carrying capability of the circuit interrupters.

Marker 7 - Motor control center bus shall be sized based on the full load amps of connected load, and for future additional loading. Shall be silver-plated copper, connection and joint shall be bolted with Belville washers.

Marker 8 - Any future well pump or high service pump, that is not to be installed on the present job, shall have a motor starter/controller installed, including a minimum conduit stubout.

Marker 9 - 208/120vac power panels shall be connected with a tie that shall be key interlocked. Key interlocking shall not allow power panels to be tied together with both panel mains closed.

Marker 10 - Station service transformer shall be sized to carry the possible future load of both panels (panel rating).

Outdoor Dry-Type Padmount Transformers
General Purpose 3-phase 500kVA and Below:

- Transformer shall be 60Hz general purpose ventilated outdoor dry-type padmount transformers.
- Transformer and all components shall be manufactured and tested with ANSI, NEMA and NEC Standard.
- Transformers shall be UL listed and bear the UL label.
- Manufacturers shall be Cutler-Hammer, Square D, FPT, ABB or General Electric.
- Transformers shall be designed for continuous operation at rated kVA for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.

Insulation Systems:

- Transformer shall have a 220°C insulating system based upon 150°C rise.
- Required performance shall be obtained without exceeding 150°C rise in a 40°C maximum ambient.
- Insulation material shall be as defined ASTM Standard test method D635.

Core and Coil Assemblies:

- Transformer core shall be constructed with high-grade, non-aging, grain-oriented silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Maximum magnetic flux densities shall be substantially below the saturation point. The transformer core volume shall allow efficient transformer operation at 10% above the nominal tap voltage. The core laminations shall be tightly clamped and compressed. Coils shall be wound of electrical grade aluminum with continuous wound construction.
- The core and coil assembly shall be vacuum pressure impregnated with non-hydroscopic, thermosetting varnish and cured to reduce hot spots and seal out moisture. The assembly shall be installed on vibration-absorbing pads. Taps shall be two (2) steps above and two (2) steps below nominal voltage in 2.5% increments.
- The core of the transformer shall be grounded to the enclosure with flexible ground strap.
- Transformers with wye-connected secondary shall have the neutral brought out to an XO terminal grounded to the transformer enclosure with a flexible copper ground strap.

Enclosure:

- The enclosure shall be an outdoor compartmented type, made of heavy-gauge steel, minimum 11-gauge. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring. The maximum temperature of the enclosure shall not exceed 90 degrees C.
- The enclosure construction shall be ventilated, with bolted or welded lifting devices and tamper-proof access with provision for Owner's padlock.
- Ventilation openings shall be designed to prevent accidental access to live parts, in accordance with UL, NEMA, and NEC standards for ventilated enclosures.
- Provide weather shields over ventilation openings.
- The top surface of the enclosure shall be designed to prevent accumulation of standing water.
- The base shall be constructed of structural members. Side and bottom steel panels are not to be in contact with pad.

Nameplate:

- Diagrammatic stainless steel nameplate to include all rating data and wiring diagram with connection point identification.

Marker 11 - Incoming line potential transformers shall be wired to each motor starter/controller cubicle for undervoltage relay in the motor protection relay. If the incoming utility service is lost the motors will be locked out, so that when the utility service returns pumps will not attempt to start.

Marker 12 - Power factor correction capacitors shall be installed at the motor connections to correct the power factor to 95% minimum. The capacitor unit shall be a three-phase delta connected capacitor with two external current limiting fuses enclosed in a termination box. Termination box shall be steel and the access cover shall be tamper resistant or have provision for Owner's padlock. Preferred manufacturers are General Electric type HWT, Square D type MVC, and ABB type HWP.

Marker 13 - The Motor Control Center (MCC) should house all of the 5kV motor contactors used in starting the pump motors. The MCC busses shall be sized to carry the continuous load of all motors connected to bus, station service transformer, and future consideration. All bus spacing shall be per NEC. All phase busses shall be insulated with 5kV insulation. All motor contactors shall be removable draw-out type. All motor contactors shall be fused for short circuit protection. Overload protection shall be provided by thermal overloads and a motor protection relay with the minimum of the following function:

Bearing Temp. Trip
Winding Tem. Trip
Overload Trip
Under/Over Voltage Trip
Negative Sequence

A manual lockout relay shall be installed to prevent restarting of motor after trip device auto-reset. A three-phase ammeter shall be supplied for each motor contactor. All devices shall be installed on the secondary of a current transformer. Current transformer shall be sized based on motor full load amps, so that a two-thirds deflection is utilized on the ammeter. Indication lights shall be included on the front of the MCC for each contactor to indicate motor contactor status. Ammeter shall be Bitronics Model ATAIE1.

Marker 14 - The motor sizes for the pumps will be determined by SAWS Production Department. A motor controller shall be installed for each well pump. The controller shall be able to start and stop the well pump when called upon by the level in the storage tank, SCADA, manual controls, or relaying.

Marker 15 - The motor sizes for the pumps will be determined by SAWS Production Department. A motor controller shall be installed for each high service pump. The controller shall be able to start and stop the high service pump when called upon by SCADA, manual controls, or relaying.

AC INDUCTION MOTORS – 200 Horse Power and Larger
Submersible motors are not included in this section. This section applies only when referenced by motor-driven pump specifications.

- Manufacturer's accepted by SAWS are:
  Electric Machinery
  Ideal Electric
  U.S. Electrical Motors
  TECO – Westinghouse Motor Co.
  Siemens-Allis
  Louis-Allis
  Toshiba
  Reliance

Motors shall be manufactured in the USA

General Requirements:

- Meet NEMA MG1, NEMA MG13
- Motor shall be specifically designed for the use and conditions intended
- Lifting lugs on all motors
- Service factor 1.15 minimum at 40° C

Voltage and Frequency Rating:

- Motor shall be rated for service voltage of 4160 V, 3 Phase, 60Hz
- Suitable for full voltage direct-on-line starting
- Suitable for accelerating the connected load with supply voltage at motor starter supplies terminals dipping to 90% of motor rated voltage.

Lock rotor rating: safe stall time 15 seconds or greater.

Insulation Systems:

- Sealed winding as NEMA MG1-1.27.2
- Class F
- Type cycles of vacuum impregnation of 1005 solid epoxy resins.
- Insulation system materials shall be moisture and mildew resistant, and shall include a resilient outer covering which will not erode when the motor is operated in sand laden air.
- Enclosure shall be NEMA Weather – Protected Type II (WP II) with stainless steel screens over all openings. The motor shall meet all requirements for ODPG and WPI machines. In addition, the ventilating passages at both intake and discharge shall be so arranged that high-velocity air and air-borne particles driven by storms or high winds can be discharged without entering the internal ventilating passages leading directly to the electrical parts of the motor. The normal path of the ventilating air, which enters the electric parts of the motor, shall be so arranged to provide at least three abrupt changes in direction, none of which shall be less than 90 degrees. Rotor shall be constructed of copper alloy bars.

Terminal (Conduit) Boxes:

- Oversize main terminal box
- Diagonally split, rotable to each of four 90° position. Threaded hubs for conduit attachment.
- Minimum usable, volume shall be 200% as specified in NEMA MG1-11.06 and 20-62 and NFPA 70, Article 43
- Termination for connection of equipment grounding in main terminal box

Bearings and Lubrication:

A. Horizontal Motors:
- Minimum of 100000 hours L10 bearing life as AFBMA 9 and 11
- Oil lubricated

B. Vertical Motors:

Thrust Bearings:
- Antifriction self cooled bearing.
- Minimum 50,000 hours L-10 bearing life.
- Thrust bearing to be insulated from magnetic currents.
- Bearings shall be designed for the necessary up thrust and RPM as specified by the pump manufacturer.

Guide Bearings:
- Manufacturer's standard bearing type.
- Minimum 100,000 hours L-10 bearing life.
- Bearings shall be oil lubricated.

C. Oil Lubrication Systems:
- Oil reservoir with oil level sight glass. Sight glass shall be marked with the proper static and operating oil levels.
- Oil fill and drain openings with opening plugs.
- Provisions for necessary oil circulation and cooling.

D. Anti-reverse Device:
- Motors for application with well pumps shall be provided with an anti-reverse ratchet to prevent reversing due to phase reversal or backspin at shutdown.

E. Vertical Motor Shaft:
- Vertical motors shall have solid shaft.

F. Space Heater:
- Motors shall be furnished with a space heater.
- Heater shall be rated for 230 Vac, but shall be sized and operated at 120 Vac.
- Heater leads shall be wired to a terminal box separate from motor terminal box.
- Controlled by remote motor starter contact.
- Manufacturers standard construction designed for long life.

G. Winding Temperature Protection:
- All motors shall be provided with replaceable 120-ohm nickel stator RTD's.
- Six (two each phase) positioned to detect highest winding temperature and located between coil sides in stator slots.
- RTD leads brought to conduit box separate from motor terminal box, together with bearing RTD leads.

H. Bearing Temperature Protection:

- Replaceable 120 ohm nickel RTD on each bearing of motor.
  RTD leads brought to conduit box separate from motor terminal box, together with winding RTD leads.

<u>Drawing E02 – Electrical Site Plan</u>

The electrical site plan is an essential drawing that indicates the location of all electrical equipment and electrical duct banks. The site should show the location of the electrical vault, high service pump slab, well pumps, tank electrical, radio, chlorine, fluoride, utility switchgear, and duct banks connecting these. All duct banks are identified and shown with cross sections and all spares are shown as indicated. Duct bank sections are very useful when adding new equipment that requires interconnecting of two (2) points.

Marker 1 - No conduits shall be fastened to the storage tank. All conduits to be routed to the tank top shall be fastened using 1 ½" x 1 ½" stainless steel channel with stainless steel conduit straps and hardware by Thomas and Betts/ Kindorf. No conduit will be allowed on the tank ladder.

Marker 2 - Level electrode holder shall be located on the top of the storage tank within 18" of the tank-top access door. The location is for maintenance and adjustments.

Marker 3 - A 120vac-convenience outlet shall be installed on the storage tank top at all access doors. Convenience outlet shall be secured to the safety hand rail, see detail sheet E23.

<u>Drawing E03 – Electrical Vault, Slab, and Control House</u>

The electrical vault and above grade slab is the central location of the switchgear, motor control centers, control house, and SCADA. The vault serves as a convenient and safe way to interconnect 5kV cabling and control wiring between the equipment on the slab and the control house. The vault should be sized to allow conduit penetrations through the walls and ceiling, a cable tray installation, junction boxes and conduit installation. The slab on grade shall be sized to support the incoming switchgear, motor control center, control house, and two station service transformers. The MCC shall have sufficient slab in front to allow for removal of motor contactors onto slab. Reinforcement steel shall be placed in the slab to allow for sufficient strength and loading. All wall penetrations to the vault should have a steel sleeve through the wall. The low voltage and control wiring shall be separated in the vault from the medium voltage cabling. Two doors shall be installed in the control house with a padlock provision. An access door shall be installed in the control house with a padlock provision. An egress door shall be installed in the opposite end of the vault from the control house. A ladder shall be supplied at each door. The control house shall be constructed on the end of the slab on grade, to house a supervisory control panel and any panels such as: level electrode panel, cathodic protection panel, and power panels. The building shall be brick and shall be securable. A heat pump and air conditioning unit shall be installed in the wall to provide climate control. The City of San Antonio requires a building permit for the Control house. The building shall meet the requirement of the 1997 Uniform Fire Code. At this time SAWS is considering alternate option to the vault. Designer shall discuss with SAWS their latest standard prior to any new vault design.

Marker 1 - A 120vac forced air vent pipe shall be installed to circulate fresh air into the underground electrical vault. Fan shall run at all times. See detail sheet E04.

Marker 2 - Electrical switchgear and motor control centers shall be set on the slab above grade. The switchgear and MCC shall be configured to fit the area allowed with all minimum clearances required.
Marker 3 - A sump pump shall be installed in a corner of the underground electrical vault to remove any water and liquids. The sump pump shall be fed by a GFI circuit breaker. The sump pump shall sit in a pit sub level to the vault floor and shall operate on float valve.

Marker 4 - The floor shall be sloped 1% toward the sump pump.

Marker 5 - Lights and GFI convenience outlets shall be installed in the underground electrical vault.

Marker 6 – An aluminum cable tray shall be installed in the underground electrical vault to carry control wiring from incoming switchgear and motor starter/controller to the SCADA panel in the control house. No 5kV cables shall be placed in the tray; all 5kV shall be in conduit.

<u>Drawing E04 – Electrical Vault Details</u>

The vault detail outline the construction requirements of the vault floor, vault walls, and slab on grade. A vault air ventilation system is required to assure safe air conditions when entering the vault. A forced air approach is used to circulate fresh air through the vault. Permanent ladders are fastened to the vault wall for access and exit from either the access door or the egress door. A sump pump is located at the lower end of the sloped vault floor to allow for water removal. The sump pump is located in a small hole in the floor and operated with a float-valve. A control house construction detail is included to identify building materials and procedures. At this time SAWS is considering alternate option to the vault. Designer shall discuss with SAWS their latest standard prior to any new vault design.

<u>Drawing E05 – Incoming Switchgear & Controls</u>

A main-tie-main incoming switchgear drawing defines the maximum dimensions allowed for the space available. A typical drawing of the switchgear with dimensions shown allows the contractor size restraints and a configuration of switchgear layout. A feeder management relay is included to serve as the incoming circuit interrupter’s protective device. GE Multilin SR750 Feeder Management relay is the only approved relay. The setting of the relay shall follow the setting procedure found elsewhere in these design standards. All inputs and outputs of the relay are shown to allow for proper wiring and installation. A control schematic for the main interrupter along with the tie interrupter is shown to indicate functions desired internal to the incoming switchgear. Space heater, GFI receptacle and work light shall be installed in each cabinet.

Marker 1 - Main circuit interrupter controls shall be supplied with a capacitor trip unit. The remote close and remote trip shall be wired to SCADA for future use. A green indicating light shall be supplied to indicate open interrupter, and a red indicating light shall be supplied to indicate a closed interrupter. The feeder management relay shall have a direct connection to the interrupter trip coil circuit.

Drawing E06 – Well Pump Control Schematic

A well pump control schematic embodies the control and logic for the well pump controller. The schematic is required to ensure that the motor controller includes all of the functions necessary to run, stop, indicate status and monitor the operation of the well pump. All auxiliary contacts are shown to indicate state and function. A motor protection relay is used to house all of the protective device functions. Flow meter supply power, a receptacle, a worklight, test power, and a cubicle space heater circuit is included to indicate source power and wiring.

Marker 1 - A 4160-120vac control power transformer shall be used to achieve a 120vac control voltage.

Marker 2 - A test power plug shall be provided for starter/controller operation when the starter/controller is disconnected from the bus.

Marker 3 - A ground fault sensor shall be supplied with a twisted shielded pair to the motor protection relay.

Marker 4 - A shorting terminal block shall be supplied to ensure the ability to short current transformers for protection against an open current circuit.

Marker 5 - A test switch shall be supplied for in service measurements and testing. The test switch shall be 9 poles, 8 shorting current, 1 non-shorting current back connected with front cover.

Marker 6 – A block type, ambient compensated thermal overload relay with manual reset and appropriate heaters to match pump motor characteristics, external to the motor protection relay shall be supplied.

Marker 7 - A motor protection relay multifunction, microprocessor-based self-diagnostic, and programmable digital device shall be supplied to be used for all tripping required. The motor protection relay shall trip the lockout relay. The relay shall be GE Multilin 469 no approved equal. The setting of the relay shall follow the setting procedure found elsewhere in these design standards.

Marker 8 - A three-phase, triplex, digital ammeter shall be supplied. The triplex meter allows you to read the current on the three phases simultaneously. Manufacturer and model shall be Bitronics – Model ATAIE1.

Marker 9 – A three-phase power factor correction capacitor shall be installed at the motor terminal box to correct the power factor to 95%. The kVAR rating of the capacitor shall be as recommended by the motor manufacturer. The capacitor unit shall consist of three-phase delta-connected capacitor with two- (2) external current limiting fuses enclosed in a concrete pump slab. The capacitor shall be low-loss, all-film dielectric type, with non-PCB OHSA Class III B combustible fluid. The capacitor shall have internal discharge resistors to reduce terminal voltage to 50 volts or less within 5 minutes of de-energization. Preferred manufacturers are General Electric type HWT, Square D type MVC, and ABB type HWP.

Marker 10 – The HOA switch allows the motor to be started by hand or automatic when called on by level electrodes (auto). Started in hand, the motor has no time delay and starts when switched to hand. Started in auto, an electrode must call for the motor to start and a timer must timeout before well pump will start.

Marker 11 - A selector switch is located at each well pump motor starter/controller to select the level at which the well pump will be called upon to fill the storage tank.

Marker 12 - Level electrodes are used to start well pumps by referencing the level of the water in the storage tank.

Marker 13 - Supervisory has the ability to stop the well pumps during the filling of the storage tank, but does not have the ability to start a well pump to fill the tank.

Marker 14 - A time delay on pickup timer shall be installed in the auto circuit so that when called on, the well pump must time-out before starting. The timer serves an important purpose. If the station should loose utility for any period of time, allowing more than one level electrode to call for well pumps to start, at re-energization of the station the time difference set on the timers allows for staggered starting of the motors to reduce system overloading due to motor inrush.

Marker 15 - A red indicating light shall be included in the circuits to indicate when the motor is running. The light shall be located on the motor starter/controller panel front.

Marker 16 - A green indicating light shall be included in the circuits to indicate when the motor is not running. The light shall be located on the motor starter/controller panel front.

Marker 17 - An emergency stop push button shall be installed in the circuit for immediate well pump shut off and lockout. Push button shall be located on motor starter/controller panel front and at local well pump panel if used, and shall be red mushroom head without spring return.

Marker 18 - A lockout relay (86) shall be supplied so that when a protective device trips the motor the lockout must be manually reset before the motor is allowed to start.

Marker 19 - An amber indicating light shall be included to indicate status of 86 relay.

Marker 20 - The configuration of the motor protection relay should be based on number of inputs & outputs needed. Spare inputs & outputs should be considered for future.

Marker 21 - A 120vac convenience outlet shall be installed at the well pump.

Marker 22 - A 120vac circuit from the power panel shall supply the power to the motor starter/controller cubicle for a convenience outlet, work light, cubicle heater, and test power.

Marker 23 -Provisions for flow metering power shall be installed at the well pump. Flow metering shall be transit time clamp-on flowmeter from manufacturer Panametric Model XMT868 and install in accordance to manufacture specifications.

<u>Drawing E07 – High Service Pump Control Schematic</u>

A high service pump control schematic embodies the control and logic for the high service pump controller. The schematic is required to ensure that the motor controller includes all of the functions necessary to run, stop, indicate status and monitor the operation of the high service pump. All auxiliary contacts are shown to indicate state and function. A motor protection relay is used to house all of the protective device functions. A high service pump motor space heater circuit is shown to demonstrate the requested wiring. The pump will start only if the valve is closed and will stop only if the valve is closed to prevent water thrusts and surges on the system.

Marker 1 - A 4160-120vac control power transformer shall be used to achieve a 120vac control voltage.

Marker 2 - A test power plug shall be provided for starter/controller operation when the starter/controller is disconnected from the bus.

Marker 3 - A ground fault sensor shall be supplied with a twisted shielded pair to the motor protection relay.

Marker 4 - A shorting terminal block shall be supplied to ensure the ability to short current transformers for protection against an open current circuit.

Marker 5 - A test switch shall be supplied for in service measurements and testing. The test switch shall be 9 poles, 8 shorting current, and 1 non-shorting current, back connected with front cover.

Marker 6 - A block type, ambient compensated thermal overload relay with manual reset and appropriate heaters to match pump motor characteristics, external to the motor protection relay shall be supplied.

Marker 7 - A motor protection relay multifunction, microprocessor-based self-diagnostic, and programmable digital device shall be supplied to be used for all tripping required. The motor protection relay shall trip the lockout relay. The relay shall be GE Multilin 469 no approved equal. The setting of the relay shall follow the setting procedure found elsewhere in these design standards.

Marker 8 - A three phase, triplex, digital ammeter shall be supplied. The triplex meter allows you to read the current on the three phases simultaneously. Manufacturer and model shall be Bitronics – Model ATAIE1.

Marker 9 – A three-phase power factor correction capacitor shall be installed at the motor terminal box to correct the power factor to 95%.

Marker 10 - A selector switch shall be installed allowing manual (local) or supervisory (remote) control of running of high service pumps.

Marker 11 - A control switch shall be installed at the high service pump cabinet to provide for the manual starting & stopping of the motor.

Marker 12 - A control switch shall be installed at the motor starter/controller to provide for the manual starting & stopping of the high service pump motors.
Marker 13 - A red indicating light shall be included in the circuits to indicate when the motor is running. The light shall be located on the motor starter/controller panel front.

Marker 14 - A green indicating light shall be included in the circuits to indicate when the motor is not running. The light shall be located on the motor starter/controller panel front.

Marker 15 - An emergency stop push button shall be installed in the circuit for immediate high service pump shut off and lockout. Push button shall be located on motor starter/controller front panel and shall be a red mushroom head without spring return.

Marker 16 - An emergency stop push button shall be installed in the circuit for immediate high service pump shut off and lockout. Push button shall be located at high service pump control cabinet located at the high service pump motor and shall be a red mushroom head without spring return.

Marker 17 - A lockout relay (86) shall be supplied so that when a protective device trips the motor, the lockout must be manually reset before the motor is allowed to start.

Marker 18 - A green indicating light shall be included in the circuit to indicate a closed discharge valve. The light shall be located on the motor starter/controller panel front.

Marker 19 - A red indicating light shall be included in the circuit to indicate an open discharge valve. The light shall be located on the motor starter/controller panel front.

Marker 20 - An amber indicating light shall be included to indicate status of 86 relay.

Marker 21 - The configuration of the motor protection relay should be based on number of inputs & outputs needed. Spare inputs & outputs should be considered for future.

Marker 22 - A motor space heater shall be provided in all high service pump motors with power from the power panel, disconnectable by a 2-pole knife switch located in the high service pump control cabinet at the high service pump motor. Space heater shall be energized only when motor is not running.

Marker 23 - A red indicating light shall be installed in the motor space heater circuit to indicate motor space heater is energized. Light shall be located on the motor starter/controller panel front. A current relay shall be used to determine status of motor space heater.

Drawing E08 – High Service Pump Discharge Valve Control Schematic

The high service pump discharge valve control schematic is used to better understand the operation of the 208Vac, 3-phase motor operator. Valve limit switches are used to indicate the valve position and allow high service pump motors to start or stop. A valve position contact arrangement is used to illustrate when the contacts are closed or open at any valve position. Heat trace circuits are used for process piping and discharge pressure transmitters. Flow meter power supply, receptacle, worklight, test power, and cubicle space heater circuit is included to indicate source power and wiring.

Marker 1 – Thermostatically controlled heat trace system shall be supplied to protect the discharge pressure transmitter and all process piping from freezing. The heat trace shall use 120vac from power panel. The system shall include control cabinets, cable insulation and jacket. Heat cable shall be Raychem "5BTV1", 6W/ft at 40°F or equal manufactured by Chromalox or Thermon. Cable insulation and jacket manufacturer shall be Pittsburg Corning "Foamglass" Armstrong Armaflex II or approved equal. Thermostat manufacturer shall be Thermon "B4X" or approved equal.

Marker 2 - A 120vac circuit from the power panel shall supply the power to the motor starter/controller cubicle for a convenience outlet, work light, cubicle heater, and test power.

Marker 3 - A 120vac convenience outlet shall be installed at the high service pump.

Marker 4 - Provisions for flow metering power shall be installed at the high service pump. Flow metering shall be transit time clamp on manufacturer Panametric, Model XMT868 and installed in accordance with manufacturer specifications.

Marker 5 - A green indicating light shall be included in the circuit to indicate a closed valve. The light shall be located in the discharge valve control cabinet.

Marker 6 - A red indicating light shall be included in the circuit to indicate an open valve. The light shall be located in the discharge valve control cabinet.

Drawing E09 – Supervisory Control Schematic

Supervisory control schematic is used to indicate interaction between RTU, MCC, Valve and other equipment and instrumentation.

Marker 1 – Interposing relay shall be supplied in the supervisory control panel to send a signal to either open or close contact(s) located on digital input of the SCADA remote terminal unit (RTU) panel and in the supervisory control panel.

Marker 2 – Interposing relay located on the digital output of the remote terminal unit (RTU) will either open or closed a contact on the supervisory control panel.

Marker 3 – Red indicating light located at the supervisory control panel indicates that the pump is running.

Marker 4 – Green indicating light located at the supervisory control panel indicates that the valve is in the close position.

Marker 5 - Red indicating light located at the supervisory control panel indicates that the valve is in the open position.

Drawing E10 – Supervisory Control Panel (Power & Communication)

SCADA system shall include, SCADA Remote Terminal Unit (RTU), Supervisory Control Panel (SCP), transceiver and antenna for communication, and power supplies. SAWS will specify type of equipment that they require.

Marker 1 - Supervisory Control panel shall have the ability to send and receive information via 900mhz-spread spectrum radio. All communication equipment shall be included with supervisory control panel.

Marker 2 – Supervisory control panel shall include SCADA Remote Terminal Unit (RTU), 120vac un-interruptible power supply (UPS), interposing relays, voltage scaling resistor, interface wiring terminals local control, indication devices, switched interior panel light, 120vac GFI duplex receptacle and thermostat controlled space heater.

Attachment of input/output SCADA point list shall be supplied with the specification on SCADA. The list shall include: Loop description, loop number, signal type (analog input/output, digital input/output, and data field 1 (milliamps, normal, inactive, off….), data field 2 (MGD, PPM, kW, stop, start…) and input/output range.

Drawing E11 - Supervisory Control Panel (Mechanical Layout)

Enclosure shall be NEMA 12 indoor cabinet with full height, gasketed double-door access. Doors shall have three-point with key lock, and shall have full-length hinges with stainless steel pins. Lock to be keyed for Owner's key. Shall be 11-gauge sheet steel. Equipment finish shall be an electrocoating process for baked enamel, applied over rust-inhibiting phosphated base coating. All digital indicators, indicating lights push buttons and selector switch shall be on the exterior front panel. Furnish nameplate, labels and tags. Use plastic laminate nameplates having white letters on black background to identify systems and equipment. Use plastic tag with black letters on a white background in the panel interior to identify each device. Designer shall contact SAWS' SCADA department prior to any equipment specification for their latest standard equipment such as software version etc.

Drawing E12 – Supervisory Control Panel (Typical Control Loops, pg.1)

Marker 1 - Discharge pressure and chlorine injection shall be monitored by the supervisory control panel and should alarm for high/low discharge pressure and chlorine leak. Electronic gage pressure transmitter shall be used to discharge pressure indication. It shall provide local and remote indication and shall be scaled in PSI. Manufacturer shall be Rosemount – Model 1151 and shall be rated in accordance to the system.

Marker 2 - High Service Pump flow metering shall be displayed on separate New Port digital displays located on the supervisory control panel front, and must also be available for remote recording.

Marker 3 - Well Pump flow metering shall be displayed on separate New Port digital displays located on the supervisory control panel front, and must also be available for remote recording.

Drawing E13 – Supervisory Control Panel (Control Loops, pg.2)

Control drawing shall include a typical control loop for a high service pump, typical control loop for a high service pump discharge valve and a typical control loop for well pumps. Contractor shall submit a complete set of Supervisory Control Panel (SCP) wiring and construction details for each pump on the system and also for each valve actuator. The Owner will furnish control diagrams for each control loop.

Drawing E14 – Tank Level Schematic

At this time SAWS is considering alternate option to the level electrodes. Designer shall discuss with SAWS on their latest standard prior to any new level electrode design.

Tank level electrodes are used to indicate the water level in the above ground reservoir. Level electrode relays are used to start well pumps for filling the tank. In many cases the level electrodes must be able to indicate level in two tanks. Selector switches allow the option of starting any well pump at any level desired. SAWS preferred manufacturer is B/W Controls type E-1P level electrode, type E553 for level electrode holder, and type 1500 induction relay for level electrode relays. A pressure transmitter power supply circuit has been included to indicate transmitter source power and wiring. Electronic gage pressure transmitter shall be used for reservoir level pressure transmitter. It shall provide local and remote indication and shall be scaled in percent.

Marker 1 - A selector switch shall be installed in dual tank installations that allows the selection of level electrodes in either tank or in both tanks. (Tank 1, Tank 1 & 2, Tank 2) Selector switch SS1; shall make before break over lapping CAM. Allen-Bradley AB800T-J2KE7EJEJ.

Marker 2 - Level electrodes shall be suspended in tank at levels specified by SAWS Production.

Marker 3 - Contacts to be wired to selector switch at individual well pumps. Selector switch assigns well pump to set of level electrodes in storage tank.

Marker 4 - Heat trace shall be supplied to protect the level pressure transmitter and all process piping. The heat trace shall use 120vac from power panel.

Drawing E15 – Well Pump Interconnect Wiring and C & C Layout

All aspects of well pumping must be shown to give an understanding of the operations. Interconnect wiring between the well pump controller, SCADA, level electrodes, chlorine, and others are a must for correct wiring and control. The understanding of the power and control connections is the foundation for proper and assured operation.

Marker 1 - A well pump interconnect (point to point) drawing shall be included to aid in correct field wiring and troubleshooting.

Marker 2 - Flow metering shall transit time clamp on flowmeter from manufacturer Panametric Model XMT868 and installed in accordance with manufacturers specifications. Transducers shall be clamped to well discharge piping. Flow meter shall be mounted on well pump control rack at well motor.

Marker 3 - Cable and conduit layout shall be included to aid in job bidding and preparation. Layout shall indicate all conductors in conduits and spare conduits.

Marker 4 - Power factor correction capacitors shall be installed at the motor terminals in the motor termination box.

Drawing E16 – High Service Pump Cable & Conduit Layout (HSP 1, 2,3)

Detailed high service pump drawings provide a layout of the electrical equipment, cable and conduits. Panel layouts are shown for conformity and presentability.

Marker 1 - Cable and conduit layout shall be included to aid in job bidding and preparation. Layout shall indicate all conductors in conduits and spare conduits.

Marker 2 - Power factor correction capacitors shall be installed at the motor terminals at the motor termination box.

Marker 3 - A control rack shall be constructed at the high service pump motor. The rack shall include control cabinet and flow meter. The control cabinet shall include control switch, indication lights, and emergency push button stop.

Marker 4 - Flow metering shall transit time clamp on flowmeter from manufacturer Panametric Model XMT868 and installed in accordance with manufacturers specifications. Transducers shall be clamped to high service pump discharge piping. Flow meter shall be mounted on high service pump control rack at high service pump motor.

Marker 5 - A discharge valve control rack shall be constructed at the discharge valve. The rack shall include heat trace control cabinet and valve control cabinet. The valve cabinet shall include control switch and indication lights.

Drawing E17 – High Service Pump Cable and Conduit Layout (Future HSP4)

All considerations for future should be included in the drawing package. A well-planned design will allow for easy installation in the future.

Marker 1 - Cable and conduit layout shall be included to aid in job bidding and preparation. Layout shall indicate all conductors in conduits and spare conduits.

Marker 2 - A discharge pressure transmitter shall be installed on the valve control rack.

Marker 3 - A control rack shall be constructed at the future high service pump motor location. All conduits shall be stubbed up through the slab and capped for future use.

Marker 4 - A discharge valve control rack shall be constructed at the future discharge valve location. The rack shall include heat trace and discharge pressure transmitter. All conduits not used shall be stubbed up through slab and capped for future use.

Drawing E18 – High Service Pump Interconnect Wiring

Vital to all control schemes an interconnect diagram is essential for correct operation and wiring. The interconnect drawing expresses the logic and control ideas in a mapped style. In addition, a circuit schedule shall be provided as an attachment to the specification and it shall include circuit name, wire function, wire color, cable/conductor type "From", "To", conduit name, conduit size and note. The circuit schedule shall match the contract drawings.

Marker 1 - A high service pump interconnect (point to point) drawing shall be included to aid in correct field wiring and troubleshooting.

Drawing E19 – Overall Conduit Layout

A conduit layout illustrates the networking of conduits to help not only during construction, but also during tracing and future additions.

Drawing E20 – Cathodic Protection

Cathodic protection shall be used to protect steel pipe and reservoir tank from corrosion. To protect steel pipe zinc anode is connected to the tank by a solid copper wire with TW insulation. A similar process is used to protect the steel tank with the exception that a rectifier is used between the anode and the tank.

Marker 1 - Location of cathodic protection anodes and test stations shall be placed throughout the pump station to minimize corrosion on steel pipe. Cathodic protection of reservoir tank shall use a cathodic protection rectifier per tank and shall be installed in the control house; the manufacturer shall be HACO/CPS water work type TASC V11 rated for 30 Vdc and 8 Adc model TASCA 3018.

Drawing E21 – Panel Schedule and Chlorine Room

Marker 1 - A chlorine house shall be constructed to house chlorine storage cylinders. Chlorine house shall be located so that it is easily accessible by vehicles. All exposed conduit in chlorine room shall be PVC coated rigid galvanized steel. All wire gutters and HOA switch cabinets shall be NEMA, 4x, type 304 stainless steel. The control house shall included, but not limited to: Electric heater, intake fan, louver, chlorine analyzer, twin cylinder scale and digital read out. See attached Appendix: Section 11234 CHLORINE FEED SYSTEM & BUILDING. At this time SAWS is considering adding new equipment to the Chlorine Room such as scrubbers, new alarms and possibly an emergency generator. Designer shall discuss with SAWS on their latest standard prior to any new Chlorine Room control design. The City of San Antonio requires a building permit for the Chlorine room, the room shall meet the requirement of the 1997 Uniform Fire Code.

Marker 2 - Two 208/120vac-power panels shall be installed in the control house to provide low voltage power where necessary throughout the station. Panel board shall be NEMA PB1, NFPA 70 and UL 67. Rating: Applicable to a system with available short circuit of 10,000A rms symmetrical. Ground fault interrupter: 5mA trip, 10,000A interrupting capacity. Interior shall be factory assembled, capable of circuit breaker replacement without disturbing adjacent circuit breakers or without removing main bus. Circuit breakers shall be NEMA AB1 and UL 489 thermal-magnetic, quick-make, quick-break, molded case. Bolt on circuit breakers shall use multipole circuit breakers to automatically open all poles when an overload occurs on one pole.

Marker 3 - A HOA switch shall be installed to allow for automatic or manual injection of chlorine to water before it enters storage tank. In automatic the chlorine shall be injected only when well pump is running.

Marker 4 - A NEMA 4x control panel shall be installed in the chlorine room, which includes a HOA, switch for each well pump.

Marker 5 - 208/120vac power panels shall be connected with a tie that shall be key interlocked. Key interlocking shall not allow power panels to be tied together with both panel mains closed.

Drawing E22 – Panel Details

Panel details shall be drawn to assure uniformity with the existing panels and to make sure that the layout follows logical order. A nameplate shall identify each device. The description on the nameplate shall also be part of the drawing. The nameplate shall be laminated plastic, attached with stainless steel screws. The nameplate shall be black engraved to a white core. The letter height for push buttons/selector switch shall be 1/8-inch, and for panel boards, ¼-inch.

Marker 1 – Interconnect (point-to-point) drawing for level electrode panel shall be included to aid in correct field wiring and troubleshooting.

Drawing E23 – Miscellaneous Details

Miscellaneous detail shall be included in the Contract Drawings to provide or clarify useful information to the contractor for proper installation of the equipment.

Drawing E24 – Operating Logic

All pumping must be based on a logical approach to delivering water when and where it is needed. A logic diagram is very useful in understanding the pump station in a macro attempt. Operating procedures are necessary for proper operation of the entire pumping station.

Drawing E25 – Altitude Valve Control

Altitude valves are used for overflow control. To prevent an overflow the altitude valve will close, but will let the water flow back into the system. To do so the tank shall be equipped with level control. SAWS preferred level control is "Seimens-Milltronics Hydroranger 200 controller" equipped with an ultrasonic transducer. The altitude valve is activated with a solenoid valve, and can be control manually with a selector switch in the hand (close) position or automatically with a relay when the selector switch is in the auto position.

Drawing -E26 and E27 10'x10' CPS Transformer Containment Slab for limited space only

In order to prevent any oil spill into the aquifer, CPS requires a containment slab on all new pad mounted transformers on SAWS property. CPS' standard slab for containment measures 24' 10"x 23' 4" for a 2000 Kva transformer. Sheet E26 and E27 show an alternate design for the containment slab to be used only when the sites have limited spacing. Slab designs have to be approved by CPS prior to any construction.

Drawing E28 One line diagram secondary station

The following one line diagram with described equipment shall be used for the replacement of obsolete electrical equipment.   Special attention shall be taken for the selection of the 2400V Delta - 240/120V Delta transformer. Single phase load is limited to ten percent (10%) of the transformer KVA rating, equally divided between X1-X4 and X2-X4. Loading beyond this limit will result in 3-phase voltage distortion. Proper procedures shall be used for disposal of any PCB oil. Replacement equipment of the existing service pole cutout shall be equipped with a fuse and a surge arrestor.

Conclusion

In addition, a short circuit and protection device coordination study should be provided to allow for selection of electrical equipment and protective devices. Testing of the pump station shall be performed by an experienced testing firm and in accordance with the acceptance testing procedures of NETA. This handbook was developed to assist in the design of a SAWS primary pumping station. By using these recommendations, professional knowledge, a successful design can be accomplished. The handbook contains only the backbone structure required for a complete design, all of the details should be coordinated with SAWS Production and the consulting firm. Any documentation included herein is subject to change.