Section 32 - Electrical and Instrumentation

A. Introduction – The HRSD Operations Department has an Electrical and Instrumentation Division that provides electrical and instrumentation support for all of HRSD. The Engineering Department is responsible for coordinating the electrical review of plans and specifications and coordinating with the Operations Department on design and start-up issues. Based upon HRSD's history with various products and manufacturers, we have developed requirements and needs for certain specific products. Manufacturers of equipment and products are listed in the tables that follow.

B. General – Unless otherwise agreed upon, the FIRM shall design facilities and specify equipment around the names listed in this Section. In all cases NEMA is preferred over IEC rated components. IEC and NEMA/IEC components are not acceptable. Place all electric/electronic equipment indoors whenever possible. The following sections provide independent tables of products and manufacturers for pump stations, interceptor system controls and treatment plants in order to accommodate the different requirements of the various operating departments within HRSD.

- All equipment that is not NEMA rated must be approved by Engineer or Owner.

C. Pump Station and Interceptor Systems – Refer to following Table "Pump Station."

D. Treatment Plant – Refer to following Table "Treatment Plant." Equipment Numbering Sequences shall be in accordance with the Treatment Plant Section of this document.

Electrical and Instrumentation

Requirements

Index

Pump Station

Treatment Plant

Distributive Control System (DCS)

I. Item No. 1

A. Switchgear and MCCs

1. Manufacturers
    a. Eaton
    b. Square D
    c. Allen Bradley
2. Specific Criteria
    a. Design to meet arc flash standard; Reduce incident energy to 12 Cal/Cm2 or lower (MCC and VFD's incident energy should be designed to meet 1.2 Cal/Cm2 if attainable);Reference HRSD Arc Flash Mitigation Document Dated July 9-10, 2013 and additional Power Study Specifications example by SKM Power Systems Analysis, Inc. *(refer to Exhibit A)*
    b. MCCs must be placed indoors in NEMA 12 enclosures (gasketed).
    c. Switchgear must be placed indoors in NEMA 1A enclosure (gasketed).
    d. MCC's providing rear access is not acceptable.
    e. All horizontal / vertical bus must be accessible.
    f. Everything to be face-mounted, motor controls in the MCC are to be marked, lead, 1st lag, 2nd lag selectable, (any combination) with automatic failover (This may be part of the bubbler panel).
    g. Bottom entry versus Top entry routing must be evaluated for application.
    h. Provide with tin-plated copper bus.
    i. Provide feeder breakers with digital trip units.
    j. Provide extra fasteners for door cover.
    k. Provide phenolic labels with black backgrounds and white lettering.
    l. Provide spare terminals for intermediate terminal blocks for controls. Provide feeder breakers with digital trip units.
    m. Provide grounding for Switchgear (Ball type)
    n. The size of the electrical gear is based on the ampacity of the bus within. Typically, electrical rooms are designed to accommodate equipment layout without future considerations for growth, therefore electrical buildings should be sized adequately to accommodate where wall space is needed for future equipment.

o. Electrical rooms should be conditioned to increase the life of sensitive electrical and electronic equipment. Thermostat should be set up to 80 F to control condensation/moisture. Also include a hydrogen sulfide (H2S) removal system if needed.

B. Breakers / Solid State Breakers

1. Manufacturers

a. Eaton

b. Square D

2. Specific Criteria

a. Provide 20 amp minimum

b. Provide remote open/close operator to protect personnel from Arc Flash Incident; operator should be outside of arc flash boundary where possible. (refer to Exhibit M)

c. Provide ARMS “Arc Reduction Maintenance Switch” or equal, when activating downstream breakers incident energy levels will be reduced. Also, add separate pi- lot light to indicate when maintenance mode is enabled or disabled.

d. Provide LSIG digital trip unit if =/> 1000 amps and LSI if < 1000 amps

C. Provide trip units with fault indication to determine status (i.e., overloads or fault conditions) Metering Package.

1. Manufacturers

a. Schweitzer Engineering Laboratories (SEL)

b. Eaton

c. Schneider Electric (Square D)

d. GE

e. Basler

2. Specific Criteria

a. Volt Meter 3 phase & off

b. Ammeter 3 phase & off

c. kW

d. Provide 3 phase undervoltage & overcurrent protection

D. CT Cabinet

1. Manufacturers

a. Provided by Utility

2. Specific Criteria
    a. Locate meter base and CT cabinet on outside of pumping station

E. Selector Switches, Push Buttons, Lighted Push Buttons (NEMA 30mm)
    1. Manufacturers
        a. Square D
        b. Eaton
        c. Allen Bradley
    2. Specific Criteria
        a. Expandable contact blocks on operator IEC and NEMA/IEC rated switches are not acceptable.

F. Contactors
    1. Manufacturers
        a. Eaton
        b. Square D (Contactor must be able to reclose after short power blips)
        c. Allen Bradley
    2. Specific Criteria
        a. Provide with expandable auxiliary contacts for 120-volt control circuits
        b. IEC and NEMA/IEC rated contractors are not acceptable.

G. Fuses & Fuse Holders
    1. Manufacturers
        a. Bussmann
        b. Shawmut
    2. Specific Criteria
        a. Shall be locally available

H. Transformers
    1. Manufacturers
        a. Square D
        b. Eaton
        c. ACME
    2. Specific Criteria
        a. Copper coils

b. Aluminum coils are unacceptable

I. Terminal Strips

1. Manufacturers

a. Phoenix Contact

b. Square D

c. Weidmuller

d. Panduit Panduct DIN Rail Wiring Duct

2. Specific Criteria

a. DIN Rail mount if possible

b. Industrial rated

c. Provide compression type screws terminals on jumpers

J. Combination Starters (buckets)

1. Manufacturers

a. Square D

b. Eaton

c. Allen Bradley

2. Specific Criteria

a. Provide standalone combination starters in the proper enclosures (see junction/pull boxes and miscellaneous enclosures).

b. 120-volt control voltage

c. Run light – red

d. Stop light – green

e. Fault light – Amber

f. Power available light – white

g. Provide push to test indicator lights

h. Elapsed time meters (Crompton, ENB)–pump motors graduated in 1/10 hours, non-resettable

i. Externally mounted resets, operational from the front

j. Provide with adjustable thermo-magnetic breakers

k. Fused control transformer

l. MCC mounted lighting panels shall be provided with 25% spare breakers

m. Provide spare buckets (minimum 2)

n. Provide connections for motor leads directly from the motors to the starters. Do not use intermediate terminal blocks.

o. No IEC or NEMA/IEC rating (NEMA only).

K. Panel Meters

1. Analog

   a. Manufacturers

      1) GE/Yokogawa

      2) Simpson

2. Digital

   a. Manufacturers

      1) Yokogawa

      2) Red Lion

      3) Simpson

3. Elapsed Time

   a. Manufacturers

      1) Crompton

      2) ENB

      3) Yokogawa

   b. Specific Criteria

      1) Non resettable / resettable (plant site specific)

4. Pulse Counters

   a. Manufacturers

      1) Acromag

      2) Omron

5. Isolators

   a. Manufacturers

      1) Acromag

      2) AGMPhoenix

   b. Specific Criteria

      1) Isolate 4-20 MA and 1-5 volt signals

2) Powered 4-20 MA isolator splitter

3) Terminal relay

4) Compact panel temp sensor 4-20 MA

6. Signal Converters

   a. Manufacturers

      1) AGM

      2) RIS

      3) Acromag

   b. Specific Criteria

      1) Isolate 4-20 MA and digital

7. Surge Protectors

   a. Manufacturers

      1) Phoenix

      2) MTL-Crouse Hinds

   b. Specific Criteria

      1) Provide 120v AC power supply surge protectors

L. Rubber Mats (in front of gear)

1. Manufacturers

   a. Grainger

   b. Chesapeake Bay Rubber

2. Specific Criteria

   a. Contractor will provide and install at substantial completion (OSHA approved electric safety rubber matting: Type II ASTM D178)

M. Pilot Lights

1. Manufacturers

   a. Square D

   b. Eaton

2. Specific Criteria

   a. Provide LED type pilot lights

   b. Provide push to test lamp

   c. LED color and light cover color will be specified by HRSD

d. No IEC or NEMA/IEC Rating (NEMA Only)

N. Voltage Test Points

1. Manufacturer

a. Safeside- Grace Engineered Products (Load side of Main Breaker)

b. Panduit VeriSafe

II. Item No. 2

A. Emergency Generators

1. Manufacturers

a. Caterpillar

b. Cummins Onan

c. Kohler

2. Specific Criteria

a. Diesel generators

b. Propane or natural gas-powered engine generators are site specific

c. Engines to be of domestic manufacture whenever possible

d. Standby rated

e. 4-stroke

f. Parts must be available in 48 hours or less

g. Must meet current U.S. EPA and Virginia DEQ air standards

h. Low emission units

i. 48 hours of runtime/Fuel at full load

j. Remote Emergency stop pushbuttons at doorways (Pilla Model GS120 w/clear, hinged plastic cover)

B. Generator

1. Manufacturers

a. Stamford Newage

b. Caterpillar

c. KATO

d. LIMA

e. Marathon

f. Cummins

2. Specific Criteria
    a. Provide permanent magnet exciters
    b. The rectifier shall be a brushless, full-wave bridge
    c. All stator winding leads are to be brought out to the terminal box
    d. Neutrals shall be sized to full rating
    e. Temperature rise shall not exceed Class B rating with 105□□C ambient rise
    f. Alternator shall have a space heater that switches off when running
    g. Provide for 2/3 winding pitch; 5/6 pitch is not acceptable
    h. Minimum Class H insulation (epoxy) with tropicalization (anti-fungus) temperature requirements as specified by NEMA
    i. Provide voltage regulation less than +/- 1%
    j. Provide 150% minimum overspeed capability
    k. Provide amortisseur winding
    l. Provide less than 5% THD (Total Harmonic Distortion)
    m. Provide less than 50 TIF (Telephone influence factor)
    n. Provide Square D/Eaton main breaker of domestic manufacture
    o. Provide elapsed time meter graduated in 1/10 hours (analog or digital), non-resettable
    p. Voltage regulators shall be 3-phase.
    q. Provide 12 leads to switch voltages
    r. Provide flap at the end of exhaust to keep rain, birds, etc. out.
    s. The type of bird screen is site specific.
    t. Sound attenuation is site specific
    u. Provide separate room for indoor generator to reduce heat and noise.

C. Diesel Engine
  1. Manufacturers
    a. Caterpillar
    b. Cummins
    c. John Deere
  2. Specific Criteria
    a. Heavy-duty, direct-injected, 4-stroke diesel engine.
    b. Provide electronically controlled engines with an electronic control system to meet

current EPA emissions regulations

c. State the control system

d. Provide isochronous frequency regulation (no load to full load)

e. Provide +/- .25% steady state frequency regulation (minimum)

f. Size air, fuel, and oil filters to provide a minimum of 250 hours of operation before servicing

g. Engine manufacturers shall provide fuel separators

h. The heavy-duty air filter is to be a dry type with a restriction indicator

i. Provide a Racor heavy duty crankcase vapor coalescer

j. Provide a battery charging alternator 12V/65 amp, 24v/35amp minimum – negative ground)

k. Skid-mounted radiator sized to prevent overheating in the most severe conditions (122°F ambient)

l. Exhaust system and muffler shall be residential grade muffler (lowest DB reductions available). All insulation must be blanket type (non-asbestos), removable for servicing of exhaust system

m. Provide 12/24-volt DC starting system

n. Provide all diagnostic equipment for complete trouble shooting and training; operational training must be included (software/technical manuals/hardware etc.)

o. Provide speed sensing to protect against accidental starter engagement into a moving flywheel. (Battery charging alternator voltage output will not be accepted for this purpose)

p. Provide an adjustable (0-15 minutes) cool down time

q. Provide a large red emergency stop push button

r. Generator Alarms and shutdowns

    i. Low oil pressure

    ii. Not in auto

    iii. High coolant temperature

    iv. Overspeed

    v. Low fuel (Pre shutdown)

    vi. Generator running and over-crank shall shut down the engine and provide indicator lights.

    vii. All generator alarms/shutdowns provide indicator lights

viii. Separate alarms and shutdowns based on HRSD recommendation and not tie everything to common alarm

s. Provide analog or digital displays for coolant temperature, oil pressure, service hours, engine RPM, system DC volts and system diagnostic code

t. Provide Kim Hot-Start engine block heater (thermostatically controlled); isolation valves must be included.

u. Provide vibration isolators between generator set base and floor

v. Provide lifting eyes bolt

w. Provide break mean effective pressure (BMEP) calculations

x. Provide SCADA interface/data monitoring for HRSD generators

D. Battery Chargers

1. Manufacturers

a. LaMarche

b. Cummins

c. SENS

2. Specific Criteria

a. 12/24-volt chargers or equal

b. Automatic, solid state, provide continuous taper charging

c. UL listed, provide with under/over voltage, current failure, and loss of power acknowledgment

d. Evaluate full float charge versus trickle charge

E. Starting Batteries

1. Manufacturers

a. Exide

2. Specific Criteria

a. Use 8D series lead acid batteries (4D is not acceptable)

b. Provide 2 minimum

c. Each battery shall provide 1200 CCA each

d. Provide with insulated battery rack

e. Provide with 2-year full replacement guarantee

f. Provide as a minimum 2 cranking cycles at a minimum of 30 seconds each

g. Consult engine manufacturer for sizing

F. Day Tanks

1. Manufacturers

   a. Pryco

   b. Tramont

2. Specific Criteria

   a. UL Listed – double wall

   b. Provide with Oberndorfer bronze gear type pump. All pumps must be mounted on Day Tank.

   c. Pumps with rubber or nitrile impellers will not be accepted

   d. Provide with a low-level alarm and light

   e. Size for 2-hour minimum running time

   f. Provide a fuel level indicator on the day tank

   g. Provide a 2-pump system. Each pump shall be capable of pumping 100% fuel oil throughout the entire system.

   h. Provide “Not in Auto” lamp or other warning device

   i. Use momentary switch for tank fill/test

G. Transfer Switches

1. Manufacturers

   a. Eaton

   b. ASCO

2. Specific Criteria

   a. Provide with a metering package

   b. Provide with an exercise cycle of 4 hours, field adjustable from 10 minutes to 4 hours

   c. Provide with a utility power available light normal/emergency, phase indicator lights

   d. Zenith transfer switches are not acceptable.

   e. VFD compatible

   f. Time delay normal to emergency

   g. Time delay engine start

   h. Time delay emergency to normal

   i. Time delay engine cool down

   j. Three phase over voltage (Source 1 & 2)

k. Phase reversal (normal)

l. Three phase under frequency (Source 2)

m. 4 NO / NC form C contacts for (Source 1 & 2)

n. Manual Push to test button which automatically returns to utility & adjustable run timer (0- 600 minutes) (Note: This is not an exercise function)

o. Time delay neutral position

p. Three phase UV protection (Source 1 & 2)

q. Normal position light

r. Emergency position light

s. Normal source available light

t. Emergency source available light

H. Underground Storage Tanks (UST) Leak Detection

1. Manufacturers

a. Veeder Root TLS450 PLUS

b. Xerxes

2. Specific Criteria

a. Provide with leak detection system

b. Provide in accordance with EPA and all applicable state and local standards

c. Provide tank monitoring system

d. Provide a graduated stick for level measuring

e. Provide for refueling and stick access

f. Provide with electronic tank level indicating system

g. Provide with 48-hour fuel tank capacity

h. Provide AMI Model 8CH-DAC 8 channel digital/analog converter (4-20ma)

I. Louvers and Dampers

1. Manufacturers

a. Greenheck

b. Ruskin

2. Specific Criteria

a. Provide gravity damper

b. Provide anodized aluminum louvers and dampers with nylon bushings or ball bearings

c. Provide with bird screens readily removable without removing louvers or dampers

d. Designed to limit rainwater in the building

e. All hardware & components must be the same material and non-corrosive.

f. Where louvers and dampers are required provide (inside) recessed damper and (outside)

g. flange mounted louvers

J. Meter or monitoring package

1. Specific Criteria

a. Provide standard metering package

b. Frequency

c. Provide a voltage adjust rheostat

d. Provide 3 phase undervoltage and over-current protection

e. Provide automatic and manual start and stop

K. Start Up and Testing - Diesel Generator Tests

1. Specific Criteria

a. Provide factory test data

b. Contractors shall verify and provide fuel prior to start up and testing

c. Simulate and test all safety equipment. Using a reactive load bank > 500kW or a resistive load bank <500kW (0.8pF) run the generator:

i. 15 minutes at idle speed

ii. 30 minutes at 25% load

iii. 30 minutes at 50% load

iv. 60 minutes at 75% load

v. 120 minutes at 100% load

vi. 15 minutes at 25% load

vii. 15 minutes at 0% load

viii. off-Record stator, bearing, oil, ambient, and water temperatures every 15 minutes

d. Provide load bank receptacle boxes (site specific – Refer to Exhibit B)

e. Design in such that the station load is not included during load bank test.

f. Take power factor (pF) into consideration for resistive load bank test to ensure generator is not overloaded.

g. Demonstrate all warnings and shutdown alarms (simulation with laptop).

h. Record speed, voltage and amperage at 15-minute intervals as well as just prior to and after the load change

i. Hook up the generator and cycle through the light loading cycles as well as heavy loading cycles (3 each). Record same parameters every 15 minutes and before and after changing load. Tests to be witnessed by HRSD Automotive Superintendent and HRSD Electrical Engineer/Superintendent or designee

j. Create and attach to the switchgear detailed instructions. The instructions shall be laminated. The instructions shall be simple enough for anyone to pick them up and operate the diesel generator set.

k. Group A, B, and C phase cable together to cancel out EMF (Electromagnetic Field)

L. Load Bank Test Box (in Exhibit B “Leviton”)

1. Fabricated Load Bank Test Box

2. Alternative Load Bank Test Box

3. Manufacturers

a. ESL Power Systems

III. Item No. 3

A. Energy Efficient Motors

1. Specific Criteria

a. HRSD Electric Motor Specifications in Exhibit E “HRSD Electric Motor Specifications”.

b. Emergency stop pushbuttons

IV. Item No. 4

A. Sump Pumps

1. Manufacturers

a. Zoeller Co.

2. Specific Criteria

a. 120-volt

b. Plug into receptacle

c. Float controlled

V. Item No. 5 - Level Sensing Systems

A. Bubbler Type, Ultrasonic (Rosemount), and Submersible

1. Specific Criteria

a. Complete purged air bubbler system for sensing wetwell liquid level which generates and transmits level signals to a separate PLC which controls pump operations

b. Provide UPS for power failure

c. Power light – white

d. Provide with low pressure switch with normally closed dry contacts downstream of the regulator

e. Provide externally mounted duplex air compressors mounted on 30-gallon horizontal receiving tank (Model 3HBB-10-M300 AX) with lead/lag rotation control

f. Provide oil-less compressors with 120-volt 60 cycle, single phase motors with integral thermal overload protection

g. Provide manual purging of bubbler piping

h. Provide manual alternation of air compressors

i. Mount air compressors outside of the panel whenever possible

j. Provide high level alarm in wetwells. Provide with micro (non-mercury) switch backup (float ball)

k. Provide high wet well light and pressure switch

l. Provide overflow light and pressure switch

m. Provide high wet well and overflow push to test lights

n. All alarm contacts are closed in a normal operating state (Closed loop system)

o. Provide high level Floatball for alarms

B. Ultrasonic (site specific)

1. Manufacturers

a. Siemens

2. Specific Criteria

a. Microprocessor

b. FM approved (frequency modulation)

C. Level Transducer (site specific)

1. Refer to Exhibit F - Stilling Well Detail

2. Manufacturers

a. Waterpilot FMX-21 (refer to Exhibit Q)

D. Pressure Sensing Systems

1. Manufacturers

a. Foxboro
b. Rosemont
c. Siemens

2. Specific Criteria
a. Provide either an Ashcroft or Red Valve (series 40) brand pressure seal with Viton boot
b. Provide 0-100psi gauge (Ashcroft)
c. Provide a Foxboro IDPT 10 absolute pressure electronic transmitter
d. See Standard Detail “Pressure Reducing Station Pressure Sensor Detail”
e. Suction and discharge transmitters to be mounted in dry well area

E. Float Balls
1. Manufacturers
a. Flygt
b. Opti Float (Intrinsically Safe – Fiber Optic)
c. CSI Controls

2. Specific Criteria
a. Locate near sump pump in dry well and wet well
b. Alarm on high level
c. Support float ball cable to bottom of well; must be rigid and removable from top

VI. Item No. 6 – Variable Frequency Drives (VFDs)

A. Variable Frequency Drives (VFDs)
1. Manufacturers
a. YASKAWA
b. Allen Bradley

2. Specific Criteria
a. Provide thermal/mag breakers for the drive input power
b. Install equipment with the idea of keeping it clean and the temperature regulated
c. Provide thumbscrews for removable/washable filters or thumb screws replaced by snap in grills that are removable from the front of the cabinet (reusable)
d. Provide a programmable ramp time
e. Provide input reactors (MTE Corp) or TCI
f. Pulse Width Modulated (PWM)

g. IGBTs

h. Automatic restart on power disruption

i. Tune out a minimum of 3 frequencies

j. Hand/Off/Automatic (HOA) selector switch

k. Manual speed pot door mounted (in addition to keypad control)

l. Mount the resets and appropriate indicator lighting on the front of the drive or outside of the box to prevent employees from opening the panel

m. Tune drive to motor with a harmonics meter

n. Provide an input circuit breaker for short circuit protection (Fuses are not acceptable)

o. The controller electronics shall contain indicators of the following conditions:

   1) Undervoltage

   2) Overvoltage

   3) Over temperature

   4) Memory failure

   5) Emergency Stop

   6) Ground fault

   7) Instantaneous overcurrent

p. Provide auxiliary run contacts wired to run command for ventilation fan

q. Provide a NEMA 12 flanged disconnect free standing enclosure

r. Mount the resets and the appropriate indicator lighting on the front of the drive or the outside of the box

s. Provide four contact outputs for run status, power failure, VFD failure, not in auto status

t. The following are site specific options:

u. VFD must be able to be isolated and bypassed (auto/manual operation) allowing the motor to operate across the line at full load speed and current

v. Provide manual isolation and bypass capability

w. Provide three contactors for bypass operation

x. 6 Pulse Drive

y. Bypass contactors are site specific; consult with Interceptor Systems & Electrical Shop

3. Additional Design Considerations

   a. All electrical components must be NEMA only. IEC or NEMS/IEC is not acceptable.

b. Filters to HVAC units must be maintained and free from dust during construction phase.
c. VFD parameters must be included on as built prints (i.e., momentary power loss ride thru, energy savings, and fault reset)
d. Specify coil locks (Power Quality Solutions) on control relays for power dip ride thru capabilities.
e. Provide Bypass mode for critical VFD’s. Soft start or across the line depending on application.
f. Specify main circuit breaker cable operators for breaker operation instead of standard door operating mechanisms.
g. Provide One reset button to reset VFD and control circuit faults.
h. Provide finger safe barriers for main sideline breaker lugs.
i. Provide enough fans to replace each fan within a VFD (spare parts) where several VFD’s of the same size and model are specified.
j. Provide paper copies of VFD manuals.
k. To support large and heavy VFD’s 60 HP and above, provide a pedestal with a flat plate mounted inside the enclosure for VFD to rest for easy removal. Also provide a lift table to remove VFD.
l. Provide external air filter for easy access on cabinets.
m. Contractor to perform static tuning for optimal performance during startup. Contractor to supply panel shop with motor data sheets including the number of poles per motor. Also, include number of motor poles on motor nameplate.
n. Provide extended warranty by VFD manufacturer where replacement cost is justified.
o. Need all switches to indicate when not in auto
p. Need indication when control power is loss in addition to VFD fault.
q. Evaluate best routing method for bottom versus top entry of wire.
r. VFD shall be sized to provide current necessary for motor to produce continuous rated horsepower and service factor horsepower at highest carrier frequency.
s. Provide VFD Cable with copper shielding, XLPE insulation manufacture by Belden or equal.
    1) Consider these factors when designing motor HP, motor voltage and motor full load current, ambient temperature, VFD cable and connector ratings, and number of cables in raceway.
t. A Harmonic Study Analysis should be performed for all VFD applications by using IEE 519 guidelines. The design engineer should evaluate the best solution to reduce

Harmonic Distortion (ie. passive and active filters or active front end included as part of the VFD).

1) Refer to Exhibit C “Variable Frequency Drive” Specs

u. Provide auxiliary (AUX) to remove run command of VFD before opening contact. Refer to Disconnect – Aux Contact

B. Eddy Current Brake Systems/DC Drives – UNACCEPTABLE

VII. Item No. 7

A. Watt Hour Meter (for MCCs or individual motors) – Meter base and meter

1. Specific Criteria

a. Provided by utility. Locate outside of pump station.

VIII. Item No. 8

A. PLC/RTU

1. Manufacturers

a. Emerson / Control Wave /OCC100

b. Allen Bradley

2. Specific Criteria

a. Provide functional descriptions, the application program, the job-specific program data and a copy of the as-built software documentation

b. Include control & alarms

c. Controls accommodate automatic purge and latch output to current state during bubbler purge

d. Program must be provided using Function Block Programming

e. Control Wave Micro

f. PLC’s and RTU’s shall be equipped with isolation relays for all digital inputs. Example: (Idec 5-blade – 24 VDC coils- with a form C configuration contactor) relays mounted on DIN rail for the purpose isolating relay inputs. Whether a junction box is used or control panel a 24 VDC power supply with sufficient capacity to energize all of the 24 VDC relay coils simultaneously when necessary for all PLC or RTU inputs.

IX. Item No. 9

A. Exhaust Fans

1. Manufacturers

a. ILG

b. Dayton

c. Greenheck

d. Airovent

e. MK Plastics

2. Specific Criteria

a. Corrosion resistant including hardware

b. Must be explosion proof in wet wells and metering vaults

c. Direct drive

d. Belt drive not acceptable unless approved by Owner (Air detection is required if approved).

X. Item No. 10

A. Lighting

1. Manufacturers

a. Holophane

b. Hubbell

c. Thomas

d. Crouse Hinds

2. Specific Criteria

a. Provide proper levels of lighting over major equipment including switchgear, generators, pump motors, and controls. Lighting levels should conform to the IES lighting handbook as a minimum.

b. Provide exterior lighting at doorways and yard lighting required by building configuration.

c. Consider operation by photo electric cell.

d. Replace all light fixtures with LEDs if non-LED style fixture cannot be repaired.

1) Refer to Exhibit D - Lighting Policy

2) HPS, LPS, and Mercury Vapor – NOT ACCEPTABLE FOR ANY APPLICATION

B. Emergency Lighting

1. Specific Criteria

a. Dual Lite GMM-EL-W2 in admin areas

b. Emerg Lite PRO-2 in corrosive areas

c. Wall-paks are provided by HRSD

Note: Install dual input inverters if applicable

C. Exit Lighting

1. Specific Criteria

    a. Highly visible 24 hours/day for life of material

D. LED

1. Specific Criteria

2. To reduce maintenance

3. Perform payback analysis

XI. Item No. 11

A. Concrete Housekeeping Pads

1. Specific Criteria

    a. Provide a minimum of 4-inch thickness under MCCs, generators, transformers, and other general electrical equipment and around conduits at floor penetration.

    b. Chamfer all edges

XII. Item No. 12

A. Conduit and Conduit Systems

1. Specific Criteria

    a. Ream and chamfer all edges

    b. EMT or IMC are not allowed

    c. All flexible conduits shall be metallic liquidtite or equal.

    d. Flexible conduit must not be installed to complete one small run between RGS.

    e. Provide ¾ inch minimum size. (Where specifically approved or when the instrumentation restricts this size, ½ inch can be used)

    f. Do not use plastic anchors.

    g. Seal conduits with a silicone product as necessary

    h. See Miscellaneous section of these standards for markings and coatings.

    i. Seal conduits with OZ Gedney conduit and cable seals or with silicone where seals are not available.

    j. Cable trays are not acceptable unless approved by Owner.

    k. Label all conduits inside of building (Engineer must provide conduit schedule)

    l. Circuit # must be brought back to the panel/breaker.

    m. Paint RGS conduits red if requested by owner.

B. Spare Conduit Feeder

1. Specific Criteria

    a. Provide with service entrance.

    b. Add appropriate spares with pull wire.

C. PVC Coated Rigid Steel (inside and out)

1. Manufacturers

    a. Robroy

    b. OCAL

    c. Perma-Cote

    d. Gafco Industries

    e. Plastibond

    f. KorKap

2. Specific Criteria

    a. Provide in wet wells, underground (not encased), chemical areas, outside, and damp areas. Provide with PVC coated fittings, boxes and touch-up material.

    b. Provide 8” of PVC coated conduit were stubbed up through concrete (washdown areas)

D. Galvanized Rigid Steel

1. Specific Criteria

    a. Provide with applications other than PVC coated above.

E. PVC

1. Specific Criteria

    a. Underground/encased reinforced concrete, Schedule 40 can be substituted for galvanized conduit in duct banks where EMI is not a threat.

F. Tools Used

1. Specific Criteria

    a. Use suitable tools with conduit.

G. Patching/Repair

1. Specific Criteria

    a. Use appropriate material to patch and repair.

H. Flex – Liquidtite & Fittings

1. Manufacturers

a. Crouse Hinds

2. Specific Criteria

   a. Use fittings to suit installed conduit.

   b. Shall be metallic stainless steel, aluminum or equal.

I. Fixtures & Fittings (pull boxes)

1. Specific Criteria

   a. Use appropriate fittings and materials.

J. Struts and Straps

1. Specific Criteria

   a. To suit conduit materials

   b. Use matching fasteners.

   c. In outside, wet or damp areas use stainless steel fasteners.

   d. PVC coated channel or unistrut are not acceptable.

K. Pull Boxes (wire pulled through) and Junction Boxes (wires terminated inside)

1. Specific Criteria

   a. In outside, wet or damp areas, use stainless steel fasteners.

   b. Over 6-inch x 6 inch are to be hinged

   c. Gasketed

   d. Use stainless steel or aluminum in outside or damp areas.

L. Red Dye (Duct bank)

1. Specific Criteria

   a. Provide red dye in concrete duct banks.

      1) See typical duct bank details in Exhibit J

XIII. Item No. 13

A. Wire

1. Specific Criteria

   a. Provide copper stranded wire only.

   b. Provide separation of power, signal and telephone services

   c. Use compression type lugs only.

   d. **Do not splice wire – Splicing not allowed unless approved by Owner/Engineer**

   e. Telephone

1) Provide conduit and wiring for telephone.

f. Welding cable (DLO) – Design based on intermittent duty vs. continuous duty.

g. THHN, THWN, XHHW (for duct banks)

1) Follow NEC color coding.

2) All wire shall be stranded wire, rated for 600 volts.

3) #12 minimum wire size for typical applications

h. Instrumentation

1) All wire (MTW) or signal wire shall be rated at 600 volts.

2) DC wire shall be color-coded blue #16 AWG minimum.

3) AC wire shall be color-coded red #16 AWG minimum.

4) Analog signals shall be #18-2 with a shield (minimum), tinned.

5) f. Provide Ethernet cable/CAT 6 for communications to equipment.

Note: Cabinets with multiple sources must be clearly marked as such

XIV. Item No. 14 - Relays

A. Industrial

1. Manufacturers

a. Allen Bradley

b. Eaton

2. Specific Criteria

a. Fixed base

B. Electronic

1. Manufacturers

a. IDEC

b. Potter-Brumfield

c. Agastat

2. Specific Criteria

a. Plug in ice cube type with pilot lights.

XV. Item No. 15 - Lockout / Tagout (Safety) Refer to Section 22 – HRSD Safety Program in this manual for specifics.

XVI. Item No. 16

A. Switches / Receptacles / Plugs

1. Manufacturers
    a. Pass & Seymour
    b. Hubbell
    c. Crouse Hinds
2. Specific Criteria
    a. Provide compression type screw terminals on receptacles. Wire binding receptacles or switches are not acceptable.
    b. Provide for dedicated circuits for sump pumps.
    c. Provide one weatherproof (WP)/watertight receptacle with lockable cover on exterior wall of the pump station on a separate circuit; separately switches and should not be hot at all times.
    d. Provide a receptacle on each wall of the PS, upper & lower levels.
    e. Lower levels shall be mounted at 48 inches above finished floor -Provide one
    f. weatherproof/watertight receptacle on exterior walls on a single circuit, separately switched (Should be “hot” all the time)
    g. Provide ground fault receptacles and breakers where required.
    h. Provide power receptacles in control cabinets.
    i. Provide “in use” covers for indoor sump applications.

XVII. Item No. 17 – Electric Unit Heaters

A. *Not used, do not supply unless a condition requires it.*

XVIII. Item No. 18

A. Electrical Drawings
1. Specific Criteria
    a. Process and Instrumentation Diagrams (P&IDs) are to conform to ISA modified standards (Consulting engineer to provide.
    b. Provide functional descriptions with the P&IDs (Consulting engineer to provide)
    c. Provide Point-to-Point connection drawings. Contractor shall develop.
    d. Review and approval by the engineer shall be prior to installation.
    e. Label all conduits inside building.
    f. Place metal tags on cables in manholes.
    g. Provide final conduit & cable schedule on disk (AutoCAD, PDF or VISIO)

XIX. Item No. 19

A. Safety Switches (fused or unfused)

1. Manufacturers

   a. Square D

   b. Eaton

   c. Allen Bradley

2. Specific Criteria

   a. Light duty safety switches are unacceptable.

   b. Must be pad lockable.

XX. Item No. 20

A. Transformers (Dry)

1. Manufacturers

   a. Square D

   b. Eaton

   c. GE

2. Specific Criteria

   a. No aluminum wires.

   b. Provide 220° C insulation system for 15 kVA and larger.

   c. Provide 180° C insulation system for transformers less than 15 kVA.

   d. Transformers shall handle a 15% overload without exceeding the insulation rating.

XXI. Item No. 21 – Metering Vaults / Pits

A. Dehumidifiers

1. Specific Criteria

   a. Provide receptacle and location for HRSD installation.

B. Power Requirements

1. Specific Requirements

   a. Provide two receptacles with weatherproof covers.

C. Exhaust Fans

1. See Exhaust Fans (item#9)

D. Sump Pumps

1. Provide "in use" receptacle with a remote GFCI breaker located in station power panel.

2. Provide explosion proof sump pump in Class 1 division 1 areas.

E. Lighting

XXII. Item No. 22

A. Pressure Sustaining/Regulating Valves

1. Manufacturers

   a. KTM

   b. Foxboro

   c. Clow

2. Specific Criteria

   a. No butterfly valves or pinch valves with controls

   b. Provide 4-20 mA operated valves. Do not use pulsed control valves.

   c. Automatic Controls of Virginia or Valve Automation for actuator applications

B. Valve Actuators

1. Manufacturers

   a. EIM/Bettis

   b. Limitorque (refer to Exhibit P)

2. Specific Criteria

   a. Auma and Rototorque are not acceptable.

XXIII. Item No. 23

Manufacturer

1. Pure Air or approved equal Alarm Systems

3. Specific Criteria

   a. HRSD will provide and install the alarm system. Contractor shall provide sensors and wiring to a junction box and terminate on a terminal strip adjacent to the alarm panel location

   b. HRSD will provide alarm points.

C. Station Bypass Alarm Systems (Refer to Exhibit G)

1. Specific Criteria

   a. A minimum of two (2) weeks' notice is required to set up temporary alarms for a scheduled station bypass operation.

   b. HRSD will provide and install the temporary alarm system. Contractor shall provide sensors and wiring to a junction box and terminate on a terminal strip adjacent to the alarm panel location.

c. HRSD will provide alarm points.

d. Contractors to provide contact names and numbers for alarming purposes.

XXIV. Item No. 24 – Flow Meters (Size for average flows)

A. Magnetic

1. Manufacturers

a. Rosemount

b. Foxboro

2. Specific Criteria

a. Use for control or billing applications.

b. Ensure vendor is clear on application.

c. Provide with remote head, display and keyboard.

B. Ultrasonics (strap on)

1. Manufacturers

a. FUJI

b. Flexim (refer to Exhibit O)

c. Pulsar

2. Specific Criteria

a. Do not use for control.

b. Locate inside station.

C. Venturi

1. Specific Criteria

a. Generally, not used in most applications.

XXV. Item No. 25 – Antenna

A. Mobil Mark

B. Shark Fin Type

C. Omni Directional

XXVI. Item No. 26

A. Louvers/Dampers

1. Specific Criteria

a. See Emergency Diesel Generator Louvers and Dampers (Item #2)

XXVII. Item No. 27

A. Cathodic Protection (Test Stations)

1. Specific Criteria

a. Use Flush Fink Test Stations

XXVIII. Item No. 28

A. Junction Boxes and Misc. Enclosures

1. Manufacturers

a. Hoffman

b. Saginaw

c. Hammond

2. Specific Criteria

a. Provide PVC coated boxes and/or fittings when using with PVC coated conduit. Use "like" materials.

3. Inside

a. Specific Criteria

1) Stainless steel, fiberglass reinforced plastic (FRP), NEMA 4x

4. Outside

a. Specific Criteria

1) Stainless steel, NEMA 4x with Myers hubs

5. Wet

a. Use with PVC coated conduit and PVC coated hubs.

1) Stainless steel, fiberglass reinforced plastic, NEMA 4x with watertight fittings (Myers)

XXIX. Item No. 29

A. Panel Boards/Control Panels

1. Manufacturers

a. Eaton

b. Square D

c. GE

2. Specific Criteria

a. Provide with tin-plated copper bus.

b. Provide 25% spares (minimum)

c. Provide bolt-in breakers.

d. Do not provide cans with pre-stamped knockouts.

e. Provide with hinged panel cover with a latching door.

f. Provide heavy duty industrial grade panel boards.

g. Breaker operator should be outside of panel.

h. Breaker should be located inside of panel.

i. HOA switches should be on the outside of panel.

j. Dead front Hinge panel cover if available.

k. Provide LED work light, if warranted

l. Provide phenolic labels with black backgrounds and white lettering.

XXX. Item No. 30 – Miscellaneous Electrical

A. Electrical Equipment Testing

1. Specific Criteria

a. Provide testing in off-peak hours or switch off an equivalent amount of load prior to testing.

B. One Line Diagram

1. Specific Criteria

a. Provide an update to the one-line diagram with significant changes in the electrical system.

C. Thermographic Inspection

1. Specific Criteria

a. Provide a thermographic inspection of the new systems upon completion.

D. Short Circuit / Coordination Study / Arc Flash

1. Specific Criteria

a. Provide a coordination study short circuit, coordination, and arc flash analysis for new systems or systems with significant changes.

b. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum number of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable. Include Arc flash analysis results for generator protective device.

c. Contractor must adhere to NFPA 70E Electrical Safety requirements when working on electrical equipment in HRSD facilities.

d. Engineer must design electrical systems in accordance with NFPA 70E.

Refer to Exhibit A

XXXI. Item No. 31- Lightning Protection Refer to NFPA 820 and NFPA 780. - Lightning Protection applications will be site specific (Discuss with HRSD Electrical Staff).

XXXII. Item No 32 - SCADA Site Drawing (Refer to Exhibit H)

A. For sites without generators should provide battery charger and batteries to maintain reliability.

XXXIII. Item No 33 – SCADA Flowchart (refer to Exhibit L)

XXXIV. Item No 34 – Dominion Energy Coordination (refer to Exhibit K)

A. Easements

1. It is imperative that the design engineer contacts the utility company (i.e., Dominion Energy, Rappahannock Power, Prince George Electric Cooperative, etc.) to determine the responsible territory.

2. Design Engineer and HRSD should inquire with the utility company if single phase or 3-phase power is available at the proposed site.

3. Design Engineer should incorporate right-of-way (ROW), multi-use utility easements, identify property owners, and VDOT requirements as part of the preliminary engineering report (PER) to prevent delays and cost increase during the construction phase of the project. The items listed above should be explored in advance especially in rural communities where 3-phase electrical service is not available.

   a. See Exhibit K for Dominion Project Workflow Brochure “HRSD Interface on New Projects with Dominion Energy Virginia (DEV)”

XXXV. Item No. 35

A. Analyzers/Monitors: Process

1. pH

2. Manufacturers

   a. Foxboro

   b. E&H Memosens CPS16D pH probe (Incinerator scrubber water process) (Site Specific/Specific applications)

   c. M4 Knick (Site Specific/Specific applications)

B. Conductivity

1. Manufacturers

a. Hach

XXXVI. Item No. 36

A. Grounding

"50.53 Grounding Electrode System Installation.

(A) Rod, Pipe, and Plate Electrodes. Rod, pipe, and plate electrodes shall meet the requirements of 250.53(A)(1) through (A)(3).

(1) Below Permanent Moisture Level. If practicable, rod, pipe, and plate electrodes shall be embedded below permanent moisture level. Rod, pipe, and plate electrodes shall be free from nonconductive coatings such as paint or enamel.

(2) Supplemental Electrode Required. A single rod, pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). The supplemental electrode shall be permitted to be bonded to one of the following:

(1) Rod, pipe, or plate electrode

(2) Grounding electrode conductor

(3) Grounded service-entrance conductor

(4) Nonflexible grounded service raceway

(5) Any grounded service enclosure

Exception: If a single rod, pipe, or plate grounding electrode has a resistance to earth of 25 ohms or less, the supplemental electrode shall not be required.

(3) Supplemental Electrode. If multiple rod, pipe, or plate electrodes are installed to meet the requirements of this section, they shall not be less than 1.8 m (6 ft) apart."

XXXVII. Item No. 37

A. NFPA 820 Building Classification –

"1. Purpose to provide explosion and fire protection for life property, and operations.

2. Reduce or mitigate the effects of fire or explosion

3. Consult with AHJ (Authority Having Jurisdiction) to ensure that the NFPA 820 standard will be enforced.

NFPA 70 – Article 500

Class I: Flammable Gases/Vapors

Class II: Combustible Dust

Class III: Ignitable Fibers

Wastewater/Treatment/Collections Systems

Class I, Div 1 or 2, Group D (Methane)

Class I, Div 1 or 2, Group G (Sludge)

Wet Well Pump Station

Less than 12 air changes – Division 1

Greater than 12 air changes – Division 2

Typical classified areas: Barscreen, Headworks or Preliminary Treatment Facility, Grit Removal, Odor Control, Sludge Handling and Thickening, etc.

Evaluate equipment type (i.e., explosion proof, conduit seals, etc.)

NFPA 820 4.2.2 – Collections Systems – See Exhibit Y

NFPA 820 5.2.2 – Liquid Streaming – See Exhibit Z

Consideration requirements: exhaust fans, continuous ventilation, alarming, air flow and monitoring."

XXXVIII. Item No. 38 – Standard Details

A. PLC Control Wave – Temp Pump Enclosure Detail and Pump Run Status PS Schematic– See Exhibit S

B. Antenna Installation Detail - See Exhibit T

C. Wet Well Installation Detail – See Exhibit U

D. Intrinsic Safety Panel Wiring Diagram – See Exhibit V

E. Power Wiring Junction Box Detail– See Exhibit W

F. Vault Plans – See Exhibit X

XXXIX. Item No. 39 – Air Purification – Hydrogen Sulfide (H2S) Mitigation for Electrical Room – See Exhibit AA

A. Manufacturer

1. Pure Aire or approved equal.

I. Item No. 1

A. Switchgear

1. Manufacturers
   a. Eaton
   b. Square D
2. Specific Criteria
   a. Design to meet arc flash standard; Reduce hazard category rating to 2 or lower (MCC and VFD's should be designed to meet incident energy of 1.2 Cal/Cm2 or below if attainable); Reference HRSD Arc Flash Mitigation Document Dated July 9-10, 2013.
   b. Provide two 48 VDC control voltage. 48 VDC redundant battery systems for control voltage per incoming primary voltage source. Use 1 Best Battery Selector to switch between each set of batteries (per primary source side) for control voltage.
   c. Stored charge breaker systems are unacceptable.
   d. Sealed Lead acid (VRLA)
   e. NiCAD are not acceptable unless approved by Owner.
   f. Provide tin-plated copper bus.
   g. Provide switchgear indoors in a NEMA 1A (gasketed) enclosure.
   h. Switchgear to be located indoors.
   i. Provide with push to test lights.
   j. Bottom entry versus top entry must be evaluated for application.
   k. Provide in a room strictly for switchgear.
   l. Install 3- or 4-inch windows on switchgear for IR testing for new installations (consult with Electrical Manager)
   m. Equipment should be designed to be double end fed with tie breakers.
   n. Rack out breakers must be racked in and out remotely without opening doors.
   o. Provide remote open/close operator to protect personnel from Arc Flash Incident; operator should be outside of arc flash boundary where possible. (refer to Exhibit N)

p. Provide ARMS “Arc Reduction Maintenance Switch” or equal, when activating downstream breakers incident energy levels will be reduced. Also, add separate pilot light to indicate when maintenance mode is enabled or disabled.

q. Provide hinged doors if available.

r. Design electrical gear/equipment to achieve an arc flash rating of Cat 2 or less.

s. Provide trip units with fault indication to determine status (i.e., overloads or fault conditions)

t. Provide LSIG digital trip unit if =/> 1000 amps and LSI if < 1000 amps

u. Provide extra fasteners for door cover.

v. Provide phenolic labels with black backgrounds and white lettering.

w. The size of the electrical gear is based on the ampacity of the bus within. Typically, electrical rooms are designed to accommodate equipment layout without future considerations for growth, therefore electrical buildings should be sized adequately to accommodate where wall space is needed for future equipment.

x. Electrical rooms should be conditioned to increase the life of sensitive electrical and electronic equipment. Thermostat should be set up to 80 F to control condensation/moisture. Also include a hydrogen sulfide (H_2S) removal system if needed.

Note: 1. For reliability and the ability to safely troubleshoot and perform maintenance on switchgear and MCC’s, the main switchgear should be double ended with a Bus tie. (The main gear shall provide each piece of major electrical equipment with an A and B feeder from each end.) Each MCC shall have a double ended configuration with Bus ties and Kirk Key interlocks to allow isolation of ½ the electrical gear at the MCC level.

2. When this is not possible, alternatives shall be investigated for critical electrical equipment for critical processes. *(Return to MCCs)*

Reference HRSD Arc Flash Mitigation Document Dated July 9-10, 2013, and additional Power Study Specifications example by SKM Power Systems Analysis, Inc.

Refer to Exhibit A

B. Breakers/Solid State Breakers

1. Manufacturers

a. Eaton

b. Square D

2. Specific Criteria

   a. Provide appropriate spares and spaces.

C. Metering or Monitoring Package (Utility Grade Metering)

1. Manufacturers

   a. Schweitzer Engineering Laboratories (SEL)

   b. Eaton

   c. Schneider Electric (Square D)

   d. GE

   e. Basler

2. Specific Criteria

   a. Provide utility grade metering.

   b. Volt Meter 3 phase & off

   c. Ammeter 3 phase & off

   d. kW

   e. PF

   f. kVA

   g. kVAR

   h. Utility grade CTs & PTs

   i. Metering packages (See Item No. 8)

   j. Provide 3 phase undervoltage & overcurrent protection (open Delta PTs are unacceptable)

   k. Provide testing that trips the main with a loss of any of the three legs.

   l. Generator must be designed to be manually initiated to return to utility.

D. Selector Switches, Push Buttons, Lighted Push Buttons

1. Manufacturers

   a. Square D

   b. Eaton

   c. Allen Bradley

2. Specific Criteria
    a. Expandable contact blocks on operators
    b. NEMA/IEC rated switches are not acceptable.

E. Contactors
1. Manufacturers
    a. Eaton
    b. Square D
    c. Allen Bradley
2. Specific Criteria
    a. Provide with expandable auxiliary contacts for 120-volt control circuits.
    b. NEMA/IEC rated contactors are not acceptable.

F. Fuses & Fuse Holders
1. Specific Criteria
    a. Must be locally available.

G. Switchgear Control Transformers
1. Specific Criteria
    a. Provide copper coils.
    b. Aluminum coils are unacceptable.

H. Terminal Strips / DIN Rail (Space Saver)
1. Manufacturers
    a. Phoenix
    b. Contact
    c. ILSCO
    d. Square D
    e. Weidmuller
    f. Panduit Panduct
2. Specific Criteria
    a. Rail mount if possible
    b. Industrial rated
    c. Finger safe
    d. Provide compression type screws terminals on jumpers.

I. Rubber Mats

1. Specific Criteria

    a. Contractor will provide and install at substantial completion (OSHA Approved: Type I I ASTM D178)

    b. Add matting in front of gear.

J. Pilot Lighting

1. Specific Criteria

    a. Provide LED type pilot lights.

K. Protective Relays

1. Manufacturers

    a. Schweitzer Engineering Laboratories

    b. GE

    c. Basler

2. Specific Criteria

    a. Provide 10-year warranty.

    b. Solid State

    c. Provide integral remote racking system of breakers from control room via HMI to ensure the safety of employees by removing the breaker on and off bus safely and out of the Arc Flash boundary.

L. MCCs

1. Manufacturers

    a. Eaton

    b. Square D

    c. Allen Bradley

2. Specific Criteria

    a. Provide with tin-plated copper bus.

    b. MCCs to be placed indoors in a NEMA 12 (gasketed) enclosure.

    c. Provide redundant feeders to either end of the MCCs with a bus tie in the middle whenever possible.

    d. Provide with Kirk key interlocks door (mounted)

    e. Do not provide in the same room with chemical tanks or pumps.

    f. Provide with “push to test” lights.

g. Bottom entry vs. top entry must be evaluated based on application.

h. Provide with face mounted operators and resets.

i. Design to meet arc flash standard.

j. Provide extra fasteners for door cover.

k. Provide phenolic labels with black backgrounds and white lettering.

l. Provide spare terminals for intermediate terminal blocks for controls.

m. The size of the electrical gear is based on the ampacity of the bus within. Typically, electrical rooms are designed to accommodate equipment layout without future considerations for growth, therefore electrical buildings should be sized adequately to accommodate where wall space is needed for future equipment.

n. Electrical rooms should be conditioned to increase the life of sensitive electrical and electronic equipment. Thermostat should be set up to 80 F to control condensation/moisture. Also include a hydrogen sulfide (H2S) removal system if needed.

Notes: See General Notes, Item 1 – Switchgear

M. Breakers/Solid State Breakers

1. Manufacturers

   a. Eaton

   b. Square D

N. Metering/Monitoring Package (For applications other than utility grade metering)

1. Manufacturers

   a. Eaton IQ SEL

   b. Square D

   c. Power Logic

   d. Schweitzer Engineering Laboratories (SEL)

2. Specific Criteria

   a. Volt Meter 3 phase & off

   b. Ammeter 3 phase & off

   c. kW

   d. PF

e. kVA

f. kVAR

g. CTs & PTs

h. Metering packages (See Item No. 8)

O. Selector Switches, Push Buttons, Lighted Push Buttons

1. Manufacturers

    a. Square D

    b. Eaton

    c. Allen Bradley

2. Specific Criteria

    a. Expandable contact blocks on operators

P. Contactors

1. Manufacturers

    a. Eaton

    b. Square D (Contactor must be able to reclose after short power blips)

    c. Allen Bradley

2. Specific Criteria

    a. Provide with expandable auxiliary contacts for 120-volt control circuits.

Q. Fuses & Fuse Holders

1. Manufacturers

    a. Bussmann

    b. Shawmut

2. Specific Criteria

    a. Must be locally available.

R. MCC CTs and PTs

1. Manufacturers

    a. Square D

    b. Eaton

    c. Allen Bradley

2. Specific Criteria

    a. Metering

b. Provide copper coils.

c. Aluminum coils are unacceptable.

S. Terminal Strips

1. Manufacturers

a. Pheonix

b. Contract

c. ILSCO

d. Square D

e. Weidmuller

2. Specific Criteria

a. Rail mount instrumentation if possible

b. Industrial rated

T. Combination Starters (Buckets)

1. Manufacturers

a. Square D

b. Eaton

c. Allen Bradley

2. Specific Criteria

a. 120-volt control voltage

b. Run light – red.

c. Stop light – green.

d. Fault light – amber

e. Power available light – white

f. Provide push to test indicator lights.

g. Elapsed time meters–graduated in 1/10 hours Resettable or Non-resettable (plant/site specific; incorporate time meters on DCS if available)

h. Provide overload resets operational from the front (external)

i. Provide with adjustable thermo-mag breakers.

j. Fused control transformer.

k. 25% spares and/or spaces for all sizes of buckets or expandable option

l. MCC mounted lighting panels shall be provided with 25% spare breakers.

m. Provide connections for motor leads directly from the motors to the starter. Do not use intermediate terminal blocks (50 HP and smaller)

n. Provide standalone combination starters in the proper enclosures (See Junction/Pull Boxes and Miscellaneous Enclosures)

U. Rubber Mats (to be placed in front of gear)

1. Manufacturers

a. Grainger

b. Chesapeake Bay Rubber

2. Specific Criteria

a. Contractor will provide and install at substantial completion (OSHA approved: Type II ASTM D178)

V. Voltage Test Points

1. Manufacturer

a. Safeside-Grace Engineered Products (Load side of Main Breaker)

b. Panduit VeriSafe

II. Item No. 2

A. MCCs

1. Manufacturers

a. Eaton

b. Square D

c. Allen Bradley

2. Specific Criteria

a. Provide with tin-plated copper bus.

b. MCCs to be placed indoors in a NEMA 12 (gasketed) enclosure.

c. Provide redundant feeders to either end of the MCCs with a bus tie in the middle whenever possible.

d. Provide with Kirk key interlocks door (mounted)

e. Do not provide in the same room with chemical tanks or pumps.

f. Provide with "push to test" lights.

g. Bottom entry vs. top entry must be evaluated based on application.

h. Provide with face mounted operators and resets.

i. Design to meet arc flash standard.

j. Provide extra fasteners for door cover.

k. Provide phenolic labels with black backgrounds and white lettering.

l. Provide spare terminals for intermediate terminal blocks for controls.

m. The size of the electrical gear is based on the ampacity of the bus within. Typically, electrical rooms are designed to accommodate equipment layout without future considerations for growth, therefore electrical buildings should be sized adequately to accommodate where wall space is needed for future equipment.

n. Electrical rooms should be conditioned to increase the life of sensitive electrical and electronic equipment. Thermostat should be set up to 80 F to control condensation/moisture. Also include a hydrogen sulfide (H2S) removal system if needed.

Notes: See General Notes, Item 1 – Switchgear

B. Breakers/Solid State Breakers

1. Manufacturers

a. Eaton

b. Square D

C. Metering/Monitoring Package (For applications other than utility grade metering)

1. Manufacturers

a. Eaton IQ SEL

b. Square D

c. Power Logic

d. Schweitzer Engineering Laboratories (SEL)

2. Specific Criteria

a. Volt Meter 3 phase & off

b. Ammeter 3 phase & off

c. kW

d. PF

e. kVA

f. kVAR

g. CTs & PTs

h. Metering packages (See Item No. 8)

D. Selector Switches, Push Buttons, Lighted Push Buttons

1. Manufacturers

a. Square D

b. Eaton

c. Allen Bradley

2. Specific Criteria

a. Expandable contact blocks on operators

E. Contactors

1. Manufacturers

a. Eaton

b. Square D (Contactor must be able to reclose after short power blips)

c. Allen Bradley

2. Specific Criteria

a. Provide with expandable auxiliary contacts for 120-volt control circuits.

F. Fuses & Fuse Holders

1. Manufacturers

a. Bussmann

b. Shawmut

2. Specific Criteria

a. Must be locally available.

G. MCC CTs and PTs

1. Manufacturers

a. Square D

b. Eaton

c. Allen Bradley

2. Specific Criteria

a. Metering

b. Provide copper coils.

c. Aluminum coils are unacceptable.

H. Terminal Strips

1. Manufacturers
    a. Pheonix
    b. Contract
    c. ILSCO
    d. Square D
    e. Weidmuller
2. Specific Criteria
    a. Rail mount instrumentation if possible
    b. Industrial rated

I. Combination Starters (Buckets)

1. Manufacturers
    a. Square D
    b. Eaton
    c. Allen Bradley
2. Specific Criteria
    a. 120-volt control voltage
    b. Run light – red.
    c. Stop light – green.
    d. Fault light – amber
    e. Power available light – white
    f. Provide push to test indicator lights.
    g. Elapsed time meters–graduated in 1/10 hours Resettable or Non-resettable (plant/site specific; incorporate time meters on DCS if available)
    h. Provide overload resets operational from the front (external)
    i. Provide with adjustable thermo-mag breakers.
    j. Fused control transformer.
    k. 25% spares and/or spaces for all sizes of buckets or expandable option
    l. MCC mounted lighting panels shall be provided with 25% spare breakers.
    m. Provide connections for motor leads directly from the motors to the starter. Do not use intermediate terminal blocks (50 HP and smaller)
    n. Provide standalone combination starters in the proper enclosures (See Junction/Pull Boxes and Miscellaneous Enclosures)

J. Rubber Mats (to be placed in front of gear)

1. Manufacturers

   a. Grainger

   b. Chesapeake Bay Rubber

2. Specific Criteria

   a. Contractor will provide and install at substantial completion (OSHA approved: Type II ASTM D178)

K. Voltage Test Points

1. Manufacturer

   a. Safeside-Grace Engineered Products (Load side of Main Breaker)

   b. Panduit VeriSafe

III. Item No. 3

A. Emergency Generators

1. Manufacturers

   a. Caterpillar

   b. Cummins

2. Specific Criteria

   a. Diesel generators

   b. Turbine generators are not acceptable unless approved by Owner.

   c. Engines to be of domestic manufacture whenever possible.

   d. 4-stroke diesels **ONLY**

   e. Parts must be available in 48 hours or less.

   f. Must meet current U.S. EPA and Virginia DEQ air standards.

   g. Low emission units

   h. All units shall be Standby Rated

   i. Remote Emergency stop pushbuttons at doorways (Pilla Model GS120 w/clear, hinged, plastic cover)

   j. Provide separate room for indoor generator to reduce heat and noise.

B. Generator

1. Manufacturers

   a. Stamford

   b. Newage

        c. Caterpillar
        d. KATO
        e. LIMA
        f. Marathon
        g. Cummins

    2. Specific Criteria
        a. Generators 1 MWatt and larger require a two-bearing generator unless the manufacturer has engineered the engine main bearing to reliably withstand the dynamic rotor loads and weights
        b. The rectifier shall be a brushless, full-wave bridge.
        c. <400 kW and below at 480 volts bring all leads out to the terminal box.
        d. 400 kW and above – bring out 3 leads and a neutral (minimum) to the terminal box.
        e. Neutrals shall be sized to full rating (brought out to the terminal box)
        f. Temperature rise on generator voltages 4160 & higher shall not exceed Class B rating with 80° C ambient rise. All others shall not exceed 105° C rating.
        g. Alternator shall have a space heater that switches off when running.
        h. Provide for 2/3 winding pitch.
        i. Minimum Class H insulation (operating temperature class 180° C) with topicalization (anti-fungus)
        j. Provide voltage regulation less than +/- 1%
        k. Provide 150% minimum overspeed capability.
        l. Provide amortisseur winding.
        m. Provide less than 5% THD (Total Harmonic Distortion)
        n. Provide less than 50 TIF (Telephone influence factor)
        o. Voltage regulator shall be 3-phase.

C. Diesel Engine
    1. Manufacturers
        a. Caterpillar
        b. Cummins
    2. Specific Criteria
        a. Heavy-duty, direct-injected, 4-stroke diesel engine.

b. Provide electronically controlled engines.

c. Provide electronically controlled engines with an electronic control system.

d. Require vendor to identify the control system to be provided.

e. Provide system software and training to fully troubleshoot and operate the engine

f. Provide isochronous frequency regulation (no load to full load)

g. Provide +/- 0.25% steady state frequency regulation (minimum)

h. Air, fuel and oil filters shall be sized to provide a minimum of 250 hours of operation before servicing

i. Engine manufacturers shall provide fuel water separators.

j. The air filter is to be a dry type with a restriction indicator.

k. Provide RTD’s for monitoring bearing and winding temperatures.

l. Add vibration monitoring if > 1000 KW.

m. Provide a Racor heavy duty crankcase vapor coalesce.

n. All radiators and supporting appurtenances are to be galvanized steel.

o. The radiator core shall have solder coated fins to prevent corrosion by hydrogen sulfide gas.

p. Size radiator to prevent overheating in the most severe conditions (122°F ambient)

q. Exhaust system and muffler shall be residential grade muffler (lowest DB reduction available). All insulation must be blanket type (non-asbestos), removable for servicing of exhaust system.

r. The starting system shall be 24-volt DC.

s. Provide all diagnostic equipment for complete trouble shooting (software/technical manuals/hardware etc.)

t. Speed sensing shall be provided to protect against accidental starter engagement into a moving flywheel.

u. Battery charging alternation output voltage will not be acceptable for this purpose.

v. Provide an adjustable (0-15 minutes) cool down time.

w. Provide a large red emergency stop push button.

x. Low oil pressure, high coolant temperature, overspeed, and over-crank shall shut down the engine and provide indicator lights

y. Analog or digital displays shall be provided for coolant temperature, oil pressure, ser- vice hours, engine RPM, system DC volts and system diagnostic code

z. Provide Kim Hot-Start engine block heater (thermostatically controlled) set in accordance with manufacturer’s recommendation (120°F – 140°F) aa. Provide vibration isolators between generator set base and floor

bb. bb. Provide lifting eyes.

cc. Provide brake mean effective pressure (BMEP) calculations.

dd. Provide means of quantifying flows from the day tank to the diesel and from the diesel back to the main tank.

D. Battery Chargers

1. Manufacturers

a. LaMarche

b. Cummins

c. SENS

2. Specific Criteria

a. 24-volt chargers or LaMarche equal

b. Automatic, solid state, provide continuous taper charging.

c. UL listed, provide with under/over voltage, current failure and loss of power acknowledgment.

d. Full Float Charge versus trickle charge must be evaluated for application.

E. Starting Batteries

1. Manufacturers

a. Delco -DEKA

b. Exide Switch locations

2. Specific Criteria

a. Use 8D lead-acid batteries (4D is not acceptable)

b. Provide a minimum of 2. The batteries shall provide 1200 CCA each.

c. Provide with insulated battery rack.

d. Provide a 2-year full replacement guarantee.

e. Provide as a minimum 2 cranking cycles at a minimum of 30 seconds each.

F. Air Starter

1. Manufacturers

a. Ingersoll Rand

2. Specific Criteria

a. Site Specific

G. Day Tanks

1. Manufacturers

   a. Pryco

   b. Simplex

   c. Tramont

2. Specific Criteria

   a. UL Listed – double wall.

   b. Provide with Oberndorfer bronze gear type pump. Pumps with rubber or nitrile impellers will not be accepted

   c. Provide with a low-level alarm. Size for 2-hour minimum running time

   d. Provide a fuel level indicator on the day tank.

   e. Provide a two-pump system. Each pump shall be capable of pumping 100% of the fuel oil for all generators.

   f. Fuel shall be returned to the day tank.

   g. Provide Not in Auto lamp or other warning device.

   h. Meet all VDEQ requirements.

H. Underground Storage Tanks (UST)

1. Manufacturers

   a. Veeder Root TLS450 PLUS

   b. Xerxes

2. Specific Criteria

   a. Provide in accordance with EPA and all applicable state and local standards.

   b. Provide with leak detection system.

   c. Provide a graduated stick for level measuring.

   d. Provide for stick access and refueling.

   e. Provide with 7 days of fuel tank capacity.

   f. Provide an electronic tank level indicating system with a 4-20 mA output calibrated to the tank or Ethernet connection (TCP/IP)

   g. Provide AMI Model 8CH-DAC 8 channel digital/analog converter (4-20ma)

I. Sub-base Fuel Tanks

1. Provided by Generator Manufacturer.

2. Must meet all UL-142 requirements for double-walled fuel tanks (Site Specific).

3. Must provide generator 48 hours of runtime at 100% load.
4. Must include high level, low level, and leak detection alarms.

J. Enclosure
   1. Sound level is site specific. Must not exceed 75dBA @ 23 ft.
   2. Must have full access to engine, generator, and controls.
   3. Must be able to operate at 100% load in all weather conditions.

K. Louvers and Dampers
   1. Manufacturers
      a. Greenheck
      b. Ruskin
   2. Specific Criteria
      a. Aluminum or PVC with hardware
      b. Provide for gravity dampers on emergency generator systems (For motor operated applications, must fail to open position if power loss)
      c. Provide anodized aluminum dampers with nylon bushings or ball bearings.
      d. Steel and/or steel shafts are not acceptable.
      e. Provide with bird screens readily removable without removing louvers or dampers.
      f. Designed to limit rainwater in building.
      g. Where louvers and dampers are required, provide recessed dampers (inside) and flange mounted louvers (outside)
      h. Manufacturer shall set and balance the system.

L. Metering/Monitoring Package
   1. Specific Criteria
      a. Volt meter 3 phase & off
      b. Ammeter 3 phase & off
      c. Frequency
      d. kW
      e. PF
      f. kVA
      g. kVAR
      h. kWh
      i. Utility grade CTs & PTs

j. Metering packages (See Item No. 8)

k. Provide 3 phase undervoltage & overcurrent protection.

l. Synchroscope

m. Sync lights

n. Supply a TCP/IP modbus link with an HRSD supplied IP address, subnet mask, and gateway to allow the Emerson DCS (or other monitoring system) to read all data registers from the generators and the associated MCC hardware. This includes run statuses, breaker statuses, voltage, current, diesel generator engine data, etc.

M. System Operation

1. Specific Criteria

a. Provide protection such that the two sources (utility & emergency generator) can never be closed out of phase

b. Provide approvals by Dominion Virginia Power on the paralleling protection scheme

c. Provide a selector switch to allow the operator to choose “curtailment” or “loss of power” (typically set to “loss of power”).

d. In the loss of power setting, the system shall have automatic and manual operation. The manual operation would be provided in the event the automatic functions failed.

e. If the operator switches to curtailment:

f. Depressing a single push button in the automatic mode will start the engine, parallel with the utility, ramp the plant load onto the generator and open the utility breaker.

g. Depressing a second push button will ramp the load back to the utility and shut down the generators.

h. Provide a detailed sequence of operation for generator and switchgear operation.

i. Monitor temporary generator master control panel connect to DCS for monitoring.

N. Start Up and Testing

1. Specific Criteria

a. Provide factory test data.

b. Simulate and test all safety equipment. Using a reactive load bank (0.8PF) run the generator:

1) 15 minutes at idle speed

2) 30 minutes at 25% load

3) 30 minutes at 50% load

4) 60 minutes at 75% load

5) 120 minutes at 100% load

6) 15 minutes at 25% load

7) 15 minutes at 0% load (cool down) off record stator, bearing, oil, ambient, and water temperatures every 15 minutes.

c. Record speed, voltage and amperage at 15-minute intervals as well as just prior to and after a load change.

d. Demonstrate all warnings and shutdowns with laptop.

e. Hook up the generator to the main switchgear. Perform all automatic and manual functions a minimum of three times each. The plant will load the generators as much as possible. Particular attention should be observed to the larger starting loads. Record same parameters every 15 minutes and before and after changing load. Tests to be witnessed by HRSD Automotive Superintendent and HRSD Electrical Engineer or designee.

f. Create and attach to the switchgear detailed instructions. The instructions shall be laminated. The instructions shall be simple enough for anybody to pick them up and operate the diesel generator set.

g. Group A, B, and C phase cable together to cancel out EMF (Electromagnetic Field)

I. Energy Efficient Motors

1. Specific Criteria

a. See HRSD Electric Motor Specifications in *Exhibit E "HRSD Electric Motor Specifications".*

b. Provide ammeters on motors 50 HP & larger.

c. Local stop pushbuttons for VFDs, Use HOA for constant speed applications.

d. Add momentary push button at Motor.

J. Sump Pumps

1. Specific Criteria

a. Provide with 120-volt plug and receptacle. Refer to Treatment Plant/Miscellaneous Items.

K. Level Sensing Systems

1. Specific Criteria

a. Provide 4-20 mA signal.

1) See Treatment Plant No. 24

2) See Chemical Systems Plants

L. Bubbler Type – Level Sensing Systems

1. Specific Criteria

a. Complete purged air bubbler system with time delay for sensing wet well liquid level which generates and transmits level signals to control pump operations.

b. Provide UPS backup for controls.

c. Provide power light – white.

d. Provide a pressure sensing device (Foxboro or equal)

e. Provide externally mounted duplex air compressors mounted on 30-gallon horizontal receiving tank

f. Provide push button for manual purging of bubbler piping.

g. Provide manual alternation of air compressors.

h. Provide lead/lag switch – on off.

i. Provide panel mounted 4 ½ inch 0 level gauge/Analog gauge.

j. Mount air compressors outside of panel whenever possible

k. Provide pressure activated switches for point applications (Barksdale)

M. Ultrasonic – Level Sensing Systems

1. Manufacturers

a. Rosemont

b. Siemens

2. Specific Criteria

a. Microprocessor

b. FM approved (frequency modulation)

N. Capacitance – Level Sensing Systems (Not Acceptable)

1. Manufacturers

a. Warrick

b. Drexelbrook

2. Specific Criteria

a. Provide with point applications only.

b. Not for 4-20 ma applications

O. Pressure Transmitters – Level Sensing Systems

1. Manufacturers

a. Foxboro

b. Rosemount

c. Air Monitor – Incinerator draft

d. Siemens

2. Specific Criteria

a. All other locations

P. FloatBalls

1. Manufacturers

a. Flygt

b. Optifloat

2. Specific Criteria

a. Non mercury

b. Fiber Optic

Q. Pressure Sensing System – Level Sensing Systems

1. Specific Criteria

a. Provide either an Ashcroft or Red Valve (series 40) brand pressure seal with Viton boot.

b. Provide Ashcroft Gauges 100 psi.

c. Provide Foxboro IDPT 10 absolute pressure electronic transmitter.

d. See Standard Detail “Pressure Reducing Station Pressure Sensor Detail”

R. Diaphragm – Level Sensing Systems

1. Manufacturers

a. Foxboro

b. Rosemont

2. Specific Criteria

a. Pressure Transmitter (Diaphragm Type)

S. Radar – Level Sensing Systems

1. Manufacturers
    a. Rosemont
2. Specific Criteria
    a. Non-Contacting and Guided Wave types will be application dependent.

T. Variable Frequency Drives (VFDs)

1. Manufacturers
    a. Yaskawa
    b. Allen Bradley
2. Specific Criteria
    a. Install the equipment with the idea of keeping it clean and temperature regulated.
    b. Provide thumbscrews for removable/washable filters or thumb screws replaced by snap in grills that are removable from the front of the cabinet (reusable)
    c. Provide a programmable ramp time.
    d. Provide input reactors (MTE Corp) or TCI
    e. Pulse Width Modulated (PWM)
    f. Use IGBTs
    g. Automatic restart on power disruption
    h. Tune out a minimum of 3 frequencies.
    i. Hand/Off/Automatic (HOA) selector switch
    j. Manual speed control by potentiometer (door mounted) in addition to keypad control.
    k. Tune drive to motor with a harmonics meter
    l. Provide an input circuit breaker for short circuit protection (Fuses are not acceptable)
    m. The controller electronics shall contain indicators of the following conditions:
        1) Undervoltage
        2) Overvoltage
        3) Over temperature
        4) Memory failure
        5) Emergency Stop

6) Ground fault

7) Instantaneous overcurrent

n. Provide a NEMA 12 flanged disconnect free standing enclosure.

o. Provide auxiliary run contactor wired to run command for ventilation fan.

p. Mount the resets & appropriate indicator lighting on the front of the drive or the outside of the box to prevent employees from opening the panel.

q. Provide four contact outputs for run status, power failure, VFD failure, not in auto status.

r. The following are site specific options:

1) VFD must be able to be isolated and bypassed (auto/manual operation) allowing the motor to operate across the line at full-load speed and current. Site specific

2) Provide manual isolation and bypass capability.

3) Provide three contactors for bypass operation.

s. VFD “T” leads in free air shall be run in RGS or PVC coated RGS.

t. “T” leads can be run in PVC if in a duct bank.

u. Do not run “T” leads in conduit with any other conductors.

v. “T” leads shall be run in a separate conduit per each drive.

w. 6 pulse drive or Matrix drive or AB 755T

3. Additional Design Considerations

a. All electrical components must be NEMA only. IEC or NEMS/IEC is not acceptable.

b. Filters to HVAC units must be maintained and free from dust during construction phase.

c. VFD parameters must be included on as built prints (i.e., momentary power loss ride thru, energy savings, and fault reset)

d. Specify coil locks (Power Quality Solutions) on control relays for power dip ride thru capabilities.

e. Specify Baker SKF EP 1000 Dynamic motor link on all motor/VFD system 100HP and above or designated as critical equipment.

f. Provide Bypass mode for critical VFD’s. Soft start or across the line depending on application.

g. Specify main circuit breaker cable operators for breaker operation instead of standard door operating mechanisms.

h. Provide One reset button to reset VFD and control circuit faults.

i. Provide finger safe barriers for main sideline breaker lugs.

j. Provide enough fans to replace each fan within a VFD (spare parts) where several VFD's of the same size and model are specified.

k. Provide paper copies of VFD manuals.

l. To support large and heavy VFD's 60 HP and above, provide a pedestal with a flat plate mounted inside the enclosure for VFD to rest for easy removal. Also provide a lift table to remove VFD.

m. Provide external air filter for easy access on cabinets.

n. VFD shall be sized to provide current necessary for motor to produce continuous rated horsepower and service factor horsepower at highest carrier frequency.

o. Contractor to perform static tuning for optimal performance during startup. Contractor to supply panel shop with motor data sheets including the number of poles per motor. Also, include number of motor poles on motor nameplate.

p. Provide extended warranty by VFD manufacturer where replacement cost is justified.

q. Need all switches to indicate when not in auto.

r. Need indication when control power is loss in addition to VFD fault.

s. Evaluate best routing method for bottom versus top entry of wire.

t. Provide VFD Cable with copper shielding, XLPE insulation manufacture by Belden or equal.

    1) Consider these factors when designing motor HP, motor voltage and motor full load current, ambient temperature, VFD cable and connector ratings, and number of cables in raceway.

u. A Harmonic Study Analysis should be performed for all VFD applications by using IEE 519 guidelines. The design engineer should evaluate the best solution to reduce Harmonic Distortion (ie. passive and active filters or active front end included as part of the VFD) (refer to Exhibit C)

Provide auxiliary (AUX) to remove run command of VFD before opening contact.

Refer to Disconnect – Aux Contact

IV. Item No. 4

A. Energy Efficient Motors

1. Specific Criteria

   a. See HRSD Electric Motor Specifications in *Exhibit E "HRSD Electric Motor Specifications".*

   b. Provide ammeters on motors 50 HP & larger.

   c. Local stop pushbuttons for VFDs, Use HOA for constant speed applications.

   d. Add momentary push button at Motor.

V. Item No. 5

A. Sump Pumps

1. Specific Criteria

   a. Provide with 120-volt plug and receptacle. Refer to Treatment Plant/Miscellaneous Items.

VI. Item No. 6

A. Level Sensing Systems

1. Specific Criteria

   a. Provide 4-20 mA signal.

      1) See Treatment Plant No. 24

      2) See Chemical Systems Plants

B. Bubbler Type – Level Sensing Systems

1. Specific Criteria

   a. Complete purged air bubbler system with time delay for sensing wet well liquid level which generates and transmits level signals to control pump operations.

   b. Provide UPS backup for controls.

   c. Provide power light – white.

   d. Provide a pressure sensing device (Foxboro or equal)

   e. Provide externally mounted duplex air compressors mounted on 30-gallon horizontal receiving tank

   f. Provide push button for manual purging of bubbler piping.

   g. Provide manual alternation of air compressors.

   h. Provide lead/lag switch – on off.

i. Provide panel mounted 4 ½ inch 0 level gauge/Analog gauge.
j. Mount air compressors outside of panel whenever possible
k. Provide pressure activated switches for point applications (Barksdale)

C. Ultrasonic – Level Sensing Systems
1. Manufacturers
a. Rosemont
b. Siemens
2. Specific Criteria
a. Microprocessor
b. FM approved (frequency modulation)

D. Capacitance – Level Sensing Systems (Not Acceptable)
1. Manufacturers
a. Warrick
b. Drexelbrook
2. Specific Criteria
a. Provide with point applications only.
b. Not for 4-20 ma applications

E. Pressure Transmitters – Level Sensing Systems
1. Manufacturers
a. Foxboro
b. Rosemount
c. Air Monitor – Incinerator draft
d. Siemens
2. Specific Criteria
a. All other locations

F. FloatBalls
1. Manufacturers
a. Flygt
b. Optifloat
2. Specific Criteria

a. Non mercury

b. Fiber Optic

G. Pressure Sensing System – Level Sensing Systems

1. Specific Criteria

a. Provide either an Ashcroft or Red Valve (series 40) brand pressure seal with Viton boot.

b. Provide Ashcroft Gauges 100 psi.

c. Provide Foxboro IDPT 10 absolute pressure electronic transmitter.

d. See Standard Detail "Pressure Reducing Station Pressure Sensor Detail"

H. Diaphragm – Level Sensing Systems

1. Manufacturers

a. Foxboro

b. Rosemont

2. Specific Criteria

a. Pressure Transmitter (Diaphragm Type)

I. Radar – Level Sensing Systems

1. Manufacturers

a. Rosemont

2. Specific Criteria

a. Non-Contacting and Guided Wave types will be application dependent.

VII. Item No. 7

A. Variable Frequency Drives (VFDs)

1. Manufacturers

a. Yaskawa

b. Allen Bradley

2. Specific Criteria

a. Install the equipment with the idea of keeping it clean and temperature regulated.

b. Provide thumbscrews for removable/washable filters or thumb screws replaced by snap in grills that are removable from the front of the cabinet (reusable)

c. Provide a programmable ramp time.

d. Provide input reactors (MTE Corp) or TCI

e. Pulse Width Modulated (PWM)

f. Use IGBTs

g. Automatic restart on power disruption

h. Tune out a minimum of 3 frequencies.

i. Hand/Off/Automatic (HOA) selector switch

j. Manual speed control by potentiometer (door mounted) in addition to keypad control.

k. Tune drive to motor with a harmonics meter

l. Provide an input circuit breaker for short circuit protection (Fuses are not acceptable)

m. The controller electronics shall contain indicators of the following conditions:

    1) Undervoltage

    2) Overvoltage

    3) Over temperature

    4) Memory failure

    5) Emergency Stop

    6) Ground fault

    7) Instantaneous overcurrent

n. Provide a NEMA 12 flanged disconnect free standing enclosure.

o. Provide auxiliary run contactor wired to run command for ventilation fan.

p. Mount the resets & appropriate indicator lighting on the front of the drive or the outside of the box to prevent employees from opening the panel.

q. Provide four contact outputs for run status, power failure, VFD failure, not in auto status.

r. The following are site specific options:

    1) VFD must be able to be isolated and bypassed (auto/manual operation) allowing the motor to operate across the line at full-load speed and current. Site specific

    2) Provide manual isolation and bypass capability.

    3) Provide three contactors for bypass operation.

s. VFD “T” leads in free air shall be run in RGS or PVC coated RGS.

t. “T” leads can be run in PVC if in a duct bank.

u. Do not run “T” leads in conduit with any other conductors.

v. “T” leads shall be run in a separate conduit per each drive.

w. 6 pulse drive or Matrix drive or AB 755T

3. Additional Design Considerations

a. All electrical components must be NEMA only. IEC or NEMS/IEC is not acceptable.

b. Filters to HVAC units must be maintained and free from dust during construction phase.

c. VFD parameters must be included on as built prints (i.e., momentary power loss ride thru, energy savings, and fault reset)

d. Specify coil locks (Power Quality Solutions) on control relays for power dip ride thru capabilities.

e. Specify Baker SKF EP 1000 Dynamic motor link on all motor/VFD system 100HP and above or designated as critical equipment.

f. Provide Bypass mode for critical VFD’s. Soft start or across the line depending on application.

g. Specify main circuit breaker cable operators for breaker operation instead of standard door operating mechanisms.

h. Provide One reset button to reset VFD and control circuit faults.

i. Provide finger safe barriers for main sideline breaker lugs.

j. Provide enough fans to replace each fan within a VFD (spare parts) where several VFD’s of the same size and model are specified.

k. Provide paper copies of VFD manuals.

l. To support large and heavy VFD’s 60 HP and above, provide a pedestal with a flat plate mounted inside the enclosure for VFD to rest for easy removal. Also provide a lift table to remove VFD.

m. Provide external air filter for easy access on cabinets.

n. VFD shall be sized to provide current necessary for motor to produce continuous rated horsepower and service factor horsepower at highest carrier frequency.

o. Contractor to perform static tuning for optimal performance during startup. Contractor to supply panel shop with motor data sheets including the number of poles per motor. Also, include number of motor poles on motor nameplate.

p. Provide extended warranty by VFD manufacturer where replacement cost is justified.

q. Need all switches to indicate when not in auto.

r. Need indication when control power is loss in addition to VFD fault.

s. Evaluate best routing method for bottom versus top entry of wire.

t. Provide VFD Cable with copper shielding, XLPE insulation manufacture by Belden or equal.

   1) Consider these factors when designing motor HP, motor voltage and motor full load current, ambient temperature, VFD cable and connector ratings, and number of cables in raceway.

u. A Harmonic Study Analysis should be performed for all VFD applications by using IEE 519 guidelines. The design engineer should evaluate the best solution to reduce Harmonic Distortion (ie. passive and active filters or active front end included as part of the VFD) (refer to Exhibit C)

Provide auxiliary (AUX) to remove run command of VFD before opening contact.

Refer to Disconnect – Aux Contact

B. DC Drives

   1. Specific Criteria

      a. Unacceptable

C. Eddy Current Brake Systems

   1. Specific Criteria

      a. Unacceptable

D. DC Drives

   1. Specific Criteria

      a. Unacceptable

E. Eddy Current Brake Systems

   1. Specific Criteria

      a. Unacceptable

VIII. Item No. 8

A. Metering Packages for Switchgear

   1. Manufacturers

a. Schweitzer Engineering Lab (SEL)

b. Xpert (Eaton)

c. Power Logic (Square D)

d. Multilin (GE)

2. Specific Criteria

a. Provide cumulative watt-hour meters on each MCC, or specific motor

b. Provide a meter on each MCC to indicate 3 phase parameters on the MCC, i.e., volts, amps, kW, PF, kVA, kWh, etc.

c. Provide with motors 200 HP and above.

IX. Item No. 9

A. PLCs

1. Manufacturers

a. Allen Bradley (i.e. –SLC 500, Compact Logix 5000, Micro Logix 5000)

2. Specific Criteria

a. Provide functional descriptions, the application program, the job- specific program data, and a copy of the as-built software documentation

b. Include PLC fail indicator.

c. Provide license, software, programmed files with labels (as Built)

d. PLC's and RTU's shall be equipped with isolation relays for all digital inputs. Ex- ample: (Idec 5-blade – 24 VDC coils- with a form C configuration contactor) relays mounted on DIN rail for the purpose isolating relay inputs. Whether a junction box is used or control panel a 24 VDC power supply with sufficient capacity to energize all the 24 VDC relay coils simultaneously when necessary for all PLC or RTU inputs.

X. Item No. 10

A. Exhaust Fans

1. Manufacturers

a. ILG

b. Dayton

c. Greenheck

d. Airovent

e. Mk Plastics

2. Specific Criteria

a. Corrosion resistant including hardware.

b. Must be explosion proof in hazardous areas.

c. Direct Drive

1) Belt drive not acceptable unless approved by Owner (Air detection is required if approved).

XI. Item No. 11

B. Lighting

1. Manufacturers

a. Holophane

b. Hubbell

c. Thomas

d. Crouse-Hinds

2. Specific Criteria

a. Replace all light fixtures with LEDs if Non-LED style fixture cannot be repaired.

b. Provide proper levels of lighting over major equipment including switchgear, generators, pump motors, and controls. Minimum lighting levels should conform to the IES lighting handbook.

c. Exterior lights shall be placed on a single photocell (within reason)

Refer to Exhibit D - Lighting Policy

3. Other

a. HPS

1) Specific Criteria

i. Not acceptable for any application

b. LPS

1) Specific Criteria

i. Not acceptable for any application

c. Mercury Vapor

1) Specific Criteria

i. Not acceptable for any application

d. Emergency Lighting

1) Manufacturers

i. Dual Lite

ii. Emergency Lite

Note: Install dual input inverters if applicable

2) Specific Criteria

i. Dual Lite GMM-EL-W2 in admin areas

ii. Emerg Lite PRO-2 in corrosive areas

e. Exit Lighting

1) Manufacturers

i. Dual Lite

ii. Lithonia

2) Specific Criteria

i. Highly visible 24 hours/day for life (self-illuminating)

ii. Provide lighted only if required.

f. High-Mast Lighting

1) Manufacturers

i. Holophane

2) Specific Criteria

i. Site specific

g. LED

1) Specific Criteria

i. To reduce maintenance

ii. Perform payback analysis.

XII. Item No. 12

A. Concrete Housekeeping Pads

1. Specific Criteria

a. Provide a minimum of 4-inch thickness under Switchgear, MCCs, transformers, general electrical equipment, and around conduits at floor penetrations.

b. Chamfer all edges.

XIII. Item No. 13

A. Conduit and Conduit Systems

1. Specific Criteria
    a. Provide three separate conduit systems. One for power circuits >600 volts, one for power circuits less than 600 volts, and one for communication circuits
    b. Instrumentation (<25v) can be placed in the communication duct bank.
    c. Use compression type lugs only.
    d. Ream and chamfer all edges.
    e. EMT or IMC are not acceptable unless approved by Owner.
    f. All flexible conduits shall be heavy duty metallic liquidtite or equal.
    g. Provide ¾ inch minimum size (when specifically approved or when instrumentation restricts this size, ½ inch can be used)
    h. Do not use plastic anchors.
    i. Seal conduits with a silicone product as necessary (in the manholes to the buildings)
    j. Administrative areas (plenum) can use EMT down to ½ inch (lighting only)
    k. Label all conduits inside of building (Engineer must provide conduit schedule)
    l. Circuit # must be brought back to the panel/breaker.
    m. Place metal tags on cables in manholes
    n. See the Miscellaneous section of these standards for markings and coatings.
    o. Provide Oz Gedney conduit and cable seals or silicone where seals are not available.
    p. Cable trays are not acceptable unless approved by Owner.
    q. Evaluate cost of stainless steel or aluminum conduit vs. PVC coated rigid steel conduit (where applicable)

B. Spare Conduits

1. Specific Criteria
    a. Provide with service entrance.
    b. Add appropriate spares with pull wires.

C. Future Conduits

1. Specific Criteria
    a. Some future conduits may become trip hazards, they must be cut flush

and grouted at the finish floor in some cases.

D. PVC Coated Rigid Steel (inside and out)

1. Manufacturers

a. Robroy

b. Plasti-Bond

c. Perma-cote

d. Korkap

e. Ocal

f. Gafco Industries

2. Specific Criteria

a. Provide in corrosive areas, underground (not encased), chemical areas, chemical containment areas, outside and damp areas.

b. Provide with PVC coated fittings, boxes and touch-up material.

c. Provide 8” of PVC coated conduit were stubbed up through concrete (wash-down areas)

E. PVC

1. Specific Criteria

a. Underground/encased reinforced concrete.

b. Can replace RGS in duct banks where EMI is not a threat.

F. Rigid Galvanized Steel

1. Specific Criteria

a. Provide in all other areas not covered by PVC and PVC coated.

G. Tools Used

1. Specific Criteria

a. Use suitable tools with conduit.

H. Patching/Repair

1. Specific Criteria

a. Use appropriate material to patch and repair.

I. Flex – Liquidtite & Fittings

1. Specific Criteria

a. Use Myers hubs where suitable.

b. Use coated fittings where appropriate.

c. Heavy duty metallic fittings require.

d. Shall be metallic stainless steel, aluminum or equal.

J. Explosion Proof Fittings

1. Manufacturers

a. Crouse Hinds

b. Appleton

2. Specific Criteria

a. Use fittings to match installed conduit.

K. Fixtures & Fittings

1. Specific Criteria

a. Use appropriate fittings and materials.

L. Struts and Straps

1. Specific Criteria

a. To suit conduit materials

b. Use matching fasteners.

c. In outside, wet or damp areas use stainless steel fasteners.

M. Pull Boxes (wire pulled through) and Junction Boxes (wires terminated inside)

1. Specific Criteria

a. Over 6-inch x 6 inch are to be hinged

b. Gasketed

c. Use stainless steel/aluminum in outside/wet areas.

d. Use PVC coated reinforced fiberglass in hazardous and chemical areas.

N. Wire Hangers

1. Specific Criteria

a. Appropriately locate above dropped ceilings.

O. Red Dye

1. Specific Criteria

a. Provide red dye in concrete duct bank.

b. 4000 psi

c. See typical duct bank details in Exhibit J

XIV. Item No. 14

A. Wire

1. Specific Criteria

   a. Provide copper stranded wire only.

   b. Provide for separation of power, signal and telephone services.

   c. Do not splice wire - Splicing not allowed unless approved by Owner/Engineer

   d. Use compression type lugs only.

   e. Place metal tags on cables in manholes

   f. Welding cable (DLO) – Design based on intermittent duty vs. continuous duty.

   g. Provide Ethernet cable/CAT 6 for communications to equipment.

B. Telephone – Wire

1. Specific Criteria

   a. Minimum wire gauge #22-24 AWG

   b. Provide plenum rated cable in return air plenums.

C. THHN, THWN, XHHW – Wire

1. Specific Criteria

   a. Follow NEC color coding.

   b. All shall be stranded wire, rated for 600-volt.

   c. #12 minimum wire size for typical applications

D. Instrumentation – Wire

1. Specific Criteria

   a. All wire MTW or signal wire shall be rated at 600-volt.

   b. Do not combine analog circuits (twisted shielded pair-TSP) with other circuits in the same conduit.

   c. Instrumentation control wires should be sized accordingly (#16 stranded wire recommended)

   d. DC wire shall be color-coded blue #16 AWG minimum.

   e. AC wire shall be color-coded red #16 AWG minimum.

   f. Unless otherwise specified by the manufacturer, provide analog signals with #18-2 AWG with a shield, tinned

Note: Cabinets with multiple sources must be clearly marked as such

E. High Voltage Cable – Wire

1. Specific Criteria

a. Follow appropriate code.

F. Heat Tracing – Wire

1. Manufacturers

a. Letco-Dual Controls

b. Chromalox

2. Specific Criteria

a. Provide terminations above the insulation.

b. Provide thermostatically controlled constant watt tracing.

c. Provide with insulation.

d. Provide with protective outer coating.

e. Provide a metal strip on PVC pipe to distribute heat.

f. Provide with indicator light.

g. Provide with stainless steel leads in corrosive areas.

h. Provide coating for chemically corrosive areas.

XV. Item No. 15 - Relays

A. Industrial

1. Manufacturers

a. Allen Bradley

b. Eaton

2. Specific Criteria

a. Fixed base

B. Electronic

1. Manufacturers

a. IDEC

b. Potter-Brumfield

c. Agastat

2. Specific Criteria

a. Plug-in/ice cube type with pilot lights

XVI. Item No. 16

A. Lockout / Tagout → Safety

1. Specific Criteria

a. Provided for in Section 22 – HRSD Safety Program in this manual. Provide local lockout devices for all equipment.

XVII. Item No. 17

A. Switches / Receptacles / Plugs

1. Manufacturers

a. Pass & Seymour

b. Hubbell

c. Crouse Hinds

2. Specific Criteria

a. Provide compression type screw terminals on receptacles. Wire binding receptacles or switches are not acceptable.

b. Provide for dedicated circuits for sump pumps.

c. Provide power receptacle in control cabinets.

d. Provide a neutral for each circuit, multi wire circuits are not allowed without special approval and then with a two-pole breaker.

e. Provide “in use” covers for indoor sump area applications.

XVIII. Item No. 18 – Unit Heaters

A. Unit Heaters - Electric

1. Manufacturers

a. QMark

b. Dayton

2. Unit Heaters – Gas

a. Space Ray

b. Dayton

XIX. Item No. 19

A. Electrical Drawings

1. Specific Criteria

a. Process and Instrumentation Diagrams (P&IDs) are to conform to ISA modified standards (Consulting engineer to provide)

b. Provide functional descriptions with the P&IDs (Consulting engineer to provide)

c. Provide Point-to-Point connection drawings. Contractor shall develop.

d. Review and approval by the engineer shall be prior to installation.

e. Label all conduits inside building.

f. Place metal tags on cables in manholes

g. Provide final conduit & cable schedule on disk (AutoCAD, PDF & VISIO)

XX. Item No. 20

A. Safety Switches (fused or unfused)

1. Manufacturers

   a. Square D

   b. Eaton

   c. Westinghouse

   d. Allen Bradley

2. Specific Criteria

   a. Light duty safety switches are unacceptable.

   b. Must be pad lockable.

XXI. Item No. 21 - Transformers

A. Dry Transformers

1. Manufacturers

   a. Square D

   b. Eaton

   c. GE

   d. ACME

2. Specific Criteria

   a. No Aluminum Wire

   b. Provide 220° C insulation system for 15kVA and larger.

   c. Provide 180° C insulation system for transformers less than 15kVA.

   d. Transformers shall handle a 15% overload without exceeding the insulation rating.

   e. Place on 4” housekeeping pads

B. Oil Filled Transformers

1. Manufacturers

a. Square D

b. Eaton

c. GE

2. Specific Criteria

a. No PCBs allowed.

b. Provide with FR3 oil.

c. Provide housekeeping pad – elevate pad in places prone for flooding.

d. Require external sample ports.

XXII. Item No. 22

A. Metering Vaults/Pits

1. Specific Criteria

a. Provide receptacle and receptacle location per HRSD direction.

b. Provide sump pumps as needed with remote GFCI circuit breaker protection.

c. Provide explosion proof sump pump in Class 1 division 1 areas.

B. Other Metering Vaults/Pits

1. Power Requirements

a. Specific Criteria

i. Provide two receptacles with weatherproof covers with remote GFCI circuit breaker protection

2. Exhaust Fans

a. See Exhaust Fans

b. Size for 12 air changes per hour (minimum)

c. Bring exhaust duct to within 6 inches above finished floor.

3. Lighting

a. Provide incandescent lighting with a vapor tight glove and guard.

b. Provide light switch at access.

XXIII. Item No. 23

A. Pressure Sustaining/Regulating Valves

1. Manufacturers

a. KTM

b. Foxboro

c. Clow

2. Specific Criteria

a. Provide 4-20 mA operated valves. Do not use pulsed control valves.

b. Automatic Controls of Virginia or Valve Automation for actuator applications

c. Use EIM /Bettis actuators.

d. Limitorque (refer to Exhibit P)

B. Other

1. Butterfly Valves

2. V Notch Plug Valves

3. V Notch Ball Valves

XXIV. Item No. 24

A. Flow Meters – Size for average flows

1. Parshall flume

a. Specific Criteria

i. Use ultrasonic level indicator (Siemens)

2. Magnetic

a. Manufacturers

i. Rosemont

ii. Foxboro

b. Specific Criteria

i. Use for control or billing applications.

ii. Ensure vendor is clear on application.

iii. Provide with remote head, display and keyboard.

3. Ultrasonics (strap on)

a. Manufacturers

i. Fuji

ii. Flexim (refer to Exhibit O)

iii. Pulsar

b. Specific Criteria

4. Ultrasonics level
    a. Manufacturers
        i. Siemens
        ii. Rosemount
5. Insertion (mass flow)
    a. Manufacturers
        i. Magnetrol
        ii. Sierra
        iii. Kurz
    b. Specific Criteria
        i. Air
6. Venturi
    a. Specific Criteria
        i. Generally, not used in most applications.
        ii. Do not use for control.

XXV. Item No. 25

A. RTUs (Remote Terminal Unit)

1. Manufacturers
    a. Allen Bradley
    b. Emerson-Control Wave
    c. Emerson-OCC100
2. Specific Criteria
    a. HRSD shall provide.
    b. Physical size 24”x24”x8” in a NEMA 4x enclosure
    c. Physical size 12”x12”x8” in a NEMA 4x enclosure

XXVI. Item No. 26

A. Louvers/Dampers

1. Manufacturers
    a. Greenheck
    b. Ruskin
2. Specific Criteria

a. Provide gravity dampers for all applications.

b. See Emergency Generators

XXVII. Item No. 27

A. Transfer Switches

1. Manufacturers

a. Eaton

b. Square D

c. ASCO

2. Specific Criteria

a. Nema 12 Enclosure unless required otherwise.

b. IQ Plus Monitoring Device

c. Provide BUS status (A or B) to the DCS

d. Zenith transfer switches are not acceptable.

XXVIII. Item No. 28

A. On-Line Vibration Monitors

1. Manufacturers

a. Bentley-Nevada

2. Specific Criteria

a. Application specific

XXIX. Item No. 29

A. Panel Meters

1. Analog

a. Manufacturers

i. GE/Yokogawa

ii. Simpson

2. Digital

a. Manufacturers

i. Yokogawa

ii. Red Lion

iii. Simpson

3. Elapsed Time

a. Manufacturers
    i. Crompton
    ii. ENB
    iii. Yokogawa
b. Specific Criteria
    i. Non resettable / resettable (plant site specific)

4. Pulse Counters
    a. Manufacturers
        i. Acromag
        ii. Omron
5. Isolators
    a. Manufacturers
        i. Acromag
        ii. AGMPhoenix
    b. Specific Criteria
        i. Isolate 4-20 MA and 1–5-volt signals
        ii. Powered 4-20 MA isolator splitter.
        iii. Terminal relay
        iv. Compact panel temp sensor 4-20 MA
6. Signal Converters
    a. Manufacturers
        i. AGM
        ii. RIS
        iii. Acromag
    b. Specific Criteria
        i. Isolate 4-20 MA and digital.
7. Surge Protectors
    a. Manufacturers
        i. Phoenix
        ii. MTL-Crouse Hinds
    b. Specific Criteria

i. Provide 120v AC power supply surge protectors.

XXX. Item No. 30

A. Analyzers/Monitors: Safety / Gas

1. Combustible LEL

a. Manufacturers

i. Detronics

ii. MSA

2. O2

a. Manufacturers

i. Detronics

ii. MSA

3. SO2

a. Manufacturers

i. Detronics

ii. Bisulfite

4. H2S

a. Manufacturers

i. Detronics

b. Specific Criteria

i. ATI is not used for Safety.

B. Analyzers/Monitors: Process

1. pH

a. Manufacturers

i. Foxboro

ii. E&H Memosens CPS16D pH probe (Incinerator scrubber water process) (Site Specific/Specific applications)

iii. M4 Knick (Site Specific/Specific applications)

2. ORP

a. Manufacturers

i. Foxboro

b. Specific Criteria

i. Provide only.

ii. Stanco not acceptable

3. O2 (Incinerator)

a. Manufacturers

i. COSA

b. Specific Criteria

i. Provide only.

ii. Operating temperature >1500°F

4. DO

a. Manufacturers

i. Hach

ii. Insite

b. Specific Criteria

i. Optica

5. CL2

a. Manufacturers

i. Rosemount

ii. Prominent

iii. Chemtrac

6. H2S

a. Manufacturers

i. ATI

7. Conductivity

a. Manufacturers

i. Hach

XXXI. Item No. 31

A. Miscellaneous Instrumentation

1. PID Controllers

a. Manufacturers

i. Emerson Ovation

2. Electric Actuators

a. Manufacturers

i. EIM/Bettis

ii. Limitorque (refer to Exhibit P)

Note: Verify hazardous classification for small 120V actuators.

b. Specific Criteria

i. 120 volts and 480 volts AC

3. Burner Actuators

a. Manufacturers

i. Honeywell

ii. Barber Coleman

4. Alarm Panel

a. Manufacturers

i. Ronan

5. Temperature Controllers

a. Manufacturers

i. Yokogawa

XXXII. Item No. 32

A. Miscellaneous Electrical

1. Electrical Equipment Testing

a. Specific Criteria

i. Provide testing in off-peak hours or switch off an equivalent amount of load prior to testing.

2. One Line Diagram

a. Specific Criteria

i. Provide an update to the one-line diagram with significant changes in the electrical system.

3. Thermographic Inspection

a. Specific Criteria

i. Provide a thermographic inspection of the new systems upon completion.

4. Coordination Study/Short Circuit/Arc Flash

a. Specific Criteria

i. Provide a coordination study short circuit, coordination, and arc flash analysis for new systems or systems with significant changes.

ii. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum number of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable. Include Arc flash analysis results for generator protective device.

iii. Contractor must adhere to NFPA 70E Electrical Safety requirements when working on electrical equipment in HRSD facilities.

iv. Engineer must design electrical systems in accordance with NFPA 70E.

Refer to Exhibit A

XXXIII. Item No. 33

A. Heating and Cooling

1. Manufacturers
   a. Honeywell
   b. Barber Coleman
2. Specific Criteria
   a. Louver actuators to be used with building heating/ventilation systems.

XXXIV. Item No. 34

A. Junction/Pull Boxes and Miscellaneous Enclosures

1. Manufacturers
   a. Hoffman
   b. Saginaw
   c. Hammond
2. Specific Criteria
   a. Provide PVC coated boxes and/or fittings when using with PVC coated conduit.

B. Administrative Areas

1. Manufacturers
    a. Hoffman
    b. Saginaw
    c. Hammond
2. Specific Criteria
    a. NEMA 4

C. Inside

1. Specific Criteria
    a. Stainless steel, fiberglass reinforced plastic (FRP), steel, NEMA 4

D. Outside

1. Specific Criteria
    a. Stainless steel, NEMA 4x with Myers hubs

E. Wet

1. Specific Criteria
    a. Use with PVC coated conduit and PVC coated hubs.
    b. Stainless steel, fiberglass reinforced plastic, NEMA 4x with watertight fittings (Myers).

XXXV. Item No. 35

A. Panel Boards/Control Panels

1. Manufacturers
    a. Eaton
    b. Square D
    c. Siemens
    d. GE
2. Specific Criteria
    a. Provide PVC coated boxes and/or fittings when using with PVC coated conduit.
    b. Provide with tin-plated copper bus.
    c. Provide 25% spares minimum.
    d. Provide bolt in breakers.
    e. Do not provide cans with pre-stamped knockouts.

f. Provide with hinged panel cover with a latching door.

g. Provide heavy duty, industrial grade panel boards.

h. Breaker operator should be outside of panel.

i. Breaker should be located inside of panel.

j. HOA switches should be on the outside of panel.

k. Provide dead front hinged panel.

l. Provide LED work light, if warranted

XXXVI. Item No. 36

A. Distributed Control System (DCS)

1. Manufacturers

a. Emerson

2. Specific Criteria

a. Provide fail safe condition within the DCS located in the marshalling cabinet terminal strips.

b. Contact in the field must be wired to a normally closed contact in the energized position. When fault occurs, the contact will open and be displayed as a system failure. This prevents contacts which do not close properly to indicate a fault to the system. A digital status that equals 1 (one) indicates a closed contact and a 0 (zero) indicates an open contact. An open contact occurs when a fault occurs (fail open).

c. DCS DCU's and RIO's shall be equipped with isolation relay junction box(s) (interposing relays) adjacent to all the DCU's and RIO's. The junction box shall contain ample room to house relays; Example: (Idec 5-blade – 24 VDC coils- with a form C configuration contactor) relays mounted on DIN rail for the purpose isolating relay junction box. This junction shall be equipped with a 24 VDC power supply with sufficient capacity to energize all the 24 VDC relay coils simultaneously when necessary for all DCS inputs.

Note: The following HRSD design standards shall be adhered to colors for graphical screens, graphics design, and control functionality. The current HRSD DCS standards are maintained by Industrial Automation within the E&I division. These standards are available upon request.

XXXVII. Item No. 37 - Lightning Protection Refer to NFPA 820 and NFPA 780. - Lightning Protection applications will be site specific (Discuss with HRSD Electrical Staff).

XXXVIII. Item No. 38 - SWIFT (*Refer to Exhibit I*)

XXXIX. Item No. 39 - Dominion Energy Coordination (refer to Exhibit K)

A. Easements

1. It is imperative that the design engineer contacts the utility company (i.e., Dominion Energy, Rappahannock Power, Prince George Electric Cooperative, etc.) to determine the responsible territory.
2. Design Engineer and HRSD should inquire with the utility company if single phase or 3-phase power is available at the proposed site.
3. Design Engineer should incorporate right-of-way (ROW), multi-use utility easements, identify property owners, and VDOT requirements as part of the preliminary engineering report (PER) to prevent delays and cost increase during the construction phase of the project. The items listed above should be explored in advance especially in rural communities where 3-phase electrical service is not available.
4. See Exhibit K for Dominion Project Workflow Brochure "HRSD Interface on New Projects with Dominion Energy Virginia (DEV)

XL. Item No. 40

A. Grounding

"50.53 Grounding Electrode System Installation.

(A) Rod, Pipe, and Plate Electrodes. Rod, pipe, and plate

electrodes shall meet the requirements of 250.53(A)(1)

through (A)(3).

(1) Below Permanent Moisture Level. If practicable, rod, pipe, and plate electrodes shall be embedded below permanent moisture level. Rod, pipe, and plate electrodes shall be free from nonconductive coatings such as paint or enamel.

(2) Supplemental Electrode Required. A single rod, pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). The supplemental electrode shall be permitted to be bonded to one of the following:

(1) Rod, pipe, or plate electrode

(2) Grounding electrode conductor

(3) Grounded service-entrance conductor

(4) Nonflexible grounded service raceway

(5) Any grounded service enclosure

Exception: If a single rod, pipe, or plate grounding electrode has a

resistance to earth of 25 ohms or less, the supplemental electrode shall not be required.

(3) Supplemental Electrode. If multiple rod, pipe, or plate electrodes are installed to meet the requirements of this section, they shall not be less than 1.8 m (6 ft) apart."

XLI. Item No. 41 - Building Classification

"1. Purpose to provide explosion and fire protection for life property, and operations.

2. Reduce or mitigate the effects of fire or explosion

3. Consult with AHJ (Authority Having Jurisdiction) to ensure that the NFPA 820 standard will be enforced.

NFPA 70 – Article 500

Class I: Flammable Gases/Vapors

Class II: Combustible Dust

Class III: Ignitable Fibers

Wastewater/Treatment/Collections Systems

Class I, Div 1 or 2, Group D (Methane)

Class I, Div 1 or 2, Group G (Sludge)

Wet Well Pump Station

Less than 12 air changes – Division 1

Greater than 12 air changes – Division 2

Typical classified areas: Barscreen, Headworks or Preliminary Treatment Facility, Grit Removal, Odor Control, Sludge Handling and Thickening, etc.

Evaluate equipment type (i.e., explosion proof, conduit seals, etc.)

NFPA 820 4.2.2 – Collections Systems – See Exhibit Y

NFPA 820 5.2.2 – Liquid Streaming – See Exhibit Z

Consideration requirements: exhaust fans, continuous ventilation, alarming, air flow and monitoring."

XLII. Item No. 42 – Standard Details

A. PLC Control Wave – Temp Pump Enclosure Detail and Pump Run Status PS Schematic– See Exhibit S

B. Antenna Installation Detail - See Exhibit T

C. Wet Well Installation Detail – See Exhibit U

D. Intrinsic Safety Panel Wiring Diagram – See Exhibit V

E. Power Wiring Junction Box Detail– See Exhibit W

F. Vault Plans – See Exhibit X

XLIII. Item No. 42 - Air Purification – Hydrogen Sulfide (H2S) Mitigation for Electrical Room - See Exhibit AA

A. Manufacturer

1. Pure Air or approved equal.

I. Strategic Automation Configuration

A. Refer to Exhibit R

Click here to return to Switchgear and MCCs (PSs)
Click here to return to Switchgear (TPs)
Click here to return to Misc. Electrical (PSs)
Click here to return to Misc. Electrical (TPs)

Exhibit A

HDR ONE COMPANY *Many Solutions*℠

Meeting Notes

Subject:	Arc Flash Mitigation Planning Workshop		
Client:	HRSD		
Project:	Arc Flash Mitigation Workshops	Project No:	214032
Meeting Date:	July 9-10, 2013	Meeting Location:	HRSD South Shore Operations Center, Atlantic Conference Room
Notes by:	B. M'Coy		

Attendees:

<u>HRSD</u>

Sherman Pressey	Tim Marsh	Stan Saunders
Carolyn Cagle	Stephanie Laughinghouse	Lee Inman
John Haymore	Ryan Duke	Kelly Lamp
Jennifer See	Mardane McLemore	Rick Raike

<u>HDR</u>

Gary Useldinger	Natalie Wieszek
Bill M'Coy	Kevin Themes

Notes:

<u>Primary HRSD Arc Flash Hazards:</u>
1. Mechanical lock out/tag out by non-qualified personnel – treatment plants and pump stations (unattended).
2. Work on Greater Than Category 4 equipment by qualified electrical personnel.
3. Energized work in emergencies.
4. Hand-Off-Auto (HOA) selector switches located on motor control centers (MCCs) and variable frequency drive (VFD) panels – treatment plants and pump stations.

<u>HRSD Arc Flash Program Goals:</u>
1. Reduce arc flash hazard/risk category to Category 2 or lower (MCC and VFD panels should be reduced to Category 0).
2. Resolve issues with lock out/tag out by non-qualified personnel.
3. Determine method to manage changes to equipment and standard procedures:
   a. Standards & Preferences.
   b. Software (SKM model updates) and hardcopy documentation.
      i. Who will manage; where stored.
      ii. How will changes be tracked.
   c. Manage through construction.
4. Electrical Safety Program in compliance with standards.
   a. Training and qualifying personnel.

<u>HRSD Mitigation Actions to Date:</u>
1. Prepared Draft Electrical Safety Program (held up on lock out/tag out issue).
2. Initiated pilot program at Virginia Initiative Plant (VIP) - mechanical lock out/tag out:
   a. Local shared PPE at equipment (Category 2) - Grit MCC.
   b. Remote Switching Operator (RSO) device - RAS MCC.
3. Purchased Eaton remote racking device for switchgear breakers (located at VIP Blower Building).
4. Developed form for tracking equipment changes.

5. Conducted re-training for all qualified electrical personnel on NFPA 70E.
6. Installed permanent remote operating panel for opening/closing existing 2SB1 main circuit breakers at VIP.
7. Retrofitted circuit breakers with AC-PRO with QUICK-TRIP trip units to provide adjustable long time, short time, and instantaneous settings (LSI) at VIP.
8. Installing Arc Reduction Maintenance Switch (ARMS) and maintenance bypass transfer switches at Army Base Treatment Plant (ABTP).
9. VIP NRI design will include separate enclosures for the Main Switchgear main circuit breakers at VIP.
10. Compiled spreadsheet of electrical equipment with respective arc flash hazard/risk categories.

Potential Arc Flash Mitigation Alternatives for Medium Voltage Switchgear:

New	Retrofit Existing
Bus differential relays installed in switchgear • Approximately $5k • There is a concern with nuisance tripping	Bus differential relays installed in switchgear • Approximately $5k • There is a concern with nuisance tripping
Maintenance bypass switch on main and feeder circuit breakers	Maintenance bypass switch on main and feeder circuit breakers
Separate main circuit breaker • Partitions in switchgear • Separate rooms • Separate space in room	Clean air/filtration/climate control (applies to all equipment)
Permanent remote operator	Permanent remote operator
Arc flash sensing relay	Arc flash sensing relay
Main-tie-tie-main configuration (doubled ended switchgear)	Upgrade induction disc relays to microprocessor relays
5-cycle breakers	

Potential Arc Flash Mitigation Alternatives for Medium Voltage MCC:

New	Retrofit Existing
Remove HOA from MCC	Remove HOA from MCC
Bus differential installed in switchgear • Approximately $5k • There is a concern with nuisance tripping	Bus differential installed in switchgear • Approximately $5k • There is a concern with nuisance tripping
Maintenance bypass switch	Maintenance bypass switch
Separate main circuit breaker • Partitions in switchgear • Separate rooms • Separate space in room	Clean air/filtration/climate control (applies to all equipment)
Permanent remote operator	Permanent remote operator
Arc flash sensing relay	Arc flash sensing relay
Main-tie-tie-main configuration (double ended switchgear)	Upgrade induction disc relays to microprocessor relays
5-cycle breakers	

Potential Arc Flash Mitigation Alternatives for Low Voltage Switchgear:

New	Retrofit Existing
Maintenance bypass at upstream medium voltage feeder and/or at main circuit breaker	Retrofit unit substations (3.F. in Attachment A)
Remote open/close and remote racking	Remote open/close and remote racking
Separate main circuit breaker from switchgear	Remove main circuit breaker and install in separate location (if possible)
Arc flash sensing relay	Arc flash sensing relay
Arc Vault	Arc Vault
Zone selective interlocking (ZSI)	ZSI

Potential Arc Flash Mitigation Alternatives for Low Voltage Switchboards:

New	Retrofit Existing
Not preferred for new equipment	Replace with switchgear
Separate main circuit breaker from switchboard	Remove main circuit breaker and install in separate location
Arc Vault	Arc vault
Maintenance bypass switch at upstream feeder circuit breaker and/or at main circuit breaker	Maintenance bypass switch at upstream feeder circuit breaker and/or at main circuit breaker
	Remote open/close of insulated case circuit breakers

Potential Arc Flash Mitigation Alternatives for Low Voltage MCC:

New	Retrofit Existing
Separate main circuit breaker from MCC	Remove main circuit breaker and install in separate location (if possible)
Solid state trip unit on upstream feeder circuit breaker and/or main circuit breaker	Solid state trip unit on upstream feeder circuit breaker and/or main circuit breaker
Remote racking	Remote switch operator (RSO)
Arc Vault	Arc Vault

Potential Arc Flash Mitigation Alternatives for Low Voltage VFD and Control Panels:

New	Retrofit Existing
Remote mount HOAs (Category 1 or higher)	Remote mount HOAs (Category 1 or higher)
Solid state trip unit (LSI) on upstream feeder circuit breakers to VFDs and main circuit breakers	

Potential Arc Flash Mitigation Alternatives for Low Voltage Power Panels and Transfer Switches:

New	Retrofit Existing
Addressed by upstream protective device	
Address construction quality in Standards & Preferences	

Alternatives to be Evaluated for Lowering Arc Flash Hazard Category in Pump Stations:

New	Retrofit Existing
Main circuit breaker mounted outside	Main circuit breaker mounted outside
Install upstream separately-mounted circuit breaker	Install upstream separately-mounted circuit breaker
Smart MCC with networking	Remote switching

Alternatives to be Evaluated to Address Pump Station Equipment Lock Out/Tag Out:

New	Retrofit Existing
Local disconnect with remote start/stop	Local disconnect with remote start/stop
Remote switching	Remote switching
Personal protective equipment (PPE)	PPE
Achieve Category 0 at pump station	Achieve Category 0 at pump station

Alternatives to be Evaluated to Address Plant HOAs:

New	Retrofit Existing
HOA located at process equipment without VFD	Achieve Category 0 at MCC/VFD panel
HOA on VFD with DCS shutdown	Relocate HOA to motor/equipment
Local disconnect at all equipment with DCS shutdown	Connect to DCS
HOA located at HVAC equipment	

Alternatives to be Evaluated to Address Plant Equipment Lock out/Tag out:

New and Retrofit	Retrofit Existing
Local disconnect switch at all equipment with DCS shutdown	RSO devices (all categories)
Design for Category 0 at applicable panels (MCCs, VFD panels, control panels, etc.)	PPE (Category 2 or lower)
	Modify circuit breakers
	Change protective schemes

Criteria that will be used to evaluate alternatives:

- Initial cost
- Safety – achieve low arc flash hazard/risk
- Risk – loss of operation
- Ease of operation
- Reliability – of implemented equipment
- Versatility - addresses lock out/tag out and electrical work
- Annual cost
- Feasibility/Maintaining operation

Preliminary Decisions:

1. Existing pump stations and new pump stations (< 400A service):
   a. Use portable remote switching operator (RSO) devices.
   b. Relocate HOAs off of MCC.
   c. For new pump stations, separately-mount main circuit breaker inside the pump station.
2. New pump stations (≥ 400A service):
   a. Install main circuit breaker with adjustable LSI trip unit and remote switching.
   b. Separately-mount main circuit breaker inside the pump station.
   c. For Greater Than Category 4 areas, workers need to have utility shut down power at their end to work on main circuit breaker.
   d. HOAs mounted off of MCC.
   e. Consider using SCADA to shutdown equipment and install local disconnect switches.

Miscellaneous Notes:

1. 5 year audit - does it require upgrade to current code?
2. Arc flash labels - equipment based or task based?
3. Who tracks/maintains software?
4. Testing should include circuit breaker trip time.
5. Work on electrical equipment with a Greater Than Category 4 rating at plants by qualified electrical personnel requires equipment to be de-energized prior to work.

Action Items:

1. HDR to draft Standard & Preferences language for new pump station electrical service configuration.
2. HRSD to procure RSO devices for existing pump stations.
3. HRSD to contract relocation of HOAs in existing pump stations.
4. HDR to evaluate actions to achieve Category 0 at MCCs, VFD panels, and other applicable panels requiring lock out/tag out at VIP, one larger pump station, and one smaller pump station. Also, evaluate relocation of HOAs to motors at VIP. Consider risk reduction (Category 2 or lower) for electrical work at distribution equipment.
5. HRSD complete pilot testing of RSO devices and PPE at VIP.
6. HDR draft Standard & Preferences language for MCCs, VFD panels, and other applicable panels in new plant designs to address lock out/tag out (goal to achieve Category 0l, with adding local disconnects as alternative). Also, installing motorized circuit breakers that feed large VFD panels).
7. HRSD to develop cost for installation of local disconnect switches at two pump stations.
8. HDR draft Standard & Preferences language to address HOAs on new plant designs.
9. HDR draft Standard & Preferences language on managing construction process relative to arc flash (equipment shop drawings, etc.).
10. HRSD and HDR will schedule a follow-up one-day workshop upon completion of the evaluations listed in Actions Items 4 and 7.

Attachment A
Typical Approaches to Limiting Arc Flash Exposure

Limiting Arc Exposure
1. Avoiding arc flash accidents
2. Reducing the level of arc energy released
3. Proper use of personal protective equipment (PPE)

Avoiding Arc Flash Accidents
1. Preventive maintenance
    a. Keep equipment clean.
    b. Keep rodents and birds out of equipment.
    c. Control and repair corrosion of enclosure and electric components.
    d. Check for loose connections.
    e. Test insulation integrity.
    f. Test and repair relays/trip units and breakers.
    g. Test and repair moving parts (breaker racking, switch operation, etc.)
2. Working on Live Equipment
    a. If possible, always work on de-energized equipment.
    b. Use insulated tools.
    c. When excessive force is needed (loosening bolts), it is not uncommon to lose control.
    d. Do not use paint, cleaning chemicals, spray lubrication, etc. on live parts.

Reducing Incident Energy on Worker
1. Reduce the level of Fault
    a. Use smaller kVA transformers.
    b. Double ended switchgear:
        i. Keep tie breaker open in Main-Tie-Main configurations.
        ii. Use only one source of a Main-Main configuration.
        iii. Utilize two line-ups in a Main-Tie-Tie-Main configuration instead of one line-up in a Main-Tie-Main.
    c. Current limiting fuses or breakers.
    d. Current limiting reactors.
2. Reduce arcing time
    a. Reduce breaker response time safety margin.
        i. Replace electro-mechanical relays with microprocessor relays allows time margin between relays to be reduced from 0.4 second to 0.2 – 0.25 seconds.
        ii. Utilized 5 cycle breakers rather than 8 cycle breakers.
    b. Bus differential protection.
    c. Zone selective interlocking (ZSI).
    d. Temporary instantaneous settings:
        i. Arc maintenance settings on trip units.
        ii. Maintenance group setting on microprocessor relays.
        iii. Add instantaneous trip devices to breakers with no instantaneous that can be turned on and off.
    e. Arc flash sensing relays via fiber optical cable.
    f. Adjust fuse size and speed.
    g. General Electric Arc Vault.
    h. High/Low resistance grounding.
3. Equipment features
    a. Remote breaker operation (open/close).
    b. Remote breaker racking.
    c. Arc flash resistant MCC and switchgear. (not effective with doors open)
    d. MCC that can rack bucket out with door closed.
    e. Locate main breaker section remote (separate room) from distribution section.
    f. Retrofit unit substations (primary fuse switch with secondary feeder breakers) with secondary CT and relay and primary switch over breaker with trip unit to provide both primary and secondary protection.
    g. Remote switching operator (RSO) device.

SKM SYSTEMS ANALYSIS, INC

SHORT-CIRCUIT/COORDINATION STUDY/ARC FLASH RISK ASSESSMENT

PART 1 GENERAL

1.1 SCOPE

A. The contractor shall furnish short-circuit and protective device coordination studies as prepared by the electrical equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Risk Assessment Study per the requirements set forth in NFPA 70E - Standard for Electrical Safety in the Workplace. The arc flash risk assessment shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D.

C. The scope of the studies shall include all new distribution equipment supplied by the equipment Manufacturer under this contract. - OR - The scope of the studies shall include all new distribution equipment supplied by the equipment Manufacturer under this contract as well as all directly affected existing distribution equipment at the customer facility. - OR - The scope of the studies shall include all new distribution equipment supplied by the equipment Manufacturer under this contract as well as all existing distribution equipment

1.2 RELATED SECTIONS

1.3 REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
6. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):

1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers

Used in Enclosures

3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.

C. The National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code, latest edition
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.4 SUBMITTALS FOR REVIEW/APPROVAL

A. The short-circuit and protective device coordination studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1.5 SUBMITTALS FOR CONSTRUCTION

A. The results of the short-circuit, protective device coordination and arc flash risk assessment studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies of the short-circuit input and output data, where required, shall be provided on CD in PDF format.

B. Following best practices, the contractor is to provide the study project files to the Owner in electronic format to allow the Owner to review all aspects of the project input data and reprint arc flash labels, one-line diagrams, reports etc. The electronic project files are critical for disaster recovery and maintaining the power system. In addition, a copy the PTW Viewer program is required to accompany the electronic project files (or Owner to purchase directly from SKM).

C. The report shall include the following sections:

1. Executive Summary.
2. Descriptions, purpose, basis and scope of the study
3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties
4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
5. Fault current calculations including a definition of terms and guide for interpretation of the computer printout.
6. Details of the incident energy and flash protection boundary calculations

7. Recommendations for system improvements, where needed.
8. One-line diagram

Arc flash labels shall be provided in hard copy only. -OR- Arc flash labels shall be provided in hard copy and for large system studies with more than 200 bus locations, a copy of the

A. electronic format.

1.6 QUALIFICATIONS

A. The short-circuit, protective device coordination and arc flash risk assessment studies shall be conducted under the supervision and approval of a Registered/Licensed Professional Electrical Engineer skilled in performing and interpreting the power system studies.

B. The Registered/Licensed Professional Electrical Engineer shall be a full-time employee of the equipment manufacturer or an approved engineering firm

C. The Registered/Licensed Professional Electrical Engineer shall have a minimum of five
(5) years of experience in performing power system studies.

D. The equipment manufacturer or approved engineering firm shall demonstrate experience with Arc Flash Risk Assessment by submitting names of at least ten actual arc flash risk assessment it has performed in the past year.

1.7 COMPUTER ANALYSIS SOFTWARE

A. The studies shall be performed using the latest revision of the SKM Systems Analysis Power*Tools for Windows (PTW) software program or approved equal.

PART 2 PRODUCT

2.1 STUDIES

A. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer or an approved engineering firm.

B. The contractor shall furnish an Arc Flash Risk Assessment Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.5 and Annex D.

2.2 DATA COLLECTION

A. Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash risk assessment studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.

B. Source combination may include present and future motors and generators.

C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, or Contractor.

D. If applicable, include fault contribution of existing motors in the study. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

2.3 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141-1993.

B. Transformer design impedances shall be used when test impedances are not available.

C. Provide the following:

1. Calculation methods and assumptions
2. Selected base per unit quantities
3. One-line diagram of the system being evaluated
4. Source impedance data, including electric utility system and motor fault contribution characteristics
5. Tabulations of calculated quantities
6. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:

1. Electric utility's supply termination point
2. Incoming switchgear
3. Unit substation primary and secondary terminals
4. Low voltage switchgear
5. Motor control centers
6. Standby generators and automatic transfer switches
7. Branch circuit panelboards
8. Other significant locations throughout the system.

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short circuit ratings
2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
3. Notify Owner in writing, of existing, circuit protective devices improperly rated for the calculated available fault current.

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.

B. Include on each TCC graph, a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.

D. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the TCC graphs, where applicable:

1. Electric utility's overcurrent protective device
2. Medium voltage equipment overcurrent relays
3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
5. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
6. Conductor damage curves
7. Ground fault protective devices, as applicable
8. Pertinent motor starting characteristics and motor damage points, where applicable
9. Pertinent generator short-circuit decrement curve and generator damage point
10. The largest feeder circuit breaker in each motor control center and applicable panelboard.

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

2.5 ARC FLASH RISK ASSESSMENT

A. The arc flash risk assessment shall be performed according to the IEEE 1584 equations that are presented in NFPA70E, Annex D.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

C. The Arc-Flash Risk Assessment shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA where work could be performed on energized parts.

D. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm^2.

E. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility

A. contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

B. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

   1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
   2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

C. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

D. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

E. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

F. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

2.6 REPORT SECTIONS

A. Input data shall include, but not be limited to the following:

   1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic) and conductor material (copper or aluminum).

2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps and phase shift.
3. Reactor data, including voltage rating, and impedance.

4. Generation contribution data, (synchronous generators and Utility), including short- circuit reactance (X"d), rated MVA, rated voltage, three-phase and single line- ground contribution (for Utility sources) and X/R ratio.
5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.

B. Short-Circuit Output Data shall include, but not be limited to the following reports:

1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
    a. Voltage
    b. Calculated fault current magnitude and angle
    c. Fault point X/R ratio
    d. Equivalent impedance
2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
    a. Voltage
    b. Calculated symmetrical fault current magnitude and angle
    c. Fault point X/R ratio
    d. Calculated asymmetrical fault currents
        1. Based on fault point X/R ratio
        2. Based on calculated symmetrical value multiplied by 1.6
        3. Based on calculated symmetrical value multiplied by 2.7
    e. Equivalent impedance
3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:
    a. Voltage
    b. Calculated symmetrical fault current magnitude and angle
    c. Fault point X/R ratio
    d. No AC Decrement (NACD) Ratio
    e. Equivalent impedance
    f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a symmetrical basis
    g. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a total basis

C. Recommended Protective Device Settings:

1. Phase and Ground Relays:
    a. Current transformer ratio
    b. Current setting
    c. Time setting

d. Instantaneous setting
e. Recommendations on improved relaying systems, if applicable.

2. Circuit Breakers:
   a. Adjustable pickups and time delays (long time, short time, ground)
   b. Adjustable time-current characteristic

c. Adjustable instantaneous pickup
d. Recommendations on improved trip systems, if applicable.

Incident energy and flash protection boundary calculations

1. Arcing fault magnitude
2. Protective device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category*
8. Recommendations for arc flash energy reduction

*Applicable only when using the arc flash PPE category method.

PART 3 EXECUTION

3.1 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordinaField adjustments to be completed by engineering service division of the equipment manufacturer under the Acceptance Testing contract .

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Owner in writing of any required major equipment modifications.

3.2 ARC FLASH WARNING LABELS

A. The contractor of the Arc Flash Risk Assessment shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

B. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.

C. The label shall include the following information, at a minimum:

1. Location designation
2. Nominal voltage
3. Flash protection boundary
4. Hazard risk category*
5. Incident energy

6. Working distance
7. Engineering report number, revision number and issue date.

*Applicable only when using the arc flash PPE category method.

D. Labels shall be machine printed, with no field markings.

E. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.

1. For each 600, 480 and applicable 208 volt panelboard, one arc flash label shall be provided.
2. For each motor control center, one arc flash label shall be provided.
3. For each low voltage switchboard, one arc flash label shall be provided.
4. For each switchgear, one flash label shall be provided.
5. For medium voltage switches one arc flash label shall be provided

F. Labels shall be field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing

3.3 ARC FLASH TRAINING

A. The contractor of the Arc Flash Risk Assessment shall train the owner's qualified electrical personnel of the potential arc flash risks associated with working on energized equipment (minimum of 4 hours).

3.4 ARC FLASH COORDINATION MEETING

A. Conduct an ARC Flash meeting with HRSD Electrical Personnel after equipment selection to discuss reporting format, guidelines, expectations, and defining responsibilities. This includes consultants, equipment manufacturers, and electrical contractors, etc.

Click here to return to Diesel Generator Tests (PSs)

Exhibit B

North and South Shore Pump Stations
Load Bank Connection's
5560 C/S FY12 Rev 04

PART I – GENERAL

1.01 Scope of Work – Rolling Hills and Colonial Williamsburg Pump Stations

The work to be performed under this Section shall include furnishing all labor, materials, tools and equipment necessary to install and test all load bank connections.

A. Work includes providing labor and materials to build and install a Deep Hinged Window Kit with locking wing knobs and an aluminum inner plate for mounting the necessary panel receptacles.

The Deep Hinged Window Kit shall be sized and configured to insure proper safe distances between all energized components to grounding surfaces with the hinged cover closed and locked while the panel receptacles are energized.

- Special Notation
  - The amount of panel receptacles and Deep Hinged Window Kit shall be sized to meet the minimum of 100% rating of the generator load with additional room to add 50% more panel receptacles.

B. Work includes installing properly sized aluminum plate and Deep Hinged Window Kit to meet 150% of the capacity of the generator.

C. Work includes providing and installing all necessary lugs in transfer switch to accept cable for panel receptacles.

- Special Notation
  - Lugs shall be sized to accept conductors being used for panel receptacles and conductors from generator.

D. Work includes making all necessary terminations in a workmanship like manor.

E. Work includes removing a portion of the steel side door of the transfer switch and mounting an aluminum plate of adequate size to cover area removed and to accept panel receptacles to meet 150% of the capacity of the generator.

F. Work includes mounting Aluminum Plate, Panel Receptacles, and Deep Hinged Window Kit with machine screws and nuts of adequate size.

G. Work includes coordination with HRSD to perform an operational test to validate product quality and installation.

H. Work must be performed onsite between hours of 7am-3pm Mon-Fri. The time schedule may be altered if approved by owner.

1.02 Scope of Work – Rodman, Quail, and Suffolk Pump Stations

The work to be performed under this Section shall include furnishing all labor, materials, tools and equipment necessary to install and test all load bank connections.

A. Work includes providing labor and materials to install conduit, wire, and deep hinged NEMA 4X junction box with an aluminum dead front panel for mounting the necessary panel receptacles.

   The junction box shall be sized and configured to insure proper safe distances between all energized components to grounding surfaces with the hinged cover closed and locked while the panel receptacles are energized.

   - Special Notation
     - The amount of panel receptacles and junction box shall be sized to meet the minimum of 100% rating of the generator load with additional room to add 50% more panel receptacles.

B. Work includes installing properly sized aluminum plate and junction box to meet 150% of the capacity of the generator.

C. Work includes providing and installing all necessary lugs in transfer switch to accept cable for panel receptacles.

   - Special Notation
     - Lugs shall be sized to accept conductors being used for panel receptacles and conductors from generator.

D. Work includes making all necessary terminations in a workmanship like manor.

E. Work includes installing properly sized conduit and fittings necessary from the existing transfer switch to the receptacle junction box.

F. Work includes mounting aluminum dead front plate and Panel Receptacles in junction box.

G. Work includes coordination with HRSD to perform an operational test to validate product quality and installation.

H. Work must be performed onsite between hours of 7am-3pm Mon-Fri. The time schedule may be altered if approved by owner.

1.03 Submittals

B. The contractor shall submit a minimum of four copies of all submittals in a three ring binder. Any CAD drawings or other relevant information must be submitted in electronic format on a CD (Compact Disc). The Owner will review and approve before any material is purchased or any work has commenced. The submittals shall be delivered or mailed to the North Shore Electrical Shop, 2391 G Avenue Newport News, VA 23602 Attn: Dean Lowery or the South Shore Electrical Shop,1424 Air rail Ave, VA Beach VA 23455 Attn: Donnie Ward.

C. The following submittals will be provided:

a. Manufacture Product Specification's of cables, connectors, enclosure, and associated hardware.

Part 2 Products

2.01 Panel Receptacles shall be Leviton 18 series female panel receptacle, Cam type 400 amp 600v 1/0 – 4/0 AWG. (18R24-(B,O,Y,G))

A. Panel Receptacles shall be Leviton® 18series female receptacle Cam type 400amp 600v, 1/0 – 4/0 AWG (part No.18R24).

B. Panel Receptacles shall be colored to match corresponding phase and grounding conductor (grounded conductor Not Applicable)

i.e.: 480V or 240V
A phase – Brown/Black
B phase – Orange/Red
C phase – Yellow/Blue
Ground - Green
Neutral – NA

2.02 Deep Hinged Window Kit with locking wing knobs (Rolling Hills, Colonial Williamsburg)

A. Deep Hinged Window Kit with locking wing knobs may be Hoffman® (i.e. CAT No. AWDH2420N4) or equivalent quality.

B. Window Kit shall be capable of being locked.

C. Shall be mounted with machine screws and nuts.

2.03 Deep Junction Box with Aluminum dead front panel (Rodman, Quail, Suffolk)

A. Shall be lockable, hinged, and NEMA 4X

B. Shall have an aluminum dead front panel

2.04 Lugs

A. Shall be that of a manufacture with conductor size and temperature rating stamped into side of lug.

B. Shall be capable of accepting the correct number of conductors coming from the generator and panel receptacles (a minimum of 100% rating of the generator).

2.05 Aluminum Plate

A. Shall be a minimum of 1/4" thick.

B. Shall be adequate size to accept the panel receptacles capable of 150% of the generator rating.

C. Shall be mounted with machine screws and nuts.

2.06 Conductor

A. Shall be that of DLO type (Diesel Locomotive Cable)

B. Shall be a minimum of 4/0 and 600v rated.

C. Shall be supported so as not to cause stress on the insulation of the conductor or the lugs where being terminated.

D. Stranded, Copper

2.07 Conduit and Fittings

A. Shall be sized appropriately for conductors.
B. Conduit shall be galvanized ridged steel.
C. Conduit fittings shall be malleable iron,

Part 3 Execution

3.01 General and Schedule of work

A. A schedule of work shall be prepared by the Contractor and submitted to the Owner within 10 days of the project award. **The project must be completed and invoiced by Friday June 15th, 2012 to receive payment**.

B. This project is located on the North Shore as well as the South Shore at total of five separate HRSD owned waste water pumping stations.
- The North Shore Stations are:
  1. Rolling Hills – 402 Rolling Hills Dr. Williamsburg VA 23185
  2. Colonial Williamsburg – 1000 RT. 132 Williamsburg VA 23185
- The South Shore Stations are:
  1. Rodman – 2412 Rodman Ave., Portsmouth VA 23707
  2. Suffolk – 1136 Sanders Dr., Suffolk VA 23434
  3. Quail PRS – 822 Quail Ave. Chesapeake VA 23324

C. The installation of the aluminum plate with the appropriate amount of panel receptacles and Deep Hinged Window Kit with locking wing knobs shall be determined at each location.

D. The location of where the junction boxes, panel receptacles, aluminum plate and Deep Hinged Window Kit with locking wing knobs will be determined at each location depending on equipment layout.
- Special Notation
  - The preferred location will be as low to the finished floor as possible and towards the hinged side of the door or on a side of the transfer switch.
  - Where junction boxes are installed the preferred location is top of box at 6 feet from finished grade outside.

E. The successful contractor shall perform work in a safe and workmanship manner and adhere to all applicable codes.

F. The contractor must attend safety orientation training prior to starting construction, which will be facilitated by HRSD Safety Department. Call Jennifer See at (757) 460 - 7060 to schedule an appointment.

G. The successful contractor shall contact HRSD personnel when entering and exiting into the pump station. On North Shore call (757) 833-1720 and (757) 460-7072 on the South Shore. HRSD access Badges and keys will be issued by HRSD. The contractor must make a log entry in the stations log book upon arrival and departure of the station.

H. The contractor shall coordinate all shutdowns with the contact personnel. Certain weather events may dictate rescheduling a shutdown at the last minute and is up to the discretion of the owner.

I. This work will require qualified personnel to work in proximity of energized parts; a energized work permit is required to perform work "hot".

Part 4 HRSD Contacts

4.01 Contact personnel

A. North Shore Electrical Supervisor

Dean Lowery – 757-274-4947 cell 757-833-1702 desk

B. South Shore Electrical Supervisor
Donnie Ward – 757-376-2721 cell 757460-7348 desk

C. Electrical Superintendent
John Haymore – 757-376-3376 cell 757-460-7033 desk

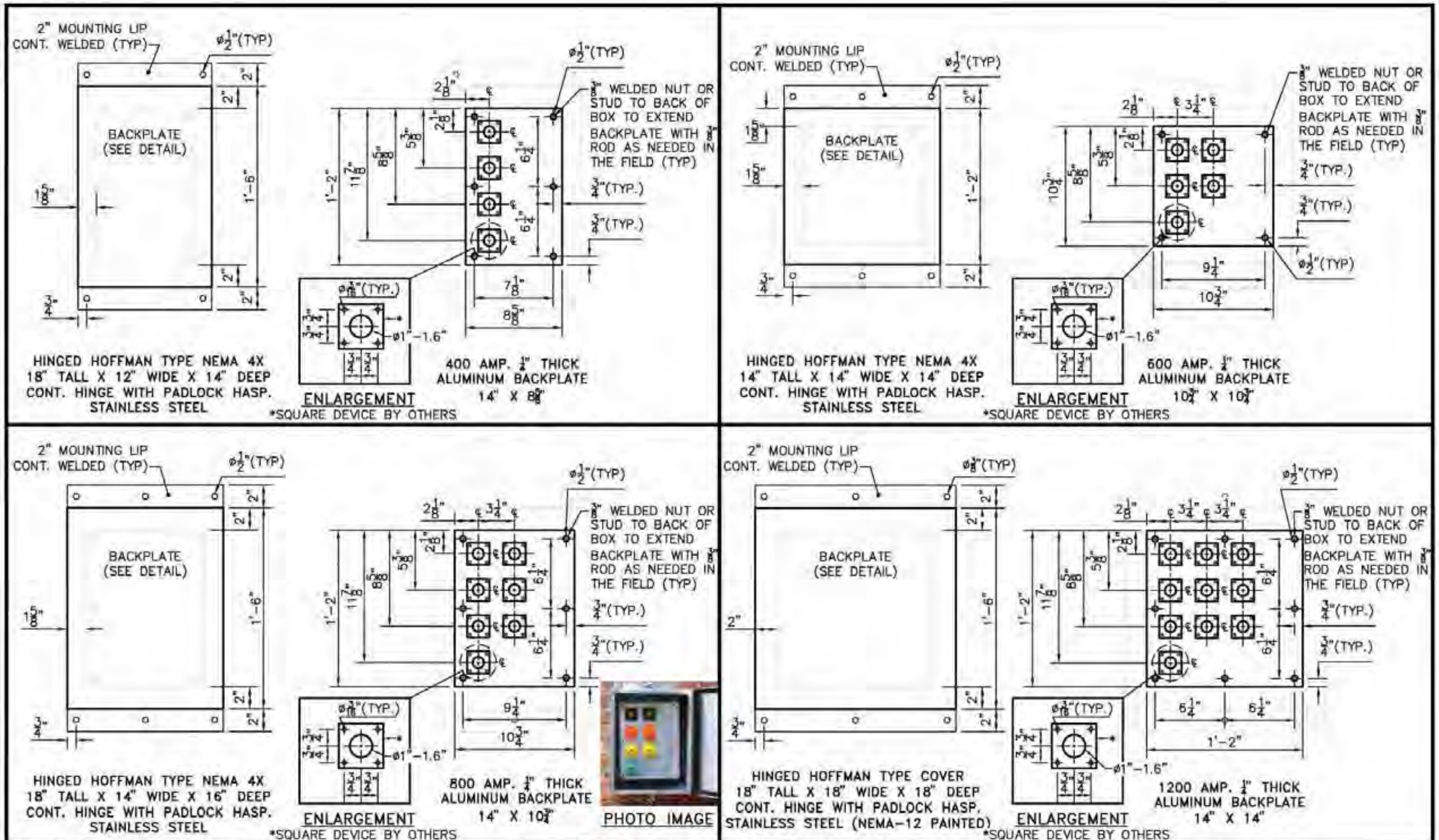
D. Electrical Manager
Sherman Pressey – 757-274-8753cell 757-833-1715 desk

Other

- Meetings (pre-bid, pre-construction, and other coordination meetings).
- Cost estimate breakdown (includes labor, material, and other associated cost).

Attachments

A – Hoffman Window Kits
B – Leviton Connectors
C – Photos



NOTES:

1. TYPICAL DIMENSIONS SHOWN FOR VARIOUS SERVICE SIZES. BOX MUST BE FIELD VERIFIED PRIOR TO FABRICATION AND INSTALLATION.

HRSD	HAMPTON ROADS SANITATION DISTRICT	DRAWING NO. 33
	STANDARD DESIGN DETAIL	SHEET 1 OF 1
	LOAD TEST HINGED BANK BOX	DATE 1/2015

Alternative Load Bank Box Solution

POWER SYSTEMS

TripleSwitch™ 3-Way Manual Transfer Switch

UL 1008 Listed

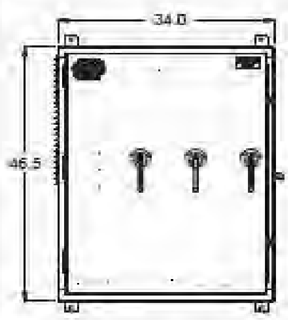
125 - 400A, up to 600VAC
Series: 3141-M

Features

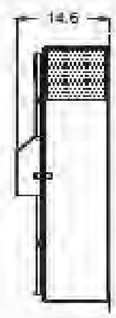
- Accepts 24VDC signal from ATS to switch power during load bank testing (other signal trip voltages available)

- Quick connect solution for permanent generator load bank testing and a backup portable generator
- Mechanically interlocked mechanism prevents cross-connecting power sources
- Dry contacts provided for annunciator circuit
- Disconnects are 3-pole circuit breakers as standard (optional 4-pole breakers or molded case switches available)
- Type 3R heavy gauge galv. steel enclosure with gray powdercoat RAL 7035 (stainless steel & additional colors optional)
- Color-coded series 16 cam style connectors for easy back-up generator (male) & load bank (female) connection
- Handle cover provides security from unauthorized use
- Wall mountable; leg kits optional
- Operating instructions silkscreened on door
- Optional extended enclosure (8" deeper) for bottom conduit feed
- NEC 700.12 compliant

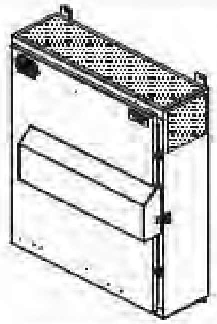
Drawing



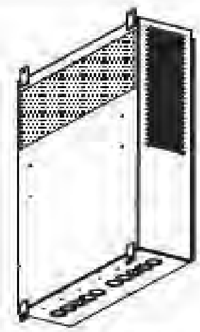
FRONT VIEW
(HANDLE COVER NOT SHOWN)



SIDE VIEW



FRONT ANGLE VIEW



REAR ANGLE VIEW

Available incoming conduit entry locations shown shaded.

Approvals

- UL/cUL 1008 Listed assembly
- UL 1691 Listed receptacles
- UL 1087 Listed molded case switch
- UL 489 Listed / CSA certified molded case circuit breaker
- OSHPD seismic certification (OSP)
- ICC-ES 156 shake-table tested/certified
- IBC 2015/ASCE 7-10 compliant

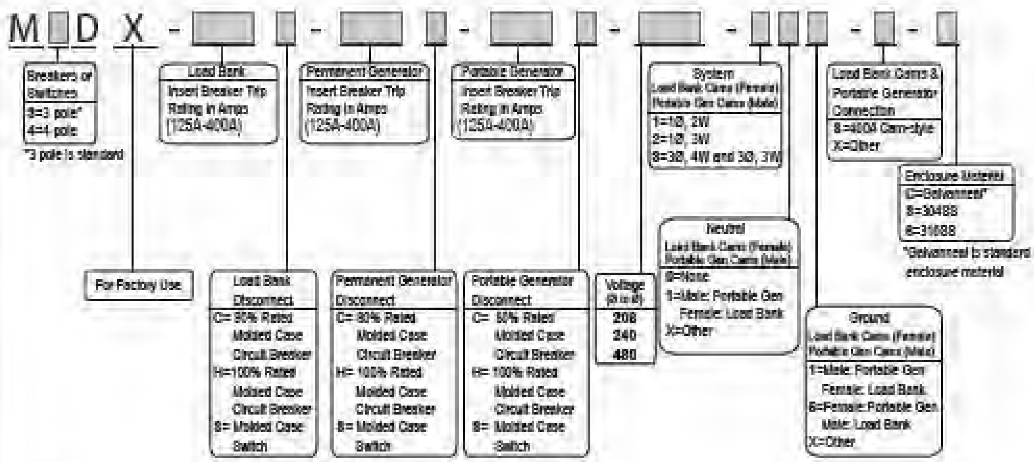
Specifications

TripleSwitch 3-Way Manual Transfer Switch
Series: 3141-M

UL 1008 Listed

Ordering Information

Example: M3D4 - 400C - 400C - 400C - 208 - 311 - S - C



Contact factory for additional options

Ratings

Short circuit rating (breakers)	65kAIC @ 208VAC & 240VAC, 35kAIC @ 480VAC, 18kAIC @ 600VAC
Withstand rating (switches)	10kA @ 208VAC to 600VAC
Cam-style receptacles	Includes the following for both load bank & portable generator: (1)400A, 600VAC for each phase, neutral and ground
Terminals	Disconnect line terminals: (2) 2/0 - 500kcmil Load terminals: (2) 2/0 - 500kcmil Ground lug: (3) #6 - 300kcmil Neutral: (4) 2/0 - 500kcmil Other options available
Environmental	Type 3R, gasketed (Type 3RX with 304SS or 316SS option)

Packaging

Approximate product weight	370 lbs.
Approximate shipping weight	410 lbs.

TripleSwitch™ 3-Way Manual Transfer Switch

UL 1008 Listed

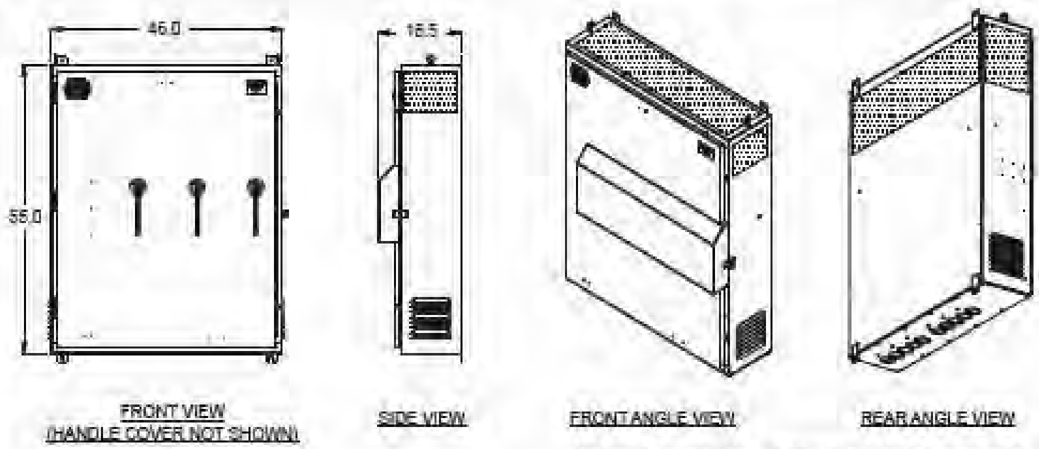
450 - 800A, up to 600VAC

Series: 3181-M

Features

- Accepts 24VDC signal from ATS to switch power during load bank testing (other signal trip voltages available)
- Quick connect solution for permanent generator load bank testing and a backup portable generator
- Mechanically interlocked mechanism prevents cross-connecting power sources
- Dry contacts provided for annunciator circuit
- Disconnects are 3-pole circuit breakers as standard (optional 4-pole breakers or molded case switches available)
- Type 3R heavy gauge galv. steel enclosure with gray powdercoat RAL 7035 (stainless steel & additional colors optional)
- Color-coded series 16 cam style connectors for easy back-up generator (male) & load bank (female) connection
- Handle cover provides security from unauthorized use
- Wall mountable; leg kits are optional
- Operating instructions silkscreened on door
- Optional extended enclosure (8" deeper) for bottom conduit feed
- NEC 700.12 compliant

Drawing



Available incoming conduit entry locations shown shaded.

Approvals

- UL/cUL 1008 Listed assembly
- UL 1691 Listed receptacles
- UL 1087 Listed molded case switch
- UL 489 Listed / CSA certified molded case circuit breaker
- OSHPD seismic certification (OSP)
- ICC-ES 156 shake-table tested/certified
- IBC 2015/ASCE 7-10 compliant

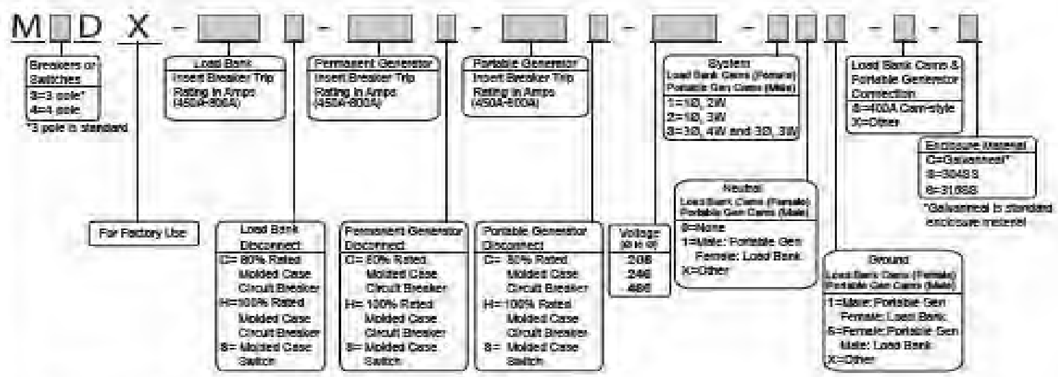
UL 1008 Listed

Specifications

TripleSwitch 3-Way Manual Transfer Switch
Series: 3181-M

Ordering Information

Example: M3D8 - 800C - 800C - 800C - 208 - 311 - S - C



Contact factory for additional options

Ratings

Short circuit rating (breakers)	65kAIC @ 208VAC & 240VAC, 35kAIC @ 480VAC, 18kAIC @ 600VAC
Withstand rating (switches)	10kA @ 208VAC to 600VAC
Cam-style receptacles	Includes the following for both load bank & portable generator: (2) Sets of 400A, 600VAC for phase & neutral (1) 400A, 600VAC for ground
Terminals	Disconnect line terminals: (3) 3/0 - 500kcmil Load terminals: (3) 3/0 - 500kcmil Ground lug: (3) #6 - 300kcmil Neutral: (6) 3/0 - 500kcmil Other options available
Environmental	Type 3R, gasketed (Type 3RX with 304SS or 316SS option)

Packaging

Approximate product weight	540 lbs.
Approximate shipping weight	575 lbs.

400A SINGLE POLE CAM STYLE MATING PLUG (SOLD SEPARATELY)

- [redacted]
- LEVITON 16 SERIES, TAPER NOSE
- [redacted]

Return to Load Bank Text Boxes

SPECIFICATIONS FOR 3-WAY MANUAL TRANSFER SWITCH WITH (2) BREAKER INTERLOCK

PART 1 – GENERAL REQUIREMENTS

1.01 **Scope:**

A. Contractor shall furnish, deliver, install and test the 3-way manual transfer switches as specified herein and in accordance with the drawings.

1.02 **Quality Assurance:**

A. 3-way manual transfer assembly switch shall be UL listed and labeled under the UL 1008 standard.

B. 3-way manual transfer switch shall be special seismic certified by OSHPD exclusively on the basis of approved shake table testing, and also certified to IBC 2015. Minimum IBC 2015 design parameters shall be as follows: Ip = 1.5, S_{DS} = 2.0g, z/h = 1.0

C. 3-way manual transfer switch manufacturer shall provide a complete factory assembled, wired and tested 3-way manual transfer switch.

D. 3-way manual transfer switch shall be factory Hi-pot tested for a period of not less than 60 seconds.

E. 3-way manual transfer switch installation shall meet all applicable NEC standards.
   1. 2017 NEC 700.3 (F) compliant when used in conjunction with an ATS and appropriate auxiliary equipment.

1.03 **Submittals:**

A. Contractor shall submit manufacturer's drawings and data of 3-way manual transfer switches for Engineer's approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings and wiring diagrams, UL listing information including UL file or control number, short circuit rating or withstand rating, component data, mounting provisions, conduit entry locations and installation instructions.

B. Upon installation of 3-way manual transfer switches Contractor shall submit manufacturer's Operating & Maintenance Manual which shall include as a minimum:
   1. Certified as-built General Arrangement drawings and Wiring Diagram.
   2. Materials / Component List including part numbers.
   3. Maintenance and service requirements.
   4. Certificate of Compliance and hi-pot test data.

200929

1.04 **Warranty:**

A. 3-way manual transfer switches shall be covered by manufacturer's warranty for a minimum period of (1) one year after shipment from manufacturer.

SECTION 2 - PRODUCTS

2.01 **General:**

A. All equipment shall be new.

B. 3-way manual transfer switch manufacturer must have produced and sold UL 1008 Listed manual transfer switches as a standard product for minimum of (3) years.

C. 3-way manual transfer switches shall be molded case circuit breaker type; knife switch or fused switches are not acceptable.

D. Contractor shall be responsible for the equipment until it has been installed and is finally inspected, tested and accepted in accordance with the requirements of this Specification.

E. 3- way manual transfer switches shall be TripleSwitch as manufactured by ESL Power Systems, Inc. or equal as approved by the Engineer.

2.02 **3-way Manual Transfer Switches:**

A. 3-way manual transfer switch shall consist of (2) mechanically-interlocked molded case circuit breakers, and (1) independent load bank breaker with a shunt trip (shunt trip voltage to be per the drawings), male cam-style inlet connectors, female cam-style outlet connectors, power distribution blocks and grounding terminals, all housed within a padlockable enclosure.

B. WALL-MOUNT ENCLOSURES

3-way manual transfer switch enclosure shall be Type 3R, constructed of continuous seam-welded, powder coated galvanneal steel. The main access shall be through an interlocked, hinged door that extends the full height of the enclosure. Access for both portable generator cables with female cam-style plugs and for load bank cables with male cam-style plugs shall be via a drawn flange cable entry openings in the bottom of enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be wrinkle gray RAL 7035.

PAD-MOUNT ENCLOSURES

3-way manual transfer switch enclosure shall be Type 3R, constructed of continuous seam-welded, powder coated galvanneal steel. The main access shall be through a hinged door that extends the full height of the enclosure. Access for both portable generator cables with female cam-style plugs and for load bank cables with male cam-style plugs shall be via a hinged lower flap door. Hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be wrinkle gray RAL 7035.

C. Cam-style male connectors (inlets) and cam-style female connectors (outlets) shall be UL Listed single-pole separable type and rated 400 amps at 600VAC. All cam-style connectors shall be color coded. Cam-style connectors shall be provided for each phase and for ground, and shall also be provided for neutral. Each of the phase cam-style connectors and the neutral cam-style connectors within the enclosure shall be factory-wired to a molded case circuit breaker. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. None of the cam-style connectors shall be accessible unless all (3) molded case circuit breakers are in the "OFF" position and the main access door is open.

D. A power distribution block shall be provided for load-side field wiring. The power distribution block shall be factory wired to the molded case circuit breakers.

E. Molded case circuit breakers shall be UL Listed 3-pole and the short circuit interrupt rating shall be a minimum of 35kAIC at 480VAC (wall mount units) or 50kAIC at 480VAC (pad mount units). Trip rating of the molded case circuit breakers shall be as shown on the drawings. One molded case circuit breaker shall control the connection between the permanent generator and the automatic transfer switch. A second circuit breaker shall control the connection between the permanent generator and the load bank female cam-style connectors. A third circuit breaker shall control the connection between the portable generator (via male cam-style connectors) and the automatic transfer switch. All (3) molded case circuit breakers shall include UL Listed door-mounted operating mechanisms, preventing the opening of the main access door unless all (3) breakers are in the "OFF" position. All (3) molded case circuit breakers shall be mounted behind a deadfront panel. The load-side of the molded case circuit breakers shall not be energizable unless the main access door is closed and one of the molded case circuit breakers is in the "ON" position. The (2) molded case circuit breakers controlling the connections between the permanent generator and the automatic transfer switch, and the connection between the portable generator and automatic transfer switch shall be safety interlocked by mechanical means to ensure that only one of these breakers can be closed at any given time.

F. An auxiliary contact shall be provided in the circuit breaker controlling the connection from the Permanent Generator to the ATS and shall be factory wired to terminal blocks within the enclosure. The auxiliary contact is provided in compliance with NEC 2017 700.3 (F)(5) which requires a means to activate an annunciator circuit.

Section 3 - Execution

3.01 **Installation:**

A. Prior to installation of 3-way manual transfer switches, Contractor shall examine the areas and conditions under which the 3-way manual transfer switch is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.

B. 3-way manual transfer switch shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation".

C. Conduit entry into the 3-way manual transfer switch shall be by Contractor; Contractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS or T&B, for each conduit entry on the 3-way manual transfer switch. The incoming hub size shall match the conduit size for feeders and ground as shown on the drawings. The outgoing hub size shall match the conduit size for loads and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the 3-way manual transfer switch enclosure.

D. Contractor shall terminate feeder conductors, load conductors and ground per the manufacturer's instructions. All field wiring terminations shall be torqued as required per the instructions on the 3-way manual transfer switch's power distribution blocks, circuit breakers & ground lugs.

3.02 **Field Testing:**

A. Prior to energizing 3-way manual transfer switch, the Contractor shall perform the following checks and tests as a minimum:

1. Verify mounting and connections are complete and secure.
2. Verify internal components and wiring are secure.
3. Perform continuity check of all circuits.
4. Perform 1,000 VDC megger test on feeder and load cables. Prior to testing, all auxiliary circuits must be turned OFF and all fuses, microswitches and shunt trip circuits must be disconnected. It is required to take out the rating plug of any electronic trip circuit breakers while performing a megger (insulation) test.
5. Verify deadfront is secure.
6. With the 3-way manual transfer switch deadfront in place and the main access door closed and properly latched, actuate all (3) Operator Mechanisms; verify:
   A). With the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) in the "ON" position, the breaker controlling the connection between permanent generator and the load bank can be turned to the "ON" and "OFF" position and the breaker controlling the connection between the

portable generator and the automatic transfer switch cannot be turned "ON"

B) With the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) in the "OFF" position, the other (2) breakers controlling the connection between the permanent generator and load bank can be turned "ON" or "OFF", and the breaker controlling the connection between the portable generator and the automatic transfer switch can be turned "ON" and "OFF"

C) With the breaker controlling the connection between the portable generator and the automatic transfer switch (ATS) in the "ON" position, the breaker controlling the connection between the permanent generator and the automatic transfer switch (ATS) cannot be turned "ON" and the breaker controlling the connection between the permanent generator and load bank can be turned "ON" and "OFF".

7. Confirm operation of the 3-way manual transfer switch ground receptacle by attaching a plug to the 3-way manual transfer switch ground receptacle and then verify that the plug is grounded to the facility ground.
8. Once normal power has been applied, confirm operation of 3-way manual transfer switch by following directions on main access door.

End of Section

HAMPTON ROADS SANITATION DISTRICT
Electrical Department
2391 G Avenue
Newport News, VA 23602
Phone: 757-833-1702
Fax: 757-875-0273

Drive Specifications:
Date: 09-10-15

Variable Frequency Drive w/ Waste Water Package

1.) Horsepower: __________
2.) Full Load Amps: __________
3.) ________ VAC, Three Phase, 60 Hertz, with internal DC Link Choke and Line Reactor.
4.) NEMA 12 free standing enclosure, 90" x 36" x 20" with viewing window and positive pressure blower & filter. Viewing window shall be made by Tegam (www.tegam.com- Item# AWXXXX). Also note, width may vary depending on air exchanges needed for correct cooling factor and/ or dimension of the VFD.
   Tegam windows are not required if the VFD's are installed in a controlled environment.
5.) Door mounted digital keypad operator
6.) Fully NEMA rated door interlocking circuit breaker approved for thermal & magnetic trips. ***IEC or DUAL RATED NOT ACCEPTED.***
7.) Fully NEMA rated three contactor by-pass configuration fully rated for continuous drive operation. Also, shall operate automatically when in the by-pass position. ***IEC or DUAL RATED NOT ACCEPTED.***
8.) NEMA rated – "Drive/ Off/ By-Pass" and "Test/Off/Run" selector switches.

9.) NEMA Rated- "Manual/Auto" selector switch programmed for a voltage (manual) and current (auto) input. Additional contact on "Auto" side of switch to provide closure in auto mode and wired to terminal on drive.

10.) Door mounted ~~Yokogawa elapsed time meter Model # 240311AAAB7 120~~ VAC non- resettable. Crompton elapsed time meter is UL listed

11.) 4-20 MADC speed reference for input and output signals.

12.) NEMA rated speed potentiometer mounted on door for manual speed control.

13.) Isolation form "C" relay TPDT for each "Run", "Fault" and "Man/ Auto" status.

14.) Enclosure shall be manufactured by Hoffman.

15.) Control transformer should be ***1,000 VA or larger*** based on control needs in cabinet.

16.) Auxiliary contact for cabinet cooling fans to be form "C" relay TPDT and controlled from Run Status contacts of VFD.

17.) Cooling air fans shall be sized to provide correct air exchanges in cabinet to maintain temperature in cabinet below VFD rating.

18.) Extended 5 year warranty must be included.

19.) The assembly shall be listed per UL508 and 508A or equivalent NRTL standard. The entire assembly shall be affixed with UL508A label prior to shipment.

20.) Application specific - evaluate need for soft start for bypass for 100 HP motors or greater.

21.) Door mounted cradle for controller that could be removed and connected via (3m or 9ft) cable so that drive can be operated outside of the arc flash boundary.

Note for Vendor:

1.) Must visit the site to verify that equipment ordered is correct for operation.

2.) Drawings for approval are required to be submitted to HRSD Electrical Department.

3.) Items 6 & 7 shall be approved NEMA rated Cutler-Hammer, Allen-Bradley or Square D. Or other manufacture NEMA rated with written approval by the HRSD site.

4.) All switches and lights shall be heavy duty NEMA Rated Cutler-Hammer or Allen-Bradley 30mm.

5.) All switches, lights and keypad shall be mounted inside of viewing window on door. If applicable

6.) All spare relay contacts should be wired to terminal blocks.

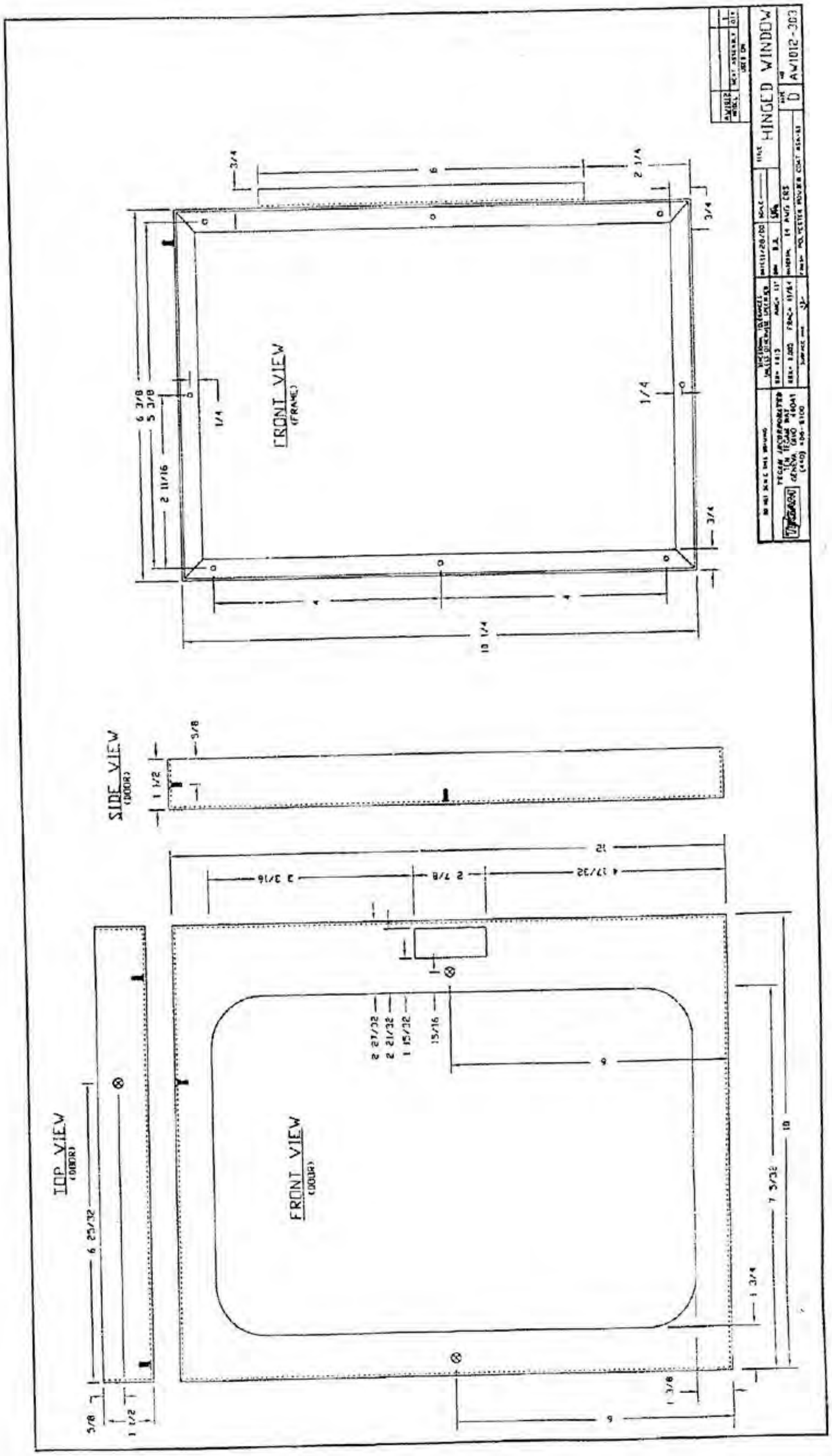
7.) Fault relay should be controlled from Normally Closed (N.C.) contacts of VFD MB & MC Terminals and to be wired after Overload (O/L) contacts on drawing.

8.) All VFD's will be shipped attached Horizontally on pallets and with sufficient protection for the switches, lights and On/Off breaker.

9.) ***THERE SHALL BE NO IEC OR DUAL RATED NEMA DEVICES ACCEPTED.***

Examples: Lights, position switches, circuit breakers, contactors and speed potentiometer.

Mount Thermostat above or close to the VFD. Not at the bottom of the cabinet


HINGED WINDOW
AW1012-303
FRONT VIEW
(FRAME)
SIDE VIEW
(DOOR)
TOP VIEW
(DOOR)
FRONT VIEW
(DOOR)

Technical Memorandum

VFD Harmonic Mitigation

To:
Laura Kirkwood, PE, HRSD

Issued By:
Mike Gaffney, PE, RK&K
Ryan Delo, PE, RK&K
Tim Bollinger, PE, RK&K
Jason Hoyt, RK&K

Date:
June 12, 2018

Program Name:
Hampton Roads Sanitation District
Chesapeake Elizabeth Interceptor System Diversion Improvements

Subject:
Technical Memorandum to Provide Harmonic Mitigation Recommendation for Variable Frequency Drives at Pressure Reducing Stations

Introduction

It is our experience variable frequency drives (VFDs) operating motors 100HP or larger benefit from harmonic filters to reduce the effects of harmonic distortion. Harmonic distortion can increase generator sizing, reduce equipment life expectancy, and reduce the efficiency of the power system ultimately resulting in higher operation and maintenance costs. HRSD's standard Yaskawa A1000 VFD with a line reactor reduces the harmonic distortion, but it is estimated the total distortion will be greater than the limits recommended by IEEE-519. See **Figure 1** below for the IEEE-519 recommended limits, and **Figure 2** for the harmonic estimation of HRSD's standard configuration.

Harmonic Mitigation Options

There are two options for mitigating the harmonics generated by the VFDs. The first option for harmonic mitigation is to add a passive harmonic filter. A passive harmonic filter may be added to HRSD's standard configuration. Adding a passive harmonic filter will reduce the effects of harmonic distortion within the limits recommended by IEEE-519, see **Figure 3** for the harmonic estimation. This option will increase the foot print of the drive enclosure, additional labor will be required for wiring, and additional ventilation will be required for heat dissipation.

The second option for harmonic mitigation is to utilize the Yaskawa U1000 Matrix VFD. The Yaskawa U1000 Matrix VFD will replace the Yaskawa A1000 VFD and line reactor. Use of the Yaskawa U1000 Matrix VFD will reduce the effects of harmonic distortion within the limits recommended by IEEE-519, see **Figure 4** for the harmonic estimation. This option will not impact the foot print of the drive enclosure, labor for wiring will be reduced because the line reactor is no longer required, and additional ventilation will not be required for heat dissipation.

Either option will increase the cost an estimated $25,000 per drive, based on powering a 215 hp motor.

Recommendation

Of the options available for harmonic mitigation we recommend the Yaskawa U1000 Matrix VFD be used as the standard variable frequency drive for all motors 100HP and larger. Use of the Yaskawa U1000 Matrix VFD will reduce the effects of harmonic distortion to within the limits recommended by IEEE-519, eliminate the need for a line reactor and passive harmonic filter, and reduce the foot print of the drive enclosure compared to a variable frequency drive panel with a line reactor and passive harmonic filter. The Yaskawa A1000 VFD uses the typical AC to DC conversion, then DC to variable AC pulse width modulated (PWM) waveform for speed control. The Yaskawa U1000 Matrix VFD reduces harmonics by AC to AC operation with the use of 9 bi-directional insulated-gate bipolar transistors (IGBTs) for speed control. In addition to the low harmonics of the Yaskawa U1000 Matrix VFD the use of bi-directional IGBTs allows the variable frequency drive to handle continuous power regeneration.

Aside from the advantages listed above for the Yaskawa U1000 Matrix VFD, the variable frequency drive has the same user interface and terminal layout as the Yaskawa A1000 VFD, eliminating the need for any additional operator training for the set-up and programming of the VFD.

Allen Bradley manufactures the PowerFlex 755TL VFD capable of reducing harmonics. While an extensive evaluation of this drive was not completed (as it is not the model indicated in HRSD's Preferences) as part of this technical memorandum, this alternative may be worthy of evaluation to determine suitability for installation in the pressure reducing stations.

Figure 1. IEEE-519 (2014) Limits

IEEE-519 (2014)

Current Distortion Limits

Harmonic Current Distortion Limits for general distribution systems (120V through 69kV)

Isc/IL	TDD
<20	5.0 %
20 - 50	8.0 %
50 - 100	12.0 %
100 - 1000	15.0 %
> 1000	20.0 %

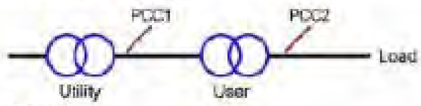
TDD = Total Demand Distortion, in percent of IL
Isc = Maximum short circuit current at PCC (Point of Common Coupling)
IL = Maximum demand load current at PCC (Point of Common Coupling)

Voltage Distortion Limits

Bus voltage V at PCC	THD
V <= 1.0 kV	8.0 %
1 kV < V <= 69 kV	5.0 %
69 kV < V <= 161 kV	2.5 %
161 kV < V	1.5 %

Figure 2. Harmonic Estimation with a Yaskawa A1000 VFD and Line Reactor

Project: Providence Road PRS



Linear: 15 HP

Non-Linear: 800 HP

Utility: Dominion Energy

Source Data I

Source	Frequency (Hz)	Rating (kVA)	Impedance Z (%)	Sec. Voltage (V)	Isc (A)
Utility XFMR	60	50,000	8.00	13,800	26,148
User XFMR	60	1,500	5.75	480	31,378

Source Data II

Source	Rated Amps, rms (A)	Amps Fundamental (A)	Amps Harmonics (A)	Total Amps (A)
Utility XFMR	2,092	30.9	8.6	32.1
User XFMR	1,804	889.7	247.4	923.5

Harmonic Summary

Location	Current TDD (%)	Voltage TDD (%)	Isc/Load	Transformer Load (%)
PCC2	27.8	4.7	35.3	56.7

IEEE-519 (2014) limits at PCC2 for specified system based on Isc/IL: Voltage THD: 8.0 %, Current TDD: 20.0 %

Project Compliance

Location	IEEE-519 (2014)	IEC
PCC2	No	No

Figure 3. Harmonic Estimation with a Yaskawa A1000 VFD and Passive Filter

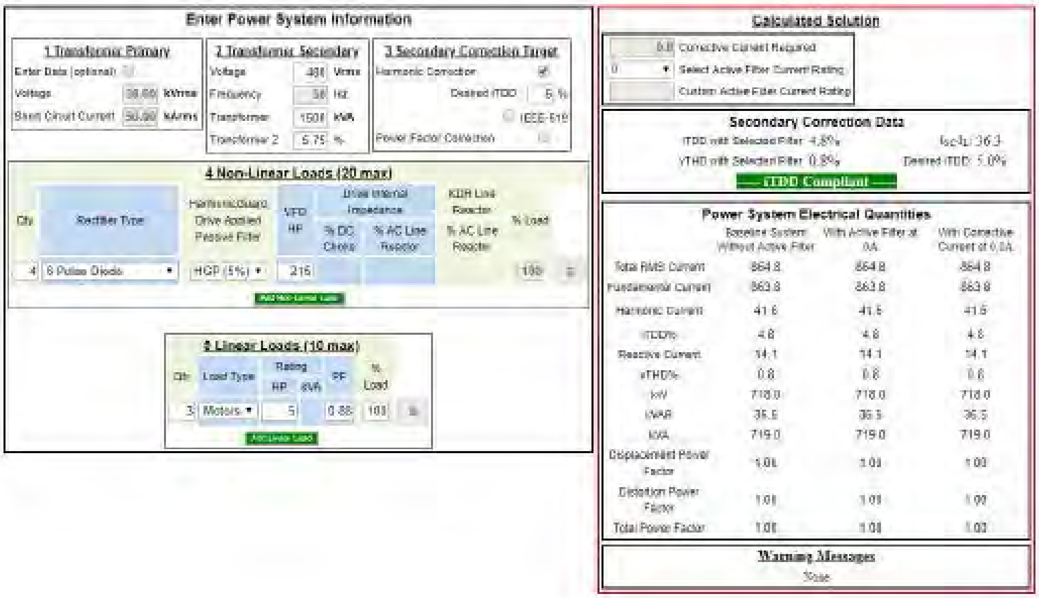
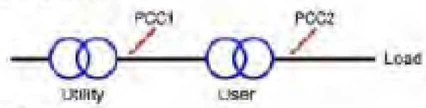


Figure 4. Harmonic Estimation with a Yaskawa U1000 Matrix VFD

Project: Providence Road PRS



Linear: 15 HP
Non-Linear: 860 HP

Utility: Dominion Energy

Source Data I

Source	Frequency (Hz)	Rating (kVA)	Impedence Z (%)	Sec. Voltage (V)	Isc (A)
Utility XFMR	60	50,000	8.00	13,800	26,148
User XFMR	60	1,500	5.75	480	31,378

Source Data II

Source	Rated Amps, rms (A)	Amps Fundamental (A)	Amps Harmonics (A)	Total Amps (A)
Utility XFMR	2,092	30.9	0.9	31.0
User XFMR	1,804	889.7	25.0	890.1

Harmonic Summary

Location	Current TDD (%)	Voltage TDD (%)	Isc/Load	Transformer Load (%)
PCC2	2.9	1.2	35.3	49.9

IEEE-519 (2014) limits at PCC2 for specified system based on Isc/IL: Voltage THD: 8.0 %, Current TDD: 8.0 %

Project Compliance

Location	IEEE-519 (2014)	IEC
PCC2	Yes	Yes

Click here to return to VFH (AUX) (PSs)

Click here to return to VFD (AUX) (TPs)

Safety Switches with Variable Frequency Drives

Introduction

The National Electrical Code® (NEC®) requires that a disconnecting means shall be located in sight from the motor location and the driven machinery location (Article 430.102(B)). The NEC® defines "in sight" as visible and not more than 50 feet (15.24 m) distant (Article 100 – definitions).

In many cases, motor starters will be located in another space then the motor and to meet code requirements, a safety switch is used to add a way to disconnect and lockout a motor. When an across the line starter is used, this won't cause an issue, but it can cause issues with a Variable Frequency Drive. When a motor is running with a VFD and is turned off at the safety switch, the VFD does not have a way of sensing that the motor load has dropped off completely in V/Hz control. The drive is designed to supply as much voltage as the motor is demanding and it would not be uncommon for the motor to not require any power once the load is moving due to inertia. Because of this, the VFD will continue to function and run as it normally would even though the load has been disconnected. When the safety switch is closed again, the VFD will function like an across the line starter and an enormous amount of inrush current will be generated and pulled through the drive.

Across the line starters are designed to handle these large current spikes for a short amount of time, but a VFD is meant to be used to ramp up and down the speed of a motor. Until recently, this inrush current could cause the IGBTs to fail and require complete replacement which can be very costly due to down time and the process being very labor intensive. A way to prevent these issues is to provide feedback from the safety switch back into the VFD that the switch has been opened and the VFD should stop running.

As a standard, safety switches are simple devices that cut off power to the motor, however, they have additional options including an auxiliary contact that will change states when the switch is changed. There are multiple ways to tie this back into the VFD to prevent it from running, but the two most common ways are to use it as a lockout contact that is wired into the RUN input of the drive or a Normally Closed contact is wired into the EXTERNAL FAULT input on the drive. Each method will be discussed in more detail below.

Interlocking with RUN signal

Eaton provides terminal blocks to interlock an external signal to the RUN input as a standard on all Enclosed VFD Assemblies. From the factory, these terminal blocks come jumpered as in most cases this interlock signal is not required. This makes interlocking your safety switch as easy as running two wires from the safety switch into the VFD enclosure that are rated for 120Vac.

In the case that an open component VFD is being used or the drive was installed into an enclosure by a local panel builder, it will take some rewiring to interlock the VFD with the Safety Switch. Figure 1 below shows a simplified wiring scheme. By wiring a Normally Open Contact from the Safety Switch in series with the VFD's RUN Input, the drive will only be allowed to RUN when the switch is closed.

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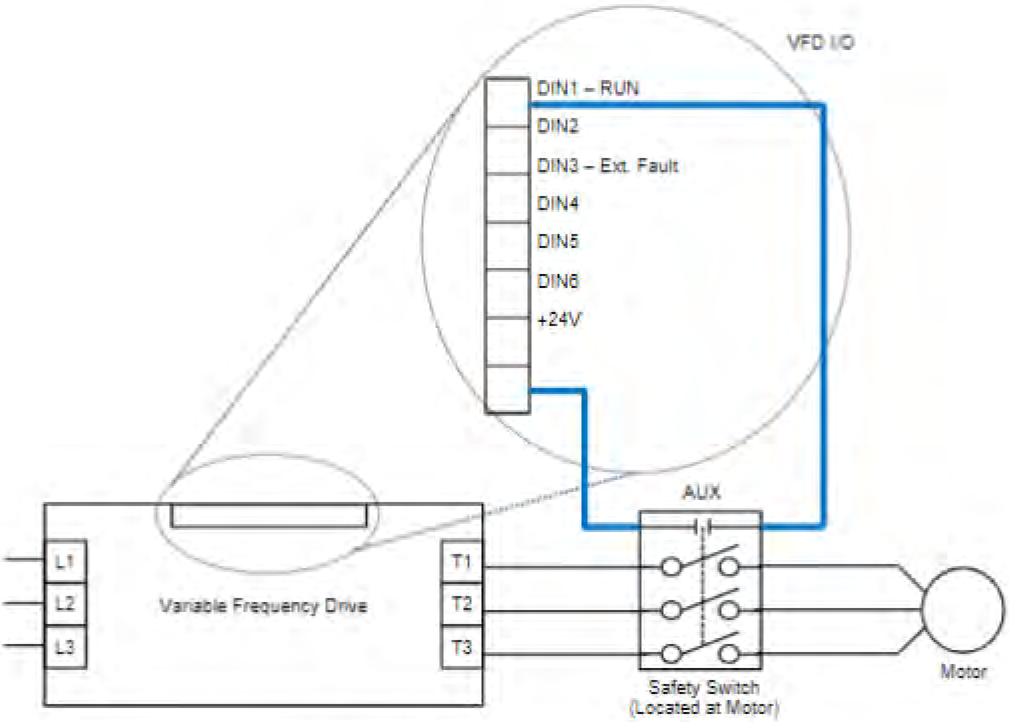

Figure 1 – Interlocking with the VFD RUN input

One of the main advantages of going this route is that the VFD will start to run again as soon as the Safety Switch is put back into the closed position. In the case where you don't have a local control station near the motor, this will save some time from having to go back to the main VFD to reset it to allow the unit to start back up. Some people would prefer that the motor needs to be manually restarted again in which case interlocking the Safety Switch with the VFD EXTERNAL FAULT input is a better solution.

Interlocking with EXTERNAL FAULT signal

Wiring into the EXTERNAL FAULT input on the drive is a less common way of interlocking the Safety Switch with the VFD, but it will provide similar results. Figure 2 below shows a simplified wiring scheme on how to do this. By wiring a Normally Closed Contact from the Safety Switch in series with the VFD's EXTERNAL FAULT Input, the drive will register a Fault anytime the Switch is opened, causing the VFD to shut down.

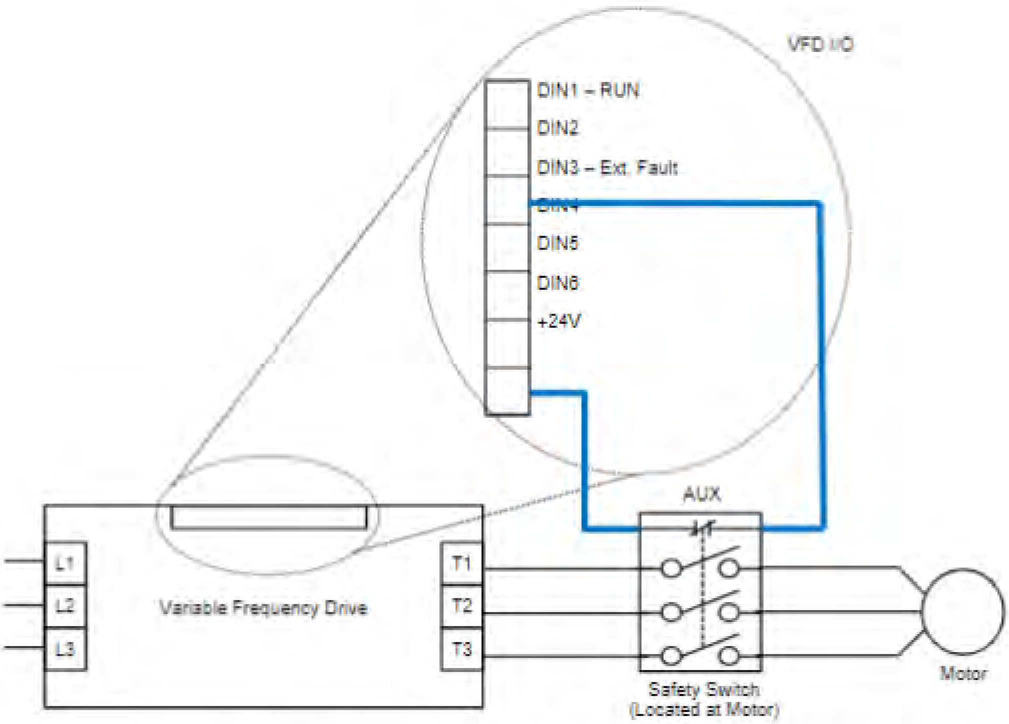

Figure 2 – Interlocking with the VFD EXTERNAL FAULT Input

External Faults are typically looking for low signals to prevent issues with wires coming lose and faults not registering. In this case, as soon as the motor's power is cut at the safety switch, the drive will register an External Fault which cannot be cleared until the Safety Switch is closed again. The Drive can then be reset locally at the keypad or through a remote reset button with is wired into a RESET input on the VFD. The reset can also be done over the communication bus as well.

Additional Help

In the US or Canada: please contact the Technical Resource Center at 1-877-ETN-CARE or 1-877-326-2273 option 2, option 6.

All other supporting documentation is located on the Eaton web site at www.eaton.com/Drives

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Click here to return to Lighting (PSs)

Exhibit D

Click here to return to Lighting (TPs)

HRSD Lighting Guidelines Rev. 092718

The purpose of these guidelines is to provide direction for sustainable lighting solutions to meet the needs of facilities and help accomplish the Mission and Vision of HRSD.

Sustainable lighting meets the qualitative needs of the visual environment with the least impact on the physical environment.

- **Sustainable lighting elements**
  - Optimize use of daylight
  - Minimize use of energy
  - Reduce light pollution and light trespass
  - Minimize embodied environmental effects
  - Specify environmentally preferable materials and equipment
  - Ensure system quality, flexibility, adaptability, maintainability and durability
  - Provide staff orientation and training

I. Qualitative needs

- Support work
  - Productivity, safety, security
- Regulatory
  - Minimum required light levels maintained
- Human Centric
  - The psychological wellbeing, interest, and enthusiasm of people.

II. Optimize use of daylight

- Daylight can provide potential benefits in terms of health, performance, or general well being
- Minimize electric lighting, turn off (or down) in response to daylight
  - Simple solution: Photo-sensor, controller, step-dimming ballast (bi-level option) for fixture retrofit
  - Optional feature for occupancy/vacancy sensors- Built in photo-sensor- Inhibits room lights from turning on when there is sufficient daylight present

III. **Minimize use of energy**

- Integrated design
  - Optimize integration with daylighting
- Appropriate, high quality design
  - Appropriate light levels, noticeable improvement

- Effective controls
  - To reduce kWh by turning off lighting
    - Switching controls
  - To reduce kW by turning down lighting
    - Dimming controls

IV. **Reduce light pollution and light trespass**

- Light pollution is:
  - Unnecessary, unwanted or wasted light
  - Light that damages or degrades the nighttime luminous environment
  - Light that negatively impacts humans, animals or plants
- Sustainability issue because:
  - Affects use of energy & enjoyment of natural nighttime sky
- Light Trespass
  - Obtrusive light that crosses a property line
  - Difficult to quantify
    - When, where & how much light is unwanted
- Can be avoided by:
  - Aiming lights down
  - Choosing fixtures with hoods, visors, or shields
  - Installing motion sensors to turn off lights when not needed
  - Use lowest wattage lamp to do the job
  - Lighting should not be overly bright in relation to the surrounding area.
  - B.U.G. rating of fixture, Back, Up, Glare.

V. **Minimize embodied environmental effects**

- Total energy required to produce a product, service or material including all life cycle phases from raw extraction to end of life
  - Includes manufacturing, packaging, transportation, installation, recycling
- Buy American (locally)
  - Minimize transportation
- Retrofit vs. Re-lighting (w/new fixtures)

    - Retrofit uses less material (often w/ lamps & ballasts or LED retrofit kits only)

VI. **Specify environmentally preferable materials and equipment**

- Lighting equipment manufacturers demonstrating their commitment to environmental responsibility with improvements to manufacturing.
- RoHS COMPLIANCE
    - Reduction of Hazardous Substances Directive
    - Aims to restrict certain dangerous substances commonly used in electronic equipment

VII. **Ensure system quality, flexibility, adaptability, maintainability and durability**

- Quality
    - Lighting that positively addresses human needs, architecture, economics, energy and the environment.
- Flexibility
    - To extend useful life of facility & better serve user's changing needs
        - Ex: Flexible lighting controls, such as wireless
        - Ex: Flexible wiring systems
- Adaptability
    - Should anticipate change to allow system reconfiguration and reuse in future remodeling
        - LED's improving Lumens Per Watt at 20% a year
        - Ex: Lighting controls – reprogram for new space uses
        - Ex: Lighting controls – wireless
- Maintainability & Durability
    - Lighting systems that perform the longest with the least maintenance effort have best economic and environmental value
        - SSL equipment & LED bulbs – lowest life-cycle cost
        - Long-life lamps have great value
        - Ex: Standardizing and minimizing the number of different lamp types reduces inventory and maintenance labor

VIII. **Provide staff orientation and training**

- Ensures operation and maintenance

IX. **Lighting Metrics**

- Provides a means to make comparisons between various lighting sources
    - Lumens-Total amount of light emitted by a source in all directions
    - Lumens Per Watt-Measure of light source energy efficiency

- CRI- Color Rendering Index is the measurement of how colors look under a light source when compared with sunlight. The index is measured from 0-100, with a perfect 100 indicating that colors under the light source appear the same as they would under natural sunlight.
- CCT- Correlated Color Temperature, measured in degrees Kelvin, refers to the amount of orange vs blue hue to the white light. "Warm" Light has a more orange hue vs. "Cool" light, which has a more bluish tint to it.
- Foot Candles- Measurement of total quantity of light falling on a square foot of a surface. This measurement is useful because working conditions are often specified in foot candles.

X. **Warranties**

- Unfortunately, there are still a number of unproven products and manufacturers out there that are causing challenges for both consumers and the industry.
- Half of new businesses last less than 5 years.

XI. **Reference Resources**

- Department Of Energy (DOE)
  - Caliper Reports
- DesignLights Consortium (DLC)
  The DesignLights Consortium® (DLC) is a non-profit organization dedicated to accelerating the widespread adoption of high-performing commercial lighting solutions. The DLC promotes high-quality, energy-efficient lighting products in collaboration with utilities and energy efficiency program members, manufacturers, lighting designers, and federal, state, and local entities. Through these partnerships, the DLC establishes product quality specifications, facilitates thought leadership, and provides information, education, tools and technical expertise.

- Illuminating Engineering Society (IES)

- Occupational Safety and Health Administration (OSHA)

- International Dark Sky Association (IDA)
  IDA is non-profit, tax-exempt, membership-based organization to help preserve & restore dark skies while maximizing the quality and efficiency of nighttime outdoor lighting.

XLIV. **A Practical Guide for Choosing the Appropriate LED Lighting**

There's More to It Than Just Lumens Per Watt

General

- Deplete existing parts inventory
- Plan for future network connectivity
- Use motion activating controls with overrides
- Color Rendering (CRI) Index of 80 or greater
- Correlated Color Temperature (CCT) 3500-4000K, Exterior
- Correlated Color Temperature (CCT) 4000K and above, Interior
- Consider glare use diffuser and or indirect fixture
- Consider vertical and up-light levels of illumination
- Consider light trespass and pollution, Exterior
- Ask for photo metrics of fixtures

Recommendations

- LED replacement tubes and cob lamps (plug and play) are not recommended due to safety and efficiency concerns.
- New fixtures designed around the LED light source are recommended.
- LED fixture retrofits are an option if more feasible than new fixture.
- Buy a few or ask vendor to supply fixtures for a temporary trial
- Use a light meter and record foot-candle readings horizontal and vertical before and after changes

Difficult Access Areas

  – Replace with LED fixture

Outside / Exterior Lighting

- High Mast Lighting
  - – No new installations, Install LED Street lighting
  - – Replace with LED fixture
  - – Consider light trespass and pollution

- Street Lighting/Building Exterior
  - LED replacement cob lamps not recommended due to safety and efficiency concerns
  - Low and High Pressure Sodium- replace with LED
  - Metal Halide- replace with LED
  - Incandescent/Halogen- replace with LED
  - Consider light trespass and pollution

Fluorescent Lighting

- LED replacement tubes not recommended due to safety and efficiency concerns
- Existing T-12, Fixtures 8’0
  - Retrofit with LED kit or replace with new LED fixture preferred
  - Consider vertical levels of illumination
  - Consider glare, use indirect or diffuser
- Existing T-12, Fixtures 4’0
  - Retrofit with LED kit or replace with new LED fixture preferred
  - Consider vertical levels of illumination
  - Consider glare, use indirect or diffuser

Hazardous (Classified) Areas, PTF, Wet Well, Digester etc.

- Replace with LED fixture rated for specific conditions, Class and Division
  - Correlated Color Temperature (CCT) 4000K and above
  - Color Rendering (CRI) Index of 90 or greater
  - Consider vertical and uplight levels of illumination
  - Consider glare, use diffuser

Click here to return to Motor Specs (PSs)

Click here to return to Motor Specs (TPs)

Exhibit E

HRSD ELECTRIC MOTOR SPECIFICATIONS

The following specifications shall be used for the purchase of new motors.

A. The motor shall meet or exceed the efficiency levels from NEMA MG1 Table 12-11 which comply with levels set by The Energy Policy Act and Conservation Act (EPCA), as amended by the Emergency and Security Act of 2007 (EISA). See NEMA MG1 Table 12-11.

B. The motor efficiency shall be determined using the test standards found in IEEE Standard 112-2004, Standard Test Procedure for Polyphase Induction Motors and Generators, or by other internationally accepted methods.

C. The motor shall be properly sized for the given load.

D. The motor shall be Totally-Enclosed, Fan-Cooled (TEFC), unless noted. Open Drip Proof (ODP) is acceptable in cases where TEFC is not available.

E. The motor shall have a minimum service factor of 1.15.

F. The motor shall have a minimum insulation class of F.

G. Motors used with variable frequency drives shall be examined for inverter duty motor applicability.

H. The following parameters shall be specified for the motor:

1. Motor horsepower
2. Voltage
3. Full load amps
4. Speed
5. Frequency
6. Phase
7. Shaft size
8. Environmental conditions (ambient operating temperature range, humidity level, etc.)
9. Starting torque (loaded or unloaded)
10. Classification of hazard (explosion proof, non-explosion proof, etc.)
11. Special equipment requirements (thermal protection, space heaters for outside, wet or high humidity area, standard or nonstandard conduit boxes, etc.)
12. Maximum number of starts per day/per hour
13. High temperature grease (for special cases, if required)

I. Where a Contractor is required to coat a motor, the motor shall be coated with an industrial enamel at a thickness of 5 mil D.F.T. The coating color shall be gray, U.S. Government Federal Register 595 Paint Color Number 16473.

NEMA MG1 Table 12-11
Motor Efficiencies

OPEN MOTORS

HP	FULL-LOAD EFFICIENCIES OF ENERGY EFFICIENT MOTORS							
	Nominal Efficiency 2 POLE	Minimum Efficiency 2 POLE	Nominal Efficiency 4 POLE	Minimum Efficiency 4 POLE	Nominal Efficiency 6 POLE	Minimum Efficiency 6 POLE	Nominal Efficiency 8 POLE	Minimum Efficiency 8 POLE
1	…	…	82.5	80.0	80.0	77.0	74.0	70.0
1.5	82.5	80.0	84.0	81.5	84.0	81.5	75.5	72.0
2	84.0	81.5	84.0	81.5	85.5	82.5	85.5	82.5
3	84.0	81.5	86.5	84.0	86.5	84.0	86.5	84.0
5	85.5	82.5	87.5	85.5	87.5	85.5	87.5	85.5
7.5	87.7	85.5	88.5	86.5	88.5	86.5	88.5	86.5
10	88.5	86.5	89.5	87.5	90.2	88.5	89.5	87.5
15	89.5	87.5	91.0	89.5	90.2	88.5	89.5	87.5
20	90.2	88.5	91.0	89.5	91.0	89.5	90.2	88.5
25	91.0	89.5	91.7	90.2	91.7	90.2	90.2	88.5
30	91.0	89.5	92.4	91.0	92.4	91.0	91.0	89.5
40	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
50	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
60	93.0	91.7	93.6	92.4	93.6	92.4	92.4	91.0
75	93.0	91.7	94.1	93.0	93.6	92.4	93.6	92.4
100	93.0	91.7	94.1	93.0	94.1	93.0	93.6	92.4
125	93.6	92.4	94.5	93.6	94.1	93.0	93.6	92.4
150	93.6	92.4	95.0	94.1	94.5	93.6	93.6	92.4
200	94.5	93.6	95.0	94.1	94.5	93.6	93.6	92.4
250	94.5	93.6	95.4	94.5	95.4	94.5	94.5	93.6
300	95.0	94.1	95.4	94.5	95.4	94.5	…	…
350	95.0	94.1	95.4	94.5	95.4	94.5	…	…
400	95.4	94.5	95.4	94.5	…	…	…	…
450	95.8	95.0	95.8	95.0	…	…	…	…
500	95.8	95.0	95.8	95.0	…	…	…	…

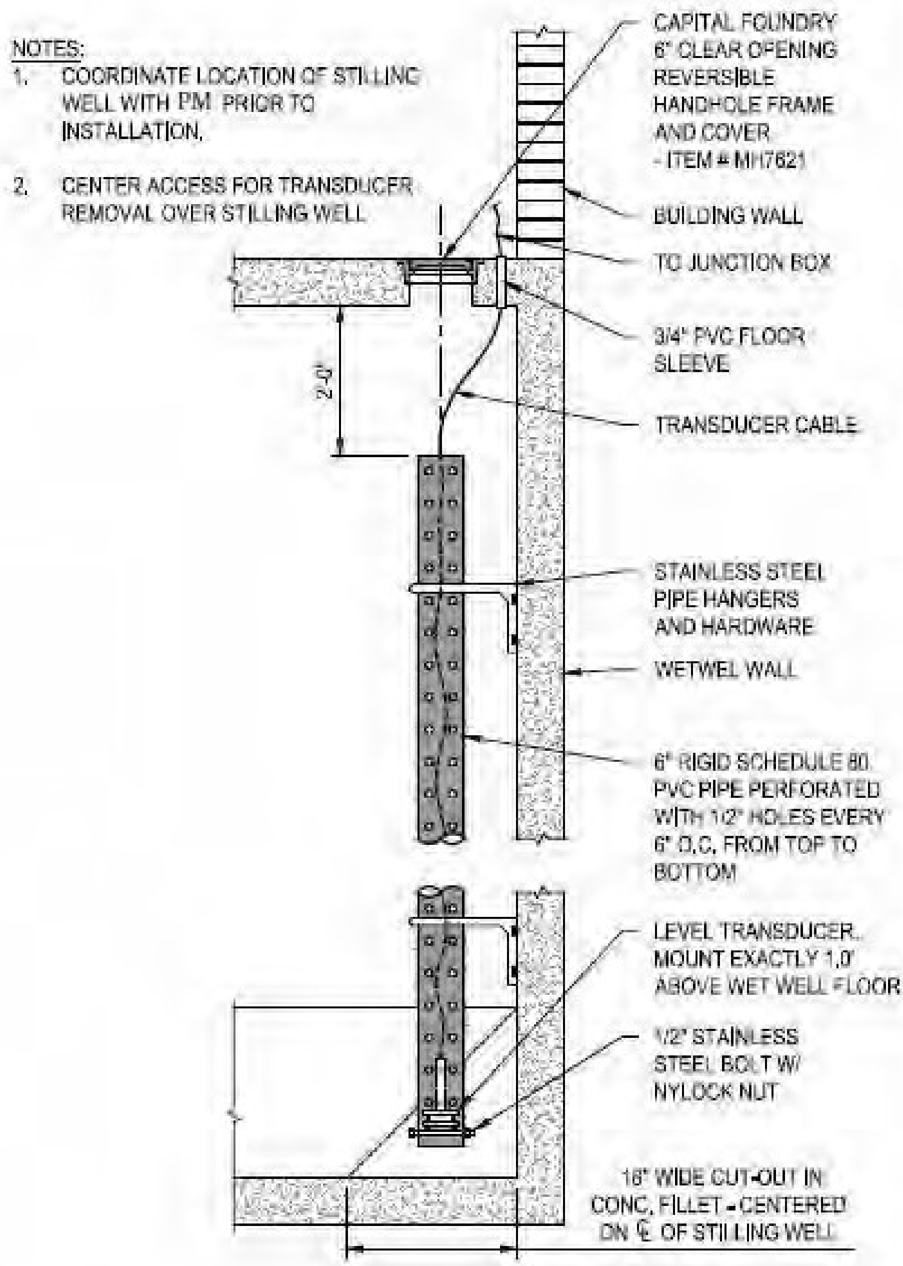
NEMA MG1 Table 12-11
Motor Efficiencies

ENCLOSED MOTORS

HP	FULL-LOAD EFFICIENCIES OF ENERGY EFFICIENT MOTORS							
	Nominal Efficiency 2 POLE	Minimum Efficiency 2 POLE	Nominal Efficiency 4 POLE	Minimum Efficiency 4 POLE	Nominal Efficiency 6 POLE	Minimum Efficiency 6 POLE	Nominal Efficiency 8 POLE	Minimum Efficiency 8 POLE
1	75.5	72.0	82.5	80.0	80.0	77.0	74.0	70.0
1.5	82.5	80.0	84.0	81.5	85.5	82.5	77.0	74.0
2	84.0	81.5	84.0	81.5	86.5	84.0	82.5	80.0
3	85.5	82.5	87.5	85.5	87.5	85.5	84.0	81.5
5	87.5	85.5	87.5	85.5	87.5	85.5	85.5	82.5
7.5	88.5	86.5	89.5	87.5	89.5	87.5	85.5	82.5
10	89.5	87.5	89.5	87.5	89.5	87.5	88.5	86.5
15	90.2	88.5	91.0	89.5	90.2	88.5	88.5	86.5
20	90.2	88.5	91.0	89.5	90.2	88.5	89.5	87.5
25	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
30	91.0	89.5	92.4	91.0	91.7	90.2	91.0	89.5
40	91.7	90.2	93.0	91.7	93.0	91.7	91.0	89.5
50	92.4	91.0	93.0	91.7	93.0	91.7	91.7	90.2
60	93.0	91.7	93.6	92.4	93.6	92.4	91.7	90.2
75	93.0	91.7	94.1	93.0	93.6	92.4	93.0	91.7
100	93.6	92.4	94.5	93.6	94.1	93.0	93.0	91.7
125	94.5	93.6	94.5	93.6	94.1	93.0	93.6	92.4
150	94.5	93.6	95.0	94.1	95.0	94.1	93.6	92.4
200	95.0	94.1	95.0	94.1	95.0	94.1	94.1	93.0
250	95.4	94.5	95.0	94.1	95.0	94.1	94.5	93.6
300	95.4	94.5	95.4	94.5	95.0	94.1	…	…
350	95.4	94.5	95.4	94.5	95.0	94.1	…	…
400	95.4	94.5	95.4	94.5	…	…	…	…
450	95.4	94.5	95.4	94.5	…	…	…	…
500	95.4	94.0	95.8	95.0	…	…	…	…

Click here to return to Level Sensing Systems (PSs)

Exhibit F



Stilling Well for Level Transducer

Pumping Station or Treatment Plant

Click here to return to Alarm Systems (PSs)

Exhibit G

Temporary Portable Pump Alarms and Setup Standards

When a project requires a temporary portable pump to be alarmed, the following guidelines need to be followed.

- **When work is performed at station:** If power is available, all alarms are to be routed through existing HRSD's SCADA system. Portable pump manufacture call box is not acceptable unless otherwise approved for site specific situations. If power is not available then, HRSD solar SCADA panel will be provided. A portable generator may be required depending on site specific situations.
- **When work is performed at a manhole:** If power is available, all alarms are to be routed through existing HRSD's SCADA system. Portable pump manufacture call box is not acceptable unless otherwise ap- proved for site specific situations. If power is not available then, HRSD solar Scada panel will be pro- vided. A portable generator may be required depending on site specific situations. Naming of the alarms from a manhole should indicate the location of the manhole (i.e., Pearl and Ligon)
- The name of the site is to be used followed by temporary lead, lag or second lag, depending on the number of pumps. (Example: Arctic Temporary Lead, Arctic Temporary Lag and Arctic Second Lag.)
- Both contractor and HRSD will be alerted in the event of a pump alarm. The contractor is responsible to be primary responder with the support of HRSD staff.
- All pump maintenance and fuel requirement are the contractor's responsibility.
- Pump maintenance records are to be provided monthly through the duration of the project by contractor, depending on length of project.
- Battery chargers are required with all pumps. In situations where power is not available a portable generator may be required.
- All discharge piping is to be pressure rated flanged or fused pipe. Isolations valves are required at each pump along with an additional external swing check valve. A means to bleed air off the discharge piping is required.
- Float balls, level transducers and pressure transducers are acceptable. In a Lift station or manhole application, level transducers are used. If float balls are used for control, a two float setup is required per pump. All floats are to be secured in manhole or wet well so as not to become tangled, hindering pump operation. In a temporary PRS setup, owner furnished sensor valve will be provided to allow contractor to connect pressure transducers for control. An isolation valve is required to be furnished by contractor at this location.
- If work is to be performed during cold weather, the contractor is responsible for providing freeze protection on pumps and controls, specifically transducers.
- Depending on location and duration of job, concrete protective barrier wall may be required.

- All manholes and wet wells where temporary pumps are being used must be secured to prevent trip hazards, fall risks and odor issues.

The following standard alarms are required. Site specific alarms will be evaluated on a as need basis.

I. Two Pump Lift station Or Manhole (Diesel Pumps)

Lead Fail / Normal

Lag On / off

High well Alarm / Normal (HRSD furnished float ball if station alarms cannot be used)

Overflow Alarm / Normal (Determined necessary according to length of Job. HRSD furnished float ball if station alarms cannot be used.)

II. Three Pump Lift station Or Manhole (Diesel Pumps)

Lead Fail / Normal

Lag

On / off

Second La

On / Off

High well Alarm / Normal (HRSD furnished float ball if station alarms cannot be used)

Overflow Alarm / Normal (Determined necessary according to length of Job. HRSD furnished float ball if station alarms cannot be used.)

III. Two Pump Lift Station or Manhole (Diesel Pumps) New Prime Guard Controller

Lead Fail / Normal

Lag On / off and Fail / Normal

High well Alarm / Normal (HRSD furnished float ball if station alarms cannot be used)

Overflow Alarm / Normal (Determined necessary according to length of Job.

HRSD furnished float ball if station alarms cannot be used.)

IV. Two Pump Lift Station or Manhole (One electric one diesel pump) New Prime Guard Controller

Dominion Power O n / OFF

Lead Fail / Normal (Electric)

Lag On / off and Fail / Normal

High well Alarm / Normal (HRSD furnished float ball if station alarms cannot be used)

Overflow Alarm / Normal (Determined necessary according to length of Job. HRSD furnished float ball if station alarms cannot be used.)

(For HRSD monitoring purposes only, provide well level.)

V. Three Pump Lift Station or Manhole (One electric two diesel pump) New Prime Guard Controller

Dominion Power O n / OFF

Lead Fail / Normal (Electric)

Lag On / off and Fail /

Normal Second Lag On / off and

Fail / Normal

High well Alarm / Normal (HRSD furnished float ball if station alarms cannot be used)

Overflow Alarm / Normal (Determined necessary according to length of Job. HRSD furnished float ball if station alarms cannot be used.)

(For HRSD monitoring purposes only, provide well level.)

VI. Two Pump PRS (Diesel Pumps) New Prime Guard Controller

Lead Fail / Normal

Lag On / off and Fail / Normal

(For HRSD monitoring purposes only, provide Suction and Discharge pressures.)

VII. Three Pump PRS (Diesel Pumps) New Prime Guard Controller

Lead Fail / Normal

Lag On / off and Fail /

Normal Second Lag On / off and

Fail / Normal

(For HRSD monitoring purposes only, provide Suction and Discharge pressures.)

<u>VIII. Two Pump PRS (One electric one diesel pump) New Prime Guard Controller</u>

Dominion Power O n / OFF

Lead Fail / Normal (Electric)

Lag On / off and Fail / Normal

(For HRSD monitoring purposes only, provide Suction and Discharge pressures.)

<u>IX. Three Pump PRS (One electric two diesel pump) New Prime Guard Controller</u>

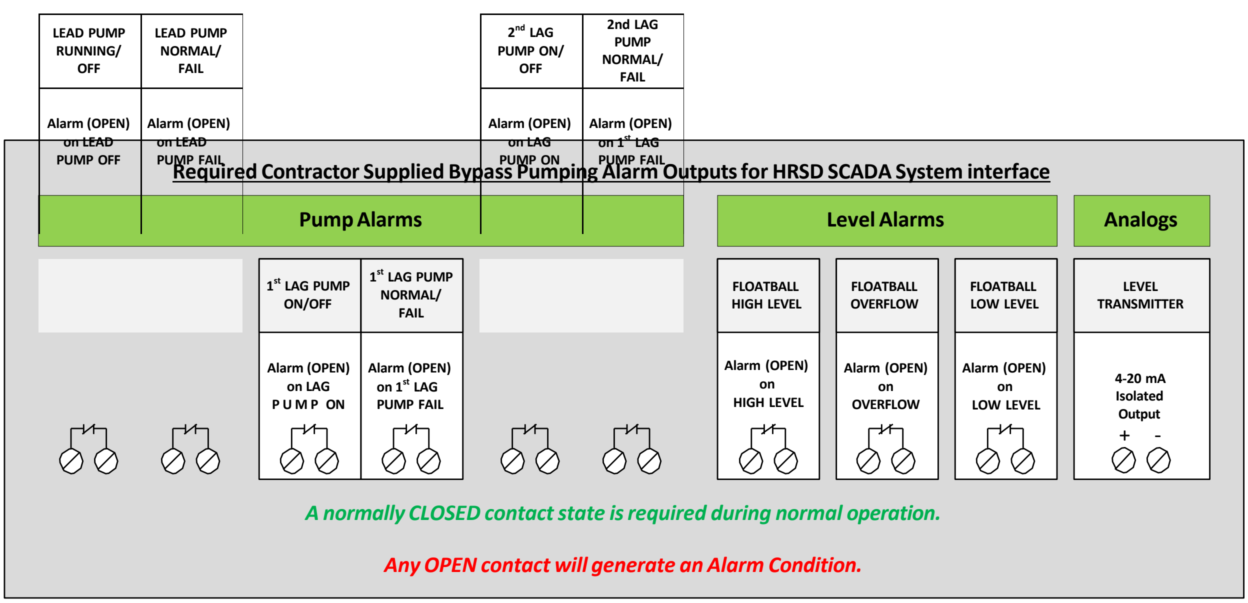
Dominion Power O n / OFF

Lead Fail / Normal (Electric)

Lag On / off and Fail / Normal

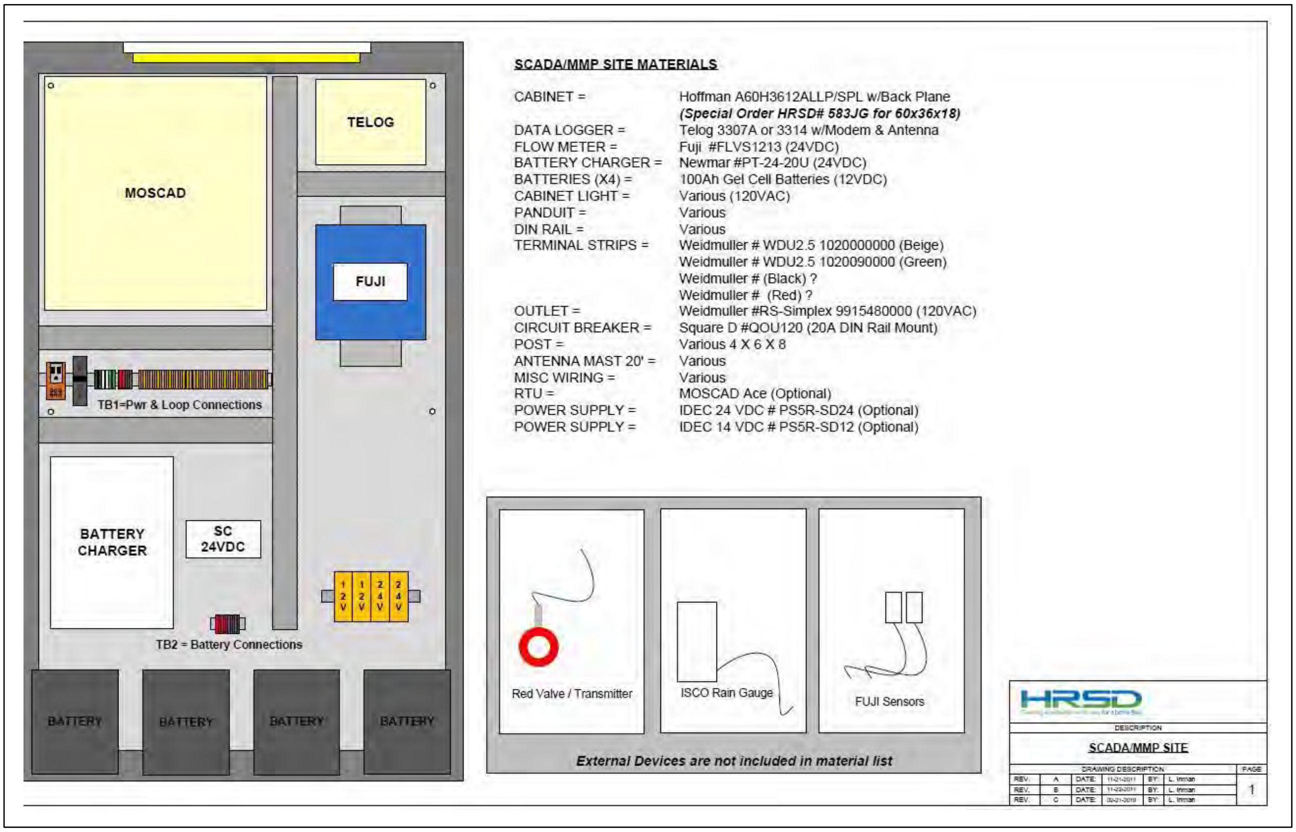
Second Lag On / off and Fail / Normal

(For HRSD monitoring purposes only, provide Suction and Discharge pressures.)



Click here to return to SCADA Site Drawings

Exhibit H



Click here to return to SWIFT

Exhibit I

RECOMMENDED ADDITIONS/CHANGES TO SPECIFICATIONS FOR FUTURE SWIFT DESIGN

PREPARED BY HRSD EEM STAFF

ELECTRICAL

1.1 ELECTRICAL CONDUIT/ ROUGH IN METHODS

A. ALL EXTERIOR POWER AND CONTROL CONDUCTORS MUST BE FULLY ENCASED IN CONDUIT. CABLE TRAY MAY NOT BE USED ON AREAS DEFINED AS "WET LOCATION" BY THE NEC. CONDUIT STUB UPS SHALL EXTEND COMPLETELY UP TO ALL ENCLOSURES, DISCONNECTS OR WIREWAYS. NO EXTERIOR CABLE WILL BE ALLOWED TO BE RAN "FREE AIR". EXPANSION JOINTS TO BE USED WHERE REQUIRED.

B. ALL OUTLET BOX ROUGH-INS OF GWB CONSTRUCTION SHALL USE A BRACKET TO MOUNT TO AT LEAST TWO WALL STUDS. SCREW EAR BOXES ARE NOT ACCEPTABLE. USE OF THESE BRACKETS WILL ALSO INSURE THAT BOXES MOUNTED NEXT TO EACH OTHER WILL BE LEVEL.

C. ALL CONDUIT/RACEWAYS SHALL BE RAN CONCEALED IN AREAS OF GWB CONSTRUCTION.

D. ALLOW ½" TRADE SIZE EMT TO BE RAN ON RECEPTACLE AND LIGHTING CIRCUITS CONCEALED IN GWB CONSTRUCTION, OR ABOVE CEILING TILES.

1.2 LIGHTING

A. CONTROL ROOM LIGHTING SHALL BE OF A LOW GLARE DESIGN IN RELATION TO THE VIDEO DISPLAYS, WITH DIMMABLE SWITCHING AND OCCUPANCY SENSOR OVERIDE.

B. ELECTRICAL AND MECHANICAL SPACES SHALL HAVE A MINUMUM LIGHTING LEVEL OF 30 VERTICAL AND HORIZONTAL FOOT CANDLES PER IES STANDARDS. 75% OF EACH ELECTRICAL AND MECHANICAL ROOM SPACE LIGHTING FIXTURES SHALL BE ON DUAL TECHNOLOGY OCCUPANCY SENSORS WITH ADEQUATE COVERAGE OF ENTIRE SPACE. THE 25% REMAINDER OF LIGHTING SHALL BE CONNECTED TO TRADITIONAL MANUAL SWITCHING.

C. NO STAIRWAY LIGHTING SHALL BE MOUNTED IN A LOCATION THAT IS NOT ACCESSIBLE VIA A STANDARD 8' A-FRAME LADDER SET ON STAIR LANDINGS.

D. NO LIGHTING ABOVE FANS DUE TO STROBING EFFECT.

1.3 DESIGN / LAYOUT

A. LAB COUNTER TOP RECPTACLES SHALL BE ONE DUPLEX EVERY FIVE FEET OF COUNTER WITH A MINIMUM OF TWO DUPLEX RECEPTACLES FOR ANY SIZE COUNTER SPACE.

B. CONTROL ROOM DESIGN SHALL INCLUDE RACEWAYS FOR VIDEO AND DATA CABLING, AND A DUPLEX RECPTACLE BEHIND EACH WALL MOUNTED VIDEO MONITOR OR COMPUTER DISPLAY.

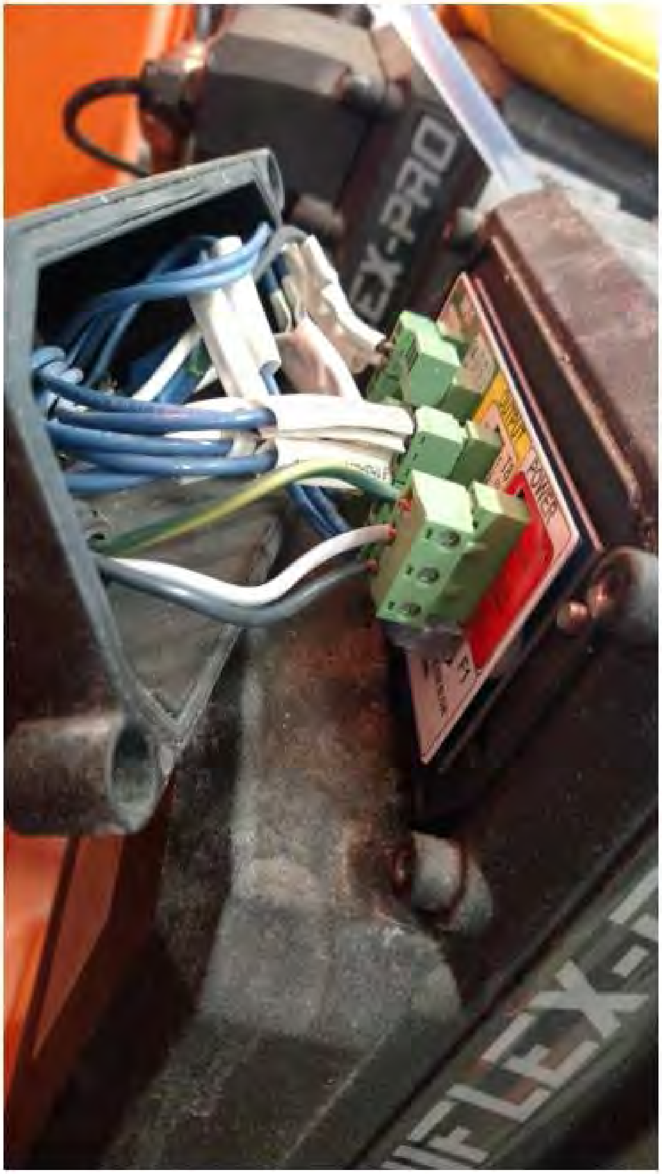
2.1 MOLEX CONNECTORS

A. FIELD POWERED TRANSMITTERS SHALL USE MOLEX CONNECTOR CAT. #WH1R3006A20M005G8 MOUNTED ON THE BOTTOM OF THE TRANSMITTER. THE MATING PLUG/CABLE IS CAT. #WH103000A45M0208 (2 METER CABLE LENGTH) FOR 120 VOLT POWER CONNECTIONS. THIS CONNECTOR WILL SERVE AS A MEANS OF DISCONNECT FOR INDIVIDUAL UNITS.

B. TRANSMITTERS AND SENSORS WILL USE A MOLEX CONNECTOR CAT. # WH8R4006A18M0058 MOUNTED ON THE BOTTOM OF TRANSMITTER/SENSOR WHEN POSSIBLE. THE MATING PLUG/CABLE IS CAT. # WH80400D01M0208 THIS IS A TWO PAIR CONFIGURATION THAT WILL ALLOW FOR TWO ANALOG 4-20MA CURRENT LOOPS OR TWO DIGITAL SIGNALS. IF THE EQUIPMENT REQUIRES MORE THAN TWO PAIR SHIELDED CONDUCTORS HARD WIRING IS ACCEPTABLE.

2.2 WIRING TERMINATIONS

A. ALL CONTROL WIRING TERMINATIONS WILL USE A CRIMP ON TYPE CONNECTOR OF EITHER A FORK TYPE OR A PIN TYPE APPROPRIATE FOR TERMINAL BLOCK STYLE.



B. UPON OWNER REVIEW AND APPROVAL THE MINUMUM CONTROL WIRE SIZE MAY BE REDUCED TO ACCOMODATE EQUIPMENT WITH SMALL/CONGESTED TERMINATION SPACES. EXAMPLE: METERING PUMPS WITH 12-16 CONTROL CONDUCTORS.

2.3 VFD CABINET CONSTRUCTION

A. THE MOUNTING LOCATION OF COOLING FAN THERMOSTAT INSIDE THE CABINET SHALL BE PARALLEL OR HIGHER THAN THE TOP OF THE ACTUAL VFD UNIT WHERE THE HEAT ORIGINATES.

B. COOLING FAN POWER SHALL BE RAN THROUGH THE RUN RELAY SO THAT THE FAN DOES NOT RUN IF VFD IS NOT IN RUN MODE.

C. COOLING FAN EXHAUST OUTLETS INSIDE CONDITIONED SPACES SHALL NOT HAVE FILTERS, AND SHALL EXHAUST OUT THE SIDE OR TOP OF THE CABINET CONSISTANT WITH U.L. STANDARDS.

D. INCLUDE A BULKHEAD MOUNT WITH DUST COVER USB CONNECTOR ON THE CONTROL SURFACE OF THE VFD CABINET WHICH IS CONNECTED TO THE DATA PORT ON THE VFD UNIT. THIS IS TO ALLOW A LAPTOP CONNECTION TO THE VFD TO MODIFY PARAMETERS, ETC. WITHOUT NEEDING TO OPEN THE CABINET.

2.4 INSTRUMENT GENERAL

A. WHERE POSSIBLE MOUNT ALL TRANSMITTERS AT APPROX 5' AFF OR WALKWAY FOR EASE OF ACCESS AND VISUAL INSPECTION.

B. PROVIDE LOCAL AUDIBLE AND VISUAL ALARMS IN CHEMICAL ROOMS FOR CHLORINE AND SULPHER DIOXIDE GAS DETECTORS. CURRENTLY INSTALLED GAS DETECTORS ONLY HAVE A BLINKING DISPLAY WHEN ALARM CONDITION EXISTS.

C. PROVIDE A UPS TO POWER SHIMADZU TOC ANALYZER SIZED TO CARRY IT THROUGH GENERATOR STARTUP/SWITCHING.

INSTRUMENTATION PIPING METHODS

3.1 SAMPLE PIPING

A. FIRST SAMPLE INSTRUMENT IN A LINE UP SHALL NOT BE AFFECTED BY AIR BUBBLES. FOR EXAMPLE A PH PROBE FIRST IN LINE WILL ALLOW AIR TO ESCAPE BEFORE REACHING TURBIDITY METERS.

B. ALTERNATIVE METHODS SHOULD BE INVESTIGATED TO CONTROL FLOW TO INSTRUMENT LINE UPS ON INFLUENT AND FLOC/SED INSTRUMENTATION. ROTAMETERS AND REGULATORS ARE CLOGGING CAUSING LOW OR NO FLOW CONDITIONS.

C. PROVIDE A MEANS TO FLUSH BIOFILTER HEADLOSS TRANSDUCER SAMPLE LINES.

D. INCORPORATE A FULL DIAMETER FLUSH VALVE AT LOW POINT OF INSTRUMENT LINEUP SAMPLE LINES.

3.2 DRAIN PIPING

A. FLOOR DRAINS AT EACH INTERIOR INSTRUMENT LINEUP.

B. INSTRUMENT DRAIN LINES ON FRONT OF INSTRUMENT LINEUP WITH AIR GAP TO ALLOW VISUAL FLOW CONFIRMATION.

3.3 GENERAL

C. METERING PUMPS ON TURBIDITY INSTRUMENTS.

D. SELF CLEANING DEVICES ON INFLUENT AND FLOC/SED TURBIDITY INSTRUMENTS.

E. HEAT TRACING AND INSULATION ON ALL EXTERIOR SAMPLE AND DRAIN LINES INCLUDING PRESSURE TRANSMITTERS AND SWITCHES.

DCS

4.1 INTERPOSING RELAY CABINET

A. PROVIDE A POWER MONITORING OUTPUT POINT TO DCS THAT WILL INDICATE POWER LOSS TO ANY INTERPOSING RELAY CABINET CONTROL CIRCUITS.

4.2 OPCON

A. AT LEAST ONE ADDITIONAL OPERATORS CONSOLE FOR DCS THAT IS NOT LOCATED IN THE MAIN CONTROL ROOM.

4.3 NETWORK

A. SPEC FIBER OPTIC CAPABLE CISCO NETWORK SWITCHES IN ALL VENDOR PROVIDED EQUIPMENT THAT WILL CONNECTED THIRD PARTY TO THE DCS.

B. ENCOURAGE THE USE OF FIBER OPTIC CABLE IN LEIU OF TYPE TC CAT-6 CABLE.

C. IF CAT-6 TYPE TC IS USED IT MUST BE TERMINATED TO A PATCH PANEL AND NOT DIRECTLY CONNECTED TO NETWORK EQUIPMENT. THIS IS TO PREVENT DAMAGE TO NETWORK JACKS FROM THE RELATIVELY LARGE HEAVY CABLE.

D. INVESTIGATE THE USE OF VENDOR NETWORKS TO ALLOW THIRD PARTY COMMUNICATION TO THE DCS. SUCH AS HACH INSTRUMENTS, YASKAWA VFD AND CHEMICAL METERING PUMPS. THIS WOULD ALLOW MORE DETAILED INFORMATION TO BE AVAILABLE TO THE DCS. IT WOULD ALSO ALLOW ALL CONTROL WIRING TO REMOTE AREAS SUCH AS RECHARGE WELL HOUSES TO BE FIBER OPTIC. THIS

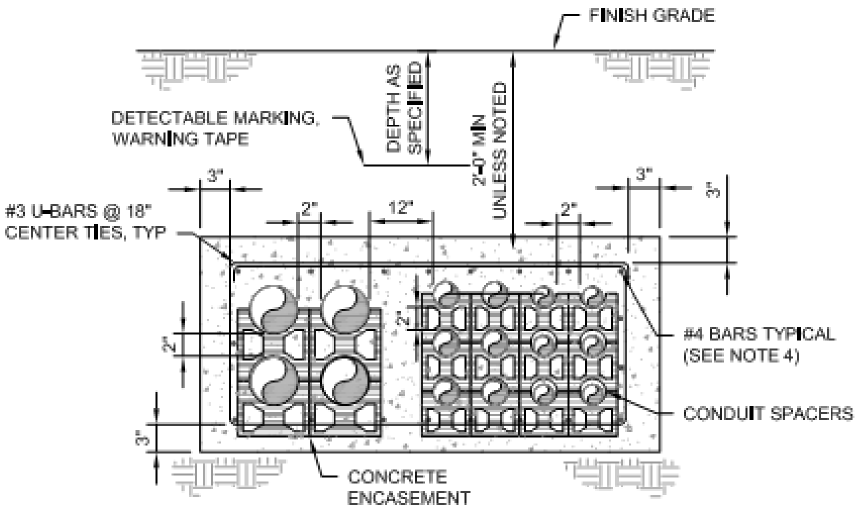
NEEDS TO BE FURTHER DISCUSSED WITHIN HRSD TO DETERMINE IF WE WILL GET ALL NEEDED ALARMS WE DESIRE FROM THE VFD CABINET. IE: POWER LOSS INDICATION

E. PROVIDE A HRSD CORPORATE NETWORK HARDWIRE CONNECTION OR WI-FI AT REMOTE LOCATIONS SUCH AS PUMP HOUSES TO ALLOW TROUBLSHOOTING VIA EDS, ETC.

Click here to return to duct bank

Click here to return to duct bank

Exhibit J



NOTES FOR DUCT BANKS

1. CONDUIT SPACING SHALL BE AS REQUIRED BY NEC. MINIMUM CONCRETE THICKNESS BETWEEN CONDUITS SHALL BE 2" MIN. CONCRETE THICKNESS BETWEEN POWER AND INSTRUMENTATION CONDUITS SHALL BE 7 1/2".
2. DUCT BANKS SHALL BE REINFORCED AT ALL LOCATIONS, BOTH HORIZONTAL AND VERTICAL INSTALLATIONS.
3. SEE SPECIFICATIONS FOR UNDERGROUND WARNING TAPE.
4. QUANTITY OF BARS EQUALS THE QUANTITY OF CONDUITS PLUS ONE, PER FACE MINIMUM.
5. CONCRETE SHALL BE RED-DYED.

TYPICAL REINFORCED CONCRETE ENCASED DUCTBANK CONSTRUCTION

DETAIL 1 -

Click here to return to Dominion Energy PS

Click here to return to Dominion Energy TP

Exhibit K

Step 1: Getting Started

To request new service, call us at 1-866-DOM-HELP (1-866-366-4357) or you can visit ***www.dom.com***. Search: *work request lookup*.

A Dominion designer will contact you within three business days.

Step 2: What You'll Need

Have this information ready for the designer:

- Site readiness date
- Approved site plan
- Electricity load letter
- Proposed location of your meter
- ________________ (other)

Step 3: Working Together

Typically, within two business weeks, our designer will develop a project plan and design package. This plan will include:

- Right-of-Way agreement and easement
- Any necessary charges and
- Underground agreement.

Meanwhile, you should prepare the site. As you do, please refer to the Site Ready checklist and the Blue Book requirements on the back of this brochure.

Once your site is ready, inform the designer online at ***www.dom.com***. Search: *work request lookup*. Or contact the designer by phone.

Return the signed and completed design package to Dominion.

Then our designer will confirm the site's readiness and that the design package is complete. The designer will flag the proposed route for the electric line to be installed.

Step 4: Connecting Your Electrical Service

Our designer turns the project over to Construction for installation.

The name and phone number of your Construction contact and the estimated scheduled start date will be sent to you and posted online at ***www.dom.com*** Search: *work request lookup*.

If digging is required, we will contact Miss Utility to mark all non-private underground utilities.

We then will perform the the work required to complete your request.

Please note that inclement weather and emergency-service restoration may affect the completion dates.

Step 5: Inspection

You must schedule the required electrical inspection. After the inspection we can set the meter.

Customer Information provided to designer:	Dates
Customer Ready Date:	
Requested Project-Completion Date:	

Site Ready Checklist

Before work can begin to install service, please complete the following:

- ___ Mark property lines
- ___ Mark all private underground facilities
- ___ Ensure lot is within 6" of final grade
- ___ Install and mark conduit per Dominion requirements
- ___ Sign and return underground agreement to Dominion
- ___ Make all necessary payments to Dominion
- ___ Sign and return any required easements to Dominion
- ___ Clear obstructions from cable route
- ___ Make sure all erosion control is adequate.
- ___ When the site is ready, notify your designer at **www.dom.com**. Search: *work request lookup.*

Blue Book Requirements

Before electrical service can begin, you also must take care of the following.

- ___ Clear space around meter (Section VII, Definitions)
- ___ Overhead point of attachment (Section 290)
- ___ Overhead entrance cable (Section 270 & 280)
- ___ Overhead service entrance (Section 270 & 280)
- ___ Underground service entrance (Section 450)
- ___ Meter location (Section 230)
- ___ Meter connection (Section 240)
- ___ Footer requirements for underground (Section 450.6)

The Blue Book is available at any Dominion office or at **www.dom.com**. Search: Blue Book.

Designer:

Contact information:

Office: Fax:

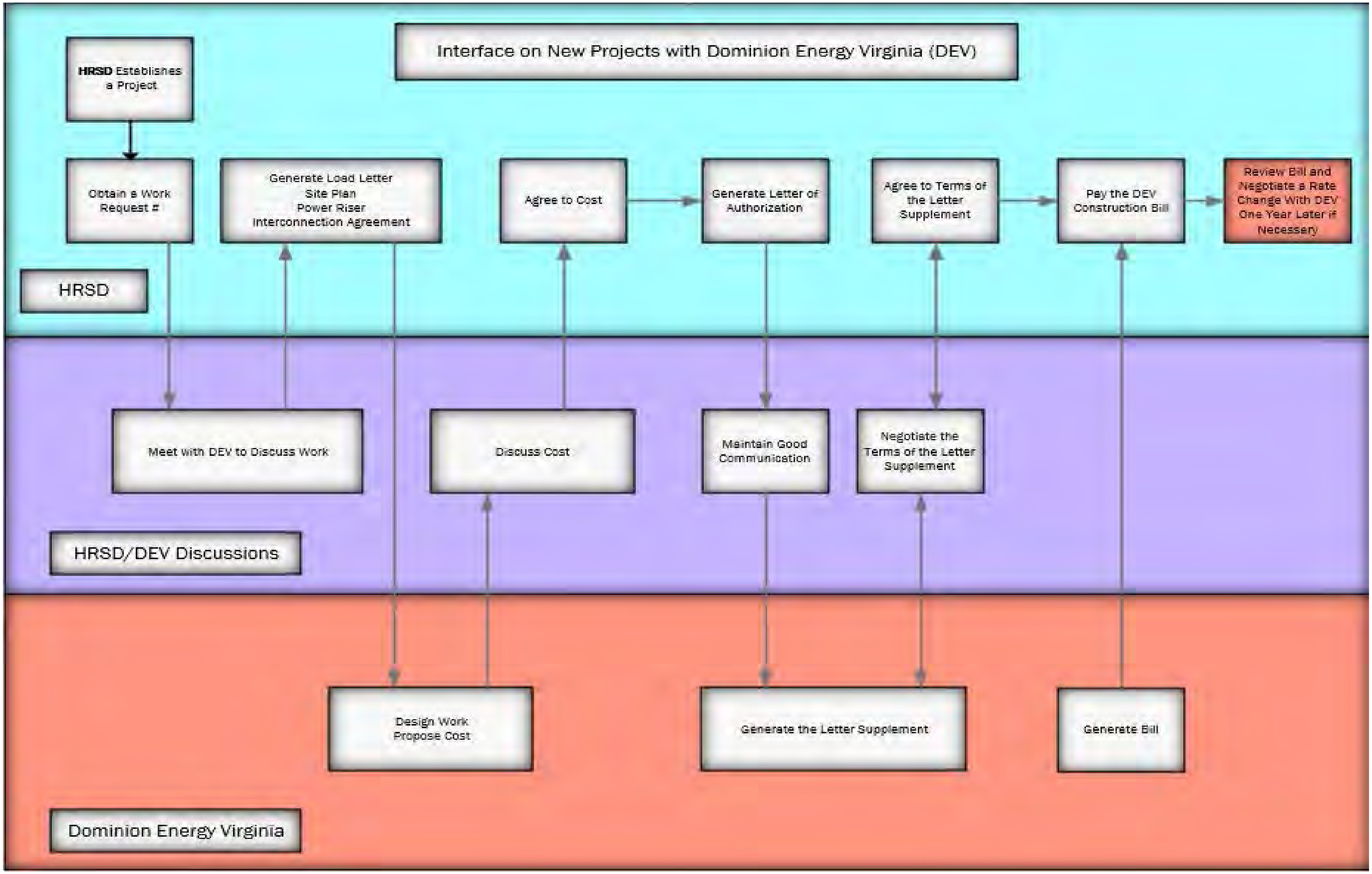
Cell: E-mail:

www.dom.com
Search: *work request lookup*

Dominion

How to get **electric service** for new construction

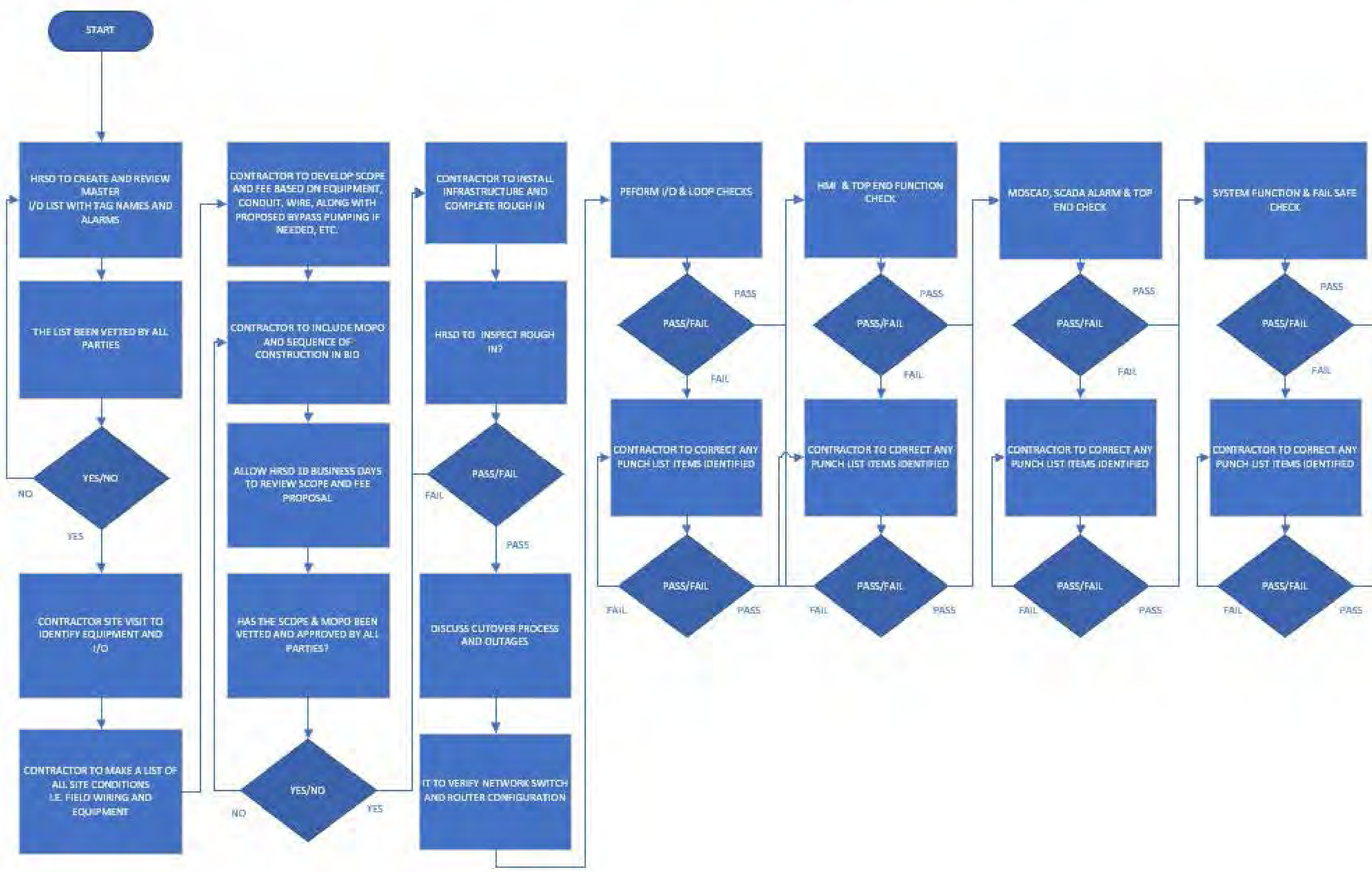
A quick reference guide


Interface on New Projects with Dominion Energy Virginia (DEV)
HRSD Establishes a Project
Obtain a Work Request #
Generate Load Letter
Site Plan
Power Riser
Interconnection Agreement
Agree to Cost
Generate Letter of Authorization
Agree to Terms of the Letter Supplement
Pay the DEV Construction Bill
Review Bill and Negotiate a Rate Change With DEV One Year Later if Necessary
HRSD
Meet with DEV to Discuss Work
Discuss Cost
Maintain Good Communication
Negotiate the Terms of the Letter Supplement
HRSD/DEV Discussions
Design Work
Propose Cost
Generate the Letter Supplement
Generate Bill
Dominion Energy Virginia

Click here to return to SCADA

Exhibit L

SCADA 2.0 PROCESS FLOWCHART

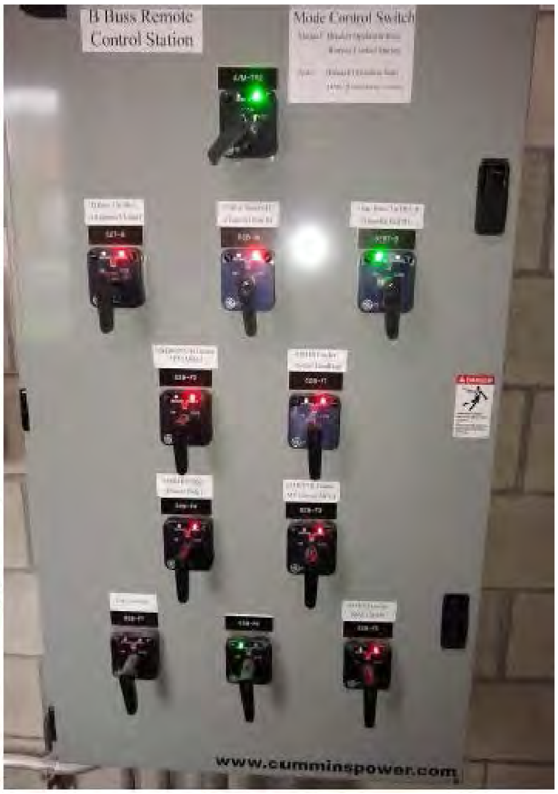


Click here to return to Remote Switch Operator (RSO) Open/Close Breaker Station (PS)

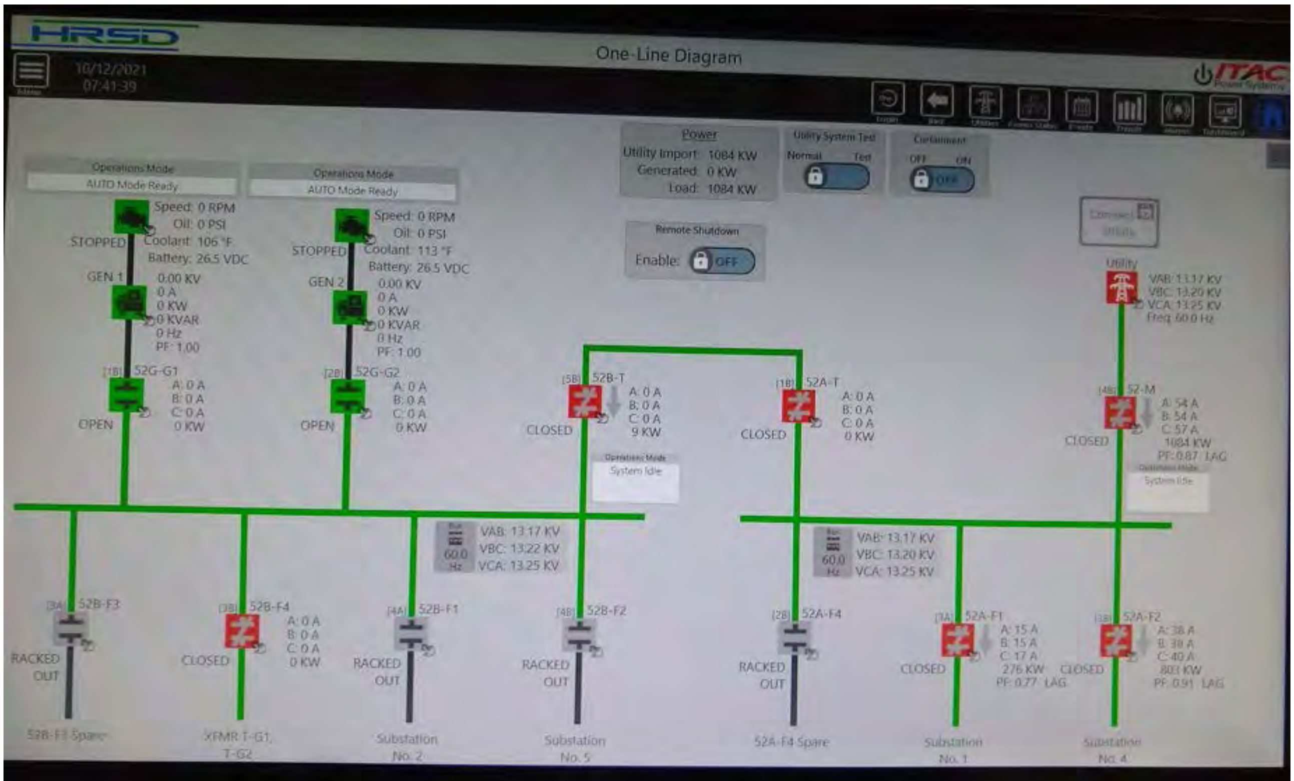
Exhibit M

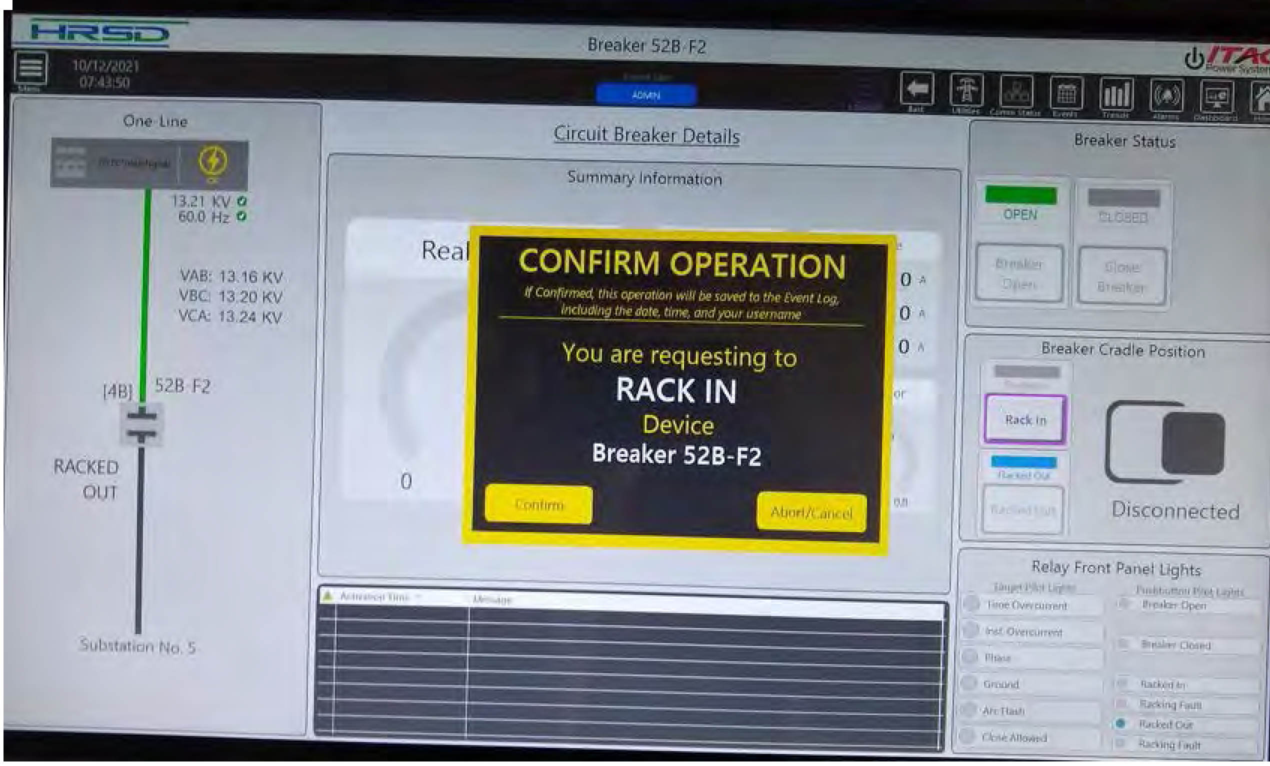
[Click here to return to Remote Switch Operator (RSO) Open/Close Breaker Station (TP)]

Exhibit N



Human Machine Interface (HMI) Panel for Open/Close Breaker Operation and Rack In/Out Capability





Click here to return to Flow Meters PS

Click here to return to Flow Meters TP

X. Exhibit O

FLEXIM

Technical specification

FLUXUS® F501SC

Ultrasonic flow measurement for the semiconductor industry

Permanently installed, completely metal-free ultrasonic clamp-on system for the flow measurement of liquids

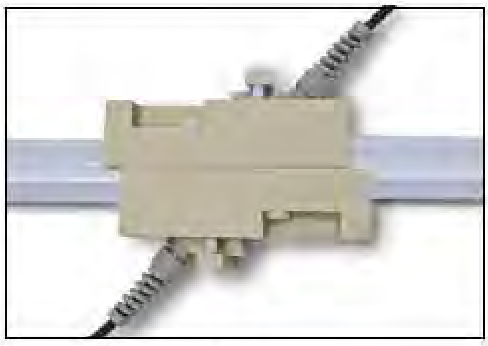
Features

- Non-intrusive flow measurement with high measuring accuracy for stationary use
- The transducer mounting fixture and the transducers are completely metal-free
- For plastic pipes and flexible tubes with diameters of 3/8 ", 1/2 ", 3/4 ", 1 ", 1 1/4 ", others on request
- High measuring accuracy, even at low flow velocities
- Installation and commissioning can be carried out during operation
- No risk for potential contamination or leaks as the transducers are clamped-on to the outside of the pipe wall
- User-friendly menu navigation - the firmware is specifically adapted to the needs of the semiconductor industry

FLUXUS F501

Applications

Flow measurement in the semicondutor industries for:
- Highly corrosive substances, e.g., acids or caustics
- Cleaning agents
- Solvents
- Ultrapure fluids



Transducers CDQ2LK1 in block fastener

Flow transmitter

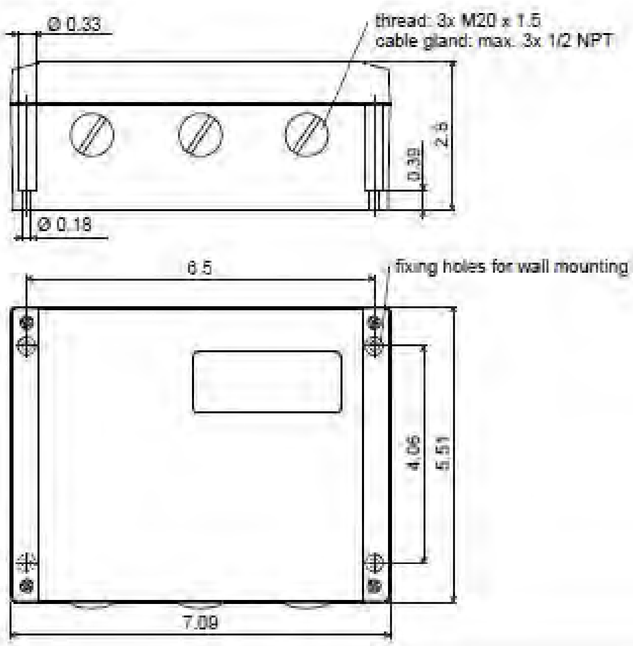
Technical data

FLUXUS	F501SC
design	field device with 1 measuring channel
application	semiconductor applications
measurement	
measurement principle	transit time difference correlation principle
flow velocity	0.03 to 82 ft/s
repeatability	0.25 % of reading ±0.03 ft/s
fluid	water and acoustically similar liquids with < 6 % gaseous or solid content by volume
accuracy[1] - volumetric flow rate	 ±2 % of reading ±0.03 ft/s
flow transmitter	
power supply	100 to 230 V/50 to 60 Hz or 20 to 32 V DC or 11 to 16 V DC
power consumption	< 10 W
number of flow measuring channels	1
damping	0 to 100 s, adjustable
measuring cycle (1 channel)	10 Hz
response time	1 s
housing material	aluminum, powder coated
degree of protection	NEMA 4
dimensions	see dimensional drawing
weight	3.3 lb
fixation	wall mounting
ambient temperature	14 to +140 °F
display	2 x 16 characters, dot matrix, backlight
menu language	English, German, French, Dutch, Spanish
measuring functions	
physical quantities	volumetric flow rate, mass flow rate, flow velocity
totalizer	volume, mass
data logger (optional)	
loggable values	all physical quantities and totalized values
capacity	> 100 000 measured values
communication	
interface	optional: RS485 (sender) or Modbus RTU or BACnet MS/TP
outputs (optional)	
	The outputs are galvanically isolated from the transmitter.
	current output
number	1
range	0/4 to 20 mA
accuracy	0.1 % of reading ±15 µA
active output	R_{ext} < 500 Ω
	binary output
number	2
optorelay	28 V/100 mA
binary output as alarm output - functions	 limit, change of flow direction or error
binary output as pulse output - pulse value - pulse width	mainly for totalizing 0.01 to 1000 units 80 to 1000 ms

[1] for reference conditions and v > 0.82 ft/s

Dimensions

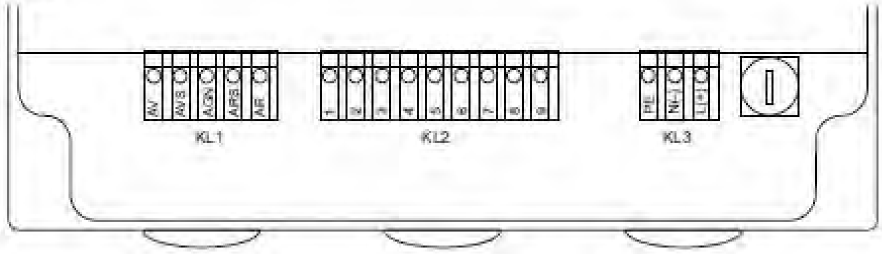
FLUXUS F501



in inch

Terminal assignment

FLUXUS F501



power supply

terminal strip KL3

terminal	connection (AC)	connection (DC)
PE	earth	earth
N(-)	neutral	-
L(+)	phase	+

transducers

terminal strip KL1

transducer cable	
measuring channel A	
terminal	**connection**
AV	transducer ↑, signal
AVS	transducer ↑, internal shield
ARS	transducer ⅄, internal shield
AR	transducer ⅄, signal
cable gland	external shield

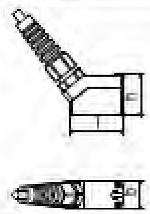
outputs

terminal strip KL2

terminal	connection
1(-), 2(+)	binary output B1
3(-), 4(+)	binary output B2
5(-), 6(+)	current output I1
7(-), 8(+), 9 (shield)	RS485 (optional)

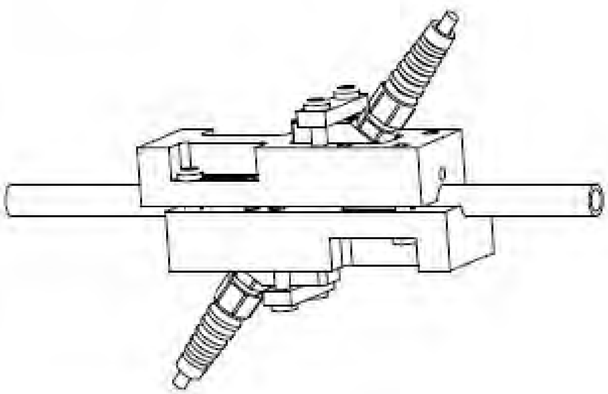
Transducers

Technical data

technical type		CDQ2LK1
transducer frequency	MHz	4
inner pipe diameter d		
min. extended	in	0.31
min. recommended	in	0.47
max. recommended	in	2
pipe wall thickness		
min.	in	0.02
material		PEEK
degree of protection		NEMA 6
transducer cable		
type		2549
length	ft	32
dimensions		
length l	in	1.57
width b	in	0.71
height h	in	1.04
dimensional drawing		
ambient temperature		
min.	°F	-20
max.	°F	+212

Transducer mounting fixture

block fastener



material: PP

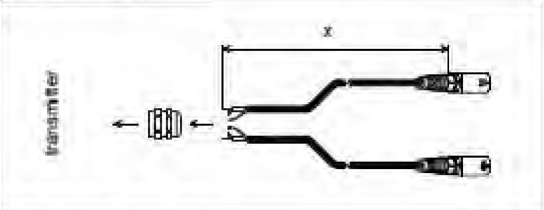
outer pipe diameter Da:
3/8 ", 1/2 ", 3/4 ", 1 ", 1 1/4 ", 1 1/3 ", 1 1/2 " (others on request)

dimensions l x b x h:

- l: 4.72 in
- b:
  3/8 ", 3/4 ", 1 ": 1.81 in
  1/2 ": 1.61 in
  1 1/4 ": 2.09 in
  1 1/3 ", 1 1/2 ": 2.4 in
- h: outer pipe diameter + 2x transducer height + 0.87 in

Connection systems

direct connection



x = transducer cable length

Transducer cable

Technical data

		transducer cable
type		2549
ambient temperature	°F	-148...+392
cable jacket		
material		PTFE
outer diameter	in	0.21
thickness	in	0.02
color		black
shield		x

Permanently installed ultrasonic flowmeter for liquids

Transmitter for permanent outdoor wall or pipe mounting

Features

- Exact and highly reliable bidirectional clamp-on volume and mass flow measurement
- Installation and startup do not require any pipe work nor any process interruptions
- High measurement accuracy even at very low as well as very high flow rates and independent of the flow direction (bidirectional)
- Possibility to measure thermal energy quantities using clamp-on or inline temperature probes
- Automatic loading of calibration data and transducer recognition
- Bidirectional communication and support of common bus technologies (Profibus PA, Foundation Fieldbus, HART, Modbus, BACnet)
- Advanced self-diagnosis and possibilities for event based triggering of data recording for the supervision and control of critical processes
- Transmitter and transducers for use in hazardous areas are available
- Transmitter and transducers are separately calibrated (traceable to national standards)
- Transducers available for a wide range of inner pipe diameters and fluid temperatures -274 to +1112 °F
- The measurement is zero point stable, drift free and independent of pipe material, process pressure, process temperature and process fluid

Applications

- Chemical industry
- Petrochemical industry
- Oil and gas industry
- Pharmaceutical industry
- Semiconductor industry
- Manufacturing industries
- Building technology/energy management
- Water and wastewater industry
- Mining industries

FLUXUS F721**-****A

FLUXUS F721**-****S

PermaRail

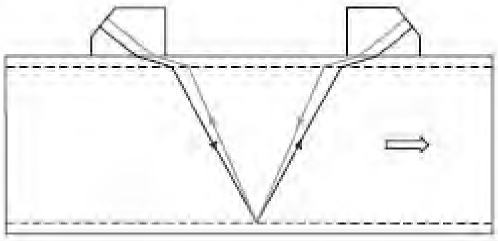
TSFLUXUS_F721V2-2US_Lus, 2018-10-30

Function

Measurement principle

The transducers are mounted on the pipe which is completely filled with the fluid. The ultrasonic signals are emitted alternately by a transducer and received by the other. The physical quantities are determined from the transit times of the ultrasonic signals.

Path of the ultrasonic signal in the flowing fluid



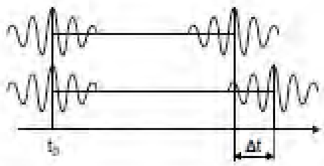
Transit time difference principle

As the fluid where the ultrasound propagates is flowing, the transit time of the ultrasonic signal in flow direction is shorter than the one against the flow direction.

The transit time difference Δt is measured and allows the flowmeter to determine the average flow velocity along the propagation path of the ultrasonic signals. A flow profile correction is then performed in order to obtain the area averaged flow velocity, which is proportional to the volumetric flow rate.

The integrated microprocessors control the entire measuring cycle. The received ultrasonic signals are checked for measurement usability and evaluated for their reliability. Noise signals are eliminated.

Transit time difference Δt



HybridTrek

If the gaseous or solid content in the fluid increases occasionally during measurement, a measurement with the transit time difference principle may no longer be possible. NoiseTrek mode will then be selected by the flowmeter. This measurement method allows the flowmeter to achieve a stable measurement even with high gaseous or solid content.

The transmitter can switch automatically between transit time and NoiseTrek mode without any changes to the measurement setup.

Calculation of volumetric flow rate

$$\dot{V} = k_{Re} \cdot A \cdot k_a \cdot \frac{\Delta t}{2 \cdot t_\gamma}$$

where

$\dot{V}$	-	volumetric flow rate
k_{Re}	-	fluid mechanics calibration factor
A	-	cross-sectional pipe area
k_a	-	acoustical calibration factor
Δt	-	transit time difference
t_γ	-	average of transit times in the fluid

Number of sound paths

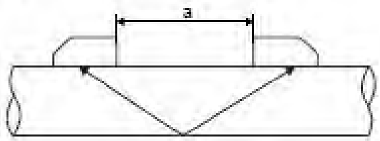
The number of sound paths is the number of transits of the ultrasonic signal through the fluid in the pipe. Depending on the number of sound paths, the following methods of installation exist:

- **reflect arrangement**
  The number of sound paths is even. The transducers are mounted on the same side of the pipe. Correct positioning of the transducers is easier.
- **diagonal arrangement**
  The number of sound paths is odd. The transducers are mounted on opposite sides of the pipe.
- **direct mode**
  Diagonal arrangement with 1 sound path. This should be used in the case of a high signal attenuation by the fluid, pipe or coatings.

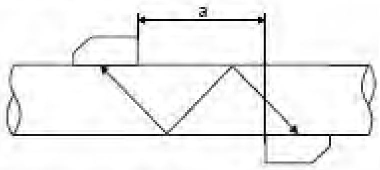
The preferred method of installation depends on the application. While increasing the number of sound paths increases the accuracy of the measurement, signal attenuation increases as well. The optimum number of sound paths for the parameters of the application will be determined automatically by the transmitter.

As the transducers can be mounted with the transducer mounting fixture in reflect arrangement or diagonal arrangement, the number of sound paths can be adjusted optimally for the application.

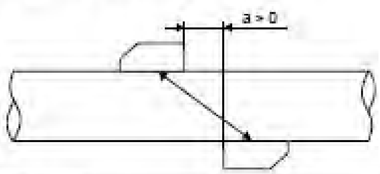
Reflect arrangement, number of sound paths: 2



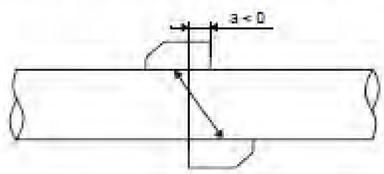
Diagonal arrangement, number of sound paths: 3



Direct mode, number of sound paths: 1



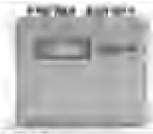
Direct mode, number of sound paths: 1, negative transducer distance



a - transducer distance

Transmitter

Technical data

		FLUXUS F721**-NN0*A	FLUXUS F721**-NN0*S	FLUXUS F721**-A20*S	FLUXUS F721**-F20*S
					
design		standard field device nonEx	field device with stainless steel housing nonEx	field device with stainless steel housing zone 2	field device with stainless steel housing FM Class I Div. 2
measurement					
measurement principle		transit time difference correlation principle, automatic NoiseTrek selection for measurements with high gaseous or solid content			
flow velocity	ft/s	0.03 to 82			
repeatability		0.15 % of reading ±0.03 ft/s			
fluid		all acoustically conductive liquids with < 10 % gaseous or solid content in volume (transit time difference principle)			
temperature compensation		corresponding to the recommendations in ANSI/ASME MFC-5.1-2011			
measurement uncertainty[1]					
with calibration traceable to NIST		±1.2 % of reading ±0.03 ft/s			
with field calibration[2]		±0.5 % of reading ±0.03 ft/s			
transmitter					
power supply		• 100 to 230 V/50 to 60 Hz or • 20 to 32 V DC or • 11 to 16 V DC			
power consumption	W	< 15			
number of measuring channels		1, optional: 2			
damping	s	0 to 100 (adjustable)			
measuring cycle	Hz	100 to 1000 (1 channel)			
response time	s	1 (1 channel), option: 0.02			
housing material		aluminum, powder coated	stainless steel 316L		
degree of protection		IP65	IP65	IP66	IP65
dimensions	in	see dimensional drawing			
weight	lb	11.9	11.2		
fixation		wall mounting, optional: 2" pipe mounting			
ambient temperature	°F	-4 to +131/140 °F	-4 to +131/140 °F	-40 to +140 °F (< -4 °F without operation of the display)	-4 to +131/140 °F
display		128 x 64 dots, backlight			
menu language		English, German, French, Spanish, Dutch, Russian, Polish, Turkish			
explosion protection					
• ATEX/IECEx					
marking		-	-	CE 0637 II3G II2D Ex nA nC ic IIC T4 Gc Ex tb IIIC T 120 °C Db T_a -40 to +60 °C	-
certification ATEX		-	-	IBExU11ATEX1015	-
certification IECEx		-	-	IECEx IBE 11.0008	-
• FM					
marking		-	-	-	F703Z2**1, F703Z2**2: NI/Cl. I,II,III/Div. 2/ GP. A,B,C,D,E,F,G/ T5 Ta = 60 °C F703Z2**9: NI/Cl. I,II,III/Div. 2/ GP. A,B,C,D,E,F,G/ T4A Ta = 55 °C

[1] for transit time difference principle, reference conditions and v > 0.49 ft/s
[2] reference uncertainty < 0.2 %
[3] outside of explosive atmosphere (housing cover open)
[4] with inputs and including parametrization of the transmitter

		FLUXUS F721**-NN0*A	FLUXUS F721**-NN0*S	FLUXUS F721**-A20*S	FLUXUS F721**-F20*S
measuring functions					
physical quantities		volumetric flow rate, mass flow rate, flow velocity, thermal energy rate (if temperature inputs are installed)			
totalizer		volume, mass, optional: thermal energy			
calculation functions		average, difference, sum (2 measuring channels necessary)			
diagnostic functions		sound speed, signal amplitude, SNR, SCNR, standard deviation of amplitudes and transit times			
communication interfaces					
service interfaces		measured value transmission, parametrization of the transmitter: • USB[3] • LAN[3]			
process interfaces		max. 1 option: • RS485 (ASCII sender) • Modbus RTU[4] • BACnet MS/TP • HART[4] • Profibus PA[4] • FF H1[4] • Modbus TCP[4] • BACnet IP	max. 1 option: • RS485 (ASCII sender) • Modbus RTU[4] • BACnet MS/TP • HART[4] • Profibus PA[4] • FF H1[4] • Modbus TCP[4] • BACnet IP	max. 1 option: • RS485 (ASCII sender) • Modbus RTU[4] • BACnet MS/TP • HART[4] • Profibus PA[4] • FF H1[4] • Modbus TCP[4] • BACnet IP	
accessories					
serial data kit		USB cable[3]			
software		• FluxDiagReader: download of measured values and parameters, graphical presentation • FluxDiag (optional): download of measurement data, graphical presentation, report generation, parametrization of the transmitter			
data logger					
loggable values		all physical quantities, totalized values and diagnostic values			
capacity		max. 800 000 measured values			
outputs					
		The outputs are galvanically isolated from the transmitter.			
number		on request			
• switchable current output					
		The switchable current outputs are menu selectable all together as passive or active.			
range	mA	4 to 20 (3.2 to 22)			
accuracy		0.04 % of reading ±3 µA			
active output		$R_{ext} < 350\ \Omega$			
passive output		$U_{ext} = 8$ to 30 V, depending on R_{ext} ($R_{ext} < 1\ k\Omega$ at 30 V)			
• HART					
range	mA	4 to 20			
accuracy		0.1 % of reading ±15 µA			
active output		$U_{int} = 24$ V, $R_{ext} < 500\ \Omega$			
passive output		$U_{ext} = 10$ to 24 V DC, depending on R_{ext} ($R_{ext} < 1\ k\Omega$ at 24 V)			
• voltage output					
range	V	0 to 1 or 0 to 10			
accuracy		0 to 1 V: 0.1 % of reading ±1 mV 0 to 10 V: 0.1 % of reading ±10 mV			
internal resistance		$R_{int} = 500\ \Omega$			
• frequency output					
range	kHz	0 to 5			
optorelay		24 V/4 mA, $R_{int} = 66.5\ \Omega$			
• binary output					
optorelay		26 V/100 mA, $R_{int} = 22\ \Omega$			
Reed relay		48 V/100 mA, $R_{int} = 22\ \Omega$			
binary output as alarm output					
• functions		limit, change of flow direction or error			
binary output as pulse output					
• functions		mainly for totalizing			
• pulse value	units	0.01 to 1000			
• pulse width	ms	optorelay: 1 to 1000 Reed relay: 80 to 1000			

[1] for transit time difference principle, reference conditions and v > 0.49 ft/s

[2] reference uncertainty < 0.2 %

[3] outside of explosive atmosphere (housing cover open)

[4] with inputs and including parametrization of the transmitter

		FLUXUS F721**-NN0*A	FLUXUS F721**-NN0*S	FLUXUS F721**-A20*S	FLUXUS F721**-F20*S
inputs					
		The inputs are galvanically isolated from the transmitter.			
number		max. 4, on request			
• temperature input					
type		Pt100/Pt1000			
connection		4-wire			
range	°F	-238 to +1040			
resolution	K	0.01			
accuracy		±0.01 % of reading ±0.03 K			
• current input					
accuracy		0.1 % of reading ±10 µA			
active input		U_{int} = 24 V, R_{int} = 50 Ω, P_{int} < 0.5 W, not short-circuit proof			
• range	mA	0 to 20			
passive input		R_{int} = 50 Ω, P_{int} < 0.3 W			
• range	mA	-20 to +20			
• voltage input					
range	V	0 to 1			
accuracy		0.1 % of reading ±1 mV			
internal resistance		R_{int} = 1 MΩ			
• binary input					
switching signal		5 to 30 V, 1 mA	5 to 30 V, 1 mA		5 to 26 V, 1 mA
functions		• resetting the measured values • resetting the totalizers • stopping the totalizers • activation of the measuring mode for highly dynamic flows			

[1] for transit time difference principle, reference conditions and v > 0.49 ft/s

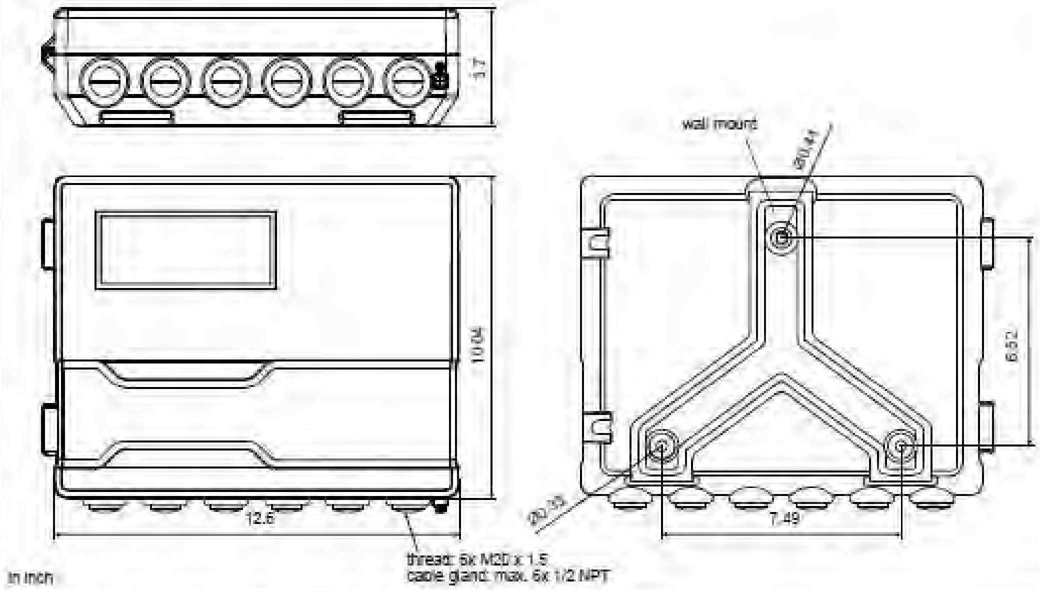
[2] reference uncertainty < 0.2 %

[3] outside of explosive atmosphere (housing cover open)

[4] with inputs and including parametrization of the transmitter

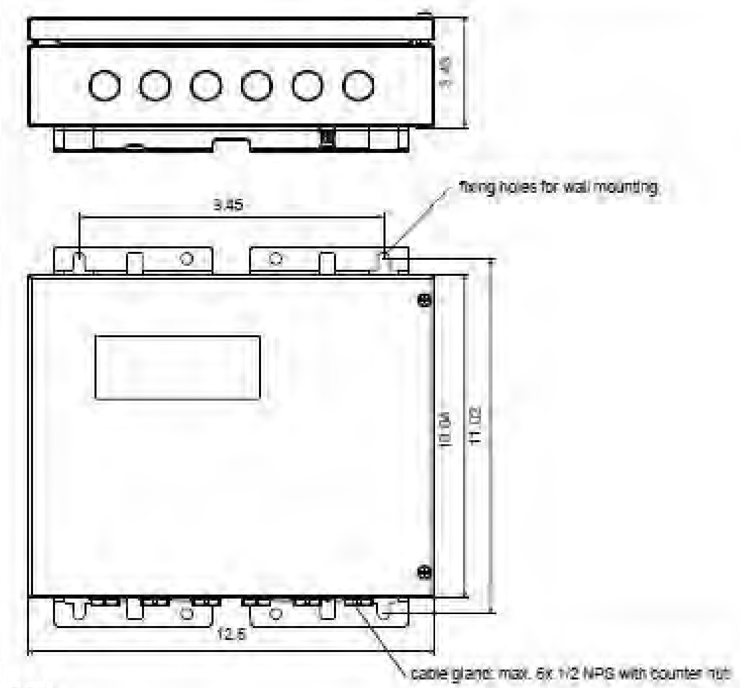
Dimensions

*721**-****A



in inch

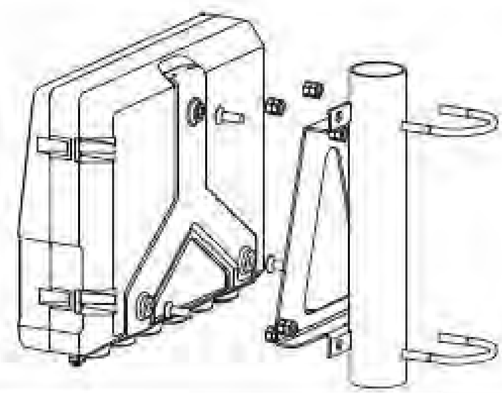
*721**-****S



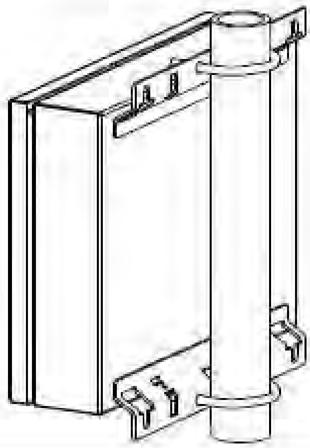
in inch

2" pipe mounting kit

*721**-****A

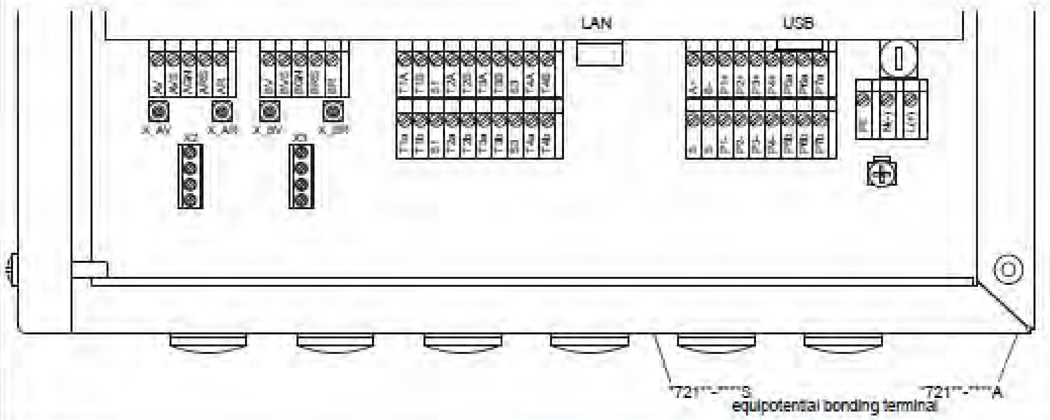


*721**-****S



Terminal assignment

*721



power supply[1]		
terminal	**connection (AC)**	**connection (DC)**
PE	earth	earth
N(-)	neutral	-
L(+)	phase	+

transducers							
transducer cable (transducers ****LI*), extension cable					transducer cable (transducers *****52)		
measuring channel A		**measuring channel B**			**measuring channel A**	**measuring channel B**	
terminal	**connection**	**terminal**	**connection**	**transducer**	**terminal**		**connection**
AV	signal	BV	signal		X_AV	X_BV	SMB connector
AVS	shield	BVS	shield				
ARS	shield	BRS	shield		X_AR	X_BR	SMB connector
AR	signal	BR	signal				

outputs[1, 2]				
terminal	**connection**	**terminal**	**connection**	**communication interface**
P1+ to P4+ P1- to P4-	current output, voltage output, frequency output, binary output (Reed relay), HART (P1)	A+	signal +	• RS485[1] • Modbus RTU[1] • BACnet MS/TP[1] • Profibus PA[1] • FF H1[1]
		B-	signal -	
P5a to P7a P5b to P7b	binary output (optorelay)	S	shield	
		USB	type B	• service (FluxDiag/ FluxDiagReader)
		LAN	RJ45	• service (FluxDiag/ FluxDiagReader) • BACnet IP • Modbus TCP

analog inputs[1, 2]						
	temperature probe				**passive sensor**	**active sensor**
terminal	**with connector**		**without connector**		**connection**	**connection**
	direct connection	**connection with extension cable**	**direct connection**	**connection with extension cable**		
T1a to T4a	red	red	red	white	not connected	not connected
T1A to T4A	red/blue	gray	red	black	-	+
T1b to T4b	white/blue	blue	white	red	+	not connected
T1B to T4B	white	white	white	green	not connected	-
S1, S3	shield	shield	-	-	not connected	not connected

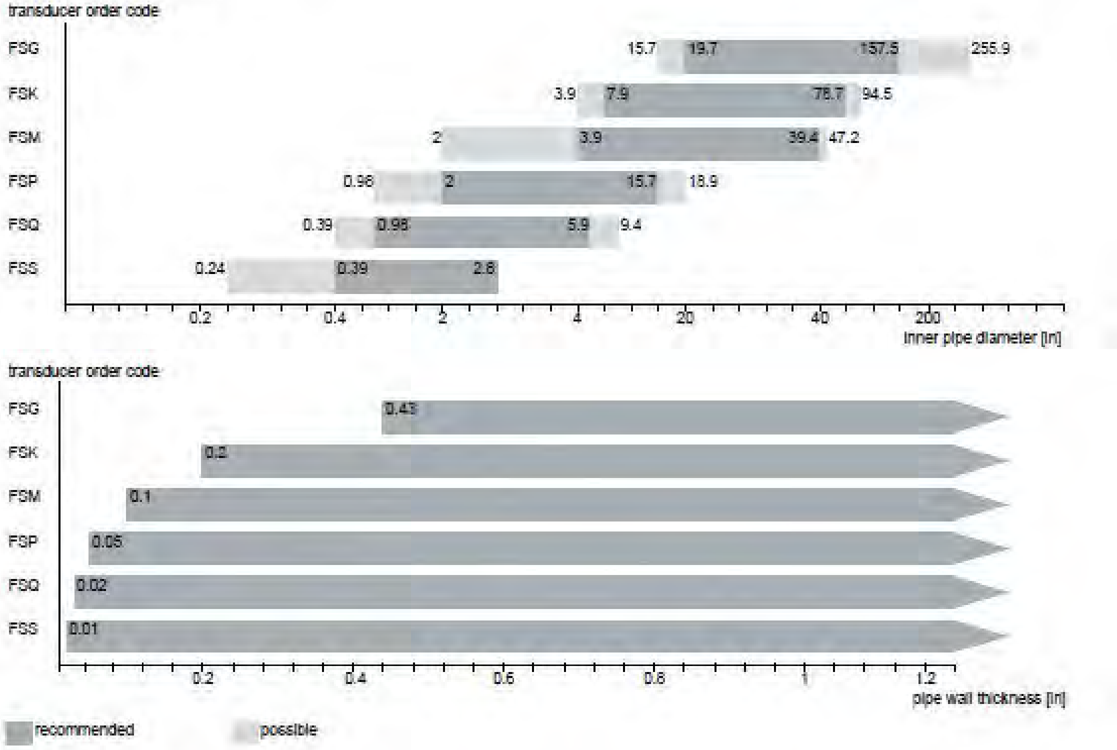
Binary inputs[1, 2]
terminal
P1+ to P2+, P1- to P2-

[1] cable (by customer):
- e.g., flexible leads, with insulated wire end ferrules, lead cross sectional area: AWG14 to 24
- outer diameter of the cable (*721**-****S with ferrite nut): max. 0.3 in

[2] The number, type and terminal assignment will be customized.

Transducers

Transducer selection

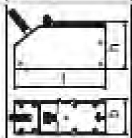
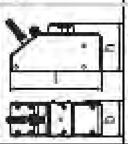
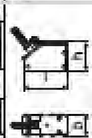
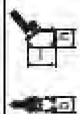
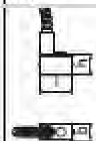


Transducer order code

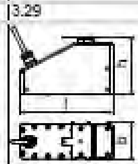
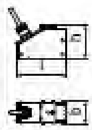
1, 2	3		4	5, 6	7, 8		9 to 11			no. of character
transducer	transducer frequency	-	ambient temperature	explosion protection	connection system	-	extension cable	/	option	description
FS										set of ultrasonic flow transducers for liquids measurement, shear wave
	G									0.2 MHz
	K									0.5 MHz
	M									1 MHz
	P									2 MHz
	Q									4 MHz
	S									8 MHz
			N							normal temperature range
			E							extended temperature range
				NN						not explosion proof
				A2						ATEX zone 2/IECEx zone 2
				A1						ATEX zone 1/IECEx zone 1
				F2						FM Class I Div. 2
					TS					direct connection or connection via junction box
							XXX			0 m: without extension cable > 0 m: with extension cable
									LC	long transducer cable
									IP68	degree of protection IP68
									OS	housing with stainless steel 316

Technical data

Shear wave transducers (zone 2 - FM Class I Div. 2 - nonEx, TS)

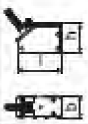
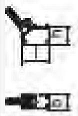
order code		FSG-N**TS/**	FSK-N**TS/**	FSM-N**TS/**	FSP-N**TS/**	FSQ-N**TS/**	FSS-N**TS/**
technical type		C(DL)G1N52	C(DL)K1N52	C(DL)M2N52	C(DL)P2N52	C(DL)Q2N52	CDS1N52
transducer frequency	MHz	0.2	0.5	1	2	4	8
inner pipe diameter d							
min. extended	in	15.7	3.9	2	0.98	0.39	0.24
min. recommended	in	19.7	7.9	3.9	2	0.98	0.39
max. recommended	in	157.5	78.7	39.4	15.7	5.9	2.8
max. extended	in	255.9	94.5	47.2	18.9	9.4	2.8
pipe wall thickness							
min.	in	0.43	0.2	0.1	0.05	0.02	0.01
material							
housing		PEEK with stainless steel cap 304, ***-*****/OS: 316L		PEEK with stainless steel cap 304, ***-*****/OS: 316L			stainless steel 304
contact surface		PEEK		PEEK			PEI
degree of protection		NEMA 6		NEMA 6			NEMA 4
transducer cable							
type		1699		1699			1699
length	ft	16		13		9	6
length (***-*****/LC)	ft	29		29		29	-
dimensions							
length l	in	5.1	4.98	2.52		1.57	0.98
width b	in	2.01	2.01	1.26		0.87	0.51
height h	in	2.64	2.66	1.59		1	0.67
dimensional drawing							
weight (without cable)	lb	1	0.79	0.15		0.04	0.01
ambient temperature							
min.	°F	-40		-40			-22
max.	°F	+266		+266			+266
temperature compensation		x					-
explosion protection							
• ATEX/IECEx							
order code		FSG-NA2TS/**	FSK-NA2TS/**	FSM-NA2TS/**	FSP-NA2TS/**	FSQ-NA2TS/**	-
explosion protection temperature (pipe surface)							
• min.	°C	-55		-55			-
• max.	°C	gas: +190, dust: +180		gas: +190, dust: +180			-
marking		CE 0637 II3G II2D Ex nA IIC T6...T2 Gc Ex tb IIIC TX Db		CE 0637 II3G II2D Ex nA IIC T6...T2 Gc Ex tb IIIC TX Db			-
certification ATEX		IBExU10ATEX1163 X		IBExU10ATEX1163 X			-
certification IECEx		IECEx IBE 12.0005X		IECEx IBE 12.0005X			-
• FM							
order code		FSG-NF2TS/**	FSK-NF2TS/**	FSM-NF2TS/**	FSP-NF2TS/**	FSQ-NF2TS/**	FSS-NF2TS/**
explosion protection temperature							
• min.	°F	-40		-40			-40
• max.	°F	+257		+374			+257
degree of protection		IP66		IP66			IP66
marking		NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860		NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860			NI/Cl. I,II,III/ Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860

Shear wave transducers (zone 2 - nonEx, TS, IP68)

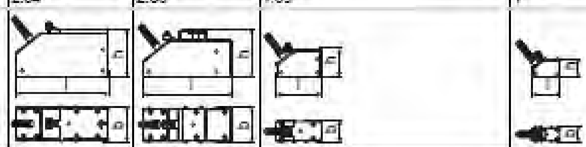
order code		FSG-N**TS/IP68	FSK-N**TS/IP68	FSM-N**TS/IP68	FSP-N**TS/IP68
technical type		CDG1LI8	CDK1LI8	CDM2LI8	CDP2LI8
transducer frequency	MHz	0.2	0.5	1	2
inner pipe diameter d					
min. extended	in	15.7	3.9	2	0.98
min. recommended	in	19.7	7.9	3.9	2
max. recommended	in	157.5	78.7	39.4	15.7
max. extended	in	255.9	94.5	47.2	18.9
pipe wall thickness					
min.	in	0.43	0.2	0.1	0.05
material					
housing		PEEK with stainless steel cap 316Ti			
contact surface		PEEK			
degree of protection		IP68[1]			
transducer cable					
type		2550			
length	ft	39			
dimensions					
length l	in	5.12		2.76	
width b	in	2.13		1.26	
height h	in	3.29		1.81	
dimensional drawing					
weight (without cable)	lb	0.95		0.19	
ambient temperature					
min.	°F	-40			
max.	°F	+212			
temperature compensation		x			
explosion protection					
• **ATEX/IECEx**					
order code		FSG-NA2TS/IP68	FSK-NA2TS/IP68	FSM-NA2TS/IP68	FSP-NA2TS/IP68
explosion protection temperature (pipe surface)					
• min.	°C	-40			
• max.	°C	gas: +90, dust: +80			
marking		CE 0637 Ex II3G II2D Ex nA IIC T6...T2 Gc Ex tb IIIC TX Db			
certification ATEX		IBExU10ATEX1163 X			
certification IECEx		IECEx IBE 12.0005X			

[1] test conditions: 3 months/29 psi (65 ft)/36 °F

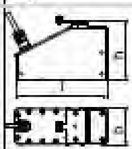
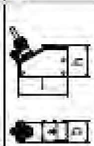
Shear wave transducers (zone 2 - FM Class I Div. 2 - nonEx, TS, extended temperature range)

order code		FSM-E**TS/**	FSP-E**TS/**	FSQ-E**TS/**
technical type		C(DL)M2E52	C(DL)P2E52	C(DL)Q2E52
transducer frequency	MHz	1	2	4
inner pipe diameter d				
min. extended	in	2	0.98	0.39
min. recommended	in	3.9	2	0.98
max. recommended	in	39.4	15.7	5.9
max. extended	in	47.2	18.9	9.4
pipe wall thickness				
min.	in	0.1	0.05	0.02
material				
housing		PI with stainless steel cap 304, ***-****/OS: 316L		
contact surface		PI		
degree of protection		NEMA 4		
transducer cable				
type		6111		
length	ft	13		9
length (***-****/LC)	ft	29		
dimensions				
length l	in	2.52		1.57
width b	in	1.26		0.87
height h	in	1.59		1
dimensional drawing				
weight (without cable)	lb	0.15		0.04
ambient temperature				
min.	°F	-22		
max.	°F	+392		
temperature compensation		x		
explosion protection				
• ATEX/IECEx				
order code		FSM-EA2TS/**	FSP-EA2TS/**	FSQ-EA2TS/**
explosion protection temperature (pipe surface)				
• min.	°C	-45		
• max.	°C	gas: +235, dust: +225		
marking		CE 0637 Ex II3G II2D Ex nA IIC T6...T2 Gc Ex tb IIIA TX Db		
certification ATEX		IBExU10ATEX1163 X		
certification IECEx		IECEx IBE 12.0005X		
• FM				
order code		FSM-EF2TS/**	FSP-EF2TS/**	FSQ-EF2TS/**
explosion protection temperature				
• min.	°F	-40		
• max.	°F	+455		
degree of protection		IP66		
marking		NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ Temp. Codes dwg 3860		

Shear wave transducers (zone 1, TS)

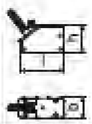
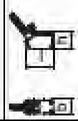
order code		FSG-N*1TS/**	FSK-N*1TS/**	FSM-N*1TS/**	FSP-N*1TS/**	FSQ-N*1TS/**
technical type		C(DL)G1N81	C(DL)K1N81	C(DL)M2N81	C(DL)P2N81	C(DL)Q2N81
transducer frequency	MHz	0.2	0.5	1	2	4
inner pipe diameter d						
min. extended	in	15.7	3.9	2	0.98	0.39
min. recommended	in	19.7	7.9	3.9	2	0.98
max. recommended	in	157.5	78.7	39.4	15.7	5.9
max. extended	in	255.9	94.5	47.2	18.9	9.4
pipe wall thickness						
min.	in	0.43	0.2	0.1	0.05	0.02
material						
housing		PEEK with stainless steel cap 304 , ***-*****/OS: 316L				
contact surface		PEEK				
degree of protection		IP65	IP66			IP65
transducer cable						
type		1699				
length	ft	16		13		9
length (***-*****/LC)	ft	29				
dimensions						
length l	in	5.1	4.98	2.52		1.57
width b	in	2.01	2.01	1.26		0.87
height h	in	2.64	2.66	1.59		1
dimensional drawing						
weight (without cable)	lb	1	0.79	0.15		0.04
ambient temperature						
min.	°F	-40				
max.	°F	+266				
temperature compensation		x				
explosion protection						
• **ATEX/IECEx**						
order code		FSG-NA1TS/**	FSK-NA1TS/**	FSM-NA1TS/**	FSP-NA1TS/**	FSQ-NA1TS/**
explosion protection temperature (pipe surface)						
• min.	°C	-55				
• max.	°C	+180				
marking		CE 0637 Ex II2G II2D Ex q IIC T6...T3 Gb Ex tb IIIC TX Db				
certification ATEX		IBExU07ATEX1168 X				
certification IECEx		IECEx IBE 08.0007X				

Shear wave transducers (zone 1, TS, IP68)

order code		FSG-N*1TS/IP68	FSK-N*1TS/IP68	FSM-N*1TS/IP68	FSP-N*1TS/IP68
technical type		CDG1LI1	CDK1LI1	CDM2LI1	CDP2LI1
transducer frequency	MHz	0.2	0.5	1	2
inner pipe diameter d					
min. extended	in	15.7	3.9	2	0.98
min. recommended	in	19.7	7.9	3.9	2
max. recommended	in	157.5	78.7	39.4	15.7
max. extended	in	255.9	94.5	47.2	18.9
pipe wall thickness					
min.	in	0.43	0.2	0.1	0.05
material					
housing		PEEK with stainless steel cap 316Ti			
contact surface		PEEK			
degree of protection		IP68[1]			
transducer cable					
type		2550			
length	ft	39			
dimensions					
length l	in	5.12		2.76	
width b	in	2.13		1.26	
height h	in	3.29		1.81	
dimensional drawing					
weight (without cable)	lb	0.95		0.19	
ambient temperature					
min.	°F	-40			
max.	°F	+212			
temperature compensation		x			
explosion protection					
• ATEX/IECEx					
order code		FSG-NA1TS/IP68	FSK-NA1TS/IP68	FSM-NA1TS/IP68	FSP-NA1TS/IP68
explosion protection temperature (pipe surface)					
• min.	°C	-55			
• max.	°C	+180			
marking		CE 0637 II2G II2D Ex q IIC T6...T3 Gb Ex tb IIIC TX Db			
certification ATEX		IBExU07ATEX1168 X			
certification IECEx		IECEx IBE 08.0007X			

[1] test conditions: 3 months/29 psi (65 ft)/36 °F

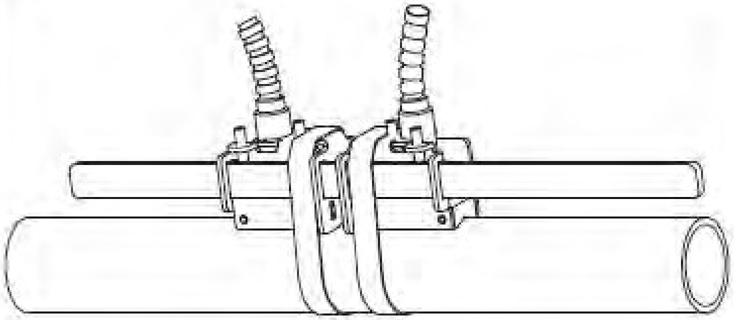
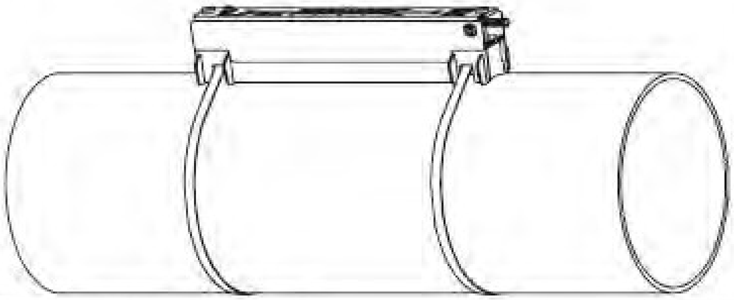
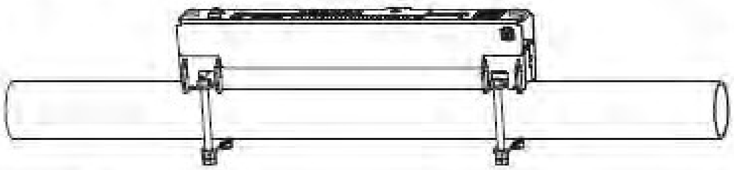
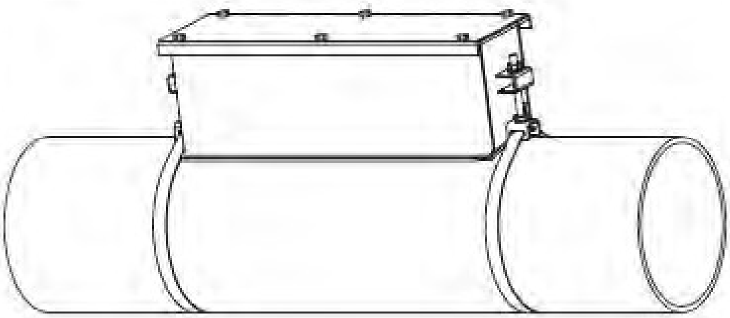
Shear wave transducers (zone 1, TS, extended temperature range)

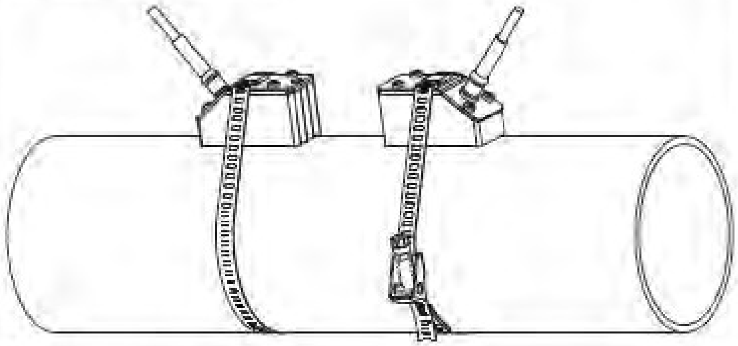
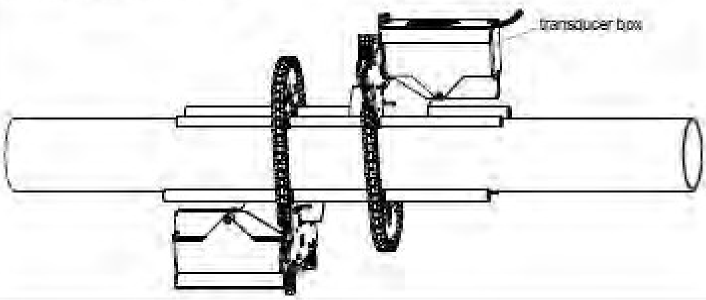
order code		FSM-E*1TS/**	FSP-E*1TS/**	FSQ-E*1TS/**
technical type		C(DL)M2E85	C(DL)P2E85	C(DL)Q2E85
transducer frequency	MHz	1	2	4
inner pipe diameter d				
min. extended	in	2	0.98	0.39
min. recommended	in	3.9	2	0.98
max. recommended	in	39.4	15.7	5.9
max. extended	in	47.2	18.9	9.4
pipe wall thickness				
min.	in	0.1	0.05	0.02
material				
housing		PI with stainless steel cap 304, ***-*****/OS: 316L		
contact surface		PI		
degree of protection		IP66		IP56
transducer cable				
type		6111		
length	ft	13		9
length (***-*****/LC)	ft	29		
dimensions				
length l	in	2.52		1.57
width b	in	1.26		0.87
height h	in	1.59		1
dimensional drawing				
weight (without cable)	lb	0.15		0.04
ambient temperature				
min.	°F	-22		
max.	°F	+392		
temperature compensation		x		
explosion protection				
• ATEX/IECEx				
order code		FSM-EA1TS/**	FSP-EA1TS/**	FSQ-EA1TS/**
explosion protection temperature (pipe surface)				
• min.	°C	-45		
• max.	°C	+225		
marking		CE 0637 II2G II2D Ex q IIC T6...T2 Gb Ex tb IIIA TX Db		
certification ATEX		IBExU07ATEX1168 X		
certification IECEx		IECEx IBE 08.0007X		

Transducer mounting fixture

Order code

1, 2	3		4	5		6	7 to 9			no. of character
transducer mounting fixture	transducer	-	measurement arrangement	size	-	fixation	outer pipe diameter	/	option	description
PL										PermaLok
VL										PermaRail
WI										transducer box for WaveInjector
	K									transducers with transducer frequency G, K
	M									transducers with transducer frequency M, P
	Q									transducers with transducer frequency Q
	S									transducers with transducer frequency S
			D							reflect arrangement or diagonal arrangement/direct mode
			R							reflect arrangement
				S						small
				M						medium
				L						large
						B				bolts
						S				tension straps
						W				welding
						N				without fixation
							SK1			0.5 to 2.5 in
							SK2			3 to 6 in
							SK3			8 to 10 in
							SK4			12 to 18 in
							SK5			20 to 36 in
							SK6			42 to 100 in
							SK7			100 to 170 in
							SK8			170 to 370 in
							NDR			any
									IP68	for transducers with degree of protection IP68
									OS	housing with stainless steel 316
									Z	special design

PermaRail (VLS) 	transducer frequency: S material: stainless steel 304, 303
PermaRail (VLK, VLM, VLQ) 	material: stainless steel 304, 301, 410 option OS: 316TI, 316L, 17-7PH inner length: **VLK**: 13.7 in, option IP68: 14.5 in **VLM**: 9.2 in **VLQ**: 6.9 in dimensions: **VLK**: 16.55 x 3.54 x 3.66 in option IP68: 17.44 x 3.7 x 4.13 in **VLM**: 12.17 x 2.24 x 2.48 in **VLQ**: 9.72 x 1.69 x 1.85 in
PermaRail with bolt mounting plates (VL*--B)** 	material: stainless steel 304, 301, 410 option OS: 316TI, 316L, 17-7PH inner length: **VLM**: 9.2 in **VLQ**: 6.9 in dimensions: **VLM**: 12.17 x 2.24 x 2.48 in **VLQ**: 9.72 x 1.69 x 1.85 in outer pipe diameter: max. 1.9 in
PermaLok PL 	material: stainless steel 316

quick release clasp and tension straps 	material: stainless steel 410, 200
transducer box WI for WaveInjector 	see Technical specification TSWaveInjectorVx-x

Coupling materials for transducers

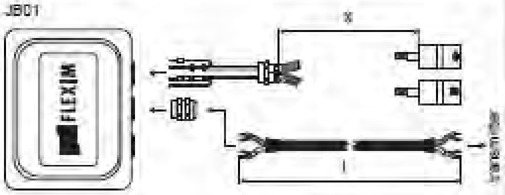
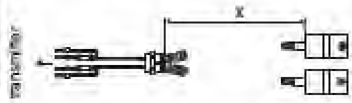
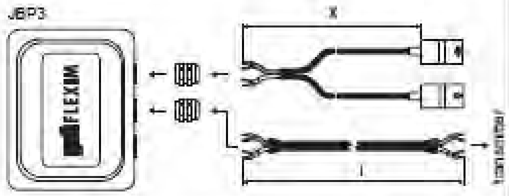
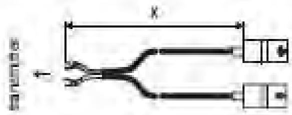
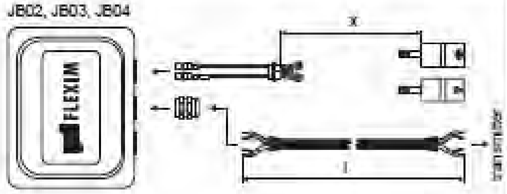
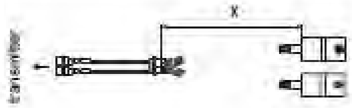
	normal temperature range (4th character of transducer order code = N)		extended temperature range (4th character of transducer order code = E)		WaveInjector WI-400	
	< 212 °F	< 338 °F	< 302 °F	< 392 °F	< 536 °F	536 to 752 °F
< 24 h	coupling compound type N or coupling pad type VT	coupling compound type E or coupling pad type VT	coupling compound type E or coupling pad type VT	coupling compound type E or H or coupling pad type VT	coupling pad type A and coupling pad type VT	coupling pad type B and coupling pad type VT
long time measurement	coupling pad type VT[1]	coupling pad type VT[2]	coupling pad type VT[1]	coupling pad type VT[2]	coupling pad type A and coupling pad type VT	coupling pad type B and coupling pad type VT

[1] < 5 years
[2] < 6 months

Technical data

type	ambient temperature °F	material
coupling compound type N	-22 to +266	mineral grease paste
coupling compound type E	-22 to +392	silicone paste
coupling compound type H	-22 to +482	fluoropolymer paste
coupling pad type A	max. 536	lead
coupling pad type B	> 536 to 752	silver
coupling pad type VT	14 to +392	fluoroelastomer

Connection systems

connection system TS		
connection with extension cable	direct connection	transducers technical type
JB01 		****8*
JBP3 		****[illegible]
JB02, JB03, JB04 		****52

Cable

transducer cable				
type		**1699**	**2550**	**6111**
weight	lb/ft	0.06	0.02	0.06
ambient temperature	°F	-67 to +392	-40 to +212	-148 to +437
properties			longitudinal watertight	
cable jacket				
material		PTFE	PUR	PFA
outer diameter	in	0.11	0.2 ±0.01	0.11
thickness	in	0.01	0.04	0.02
color		brown	gray	white
shield		x	x	x
sheath				
material		stainless steel 304 option OS: 316Ti	-	stainless steel 304 option OS: 316Ti
outer diameter	in	0.31	-	0.31

extension cable			
type		**2615**	**5245**
weight	lb/ft	0.12	0.26
ambient temperature	°F	-22 to +158	-22 to +158
properties		halogen free fire propagation test according to IEC 60332-1 combustion test according to IEC 60754-2	halogen free fire propagation test according to IEC 60332-1 combustion test according to IEC 60754-2
cable jacket			
material		PUR	PUR
outer diameter	in	0.47	0.47
thickness	in	0.08	0.08
color		black	black
shield		x	x
sheath			
material		-	steel wire braid with copolymer sheath
outer diameter	in	-	0.61

Cable length

transducer frequency		F, G, H, K		M, P		Q		S	
connection system TS									
transducers technical type		x	l	x	l	x	l	x	l
"(DR)"""8"	ft	16	≤ 984	13	≤ 984	9	≤ 295	-	-
option LC: "(LT)"""8"	ft	29	≤ 984	29	≤ 984	29	≤ 295	-	-
"(DR)"""5"	ft	16	≤ 984	13	≤ 984	9	≤ 295	6	≤ 131
option LC: "(LT)"""5"	ft	29	≤ 984	29	≤ 984	29	≤ 295	-	-
option IP68: """"LI"	ft	39	≤ 984	39	≤ 984	-	-	-	-

x = transducer cable length

l = max. length of extension cable (depending on application)

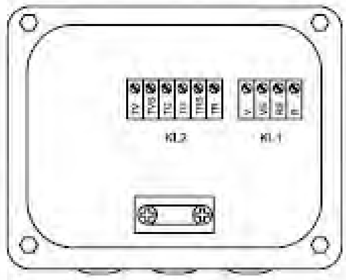
Junction box

Technical data

JB01S4E3M, JBP2, JBP3

weight	lb	2.6 lb
fixation		wall mounting optional: 2" pipe mounting
material		
housing		stainless steel 316L
gasket		silicone
degree of protection		NEMA 6
ambient temperature		
min.	°F	-40
max.	°F	+176
explosion protection		
• ATEX/IECEx (zone 1)		
junction box		JB01S4E3M
marking		CE 0637 Ex II2G II2D Ex e mb IIC (T6)...T4 Gb Ex tb IIIC T 100 °C Db Ta -40...+(70)80 °C
certification ATEX		IBExU06ATEX1161
certification IECEx		IECEx IBE 08.0006
type of protection		gas: increased safety decoupled network: encapsulation dust: protection by enclosure
• ATEX (zone 2)		
junction box		JBP2
marking		CE Ex II3G Ex nA IIC (T6)...T4 Gc II3D Ex tc IIIC T 100 °C Dc Ta -40...+(70)80 °C

connection



transducers

terminal strip	terminal	connection	transducer
KL1	V	signal	
	VS	internal shield	
	RS	internal shield	
	R	signal	

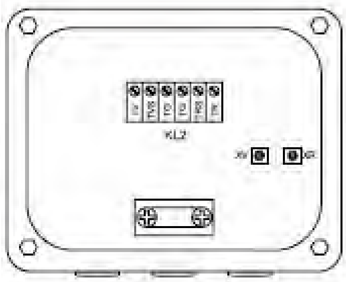
extension cable

terminal strip	terminal	connection
KL2	TV	signal
	TVS	internal shield
	TRS	internal shield
	TR	signal

JB02, JB03, JB04

weight	lb	2.6 lb
fixation		wall mounting optional: 2" pipe mounting
material		
housing		stainless steel 316L
gasket		silicone
degree of protection		IP67
ambient temperature		
min.	°F	-40
max.	°F	+176
explosion protection		
• ATEX		
junction box		JB02
marking		CE Ex II3G Ex nA IIC (T6)...T4 Gc II3D Ex tc IIIC T 100 °C Dc Ta -40...+(70)80 °C
• FM		
junction box		JB04
marking		NI/Cl. I,II,III/Div. 2 / GP A,B,C,D,E,F,G/ T6 Ta = -40...+60 °C

connection



transducers

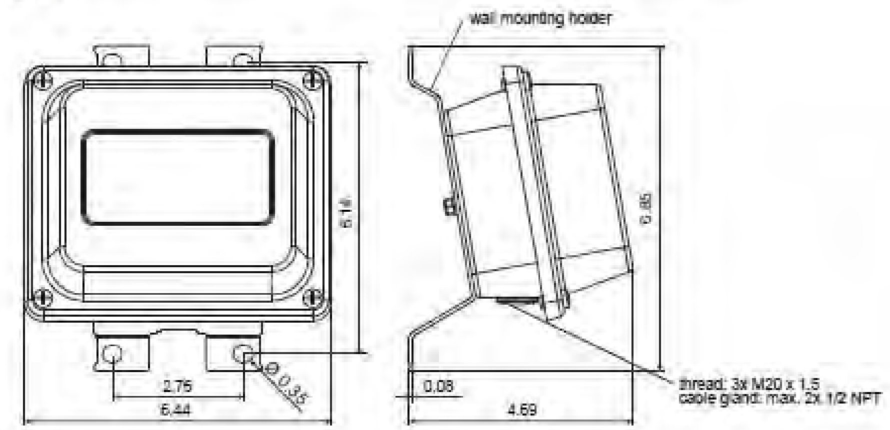
	terminal	connection	transducer
	XV	SMB connector	
	XR	SMB connector	

extension cable

terminal strip	terminal	connection
KL2	TV	signal
	TVS	internal shield
	TRS	internal shield
	TR	signal

Dimensions

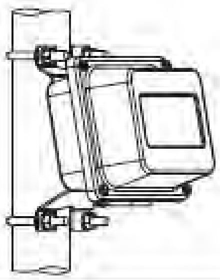
JB0*, JBP*



in inch

2" pipe mounting kit

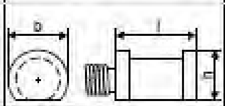
JB**



Clamp-on temperature probe (optional)

Technical data

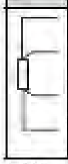
PT13N

design		clamp-on
type		Pt1000
connection		4-wire
measuring range	°F	-40 to +392
accuracy T		$\pm(0.27\ °F + 2 \cdot 10^{-3} \cdot (\lvert T\ [°F]\rvert - 32\ °F))$ class A
accuracy ΔT (2x Pt matched according to EN 1434-1)		≤ 0.03 °F (at 50 °F)
housing		360 brass alloy
degree of protection		NEMA 4
dimensions		
length l	in	0.79
width b	in	0.59
height h	in	0.49
dimensional drawing		
weight	lb	0.437
accessories		
thermal conductivity foil 482 °F		x

connection system

connection with extension cable	direct connection
extension cable 	

connection

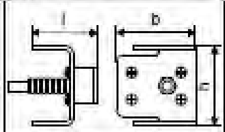


	temperature probe	extension cable
	red	red
	red	red
	white	white
	white	white

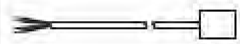
cable

		temperature probe	extension cable
type		4 x 24 AWG	4 x 18 AWG
standard length	ft	20	-
max. length	ft	-	656
cable jacket		PTFE	LS PVC

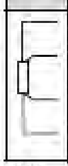
PT13F

design		clamp-on short response time
type		Pt1000
connection		4-wire
measuring range	°F	-58 to +482
accuracy T		$\pm(0.27\ °F + 2 \cdot 10^{-3} \cdot (\lvert T\ [°F]\rvert - 32\ °F))$ class A
accuracy ΔT (2x Pt matched according to EN 1434-1)		≤ 0.1 K (3 K < ΔT < 6 K), more corresponding to EN 1434
response time	s	8
housing		PEEK, stainless steel 304, copper
degree of protection		NEMA 4
dimensions		
length l	in	0.55
width b	in	1.18
height h	in	1.06
dimensional drawing		
weight	lb	0.7
accessories		
thermal conductivity paste 392 °F		x
thermal conductivity foil 482 °F		x
plastic protection plate, insulation foam		x

connection system

connection with extension cable	direct connection
extension cable 	

connection

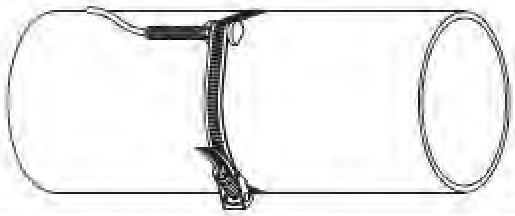
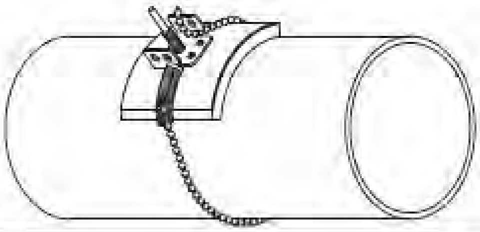


	temperature probe
	red
	red/blue
	white/blue
	white

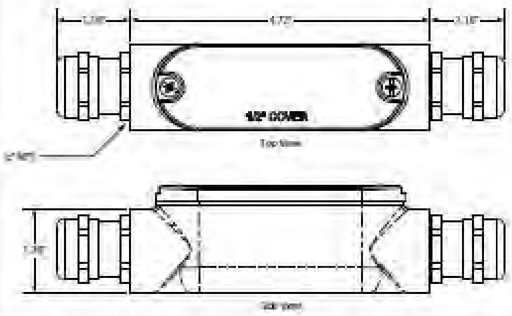
cable

		temperature probe	extension cable
type		4 x 0.25 mm² black	4 x 18 AWG
standard length	ft	9	-
max. length	ft	-	656
cable jacket		PTFE	PVC

Fixation

tension strap PT13N 	material: stainless steel 301, 410
ball chain PT13F 	material: stainless steel 316L length: 3 ft

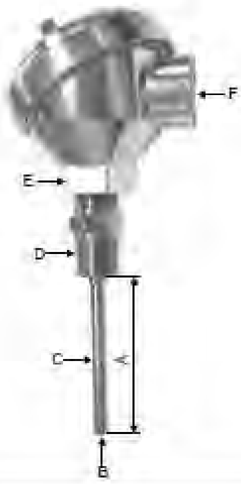
Junction box



connection

temperature probe	extension cable
red	white
red	black
white	green
white	red

Inline temperature probe (optional)



	type	Pt1000
A	insertion length	6" or specified length
B	resistance	1 000 Ω, 00385
C	insertion length	6" or specified length
	sheath material	stainless steel 316
D	thread	1/2" NPT HEX CPLG. spring loaded
E	head	aluminum screw cover head 4 terminal block
F	thread	3/4" NPT

Click here to return to Limitorque (PS)

Click here to return to Limitorque (TP)

Click here to return to Limitorque (TP2)

XI. Exhibit P

FLOWSERVE

Limitorque® MX Series B
Smart Electric Actuator

Experience In Motion

Flowserve Limitorque actuation systems

Limitorque is an operating unit of Flowserve, a $3.5 billion-a-year company strongly focused on the automation and support of the valve industry. Flowserve is the world's premier provider of flow management services.

Limitorque has evolved over 80 years since its strategic introduction of a "torque-limiting" design that changed an industry. Flowserve Limitorque offers solutions and automation choices for customers which provide:

- Cost savings from field devices such as electric valve actuators
- Greater operating efficiencies from control room performance sequencing, interlocking and continuous process optimization
- Competitive advantages derived from increased management visibility of databases and networks

SMB (1964)

L120 (1985)

MXb (2020)

MX (2000)

2 Flowserve.com

MXb actuator: The next generation in smart actuation

Limitorque MXb: unmatched reliability, precision, advanced diagnostics capabilities and a streamlined user experience.

Flowserve Limitorque introduced the MX electric actuator in 1997 as the first smart actuator that provided uncompromised reliability and performance in a design that was easy to use. The MX actuator innovations, which were market firsts — a unique absolute encoder that doesn't require battery back-up; LimiGard™ technology; easy-to-use menus in six languages; and the use of Hall effect devices to eliminate potentially troublesome reed switches — have been improved.

The MXb actuator is Limitorque's next-generation, high-performance unit, offering superior reliability, enhanced analytics and an improved user experience.

Enhanced user experience

Up to 50% faster commissioning, setup and operation from a simplified menu structure

An updated user interface coupled with a simplified, intuitive menu structure makes navigation easy and ensures a smooth, error-free setup process. The new intuitive and configurable menu structure caters to all knowledge and expertise levels by offering multiple configuration options. A quick-setup option ensures rapid and secure basic commissioning, while the advanced setup option allows the actuator to be tailored to the desired application.

Improved legibility owing to a larger, high-resolution LCD screen that extends viewing distance and detail

The larger, higher-resolution LCD display makes the information and status easily legible from as far as 9.1 m (30 ft). The new LCD display is twice as large as the display on the previous MX model and provides eight times more resolution. The built-in ambient light sensor coupled with smart software allows dynamic brightness and contrast regulation for improved visibility in all lighting conditions.

Enhanced visualization of operational graphs, logs and trends data

The advanced display uses improved graphics to provide an enriched visualization and data interpretation experience. Real-time torque graphs, alarm and event logs, and other data are accessible in higher-quality resolution.

Advanced diagnostics and analytics

Increased memory with real-time clock (RTC) improves the quality of data captured

The MXb actuator has 500 times the memory capacity of the previous MX model. A larger memory capacity allows increased data capture and storage for a higher degree of process monitoring, data logging and information feedback. Additionally, the RTC allows data logs to be time stamped in order to support asset management functions and lifecycle analysis.

Advanced diagnostics provide greater process visibility and control

An enhanced, NAMUR NE107-compliant, diagnostic notification system provides process performance monitoring by alerting the operator of potential future failures with alarm and event conditions through an internationally accepted symbol standard.

Improved reliability

Isolated input/outputs to improve protection from outside interference

In addition to its non-intrusive construction, the design isolates critical components to ensure higher reliability by addressing electronics survivability, especially in extreme environments where the equipment is subject to electrical shock and interference.

Longer service life from higher-rated components for extended operating ranges and mean time between failure (MTBF)

High MTBF-rated components and a reinforced housing provide increased robustness and reliable functionality. The use of higher-rated components and materials ensures thermal and resistance ratings that meet and go beyond application needs.

Simplified maintenance

A new electronic connector design removes the need for brackets and hold-downs, making maintenance operations easier and faster. The enhanced connector design ensures robust connectivity throughout the rated seismic and vibration envelope.

Backward interchangeability

The MXb actuator's display and control electronics assembly are backward-compatible and can be easily retrofitted to previous MX actuator models **through conversion kits.**

The performance you expect with the simplicity you want

Speed, precision and simplicity

The MXb actuator's control panel features a 240x160-pixel resolution LCD with configurable temperature and ambient lighting compensation control for LCD backlight. The larger, higher-resolution LCD display allows customers the ability to view actuator status and diagnostics in an easy to use, easy to read, graphical format. The built-in ambient light sensor coupled with smart software allows dynamic brightness and contrast regulation for improved visibility in all lighting conditions.

The industry's first multilingual actuator is now capable of configuration in English, Spanish, German, French, Italian, Portuguese, Mandarin, Russian, Bahasa Indonesia, Katakana and Turkish as standard configuration languages. In addition, the LCD can be rotated 180° for better field visibility.

Speed, precision, simplicity and fast set-up are characteristics expected of a smart actuator. Users and valve OEMs demand quick set-up and easy to understand dialog in preferred languages. The ability to either upload new software or download diagnostics is also critical to improving a plant's efficiency. The MXb actuator provides customers with the essential tools for rapid installation and root cause diagnostics.

Precision is expected in a smart actuator. The MX actuator was the first such device developed with an innovative absolute encoder that doesn't require troublesome and unpredictable battery back-up. Flowserve Limitorque's innovative absolute encoder has 18-bit resolution, allows for over 10,000 drive sleeve rotations, and is 100% repeatable. It has BIST (Built In Self Test) enhancements and redundancy.

When a device is designed for BIST, its methodology is such that much of the test functionality is embedded in the device itself. BIST design facilitates a critical component's ability to communicate its actual state for comparison to the expected state. Any deviation from expected values will be reported to the user, either locally at the actuator's LCD screen or over a network device.

Simplicity is expected in a smart actuator. In fact, one of the reasons for using an electric actuator is the simplicity of set-up, installation on a valve, and acquiring diagnostic information. The MXb actuator is the simplest and easiest to use electric actuator.

Long life and protection

Long life is expected in a smart actuator. There are more than 1,000,000 Limitorque actuators installed around the globe, in every conceivable environment. Many have been functioning for over 50 years. Introduced in 1997, the MX actuator is the Flowserve Limitorque smart actuator that inherits Limitorque's legendary longevity.

In order to last a long time in severe environments, smart actuators must have unparalleled protection. The MX actuator's IP68 enclosure rating is 15M for 96 hours, regardless of whether the unit is weatherproof or explosion-proof. Add other certifications to the list — NEMA 4, 4X, 6 — and the MX actuator is unsurpassed in unit protection.

The MX actuator is double-sealed, which isolates its terminal compartment from the controls environment. Any leakage into the terminal compartment is contained in the compartment.

Additionally, the design isolates critical components to ensure higher reliability by addressing electronics survivability, especially in extreme environments where the equipment is subject to electrical shock and interference.

The MX actuator is powder coated using a polyester resin in Blue Streak color, not only for aesthetics, but also for protection in severe corrosive environments.

Quality and certifications

Flowserve Limitorque is a global leader in quality manufacturing. All Limitorque plants are certified to ISO 9001 standards, the recognized benchmark for quality all over the world. The same unexcelled use of certified materials is found in the MX actuators as in Limitorque's naval and nuclear-qualified electric actuators. The MX actuator has used synthetic gear oils especially optimized for use with worm gear sets since the first unit was shipped in 1997. It was the first non-intrusive actuator to use rolled worms and electronic controls designed and produced using surface mount technology. A true globally certified device, the MXb actuator meets all pertinent European Directives, including IECEX, ATEX, EMC, Machinery and Noise, and displays the CE mark associated with such compliance.

Anatomy of MXb multi-turn actuators

Limitorque MX actuators respond to customer needs with advanced features designed for ease of commissioning and use, as well as time and money-saving operational benefits. What sets the MXb actuator apart is the combination of control and reliability enabled by advanced Limitorque technology, plus superior ergonomics and human interfaces for speed, comfort and ease of use.

The MXb actuator's **heavy-duty handwheel** provides backup for manual operation.

The reliable MXb actuator's motor includes **Class F insulation and three-phase ACV.** It is designed specifically for valve actuator service, with a high starting torque and low inertia to reduce valve position overshoot. Class H is an option for three-phase ACV motors.

Motor gear attachment allows the motor to be removed in one assembly for fast, easy inspection, repair and maintenance.

Double-sealed housing design provides a termination chamber that is separate and sealed from the control chamber. Control components are never exposed to the elements during site wiring or because of a faulty cable connection.

External connection block has three power terminals, a ground screw, and 54 control screw-type terminals to **simplify commissioning and upgrades.**

Long-life gear set consists of hardened alloy, steel-rolled worm and bronze worm gear immersed in an extended-life synthetic gear oil specifically developed for worm gear operation. It is completely bearing-supported.

Ductile iron thrust base is removable from main actuator housing for **easier valve installation and maintenance.** High-strength, bronze alloy stem nut is removable for machining to suit the valve stem.

Declutch lever enables the MXb actuator to be placed in manual, handwheel-drive operation. The lever automatically disengages when motor is energized and can be padlocked in the motor position.

Cast aluminum housing is powder-coated **for extreme environments.** Optional coatings are available.

Controls may be powered from an external 24 VDC source as backup for AC power, or it could be used with commissioning. Controls and display will remain active through loss of AC power.

Torque sensor derives output from motor speed, temperature and voltage—and shuts off the motor to protect the actuator and valve if the set torque is exceeded. This method of torque sensing indicates Limitorque's commitment to be fully electronic.

The absolute encoder, a key that enables MXb actuators to achieve 100% repeatable control, provides optical sensing of valve position with 18-bit resolution. The encoder measures valve position in both motor and handwheel operation. No battery or back-up power supply is required. It is redundant BIST, permitting up to a 50% fault tolerance, ensuring reliable performance in the unlikely event of component failure.

The MXb actuator offers **Bluetooth® LE technology,** which connects, receives and transmits up to 10 m (32.8 ft). Firmware can be downloaded to the actuator easily from a laptop computer.

The **high-resolution control panel display** delivers instant, up-to-the-minute actuator status and valve position in 11 languages. Both historical and real-time graphs can be viewed on the advanced display along with configuration and diagnostic information that includes motor, identification, hardware data, as well as torque profile log reports.

MXb actuators feature a **LimiGard circuit monitor** that is designed for Fail/No-Action protection. LimiGard consists of dedicated circuitry that continually monitors the motor contactor, control relays, internal logic circuits and external command signals to detect and alarm malfunctions. It now includes BIST for true predictive maintenance.

The control chamber includes an **electronic control, monitoring and protection module** mounted on a steel plate. Plug-in connectors allow fast, error-free removal and replacement of the module.

Local control switches make setup and calibration easy, using "yes" or "no" responses to straightforward questions, plus they provide the abilities to open, stop and close the actuator and select remote or local preferences. These switches are magnetically coupled, solid state Hall effect devices, which eliminate troublesome and fragile reed switches.

A **rotary knob,** unique to the Limitorque MXb design, facilitates seamless navigation and reduces setup and calibration times. The robust knob allows users the ability to quickly navigate between available menu options and helps in making faster and precision selections.

Control and diagnostics

Control is expected in a smart actuator. The MXb actuator is noted for simplifying valve control automation in three critical areas:

- Calibration/set-up
- Normal operation
- Diagnostics and troubleshooting

The MX actuator was the first non-intrusive actuator to equip users with LCD dialog screens in the language of their choice. The new and improved MXb actuator uses a graphical dot matrix display **that doubles the screen size** and offers eight times higher resolution and improves the visibility of the display. The use of this type of LCD permits the support of any language. In fact, in addition to English, Spanish, German, French, Italian and Portuguese, the MXb actuator now includes six languages — Mandarin, Russian, Bahasa, Indonesia, Katakana and Turkish — with a capacity for even more. The orientation of the text can be configured to rotate 180° and diagnostic graphs displayed for clearer data collection.

Simple "Yes" and "No" responses to dialog questions confirm the set-up of the MXb actuator via solid state Hall effect devices in all knobs. No special tools or remote devices are required. And the MXb actuator is "fit for service", offering the widest range of configuration menus of any non-intrusive, smart actuator.

The new intuitive and configurable menu structure caters to all knowledge and expertise levels by offering multiple configuration options. A quick-setup option ensures rapid and secure basic commissioning, while the advanced setup option allows the actuator to be tailored to the desired application.

Advanced setup

Main menu

Quick setup

Nothing exceeds Limitorque MXb actuators for ease and compatibility with valves of all types

Valves

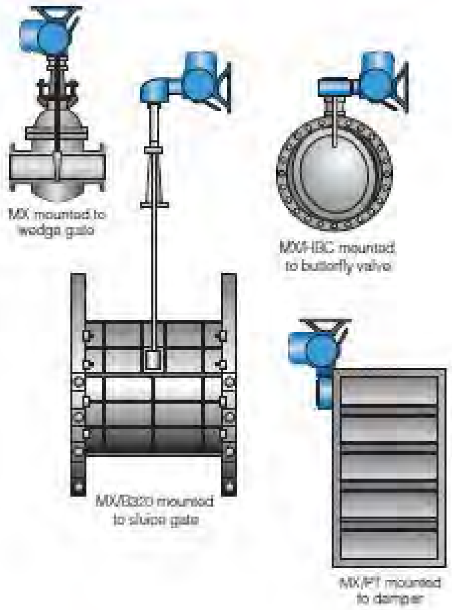
Limitorque MXb actuators have been designed to accommodate today's wide variety of valve designs and meet international standards for valve and actuator interfaces, including ISO 5210 and MSS SP-102.

MXb actuators are available in a wide variety of configurations to accommodate various applications and valve designs:

Direct mounting: The MXb actuator can be directly coupled with valves for torque-only applications. For thrust applications, a separate thrust base is used.

MX/HBC/WG: The MXb actuator can be coupled to a WG or HBC worm gear reducer for operation of part-turn valves, such as butterflies, balls, plugs and dampers. This combination provides an output torque capacity of up to 184,280 N m (136,000 ft-lb).

MX/B320/MT/V and SR: Rising stem valves may be operated by an MXb actuator coupled to a variety of bevel gear and spur gear reducers. Thrusts up to 1,445 kN (325,000 lb) and torque up to 16,320 N m (12,000 ft-lb) can be accommodated.



Couplings

Thrust actuator drive couplings:

- Type A1 – Alloy bronze (thrust)
- Type A1E – Extended bronze nut
- Linear base – Type LB1 (30 N [6,700 lb]) and LB2 (109 N [24,400 lb]) for control and choke valve applications (see LMENFL2360, MX and QXM Linear Base for further information).

Torque-only actuator drive couplings:

- Type B4 – Standard steel bushing
- Type B4E – Extended steel bushing
- Type B1 – Large fixed-bore keyway steel bushing (ISO 5210)
- Type BL – Splined steel bushing for rising rotating stem valves

Integrity and predictable performance

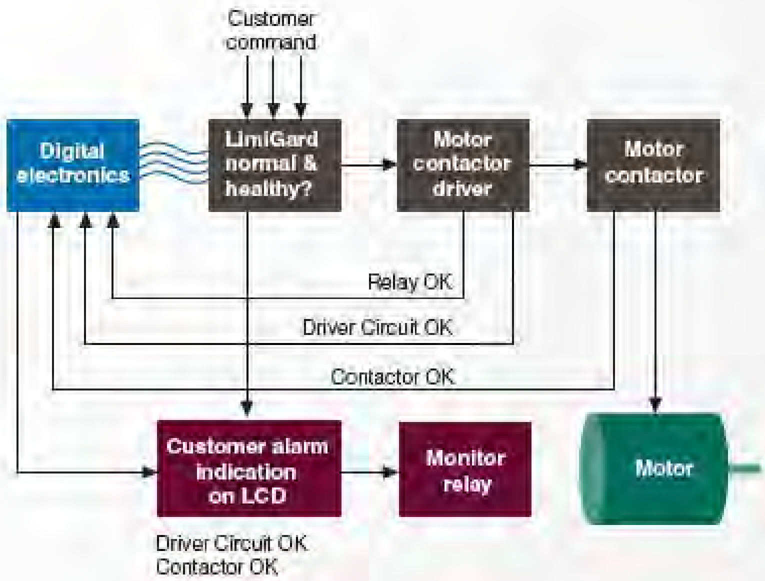
Smart actuators should have enabling technologies that ensure integrity and dependability. The MXb actuator offers three.

LimiGard — with BIST

Enhanced reliability for optimal plant operations and reduced troubleshooting costs are the primary benefits of Limitorque's unique smart actuator monitor, LimiGard.

When LimiGard wiring diagrams are followed, LimiGard continually monitors the control relays, internal logic circuits and external command signals, comparing them to reference conditions. This virtually eliminates the possibility that an actuator malfunction can occur without prompt detection and alarm communication. In the event of a malfunction, LimiGard takes over and supervises the actuator's response characteristics, maximizing safety and predictability. Fault Insertion Tests confirm this Fail/No-Action philosophy built into every MXb actuator.

A state-of-the-art electric actuator such as the MXb actuator should include means for verifying and validating that its components are designed with BIST capabilities. Selecting the MXb actuator, which incorporates a high level of BIST, can contribute greatly to the integrity and reliability of process applications and enhance the ability of a safety system to achieve its highest possible rating.

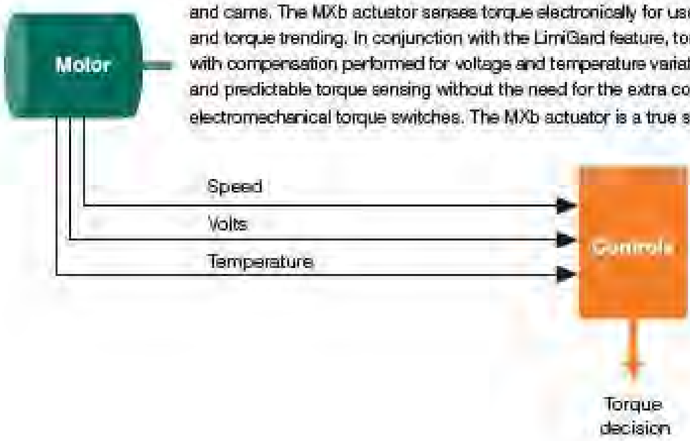


Absolute position encoder

Limitorque was the first electric actuator supplier to use an absolute encoder which doesn't require battery back-up for positioning. Customers specify absolute encoders for uninterrupted performance, and the MXb actuator meets customer expectations with an improved, 18-bit optical, 100% repeatable device. Position information is accurate with or without electrical power. The 18 bits also means that the span of the MXb actuator's encoder is now almost 10x the original — good for ~10,000 drive sleeve rotations. The encoder has redundant circuits, ensuring performance, even in the event of up to 50% component failure, continuing to provide reliable data while alerting the user to any faults.

Torque sensing

Torque limiting has been a Limitorque feature for more than 80 years. In fact, the name Limitorque was coined to identify the ability of an electric actuator to "limit torque" to a valve. In the past, electromechanical actuators have sensed torque using a complicated system of springs, switches and cams. The MXb actuator senses torque electronically for use in valve control, overload protection and torque trending. In conjunction with the LimiGard feature, torque is sensed from motor speed, with compensation performed for voltage and temperature variations. The result is highly reliable and predictable torque sensing without the need for the extra components associated with electromechanical torque switches. The MXb actuator is a true smart actuator.



MXb control, indication, protection and optional features

Standard features

- **Direct-wired remote control** – Wiring flexibility includes the following standard alternatives to open-stop-close the actuator:
  - Four-wire – Valve can be opened, closed or stopped.
  - Two-wire switched – Single open or closed contact; valve can be opened or closed, but not stopped.
  - Three-wire maintained – Two maintained contacts for self-maintained control. Valve can be opened or closed but not stopped in mid-travel.
  - Three-wire inching – Two momentary contacts; valve can be opened, closed and stopped in mid-travel.
- **Multi-mode control** – Three modes of remote control are permitted when the MXb actuator is configured for multi-control: digital (discrete) control, analog control or network (fieldbus) control. The MXb actuator will respond to the last command received. However, analog (modutronic) control is initiated by either toggling MX User Input 2 (configured for CSE input) or removing and reapplying the 4-20 mA analog signal. Refer to AITB000090 for further information.
- **Monitor relay** – Provides an N/O and N/C contact, representing "Actuator available for remote operation."
- **Emergency shutdown (ESD)** – A remote, external ESD signal may be applied to the actuator to move the valve to a predetermined user-configured shutdown position, overriding existing control signals.
- **User-defined inputs** – Three user-defined inputs are supplied.
- **Inhibit signals** – External signals may be used to inhibit actuator opening, closing, or both.
- **Control signals** – The control signal can be either 24 VDC or optional 125 VAC; it can be sourced from the actuator or customer supply.
- **Status contacts (4)** – May be set to represent up to 30 actuator conditions.
- **UPS** – Allows for a 24 VDC UPS connection for either early commissioning prior to main power or actuator status and feedback in the event of lost mains power.
- **Negative switching** – When remote control systems require the negative pole of the circuit supply to be switched to positive earth, a simple software change is made.

Bluetooth LE capable

- Standard low-power wireless communication path to the actuator enables monitoring and configuration of the unit up to 10 m (32.8 ft) in any direction via a Bluetooth LE-compatible PC. FHSS (frequency-hopping spread spectrum) allows a reliable communication link, even in a "noisy" environment, and 128-bit data encryption can be enabled to protect the privacy of the link. A visible blue LED in the controls LCD window on the face of the actuator signifies an active Bluetooth link to the actuator has been established.

Protection features

- **Autophase protection and correction** – Assures proper open/close directions and monitors and corrects phasing if connected improperly. Prevents operation if a phase is lost.
- **Instantaneous reversal protection** – Incorporates the proper time delay between the motor reversals to reduce current surges and extend contactor life.
- **Motor thermal protection** – A thermistor, placed within the motor, protects against overheating.
- **LimiGard circuit protection** – LimiGard consists of dedicated circuitry that continually monitors the motor controller, control relays, internal logic circuits and external command signals. When the recommended wiring connections are made, it virtually eliminates unexpected, erroneous actuation caused by internal electronic failures and erratic external command signals. Additionally, in the event of malfunction, LimiGard supervises the actuator response, detects the source of the failure, and signals an alarm.

Optional features

- **Four additional latched contacts** – Additional contacts may be set to represent up to 30 key actuator conditions, for a total of eight contacts.
- **Two-speed timer** – A two-speed pulsing timer may be incorporated to support variable stroke times as configured by the user.
- **Analog position transmitter (APT)** – The APT is an internally powered, non-contacting valve position transmitter that provides a 4-20 mA signal proportional to valve position.
- **Analog torque transmitter (ATT)** – The ATT is a noncontacting, internally powered transmitter that provides a 4-20 mA signal that is proportional to actuator output torque.
- **Modutronic controller** – The Modutronic controller positions the valve in response to an external 4-20 mA command signal. It includes automatic pulsing mode to prevent overshoot at the setpoint. Parameters that may be set easily during configuration include proportional band, dead band, polarity, and action on loss of command signal.
- **Partial stroke and momentary closure ESD** – The partial stroke and momentary closure ESD signals are configurable by the user. It can also be supplied with a momentary closure contact-initiated ESD signal routine with redundant circuitry.
- **Control station (CSE)** – The CSE is a separate control station designed for the operation of inaccessible actuators. It is available with LEDs, Remote/Local and Open/Close selector switches. The CSE may be powered by the actuator's internal supply, provided wire resistance and other external loads do not limit the available signal power presented to the MXb actuator.
- **Solid-state motor reverser (SSMR)** – An SSMR is available when severe modulating operating conditions demand continuous operation.
- **Isolation and load break switches** – Isolation and load break switches can be supplied for the incoming three-phase supply to the actuator. These may be coupled directly to the actuator for weather-proof (WP) applications only or supplied separately for mounting by the user. The enclosure is suitable for WP or temporary submersion service. An explosion-proof (XP) isolation switch is also available for user mounting and is suitable for mounting with all MXb actuators. Please contact factory for availability.

Network communications

The MXb actuator provides a comprehensive network option portfolio to the user. Network solutions are improved with the addition of HART and TCP/IP to complement Modbus, Foundation Fieldbus H1, DeviceNet, Profibus DP_V1 and Profibus PA. The MXb actuator provides the user with predictable, reliable and safe operation for years to come, in applications which are subject to the most rigorous requirements and environmental extremes.

DDC Modbus (distributed digital control) communication

DDC is Flowserve Limitorque's digital communication control system that provides the ability to control and monitor up to 250 actuators over a single twisted-pair cable. The communication network employs Modbus protocol on an RS-485 network and is redundant. Redundancy assures that any single break or short in the communication cable will not disable any actuators. Each actuator has included an addressable field unit that communicates over the twisted-pair network and executes open, close, stop, ESD and GO TO position commands. The field unit also transmits all actuator status and alarm diagnostic messages over the same communication network.

DDC network

- Single-ended loop (consult factory)
- Modbus protocol
- High-speed – up to 19.2 k baud

Master Station IV

MXb actuator units equipped with DDC can be controlled via Flowserve Limitorque's Master Station IV. It includes:

- Network control (up to 250 devices)
- Host interface – Industry standard Modbus Rtu, ASCI, UDP, and TCP/IP protocols and control
- 165.1 mm (6.5 in) TFT touch-screen display for network configuration status
- Configurable poling sequence priority
- Network time protocol for time synchronization of alarms diagnostics data to host device
- Modular hot-swappable redundant design; modules can operate independently or be externally coupled to form redundant communications
- Email notifications of alarm conditions
- Data/event logging

Foundation Fieldbus communication with device type manager (DTM) technology

The MXb actuator can be fitted with Foundation Fieldbus protocol that complies with the IEC 61158-2 Fieldbus H1 standard. The field unit device is able to support several topologies such as point-to-point, bus with spurs, daisy chain, tree, or a combination of these. The FF device has network features that include:

- Link Active Scheduler (LAS) that controls the system
- High-speed communications up to 31.25 kbits/sec
- Publisher-subscriber communication
- Input and output function blocks
- Device descriptions
- Network communication
- Configurable by user

Link Active Scheduler communication: Fieldbus segments have one active LAS at a given time, which is the bus arbiter, and does the following:

- Recognizes and adds new devices to the link
- Removes non-responsive devices from the link
- Schedules control activity in, and communication activity between, devices
- Regularly polls devices for process data
- Distributes a priority-driven token to devices for unscheduled transmissions
- DTM technology includes PID (proportional integral derivative) and partial stroke (PS) features

PROFIBUS DP V1 communication with DTM

The MXb actuator can be fitted with Profibus DP_V1 protocol field units that comply with EN50170 Fieldbus Standard for RS-485 communications. The device supports several topologies such as point-to-point, bus with spurs, daisy chain, tree, or a combination of these. The PB device has network features that include:

- High-speed communications up to 1.5 Mbps
- Master-to-slave communication
- Standby communication channel
- Analog and digital input and output function blocks
- Device descriptions configurable by the user
- High-Speed Data Exchange – Startup Sequence
- Power On / Reset – Power On / Reset of master or slave
- Parameterization – download of parameters into field device (selected during configuration by the user)
- I/O configuration – download of I/O configuration into the field device (selected during configuration by the user)
- Data exchange – cyclic data exchange (I/O Data) and field device reports diagnostics
- Redundant Profibus DP with single or multiple – master communications

PROFIBUS PA communication with DTM

A Profibus PA protocol is available and complies with EN50170 Fieldbus Standard and Fieldbus physical layer per IEC 61158-2 for communications. The device supports several topologies such as point-to-point, bus with spurs, daisy chain, tree, or a combination of these. The PB device has network features that include:

- High-speed communications up to 31.25 kbits/s with Manchester coding
- Master-to-slave communication
- Bus powered for 9 to 32 VDC and 15 mA per actuator
- Standby communication channel
- Analog and digital input and output function blocks
- Device descriptions
- Configurable by user

The Profibus DP-V1/PA DTM V 1.0 is a software component that contains device-specific application information. The DTM can be integrated into engineering and FDT frame applications, such as stand-alone commissioning tools or asset management systems that are equipped with FDT interfaces. FDT technology is independent from any specific communication protocol, device software or host system, allowing any device to be accessed from any DCS host through any protocol.

DeviceNet

DeviceNet complies with CAN-based protocol and provides the following features:

- DeviceNet Group 2 Server implementation
- Master-to-slave communication
- Bus-powered network interface allows power alarm information to be communicated when actuator loses main power; the actuator does NOT drop off the network when power is lost
- Standard polled I/O connection
- Standard bit strobed I/O connection
- Standard change of state / cyclic I/O connection
- Standard explicit connections defined as:
  - Various assembly objects and sizes that allow the network user to determine how much data to transfer to accommodate network installation data throughput requirements
  - Automatic baud rate detection
  - Node address configurable via local setup menu or via the remote network user
  - Broadcast or group network originated ESD support

HART Communication with DTM

- Complies with HART Communication Protocol Specification (Document HCF_SPEC-13) for Revision 7.3
- Digital signal on conventional 4-20m ADC analog signal
- 1,200 bps binary phase — continuous Frequency-Shift-Keying
- Master-Slave communication method
- Point-to-point or multi-drop network topology
- Distances up to 1800 meters/network (up to 15 devices)
- EDDL (IEC 61804-2, EDDL) with methods for all supported common practice and device-specific commands

MXb series performance ratings for units 05 through 150

MX-05 through MX-40 (three-phase: 50 Hz/380, 400, 415 and 440 Volt: 60 Hz/208, 230, 380, 460, 480, 525, 575 Volt)
MX-85 through MX-150 (three-phase: 50 Hz/380*, 400 and 415 Volt: 60 Hz/380, 460, 575 Volt)

*380/50 multiply by 0.9

Output Speed (RPM)		MX-05		MX-10		MX-20		MX-40		MX-85		MX-140		MX-150	
		Rated Output Torque													
60 Hz	50 Hz	ft-lb	N m	ft-lb	N m	ft-lb	N m	ft-lb	N m	ft-lb	N m	ft-lb	N m	ft-lb	N m
18	15	55	75	125	170	225	305	440	597	n/a	n/a	n/a	n/a	n/a	n/a
26	22	55	75	125	170	225	305	440	597	850	1,153	1,500	2,036	n/a	n/a
40	33	55	75	125	170	225	305	440	597	1,225	1,662	1,700	2,307	n/a	n/a
52	43	55	75	125	170	225	305	440	597	1,150	1,561	1,600	2,171	n/a	n/a
77	65	48	65	107	145	178	241	345	468	850	1,153	1,200	1,628	n/a	n/a
100 131[1]	84 110[1]	39	53	89	121	148	201	286	388	600	814	815	1,105	1,500	2,036
155 170[1]	127 143[1]	41	56	89	121	140	190	260	353	450	611	650	882	1,150	1,561
200	165	34	46	73	99	114	155	210	285	n/a	n/a	n/a	n/a	n/a	n/a

Note 1: MX-85, MX-140 and MX-150

Type A Couplings	lb	kN	lb	kN	lb	kN	lb	kN	lb	kN	lb	kN	lb	kN
Thrust ratings (lb/kN)	8,000	35	15,000	66	25,000	111	36,000	160	50,000	222	75,000	333	75,000	333
B4 Base (Torque Only)	**lb**	**kg**	**lb**	**kg**	**lb**	**kg**	**lb**	**kg**	**lb**	**kg**	**lb**	**kg**	**lb**	**kg**
Weights (lb/kg)	52	24	65	29	109	49	133	60	250	114	300	136	431	182

A1 Base (Thrust Only) Weight	lb	kg
MX-05 & MX-10	9	4
MX-20 & MX-40	29	13
MX-85 w/ F16/FA16 base	72	33
MX-140 & MX-150 w/ F25/FA25 base	111	50

Linear Base Weight	lb	kg
LB1	24	11
LB2	65	29.5

Maximum stem capacity

Type A Couplings	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
Type A1	1.26	32	1.57	40	2.36	60	2.64	67	3.50	88	3.50	88	3.50	88
Type A1E (extended nut)	1.26	32	1.57	40	2.36	60	2.64	67	3.50	88	3.50	88	3.50	88
Type B Couplings (Torque Only)[2]	**in**	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**
Type B4	1	25.4	1.25	30	1.94	50	2.2	55	2.88	73	2.88	73	2.625	65
Type B4E (extended)	0.75	19	0.91	22	1.56	41	1.78	46	2.25	57	2.25	57	2.625	65
Type B1 (fixed bore)[2]	n/a	42	n/a	42	n/a	60	n/a	60	n/a	n/a	n/a	n/a	n/a	n/a
Type BL (splined)	6 & 36 Splines		6 & 36 Splines		6 & 36 Splines		6 Splines		n/a	n/a	n/a	n/a	n/a	n/a
Maximum Bore and Keyway	**in**	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**	**in**	**mm**
Maximum bore (B4)	1	25.4	1.25	30	1.94	50	2.2	55	2.88	73	2.88	73	2.625	65
Maximum key dimensions	¼ sq.	8 x 7	¼ sq.	10 x 8	½ x ⅜	14 x 9	½ x ⅜	16 x 10	5/8 x 7/16	18 x 11	5/8 x 7/16	18 x 11	5/8 x 7/16	18 x 11
Maximum bore (B4E)	.75	18	0.91	22	1.56	41	1.78	46	2.25	56	2.25	56	2.50	65
Maximum key dimensions	3/16 sq.	6 x 6	¼ sq.	8 x 7	⅜ sq.	12 x 8	½ x ⅜	14 x 9	½ x ⅜	16 x 10	½ x ⅜	16 x 10	0.625 sq.	18 x 11

Note 2: Maximum bores for Type B couplings may require rectangular keys.

	MX-05	MX-10	MX-20	MX-40	MX-85	MX-140	MX-150
Mounting base (MSS SP-102/ISO 5210)	FA10/F10	FA10/F10	FA14/F14	FA14/F14	FA16/F16	FA25/F25	FA25/F25
Handwheel ratio (STD/Optional)	Direct	Direct/8:1	Direct/12:1	Direct/24:1	16/48	16/48	16/48
Side-mounted handwheel efficiencies	n/a	52%	54%	51%	53%/51%[4]	53%/51%[4]	53%/51%[4]

MXb actuator standard and optional features

Limitorque MXb electric valve actuators are designed for the operation of ON-OFF and modulating valves. They include a three-phase electric motor, worm gear reduction, absolute encoder, electronic torque sensor, reversing motor contactor, electronic control, protection and monitoring package, handwheel for manual operation, valve interface bushing, 240x160 pixel resolution LCD and local control switches — all contained in an enclosure sealed to NEMA 4, 4X, 6 and IP68. XP enclosures can also be provided when required. All MXb actuators comply with applicable European Directives and exhibit the CE mark.

Power transmission and lubrication

All mechanical gearing components are bearing supported, and final drive (output) consists of a hardened alloy steel worm and alloy worm gear. All gears are immersed in an oil bath lubricated with a synthetic oil designed specifically for extreme pressure worm and worm gear transmission service. Special lubricants are available for operation in temperatures of less than -30°C (-22°F). Consult factory.

Lubrication and temperature range	Synthetic brand
Standard lubrication: -30°C to 70°C (-22°C to 158°F)	Mobile SHC 323
Optional food-grade lubrication: -30°C to 70°C (-22°C to 158°F)	Dow Molykote

Motor, three-phase ACV

The MXb actuator's motor is a three-phase squirrel cage designed for electric valve actuators. It is specifically designed for the MXb actuator and complies with IEC 34, S2-33% duty cycle at 33% of rated torque. The motor is a true bolt-on design with a quick-disconnect plug that can be changed rapidly without sacrificing motor leads. It is equipped with a solid-state motor thermistor to prevent damage due to temperature overloads.

On-off modulating
• Standard insulation class is F to IEC 34; S4_50% for stated operating times is 100 to 600 starts per hour. • SSMR: 600 to 1,200 starts per hour; IEC 34, S4_50% is 1,200 starts per hour.

The MXb actuator's motor permits a global range of three-phase voltages to be connected without modification. The motor can energize, provided either of the listed voltages are connected:

Phase/frequency	Application Voltage
Three-phase: 60 Hz	208, 220, 230, 240, 380, 440, 460, 480, 550, 575
Three-phase: 50 Hz	380, 400, 415, 440, 525

Electronic control modules

Non-intrusive

The MXb actuator is non-intrusive, which means that all calibration/configuration is possible without removing any covers and without the use of any special tools. All calibration is performed in clear text languages; no icons are used. All configuration is performed by answering the "YES" and "NO" questions displayed on the LCD. "YES" is signaled by using the OPEN switch and "NO" by using the CLOSE switch, as indicated adjacent to the switches.

Double-sealed terminal compartment and terminal block

All customer connections are located in a terminal chamber that is separately sealed from all other actuator components. Site wiring doesn't expose actuator components to the environment. The internal sealing within the terminal chamber is suitable for NEMA 4, 6 and IP68 to 15M for 96 hours. The terminal block includes screw-type terminals: three for power and 54 for control. Customer connections are made via conduits located in the terminal housing.

Three standard conduit openings (NPT threads standard; M optional)
(2) – 1.25 in NPT or M32 (optional) (1) – 1.5 in NPT (standard) or M38 (optional) (1) – 1.0 in NPT (optional) or M25 (optional)

Controls

The controls are all solid state and include power and logic circuit boards and a motor controller that performs as the motor reverser, all mounted to a steel plate and attached in the control compartment with captive screws. All internal wiring is flame resistant, rated 105°C (221°F), and UL/CSA listed.

The controls are housed in the ACP (actuator control panel) cover, and the logic module uses solid-state Hall effect, devices for local communication and configuration. A 240x160 resolution, graphical LCD is included to display valve position as a percent of open, 0 to 100% and current actuator status. Red and green LEDs are included to signal 'Opened' and 'Closed,' and are reversible, and a yellow LED to indicate 'Valve Moving.' A blue LED is included to indicate when the Bluetooth feature is recognized by an external Bluetooth LE-enabled device and a white LED to indicate 'Overtorque Fault' or 'Torque Seated'. A padlockable LOCAL-STOP-REMOTE switch and an OPEN-CLOSE switch are included for local valve actuator control.

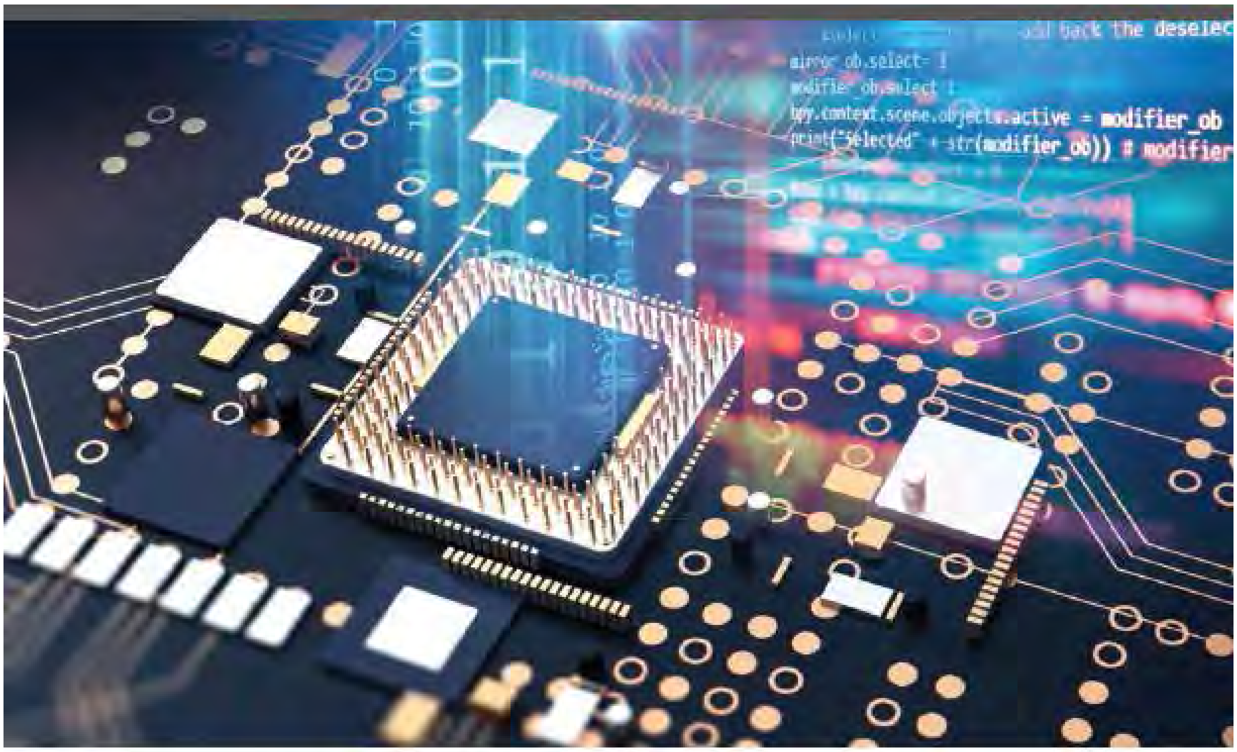
Using the knobs and LCD screen, the MXb actuator is configurable in 11 languages: English, Spanish, French, German, Portuguese, Italian, Mandarin, Russian, Bahasa Indonesia, Turkish and Katakana. A rotary knob provides ease of menu maneuvering.

S contacts for remote indication

As standard, four latching status contacts rated 250 VAC, 5A and 30 VDC, 5A are provided for remote indication of valve position, configured as 1-N/O and 1N/C for both the open and closed positions. The contacts may be configured in any of the selections depicted in the "Actuator Status Message" column.

"S" Contact AC	"S" Contact DC
5 Amps @ 250 VAC	5A @ 30 VDC

Actuator Status Message	Function
"Closed"	Valve closed "(0% OPEN)"
"Opened"	Valve open "(100% OPEN)"
"Closing"	Valve closing
"Opening"	Valve opening
"Stopped"	Valve stopped in mid-travel
"Valve Moving"	Either direction
"Local Selected"	Red selector knob in "LOCAL"
"Motor Overtemp"	Thermistor range exceeded
"Overtorque"	Torque exceeded in mid-travel
"Manual Override"	Actuator moved by handwheel
"Valve Jammed"	Valve can't move
"Close Torque SW"	Torque switch trip at "CLOSED"
"Open Torque SW"	Torque switch trip at "OPEN"
"Local Stop/Off"	Red selector knob at "STOP"
"Lost Phase"	One or more of the incoming supply lost
"ESD Signal"	Signal active
"Close Inhibit"	Close inhibit signal active
"Open Inhibit"	Open inhibit signal active
"Analog IP Lost"	4–20 mA not present
"Remote Selected"	Red selector in "REMOTE"
"Hardware Failure"	Indication
"Network Controlled"	Permits relay control via DDC, FF, or other network driver
"Function"	LimiGuard circuit protection activated
"Mid-Travel"	Valve position, 1 to 99% open
"CSE Control"	CSE station in LOCAL or STOP and controls actuator
"PS Active"	Partial stroke test in operation
"PS Passed"	PS test complete and successful
"PS Failed Target"	PS test did not achieve target value
"PS Failed Returns"	PS test did not return to start position
"PS"	Partial stroke, active if "PS" configured
"Run Load Alarm"	Single phase only
"DPTS Open"	Open torque switch trip (open torque seat or open overtorque)
"DPTS Close"	Close torque switch trip (close torque seat or close overtorque)



Monitor relay for remote indication

A monitor relay is included as standard and trips when the actuator is not available for remote operation. Both N/O and N/C contacts are included, rated 250 VAC, 5 A and 30 VDC, 5 A. The monitor relay is hard set for lost phase, valve jammed and motor overtemp, but can be aditionally configured for local knob movement, overtorque, inhibits active or ESD active. The yellow LED will blink when the monitor relay is active. The user can disable the monitor relay, if necessary.

Monitor Relay AC	Monitor Relay DC
5 Amps @ 250 VAC	5A @ 30 VDC

Remote control

Discrete remote control (user supplied) may be configured as two, three or four wires for Open-Stop-Close control. Remote control functions may be powered by external 24 VDC, 110 VAC, or the actuator's internal 24 VDC supply or optional 110 VAC supply. The internal supplies are protected against over-current and short circuit faults and utilize optical isolation to minimize electromagnetic interference. Discrete control provides isolated commons for up to three selections.

Signal Threshold for Voltage Values	Maximum Load
5.0 VAC/VDC maximum 'OFF'	24 VDC + 2 mA
19.2 VAC/VDC minimum 'ON'	110 VAC + 10 mA

Speed control

The MXb actuator permits operational speeds in either Open and Closed directions to be set independently of each. It also has an industry-leading span for the optional two-speed timer.

Two-Speed Timer Span "On" Pulse	Two-Speed Timer Span "Off" Pulse
0.5 to 20 seconds (0.5 sec. increments)	1.0 to 200 seconds (1.0 sec. increments)

Software

LimiGard

A dedicated circuit to prevent undesired valve operation in the event of an internal circuit fault or erratic command signal is included as standard on each Limitorque electric actuator. A single point failure will not result in erratic actuator movement nor will an open or short circuit in the internal circuit board logic energize the motor controller. The command inputs are optically coupled and require a valid signal pulse width from at least 250 to 350 ms to either turn on or off. In the event of an internal circuit fault, an alarm is signaled by tripping the monitor relay and through LCD indication. The control module also includes an auto reversal delay to inhibit high-current surges caused by rapid motor reversals.

Phase detection and correction (three-phase)

A phase correction circuit is included to correct motor rotation faults caused by incorrect site wiring or phase switching in the event of a power down. The phase correction circuit also detects the loss of a phase and disables operation to prevent motor damage. The monitor relay will trip and an error message is displayed on the LCD screen when loss of phase occurs.

Multi-mode remote control

The MXb actuator is capable of being configured for multi-mode remote control, which permits discrete wiring for either two, three or four wires, or network (Fieldbuses) for Open-Stop-Close control and responds to the last signal received. The actuator can also distinguish analog control for modulating applications. The QX and MX products from Limitorque are the only smart actuators with such features.

ESD

An emergency shutdown (ESD) provision is included in each actuator, and the MXb actuator has up to three configurable inputs for ESD. The ESD signal(s) can be selected to override any existing signal and send the valve to its configured emergency position. Provision for an isolated common is standard.

Inhibits

The MXb actuator has as standard provisions for inhibit movement and also contains up to three configurable inputs. Provision for an isolated common is also standard.

Advanced diagnostics

The MXb actuator incorporates advanced diagnostics that provide greater process visibility and control. It features an enhanced, **NAMUR NE107-compliant,** diagnostic notification system that provides higher process control by alerting the operator of alarm and event conditions through an internationally accepted symbol standard.

The MXb actuator tracks the actuator's environment and performance through a sophisticated set of sensors and **monitors for any deviations** that might be outside of specified tolerances. Voltage, operation, torque and vibration, to name a few, are some of the diagnostics tracked to give the user a more active approach to maintaining their equipment before failures or damage occur.

The MXb actuator provides **time-stamped data logging** capability to track local and remote move commands as well as events and alarms. The data logger event and alarm list is configurable and can store thousands of historical actions time-stamped by an RTC. The RTC is backed up by a battery with an operating life of 10+ years.

The MXb actuator also has a high-resolution graphical display that allows for local display of the actuator's diagnostics. The MXb actuator can display profiling of all sensor data with relation to position. It can display live and historical torque profiles with the ability to inspect the profile for exact torque and position values.

Valve and actuator position sensing

Valve position is sensed by an 18-bit, optical, absolute position encoder with redundant position-sensing circuits designed for BIST. Each of the position-sensing circuits is redundant, facilitating BIST. The BIST feature discerns which failures will signal a warning only and which require a warning plus safe shutdown of the actuator. Open and closed positions are stored in permanent, non-volatile memory. The encoder measures valve position at all times, including both motor and handwheel operation, with or without power present, and without the use of a battery. The absolute encoder is capable of resolving ±7° of output shaft position over 10,000 output drive rotations. This design permits continuous monitoring of valve position during motor and handwheel operation. The encoder is 100% repeatable and requires no backup power source for operation. The output is used to control the open and closed valve positions and measure and report valve position, as well as provide local and remote position feedback. The positioning accuracy is better than 99% for valves requiring 50 or more turns.

- Maximum actuator turns = 10,000
- Resolution = ± 7 degrees

Valve and actuator torque sensing

The MXb and QX are the only electric actuators that sense torque electronically. A microprocessor calculates output torque from motor speed, voltage and temperature. Torque limit may be set from 40 to 100% of rating in 1% increments. A "Jammed Valve Protection" feature is included to de-energize the motor if the output torque requirement exceeds the boost torque. A boost function is included to prevent torque trip during initial valve unseating and extreme arctic temperature operation (from 0°C down to -60°C [32°F down to -76°F]).

Exterior corrosion protection

As standard, the MXb actuator is coated with a polymer powder coat suitable for exposure to an ASTM B117 salt spray test of 2,000 hours. External fasteners are 300 series stainless steel. Optional coatings are available by contacting the factory.

Manual operation

A handwheel and declutch lever are provided for manual operation. The handwheel is metal, and changing from motor to manual operation is accomplished by engaging the declutch lever. Energizing the motor returns the MXb actuator to motor operation. The lever is padlockable in either motor or manual operation. Optional configurations for handwheels are available by consulting the factory.

Factory testing

Every MXb actuator is factory-tested to verify rated output torque, output speed, handwheel operation, local control, control power supply, valve jammed function, all customer inputs and outputs, motor current, motor thermistor, LCD and LED operations, direction of rotation, microprocessor checks and position-sensor checks. A report confirming successful completion of testing is included with the actuator. Special testing can also be performed by contacting the factory.

Design life and endurance testing

- Design life – One million drive sleeve turns is considered typical life expectancy under normal operating conditions and approved ambient working environments.
- Endurance – 50 million collective drive sleeve turns of endurance testing were performed on the MXb actuator for proof of design.
- AWWA C540-02 – "Standard for Power Actuating Devices for Valves and Sluice Gates" – 10,000 cycles with confirmation of specified torque and position accuracy

Optional features

Analog position transmitter

A non-contacting, internally powered, electrically isolated position transmitter can be included to provide a 4-20 mA or 0 to 10 VDC signal that is proportional to valve position.

Analog torque transmitter

A non-contacting, internally powered, electrically isolated torque transmitter can be included to provide a 4-20 mA or 0 to 10 VDC signal that is proportional to rated output torque.

Voltages or Currents for APT/ATT	Maximum/Minimum External Load—APT/ATT
4-20 mA	470 ohms—99.9% accuracy 750 ohms for 99% accuracy
0 to 10 VDC	1,000 ohms minimum—99.9% accuracy 2,700 ohms minimum—99% accuracy

Modutronic option

A controller that alters valve position in proportion to a 4-20 mA analog command signal can be ordered. Positioning is accomplished by comparing the command signal to a noncontacting internal position feedback. An automatic pulsing feature to prevent overshoot at the setpoint is included. Proportional bands, deadband, signal polarity, motion inhibits time and fail are adjustable using the Local control mode of configuration. Deadband is adjustable to +/- 0.5% full span.

Voltages or Currents for Modulation	Input Impedance/ Capacitance
4-20 mA	470 ohms—99.9% accuracy 750 ohms for 99% accuracy
0 to 10 VDC	1,000 ohms minimum—99.9% accuracy 2,700 ohms minimum—99% accuracy

Relays for status and alarms

Up to four additional latching output contacts rated 250 VAC/ 30 VDC, 5 A and configurable to represent any actuator status in either N/O or N/C state are available. Please refer to "Status and Alarm Contacts for Remote Indication" for list of settings.

"R" Contact and AC Ratings	"R" Contact and DC Ratings
5.0 Amps @ 250 VAC	5A @ 30 VDC (resistive)

Global certifications

Non-hazardous (weatherproof / submersion) certifications IEC 529 protection code IP68; 15 meters for 96 hours USA; NEMA 3, 4, NEMA 4X, NEMA 6

Geographic Locations	Weatherproof/Submersion	Standard Temperature
IEC 529 Protection Code IP68	15M for 96 hours	-30°C to 65°C (-22°F to 149°F)
USA & Canada, NEMA 3, 4, 6	20 ft for 24 hours	-30°C to 70°C (-22°F to 158°F)
USA & Canada, NEMA 4X	1,500 hrs. to ASTM B117	-30°C to 70°C (-22°F to 158°F)

Standard hazardous global certifications

- FM – Class I, Groups B, C & D, Div. 1 & Class II, Groups E, F & G, T4
- ATEX EExd IIB T4 ATEX II 2 G, CENELEC Norm EN 60079-0:2006 and EN 60079-1:2004
- ATEX EExd IIC T4 ATEX II 2 G, CENELEC Norm EN60079-1:2004
- EEx de IIB T4 ATEX II G, Increased Safety, CENELEC Norm EN 60079-7:2003
- ATEX EEx de II C T4
- IECEx d IIC, T4, Gb, X from -20°C to 60°C (-4°F to 140°F)
- IECEx de IIB/IIC, T4, Gb, X from -20°C to 60°C (-4°F to 140°F)
- IECEx d IIB (or IIC) T4 -20°C (-4°F) ≤ TAMB ≤ +60°C; IP68 - Size 05, 10, 20, 40, 85, 140 or 150
- IECEx d e IIB (or IIC) T4 -20°C (-4°F) ≤ TAMB ≤ +60°C; IP68 - Size 05, 10, 20, 40, 85, 140 or 150. Group IIC design also available and requires special construction. Contact factory Inmetro - same as IECEx, except that -60°C (-76°F) is N/A.

Geographic Locations	Explosion-proof Classifications	Standard Temperature
USA to Factory Mutual (FM)	Class I, Groups B, C, & D, Div. 1, T4 and Class II, Groups E, F, & G, Div. 2, T4	-30°C to 65°C (-22°F to 149°F)
ATEX II 2 G, CENELEC Norm EN 50014 & 50018	Eex d IIB T4, Eex d IIC T4, and Eex de IIB T4, Eex de IIC T4	-30°C to 65°C (-22°F to 149°F)
IECEx	Ex d IIB T4; IP68 & Ex d IIB (or IIC) T4; IP68 & Ex d e IIB (or IIC) T4	-20°C to 60°(-4°F to 140°F)

Note: Options are available to -60°C (-74°F) for TR-CU (Russia). Consult factory for availability. *Consult factory for limitations.

European directives

All MXb actuator designs have been tested to comply with pertinent EU Directives and shipped with the Declaration of Conformity listed in the Regulatory Section of VAIOM000071. The actuator is also tagged with the CE mark to demonstrate compatibility with the following European Directives:

All MXb actuator designs have been tested to demonstrate compatibility with the following European directives and are marked with the CE label:

- 2006/42/EC – Machinery Directive
- Vibration and seismic capability is in accordance with MILSTD-167, IEEE-344-1975 and IEC68-2-6. Test performed in each of three (3) axes, H1, horizontal – parallel to motor, H2, horizontal – perpendicular to motor, and "V1," vertical

Vibration Levels (MX actuator functions after event)	Seismic Levels (MX actuator functions after event)
5 to 100 Hz sine sweeps, 0.75g 3 axes	2 Hz 2g, 2.5 to 35 Hz 3g, sine dwell, 3 axes
5 to 500 Hz sine sweeps, 1.0g 3 axes	1 Hz 0.5g, 2 to 50 Hz 1g, sine sweeps, 3 axes
25 Hz 2g, 40 to 200 Hz 3g, sine dwells, 3 axes	

- 2006/42/EC – Airborne Noise to EN 60204-1. The MXb actuator has been tested for noise emissions and at 1 m (3.3 ft) distance is less than 74 dB per grade A noise requirement of MIL-STD-740 and ANSI/ISA-S82.01-1994 (harmonized std. to IEC 1010-1).
- 2014/30/EU -EMC – Electromagnetic Compatibility and 2014/35/EU Low Voltage; EN 50081-1 & 2 – Three-phase ACV actuator actuator complies with all pertinent requirements of Class A service categories in the listed table.

Three-phase ACV actuators comply with all pertinent requirements of Class A service categorizes in the listed table:

Applicable Emissions Standards	EN61326-1 (CISPR11)	Industrial Environments - Class A - Test Limits & Levels	
Radiated Emissions	EN55011:2009+A1:2010 (CISPR11)	30 MHz to 230 MHz 230 MHz to 1 GHz	40 dB (µV/m) 47 dB (µV/m)
	FCC Part 15, (CFR47 Part 15.109)	30 MHz to 88 MHz 88 MHz to 216 MHz 216 MHz to 960 MHz > 960 MHz	90 dB (µV/m) 150 dB (µV/m) 210 dB (µV/m) 300 dB (µV/m)
Conducted Emissions	EN55011:2009+A1:2010 (CISPR11)	150 kHz to 500 kHz 500 kHz to 30 MHz	79 dB (µV) (quasi-pk), 66 dB (µV) (avg) 73 dB (µV) (quasi-pk), 60 dB (µV) (avg)
	FCC Part 15, (CFR47 Part 15.107)		
Applicable Immunity Standards		**Industrial Environments - Test Limits & Levels**	
ESD	IEC61000-4-2 (B)	Air: AC, DC, Signal	±2 kV, ±4 kV, ±8 kV
		Contact: AC, DC, Signal	±1 kV, ±2 kV, ±4 kV
Radiated RF Immunity	IEC61000-4-3 (A)	Enclosure @ 80 MHz to 1 GHz	10 Vrms/m @ 80% AM, 1 kHz
		Enclosure @ 1 GHz to 2.7 GHz	3 Vrms/m @ 80% AM, 1 kHz
Fast Transients/Burst	IEC61000-4-4 (B)	AC, Signal	±2 kV, ±1 kV
Voltage Surges	IEC61000-4-5 (B)	Common: AC, Signal Differential: AC, Signal	±2 kV, ±1 kV ±1 kV, ±1 kV
Conducted RF Immunity	IEC61000-4-6 (A)	AC @ 150 kHz to 80 MHz	10 Vrms @ 80% AM, 1 kHz
Magnetic Field Immunity	IEC61000-4-8 (A)	Three mounting axis	30 A/m
Voltage Dips and Interrupts	IEC61000-4-11 (B)	3 dips, 10 sec apart	> 95% dip for 1 cycle @ 50/60 Hz 30% dip for 500 ms @ 50/60 Hz 60% dip for 200 ms @ 50/60 Hz
	IEC61000-4-11 (C)	3 dips, 10 sec apart	> 95% interrupt for 5 sec @ 50/60 Hz

Conduit entries

Three threaded conduit entries are provided tapped: 1 x 1½ in and 2 x 1¼ in NPT. Unless otherwise specified, actuator will be dispatched with adapters: 1 x M40 and 2 x M32 metric to BS3643; PG adapters are available upon request. An optional, fourth conduit, tapped to 1.0 in NPT or 25 mm, is available.

- Di-electric – Motor per NEMA MG1-12.02 and 0.03 with leakage of less than 10 mA. Control terminals per IEC-1131-2 with check against physical breakdown.

Click here to return to Waterpilot (PS)

XII. Exhibit Q

Technical Information
Waterpilot FMX21

Hydrostatic level measurement
Compact device for level measurement in fresh water, wastewater and saltwater, communication via HART

Reliable and robust level probe with ceramic measuring cell

Application

The Waterpilot FMX21 is a pressure sensor for hydrostatic level measurement. Endress+Hauser offers three different versions of the FMX21 sensor:

- FMX21 with a stainless steel housing, outer diameter of 22 mm (0.87 in): Standard version suitable for drinking water applications and for use in bore holes and wells with small diameters.
- FMX21 with a stainless steel housing, outer diameter of 42 mm (1.65 in): Heavy duty version, easy clean flush-mounted process diaphragm. Ideally suited for wastewater and sewage treatment plants.
- FMX21 with a plastic insulation, outer diameter of 29 mm (1.14 in): Corrosion resistant version generally for use in saltwater, particularly for ship ballast water tanks.

Your benefits

- High resistance to overload and aggressive media
- High-precision, robust ceramic measuring cell with long-term stability
- Climate proofed sensor thanks to completely potted electronics and 2-filter pressure compensation system
- 4 to 20 mA with superimposed HART 6.0 output signal
- Simultaneous measurement of level and temperature with optionally integrated Pt100 temperature sensor
- Accuracy
  - Reference accuracy ±0.2 %
  - PLATINUM version ±0.1 %
- Automatic density compensation to increase accuracy
- Usage in drinking water: KTW, NSF, ACS
- Approvals: ATEX, FM, CSA
- Marine certificate: GL, ABS, LR, BV, DNV
- Extensive range of accessories provides complete measuring point solutions

Table of contents

Document information

Document conventions

Safety symbols

Symbol	Meaning
⚠ DANGER	DANGER! This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in seriousor fatal injury.
⚠ WARNING	WARNING! This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in seriousor fatal injury.
⚠ CAUTION	CAUTION! This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minoror medium injury.
NOTICE	NOTICE! This symbol contains information on procedures and other facts which do not result in personalinjury.

Electrical symbols

Symbol	Meaning
⎓	**Direct current** A terminal to which DC voltage is applied or through which direct current flows.
∼	**Alternating current** A terminal to which alternating voltage is applied or through which alternating current flows.
≂	**Direct current and alternating current** ▪ A terminal to which alternating voltage or DC voltage is applied. ▪ A terminal through which alternating current or direct current flows.
⏚	**Ground connection** A grounded terminal which, as far as the operator is concerned, is grounded via a grounding system.
⊜	**Protective ground connection** A terminal which must be connected to ground prior to establishing any other connections.
⏛	**Equipotential connection** A connection that has to be connected to the plant grounding system: This may be a potential equalization line or a star grounding system depending on national or company codes of praxis.

Symbols for certain types of information

Symbol	Meaning
	**Tip** Indicates additional information.
	**Reference to page** Refers to the corresponding page number.

Symbols in graphics

Symbol	Meaning
1, 2, 3, 4, ...	Item numbers
A, B, C, D, ...	Views

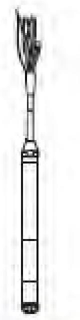
	**Hazardous area** Indicates a hazardous area.
	Safe area (non-hazardous area) Indicates a non-hazardous location.

Symbols at the device

Symbol	Meaning
	**Connecting cable immunity to temperature change** Indicates that the connecting cables must be able to withstand temperatures of at least 85 °C (185 °F).

Function and system design

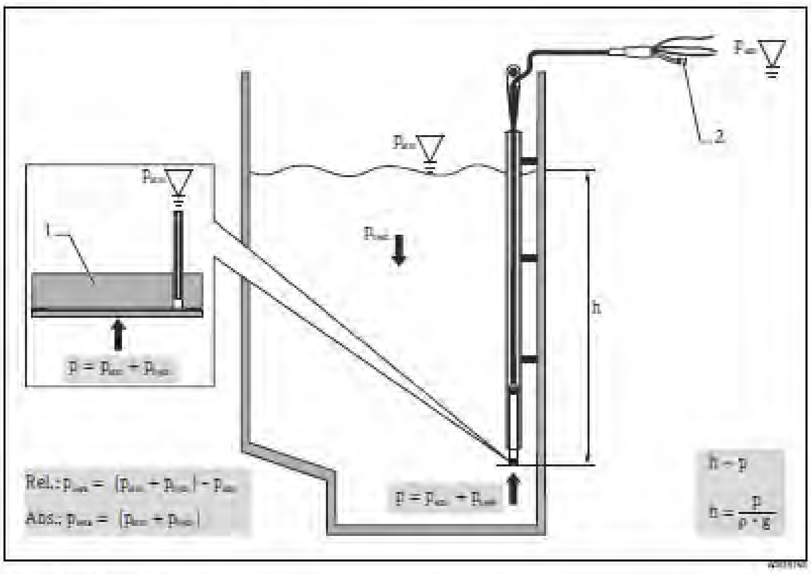
Device selection

Waterpilot FMX21			
Field of application	Hydrostatic level measurement in deep wells e.g. drinking water	Hydrostatic level measurement in wastewater	Hydrostatic level measurement in saltwater
	NOTICE **The Waterpilot is not suitable for use in biogas plants since the gases can diffuse through the elastomers (seals, extension cable).** ▸ For applications with biogas Endress+Hauser offers the level transmitter Deltapilot.		
Process connection	▪ Mounting clamp ▪ Extension cable mounting screw with G 1½" A or NPT 1½" thread		
Outer diameter	22 mm (0.87 in)	42 mm (1.65 in)	max. 29 mm (1.14 in)
Extension cable	PE, PUR, FEP (→ 25)		
Seals	▪ FKM Viton ▪ EPDM [1]	FKM Viton	▪ FKM Viton ▪ EPDM [1]
Measuring ranges	▪ Gauge pressure: from 0 to 0.1 bar to 0 to 20 bar (0 to 1.5 psi to 0 to 300 psi) ▪ Absolute pressure: from 0 to 2 bar to 0 to 20 bar (0 to 30 psi to 0 to 300 psi)		▪ Gauge pressure: from 0 to 0.1 bar to 0 to 4 bar (0 to 1.5 psi bis 0 to 60 psi) ▪ Absolute pressure: from 0 to 2 bar to 0 to 4 bar (0 to 1.5 psi bis 0 to 60 psi)
	▪ Customer-specific measuring ranges; factory-calibrated ▪ The following output units can be configured: %, mbar, bar, kPa, MPa, mmH_2O, mH_2O, inH_2O, ftH_2O, psi and numerous level units.		
Overload	Up to 40 bar (600 psi)		Up to 25 bar (375 psi)
Process temperature range	–10 to +70 °C (+14 to +158 °F)		0 to +50 °C (+32 to +122 °F)
Reference accuracy	▪ ±0.2 % of the set span ▪ Optional: ±0.1 % of set span (PLATINUM version)		
Supply voltage	10.5 to 35 V DC, Ex: 10.5 to 30 V DC		
Output	4 to 20 mA (invertible) with superimposed digital communication protocol HART 6.0, 2-wire		
Options	Drinking water approval	—	
	▪ Large selection of approvals, including ATEX, FM, CSA ▪ Broad range of accessories ▪ Integrated Pt100 temperature sensor and TMT182 temperature head transmitter (4 to 20 mA HART) ▪ Marine certificate		
Specialties	▪ High-precision, robust ceramic measuring cell with long-term stability ▪ Automatic density compensation ▪ Customer specific cable marking ▪ Absolute pressure measuring cell		

1) Recommended for drinking water applications and not for use in hazardous areas.

Measuring principle

The ceramic measuring cell is a dry measuring cell, i.e. pressure acts directly on the robust ceramic process isolating diaphragm of the Waterpilot FMX21.
Any changes in the air pressure are routed through the extension cable, via a pressure compensation tube, to the rear of the ceramic process isolating diaphragm and compensated for. A pressure-dependent change in capacitance caused by the movement of the process isolating diaphragm is measured at the electrodes of the ceramic carrier. The electronics then convert this into a signal which is proportional to the pressure and is linear to the level of the medium.



1 *Ceramic measuring cell*
2 *Pressure compensation tube*

h *Level height*
p *Total pressure = atmospheric pressure + hydrostatic pressure*
ρ *Density of the medium*
g *Gravitational acceleration*
$p_{hydr.}$ *Hydrostatic pressure*
p_{atm} *Atmospheric pressure*
p_{sens} *Pressure displayed on the sensor*

Temperature measurement with optional Pt100 resistance thermometer [1]

Endress+Hauser also offers the Waterpilot FMX21 with an optional 4-wire Pt100 resistance thermometer to measure level and temperature simultaneously (→ 30). The Pt100 belongs to Accuracy Class B in accordance with DIN EN 60751.

Temperature measurement with optional Pt100 and TMT182 temperature head transmitter [1]

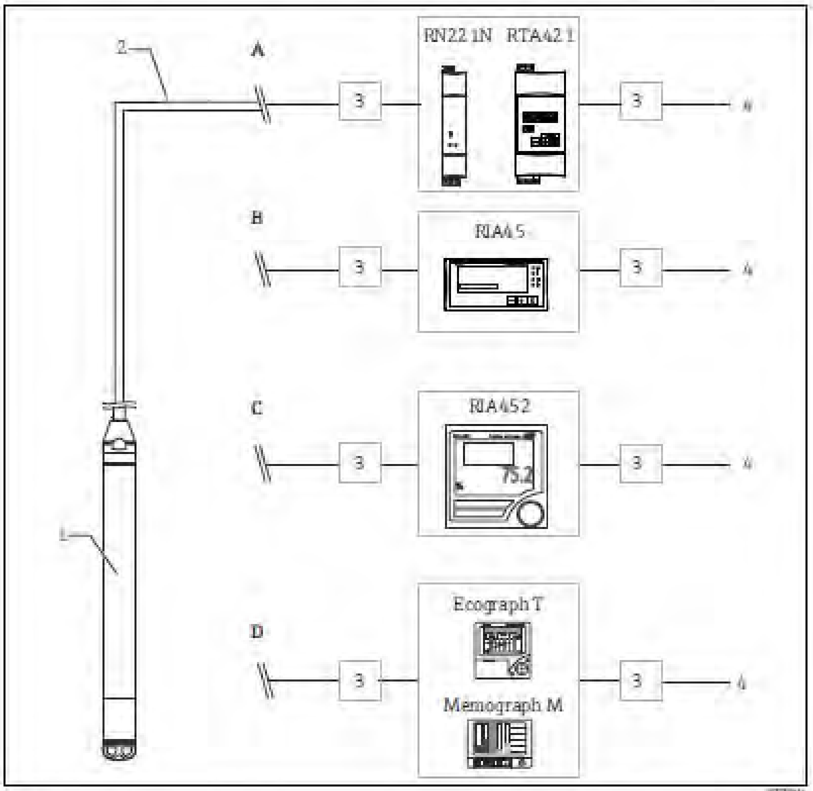
Endress+Hauser also offers the TMT182 temperature head transmitter with the HART protocol to convert the temperature signal to an analog, scalable 4 to 20 mA output signal superimposed with HART 6.0.
See also: "Density compensation with Pt100 temperature sensor" (→ 9); "Ordering information" (→ 28); "Accessories" (→ 30) and Technical Information TI00078R.

1) Not for use in hazardous areas.

Measuring system

As standard, the complete measuring system consists of a Waterpilot FMX21 and a transmitter power supply unit with a supply voltage of 10.5 to 30 V DC (hazardous areas) or 10.5 to 35 V DC (non-hazardous areas).

Possible measuring point solutions with a transmitter and evaluation units from Endress+Hauser:



Application examples

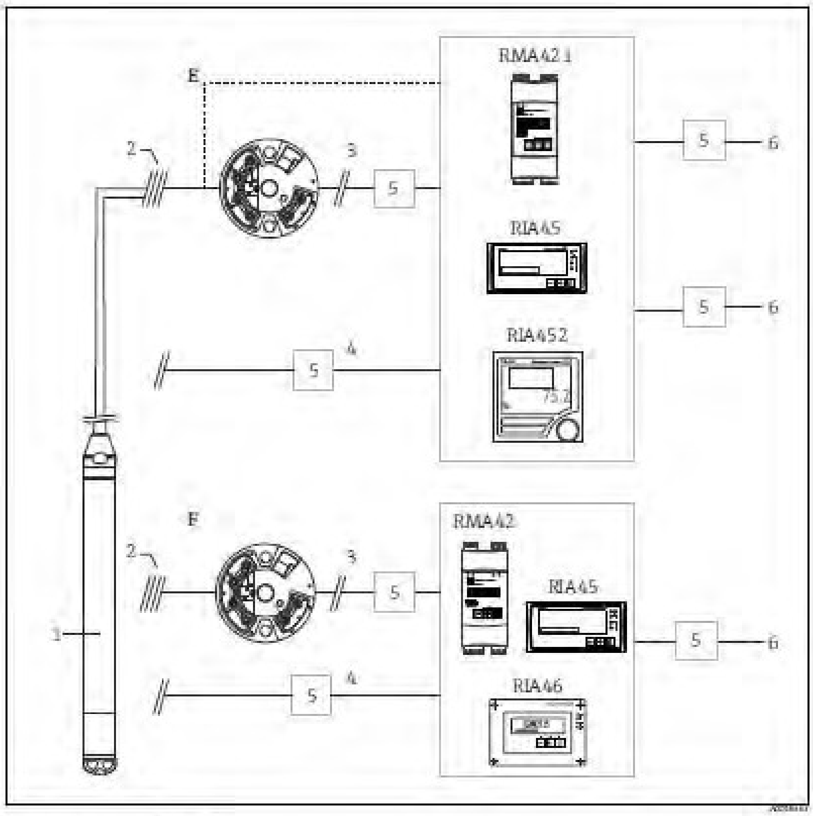
1 *Waterpilot FMX21 HART*
2 *4 to 20 mA HART*
3 *Overvoltage protection (OP), e.g. HAW from Endress+Hauser (not for use in hazardous areas)*
- OP on the sensor side for field installation: HAW569; for top-hat rail/DINrail: HAW562/intrinsically safe HAW562Z
- OP on the supply side for top-hat rail/DINrail: HAW561 (115/230 V) and HAW561K (24/48 V AC/DC)
The overvoltage protection selected must be appropriate for the supply voltage.
4 *Power supply*

A Simple cost-effective measuring point solution: Power supply of Waterpilot in hazardous and non-hazardous areas using RN221N active barrier. Power supply and additional control of two consumers, e.g. pumps, via limit switch RTA421 with onsite display.

B Evaluation unit RIA45 (for panel mounting) provides a power supply system, an onsite display and two switch outputs.

C If several pumps are used, the pump service life can be prolonged by alternate switching. With alternating pump control, the pump which was out of service for the longest period of time is switched on. The evaluation unit RIA452 (for panel mounting) provides this option in additional to several other functions.

D State-of-the-art recording technology with graphic display recorders from Endress+Hauser, such as Ecograph T, Memograph M, or paper recorders such as Alphalog for documenting, monitoring, visualizing and archiving purposes.



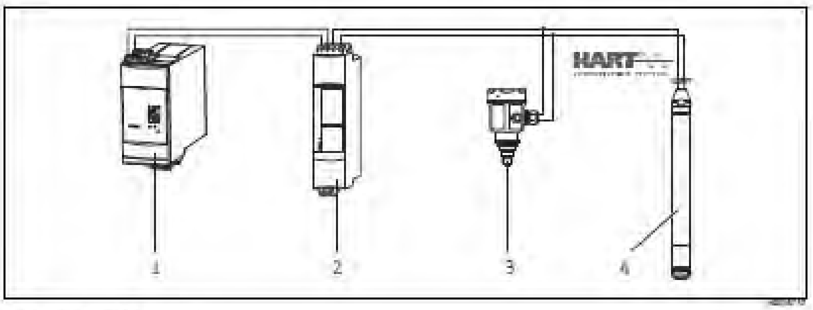
Application examples with Pt100

1	*Waterpilot FMX21 HART*
2	*Connection for integrated Pt100 temperature sensor in the FMX21*
3	*4 to 20 mA HART (Temperature)*
4	*4 to 20 mA HART (Level)*
5	*Overvoltage protection (OP), e.g. HAW from Endress+Hauser (not for use in hazardous areas)* *- OP on the sensor side for field installation: HAW569; for top-hat rail/DINrail: HAW562/intrinsically safe HAW562Z* *- OP on the supply side for top-hat rail/DINrail: HAW561 (115/230 V) and HAW561K (24/48 V AC/DC)* *The overvoltage protection selected must be appropriate for the supply voltage.*
6	*Power supply*

E If you want to measure, display and evaluate the temperature as well as the level, e.g. to monitor temperature in fresh water to detect temperature limits for germ formation, you have the following options:
The optional TMT182 temperature head transmitter can convert the Pt100 signal to a 4 to 20 mA HART signal and transfer it to any common evaluation unit. The RMA421, RIA45 and RIA452 evaluation units also offer a direct input for the Pt100 signal.

F If you want to record and evaluate the level and temperature measured value with one device, use the RMA42, RIA45 and RIA46 evaluation units with two inputs. It is even possible to mathematically link the input signals with this unit. These evaluation units are not HART-compatible.

Level measurement with absolute pressure probe and external pressure signal



1 Fieldgate FXA520
2 Multidrop-Connector FXN520
3 Cerabar
4 Waterpilot FMX21

It is advisable to use an absolute pressure probe for applications in which condensation can occur. In the case of level measurement with an absolute pressure probe, the measured value is affected by fluctuations in the ambient pressure. To correct the resulting measured error, you can connect an external absolute pressure sensor (e.g. Cerabar) to the HART signal cable, switch the waterpilot to the burst mode and the Cerabar to operate in mode "Electr. Delta P".
The external absolute pressure sensor then calculates the difference between the two pressure signals and can thus determine the level precisely. Only one level measured value can be corrected in this way.

If using intrinsically safe devices, strict compliance with the rules for interconnecting intrinsically safe circuits as stipulated in IEC60079-14 (proof of intrinsic safety) is mandatory.

Density compensation with Pt100 temperature sensor

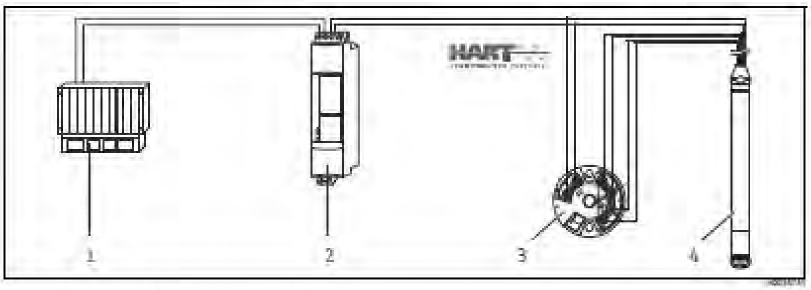
The Waterpilot FMX21 can correct measured errors that result from fluctuations in the density of the water caused by temperature. Users can choose from the following options:

Use the internally measured sensor temperature of the FMX21

The internally measured sensor temperature is calculated in the Waterpilot FMX21 for density compensation. The level signal is thus corrected according to the density characteristic line of the water.

Use the optional internal temperature sensor for density compensation in a suitable HART master (e.g. PLC)

The Waterpilot FMX21 is available with an optional Pt100 temperature sensor. Endress+Hauser additionally offers the TMT182 temperature head transmitter to convert the Pt100 signal to a 4 to 20 mA HART signal.
The temperature and pressure signals are transmitted to the HART master (e.g. PLC) where a corrected level value can be generated using a stored linearization table or the density function (of a chosen medium).

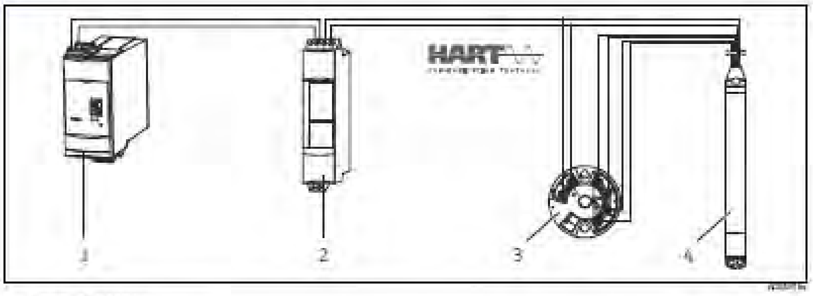


1 HART Master, e.g. PLC (programmable logic controller)
2 FXN520 Multidrop-Connector
3 TMT182 Temperature head transmitter
4 Waterpilot FMX21

Use an external temperature signal which is transmitted to the FMX21 via HART burst mode

The Waterpilot FMX21 is available with an optional Pt100 temperature sensor. In this case, the signal of the Pt100 is analyzed using a HART-compliant (at least HART 5.0) temperature transmitter that supports BURST mode. The temperature signal can thus be transmitted to the FMX21. The FMX21 uses this signal for the density correction of the level signal.

The TMT182 temperature head transmitter is not suitable for this configuration.



1 Fieldgate FXA520
2 Multidrop-Connector FXN520
3 TMT182 Temperature head transmitter
4 Waterpilot FMX21

Without additional compensation due to the anomaly of water, errors of up to 4 % may occur at a temperature of +70 °C (+158 °F), for example. With density compensation, this error can be decreased to 0.5% in the entire temperature range from 0 to +70 °C (+32 to +158 °F).

For further information please refer to the appropriate Technical documentation:
- TI00078R: TMT182 temperature head transmitter (4 to 20 mA/HART)
- TI00369F: FXA520 Fieldgate
- TI00400F: FXN520 multidrop connector

Communication protocol	4 to 20 mA HART with communication protocol
System integration	The device can be fitted with a tag name, "Ordering information", feature 895 "Marking" version "Z1" (→ 28).

Input

Measured variable

FMX21 + Pt100 (optional)

- Hydrostatic pressure of a liquid
- Pt100: temperature

TMT182 temperature head transmitter (optional)

Temperature

Measuring range

- Customer-specific measuring ranges or factory calibration
- Temperature measurement from −10 to +70 °C (+14 to +158 °F) with Pt100 (optional)

Sensor measuring range [bar (psi)]	Smallest span that can be calibrated [1] [bar (psi)]	Vacuum resistance [bar_{abs} (psi_{abs})]	Version in the order code [2]
Gauge pressure			
0.1 (1.5)	0.01 (0.15)	0.3 (4.5)	1C
0.2 (3.0)	0.02 (0.3)	0.3 (4.5)	1D
0.4 (6.0)	0.04 (1.0)	0	1F
0.6 (9.0)	0.06 (1.0)	0	1G
1.0 (15.0)	0.1 (1.5)	0	1H
2.0 (30.0)	0.2 (3.0)	0	1K
4.0 (60.0)	0.4 (6.0)	0	1M
10.0 (150) [3]	1.0 (15)	0	1P
20.0 (300) [3]	2.0 (30)	0	1Q
Absolute pressure			
2.0 (30.0)	0.2 (3.0)	0	2K
4.0 (60.0)	0.4 (6.0)	0	2M
10.0 (150) [3]	1.0 (15)	0	2P
20.0 (300) [3]	2.0 (30)	0	2Q

1) Recommended Turn down: Max 100:1
Factory calibration Turn down: Max 20:1, higher on request.

2) Ordering information (→ 28)

3) These measuring ranges are not offered for the probe version with plastic insulation, outer diameter 29 mm (1.14 in).

Input signal

FMX21 + Pt100 (optional)

- Change in capacitance
- Pt100: change in resistance

TMT182 temperature head transmitter (optional)

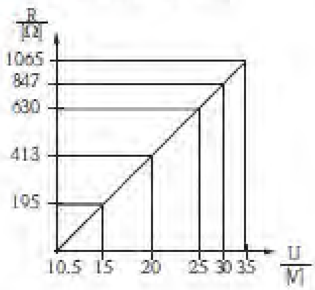
Pt100 resistance signal, 4-wire

Output

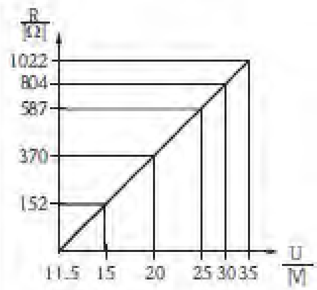
Output signal	**FMX21 + Pt100 (optional)** • 4 to 20 mA with overlying digital HART 6.0 communication protocol, 2-wire for hydrostatic pressure measured value • Pt100: Temperature-dependent resistance values	**TMT182 temperature head transmitter (optional)** 4 to 20 mA with overlying digital HART 5.0 communication protocol for temperature measured value, 2-wire
Signal range	3.8 to 20.5 mA	
Signal on alarm	**FMX21 + Pt100 (optional)** 4 to 20 mA HART Options: • Max. alarm (factory setting 22mA): can be set from 21 to 23 mA • Hold measured value: last measured value is held • Min. alarm: 3.6 mA	**TMT182 temperature head transmitter (optional)** Options: • Max. alarm ≥ 21.0 mA • Min. alarm ≤ 3.6 mA
Load	**FMX21** $R_{Lmax} \leq \frac{U - 10.5\,V}{23\,mA} - 2 \cdot 0.09\,\frac{\Omega}{m} \cdot L - R_{add}$	**TMT182 temperature head transmitter (optional)** $R_{Lmax} \leq \frac{U - 11.5\,V}{0.023\,A} - R_{add}$

R_{Lmax} = Max. load resistance [Ω]
R_{add} = Additional resistances such as resistance of evaluation unit and/or display unit, cable resistance [Ω]
U = Supply voltage [V]
L = Simple length of extension cable [m], (cable resistance per wire ≤ 0.09 Ω/m)

When using the measuring device in hazardous areas, installation must comply with the corresponding national standards and regulations and the Safety Instructions or Installation or Control Drawings (XA).



FMX21 load chart for estimating the load resistance. Additional resistances, such as the resistance of the extension cable, have to be subtracted from the value calculated as shown in the equation.



Temperature head transmitter TMT182 load chart for estimating the load resistance. Additional resistances have to be subtracted from the value calculated as shown in the equation.

When operating using a HART handheld terminal or a PC with an operating program, a minimum communication resistance of 250 Ω has to be taken into account.

Damping	▪ Continuously 0 to 999 s via HART handheld terminal or PC with operating program ▪ Factory setting: 2 s	

Power supply

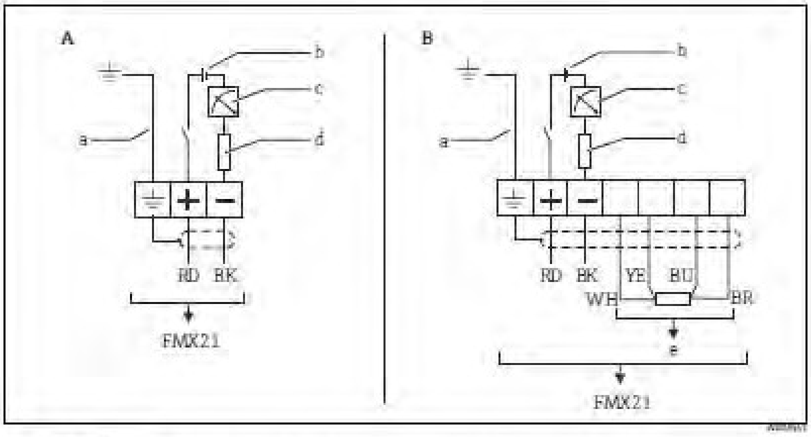
When using the measuring device in hazardous areas, installation must comply with the applicable national standards and regulations and the Safety Instructions (XAs) and the Installation or Control Drawings (ZDs). All explosion-protection data are given in a separate documentation which is available upon request. This documentation is provided with the devices as standard (→ 32).

Supply voltage	**FMX21 + Pt100 (optional)** ▪ 10.5 to 35 V (non-hazardous area) ▪ 10.5 to 30 V (hazardous area)	**TMT182 temperature head transmitter (optional)** 11.5 to 35 V DC
Power consumption	**FMX21 + Pt100 (optional)** ▪ ≤ 0.805 W at 35 V DC (non-hazardous area) ▪ ≤ 0.690 W at 30 V DC (hazardous area)	**TMT182 temperature head transmitter (optional)** ≤ 0.805 W at 35 V DC
Current consumption	**FMX21 + Pt100 (optional)** ▪ Max. current consumption: ≤ 23 mA Min. current consumption: ≥ 3.6 mA ▪ Pt100: ≤ 0.6 mA	**TMT182 temperature head transmitter (optional)** ▪ Max. current consumption: ≤ 23 mA Min. current consumption: ≥ 3.5 mA ▪ Pt100 via temperature head transmitter: ≤ 0.6 mA

Measuring unit electrical connection

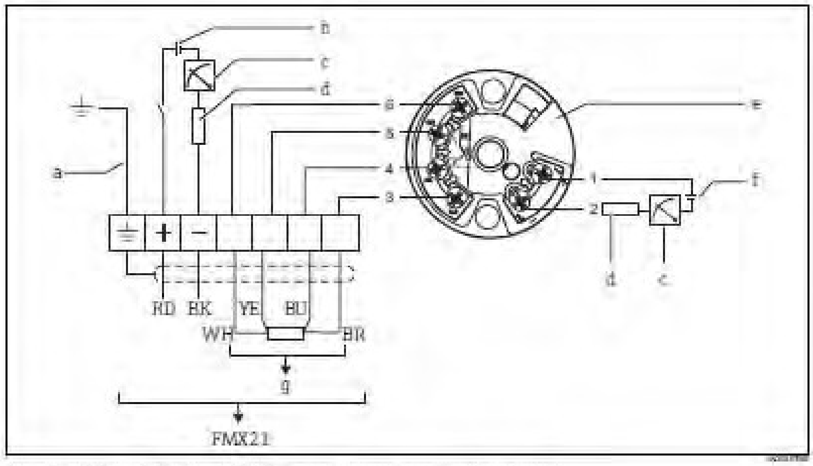
- Reverse polarity protection is integrated in the Waterpilot FMX21 and in the TMT182 temperature head transmitter. Changing the polarities will not damage the devices.
- The cable must end in a dry room or a suitable terminal box. The terminal box (IP66/IP67) with a GORE-TEX® filter from Endress+Hauser is suitable for outdoor installations. The terminal box can be ordered as an accessory using the order code for FMX21 version "PS" for feature 620 (→ 28).

The electrical connection is made with the corresponding wires of the probe cable and with the optional use of the terminal box (Commubox FXA) or an active barrier (e.g. RN221N).



A Waterpilot FMX21
B Waterpilot FMX21 with Pt100 [1]: Version "NB" for feature 610 "Accessories" in the order code (→ 28)

a Not for FMX21 with an outer diameter of 29 mm (1.14 in)
b 10.5 to 30 V DC (Ex), 10.5 to 35 V DC
c 4 to 20 mA
d Resistance (R_L)
e Pt100



Waterpilot FMX21 with Pt100 and TMT182 temperature head transmitter (4 to 20 mA) [1], versions "NB" and "PT", feature 610 and 620 in the order code (→ 28)

a Not for FMX21 with an outer diameter of 29 mm (1.14 in)
b 10.5 to 35 V DC
c 4 to 20 mA
d Resistance (R_L)
e TMT182 temperature head transmitter (4 to 20 mA)
f 11.5 to 35 V DC
g Pt100

[1] Not for use in hazardous areas.

Wire colors
RD = red, BK = black, WH = white, YE = yellow, BU = blue, BR = brown

Connection classification as per IEC 61010-1:

- Overvoltage category 1
- Pollution degree 1

Connection data in the hazardous area

4 to 20 mA	Ex ia IIC T4 to T6
Ui	30 V DC
Ii	133 mA
Pi	1.0 W
Ci	10.3 nF (sensor); 180 pF/m (cable)
Li	0 µH (sensor); 1 µH/m (cable)
Ta	−10 °C (+14 °F) ≤ Ta ≤ +70 °C (+158 °F) for T4; −10 °C (+14 °F) ≤ Ta ≤ +40 °C (+104 °F) for T6

Cable specifications

FMX21 + Pt100 (optional)

- Commercially available instrument cable
- Terminal, terminal box:
  0.08 to 2.5 mm² (28 to 14 AWG)
- If the Pt100 signal is directly connected to a display and/or evaluation unit, Endress+Hauser recommends using a shielded cable.

TMT182 temperature head transmitter (optional)

- Commercially available instrument cable
- Terminal, terminal box:
  0.08 to 2.5 mm² (28 to 14 AWG)
- Transmitter connection: max. 1.75 mm² (15 AWG)

Residual ripple

FMX21 + Pt100 (optional)

No impact on the 4 to 20 mA signal to ±5 % residual ripple within the permitted voltage range (according to HART Hardware Specification HCF_SPEC-54 (DIN IEC 60381-1))

TMT182 temperature head transmitter (optional)

$U_{ss} \geq 3$ V at $U \geq 13$ V, $f_{max.} = 1$ kHz

Performance characteristics

Reference operating conditions

FMX21 + Pt100 (optional)

- As per IEC 60770
- Ambient temperature T_A = constant, in range: +21 to +33 °C (+70 °F to +91 °F)
- Humidity φ = constant, in range: 20 to 80 % RH
- Ambient pressure p_A = constant, in range: 860 to 1060 mbar (13 to 16 psi)
- Position of the measuring cell = constant, in range, vertical: ±1°
- Supply voltage constant: 21 V DC to 27 V DC
- Load with HART: 250 Ω
- Pt100: DIN EN 60770 T_A = 25 °C (77 °F)

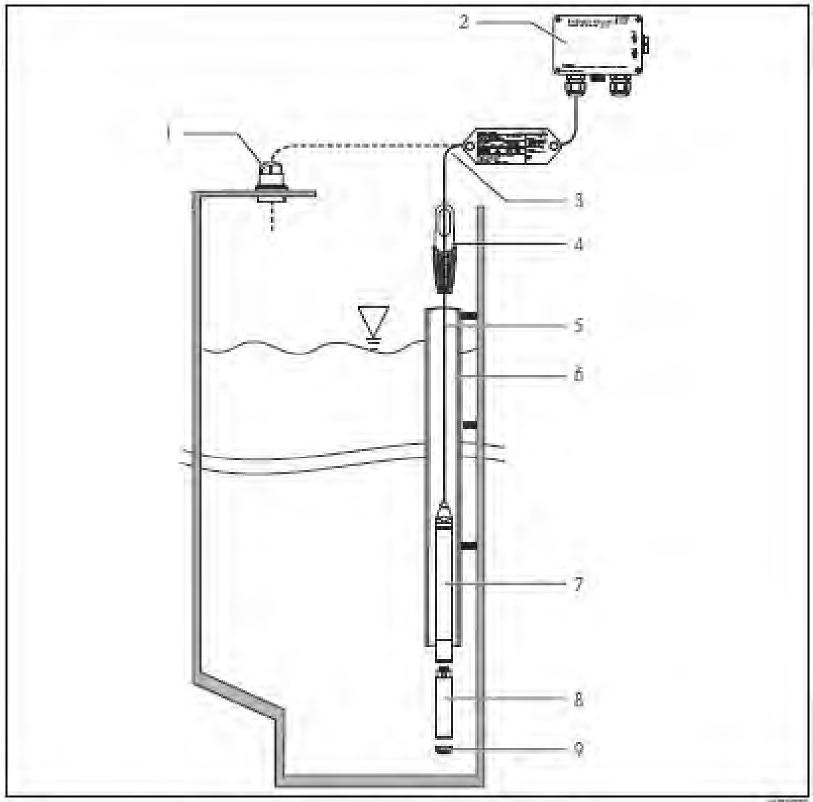
TMT182 temperature head transmitter (optional)

Calibration temperature 25 °C (77 °F) ±5 K

Reference accuracy	**FMX21 + Pt100 (optional)** The reference accuracy comprises the non-linearity after limit point configuration, hysteresis and non-repeatability in accordance with IEC 60770. ▪ Setting ±0.2 % – to TD 5:1: < 0.2 % of the set span – from TD 5:1 to TD 10:1 ±(0.02 x TD+0.1) PLATINUM version: ▪ Setting ±0.1 % (optional) – to TD 5:1: < 0.1 % of the set span – from TD 5:1 to TD 10:1 ±(0.02 x TD) ▪ Class B to DIN EN 60751 – Pt100: max. ±1 K	**TMT182 temperature head transmitter (optional)** ▪ ±0.2 K ▪ With Pt100: max. ±0.9 K
Resolution	Current output: 1 µA **Read cycle** HART commands: 2 to 3 per second on average	
Long-term stability	**FMX21 + Pt100 (optional)** ▪ ≤ 0.1 % of URL/year ▪ ≤ 0.25 % of URL/5 years	**TMT182 temperature head transmitter (optional)** ≤ 0.1 K per year
Influence of medium temperature	▪ Thermal change in the zero output and the output span 0 to +30 °C (+32 to +86 °F): <(0.15 + 0.15 x TD)% –10 to +70 °C (+14 to +158 °F): <(0.4 + 0.4 x TD)% ▪ Temperature coefficient (T_K) of the zero output and output span –10 to +70 °C (+14 to +158 °F): 0.1 % / 10 K URL	
Warm-up period	**FMX21 + Pt100 (optional)** ▪ FMX21: < 6 s ▪ Pt100: 20 ms	**TMT182 temperature head transmitter (optional)** 4 s
Step response time	**FMX21 + Pt100 (optional)** ▪ FMX21: 400 ms (T90 time), 500 ms (T99 time) ▪ Pt100: 160 s (T90 time), 300 s (T99 time)	–

Installation

Installation instructions



Installation examples, here illustrated with FMX21 with an outer diameter of 22 mm (0.87 in)

1. *Extension cable mounting screw can be ordered via order code or as an accessory (→ 28)*
2. *Terminal box can be ordered via order code or as an accessory (→ 28)*
3. *Extension cable bending radius > 120 mm (4.72 in)*
4. *Mounting clamp can be ordered via order code or as an accessory (→ 28)*
5. *Extension cable, length (→ 25)*
6. *Guide pipe*
7. *Waterpilot FMX21*
8. *Additional weight can be ordered as an accessory for FMX21 with an outer diameter of 22 mm (0.87 in) and 29 mm (1.14 in)*
9. *Protection cap*

Additional installation instruction

- Sideways movement of the level probe can result in measuring errors. For this reason, install the probe at a point free from flow and turbulence, or use a guide tube. The internal diameter of the guide tube should be at least 1 mm (0.04 in) bigger than the outer diameter of the selected FMX21.
- The device is provided with a protection cap to prevent mechanical damage to the measuring cell.
- The cable must end in a dry room or a suitable terminal box. The terminal box from Endress+Hauser provides optimum humidity and climatic protection and is suitable for outdoor installation (→ 30).
- Rod length tolerances: < 5 m (16 ft): ±17.5 mm (0.69 in); > 5 m (16 ft): ±0.2 % (→ 31)
- If the cable is shortened, the filter at the pressure compensation tube has to be reattached. Endress+Hauser offers a cable shortening kit for this purpose → 28 ff; (SD00552P/00/A6).
- Endress+Hauser recommends using twisted, shielded cables.
- Note for ship building applications: Measures for limitation of the propagation of fire along cable bundles are required (fire stops).

Environment

	FMX21 + Pt100 (optional)	TMT182 temperature head transmitter (optional)
Ambient temperature range	▪ With outer diameter of 22 mm (0.87 in) and 42 mm (1.65 in): −10 to +70 °C (+14 to +158 °F) (= medium temperature) ▪ With outer diameter of 29 mm (1.14 in): 0 to +50 °C (+32 to +122 °F) (= medium temperature) **Cable** (fixed installation) ▪ PE: −30 to +70 °C (−22 to +158 °F) ▪ FEP: −40 to +70 °C (−40 to +158 °F) ▪ PUR: −40 to +70 °C (−40 to +158 °F) **Terminal box** −40 to +80 °C (−40 to +176 °F)	−40 to +85 °C (−40 to +185 °F)
Storage temperature range	−40 to +80 °C (−40 to +176 °F) **Cable** (fixed installation) ▪ PE: −30 to +70 °C (−22 to +158 °F) ▪ FEP: −30 to +80 °C (−22 to +176 °F) ▪ PUR: −40 to +80 °C (−40 to +176 °F) **Terminal box** −40 to +80 °C (−40 to +176 °F)	−40 to +100 °C (−40 to +212 °F)
Degree of protection	IP68, permanently hermetically sealed at 20 bar (290 psi) (~200 m H_2O) **Terminal box (optional)** IP66, IP67	IP00, condensation permitted
Geometric height according to IEC61010-1 Ed.3	Up to 2 000 m (6 600 ft) above MSL.	
Electromagnetic compatibility (EMC)	▪ EMC in accordance with all the relevant requirements of the EN 61326 series. Details are provided in the Declaration of Conformity. ▪ Maximum deviation < 0.5 % of the span.	EMC in accordance with all the relevant requirements of the EN 61326 series. Details are provided in the Declaration of Conformity.

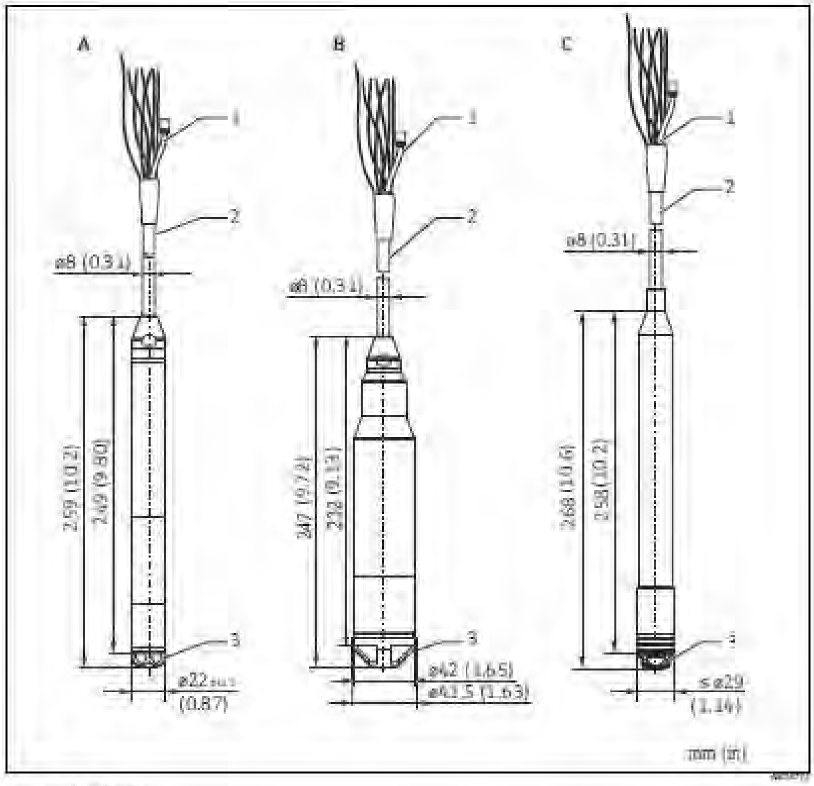
Overvoltage protection	**FMX21 + Pt100 (optional)** ▪ Integrated overvoltage protection to EN 61000-4-5 (500 V symmetrical/1000 V asymmetrical) ▪ Install overvoltage protection ≥ 1.0 kV, external if necessary	**TMT182 temperature head transmitter (optional)** Install overvoltage protection, external if necessary.

Process

Medium temperature range	**FMX21 + Pt100 (optional)** ▪ With outer diameter of 22 mm (0.87 in) and 42 mm (1.65 in): −10 to +70 °C (+14 to +158 °F) ▪ With outer diameter of 29 mm (1.14 in): 0 to +50 °C (+32 to +122 °F)	**TMT182 temperature head transmitter (optional)** –
Medium temperature limits	**FMX21 + Pt100 (optional)** ▪ With outer diameter of 22 mm (0.87 in) and 42 mm (1.65 in): −20 to +70 °C (−4 to +158 °F) In hazardous areas incl. CSA GP, the medium temperature limit is at −10 to +70 °C (+14 to +158 °F). ▪ With outer diameter of 29 mm (1.14 in): 0 to +50 °C (+32 to +122 °F) The FMX21 can be operated in this temperature range. The specification can then be exceeded, e.g. measuring accuracy.	–

Mechanical construction

Dimensions of the level probe

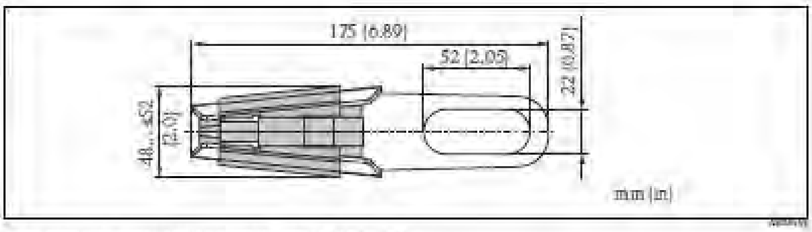


Versions of the FMX21

- A *In the order code: feature 45 "Probe tube", version "1" or "Accessories" (→ 28)*
- B *In the order code: feature 45 "Probe tube", version "2" (→ 28)*
- C *In the order code: feature 45 "Probe tube", version "5" (→ 28)*

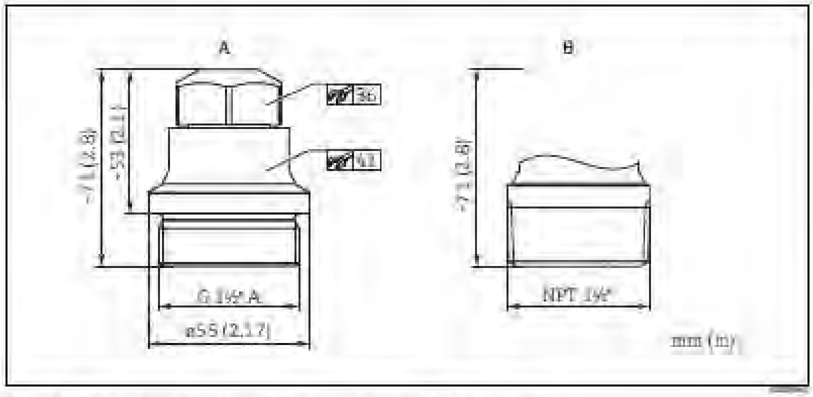
- 1 *Pressure compensation tube*
- 2 *Extension cable (Length, see → 25)*
- 3 *Protection cap*

Dimensions of the mounting clamp



In the order code: feature 620 "Accessories", version "PO" (→ 28)

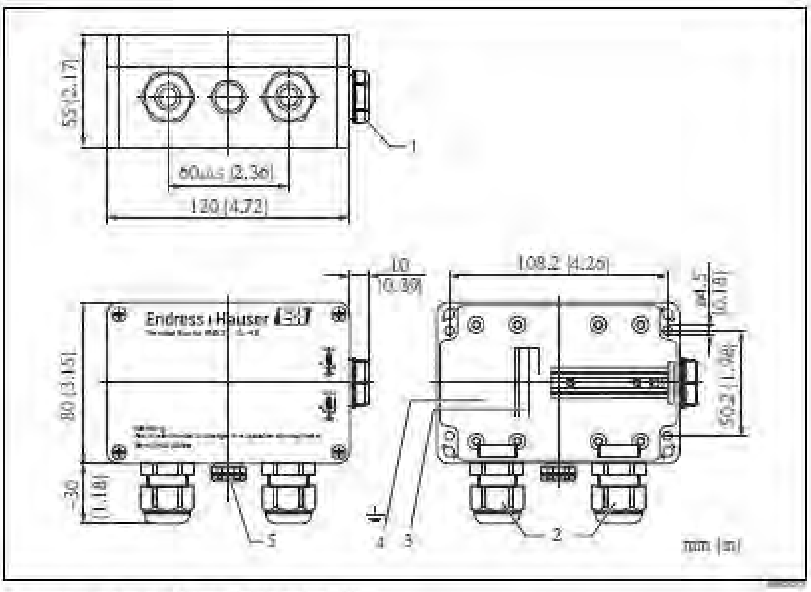
Dimensions of the extension cable mounting screws



A G 1½" A, in the order code: feature 620 "Accessories", version "PQ" (→ 28)
B NPT 1½", in the order code: feature 620 "Accessories", version "PR" for (→ 28)

Application in unpressurized containers only.

Dimensions of the IP66, IP67 terminal boxes with filters



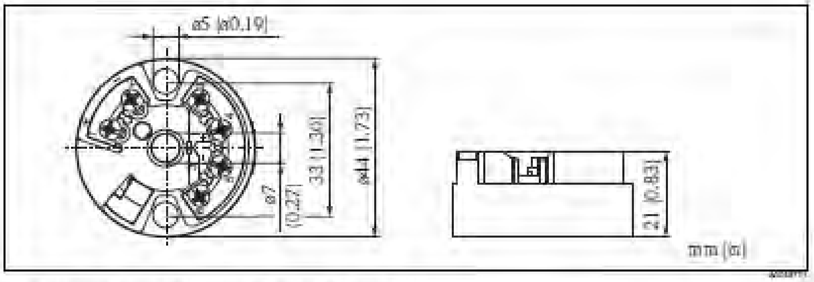
In the order code: feature 620, version "PS" or "PT" (→ 28)

1 Dummy plug M20x1.5
2 Cable gland M20x1.5
3 4 to 20 mA; terminals for 0.08 to 2.5 mm² (28 to 14 AWG)
4 Ground connection; terminals for 0.08 to 2.5 mm² (28 to 14 AWG)
5 GORE-TEX® filter

If ordered together with FMX21 but without the optional TMT182 temperatur transmitter, the terminal box is incl. a 4-terminal strip.

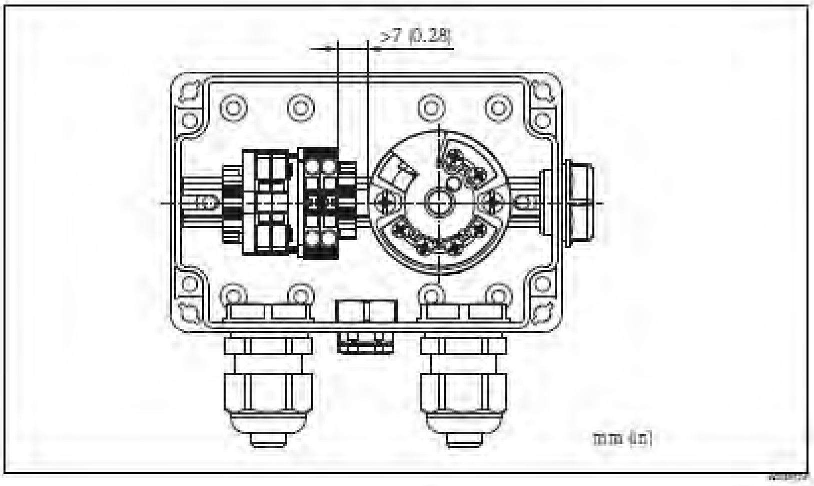
The 4-terminal strip is not intended for use in hazardous areas incl. CSA GP.

Dimensions of the TMT182 temperature head transmitter



In the order code: feature 620 "Accessories", version "PT" for (→ 18)

Terminal box with integrated TMT182 temperature head transmitter (4 to 20 mA HART)

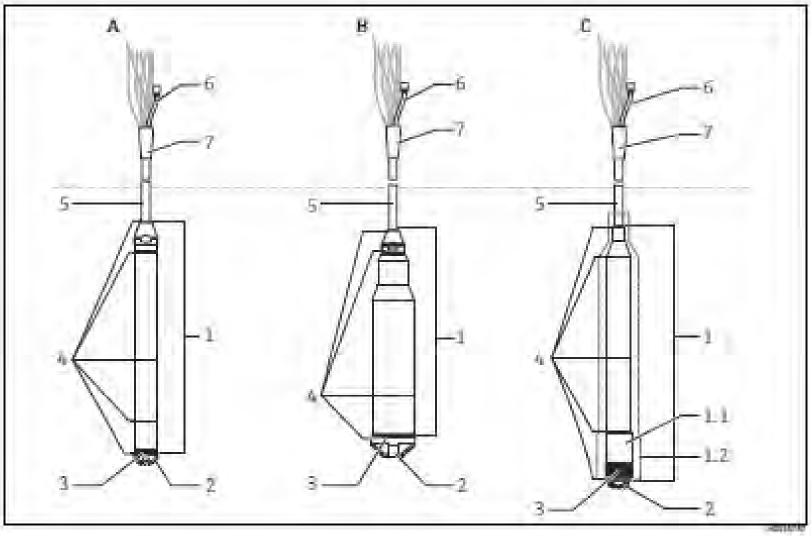


A distance of > 7 mm (> 0.28 in mm) must be maintained between the terminal strip and the TMT182 temperature head transmitter.

Weight

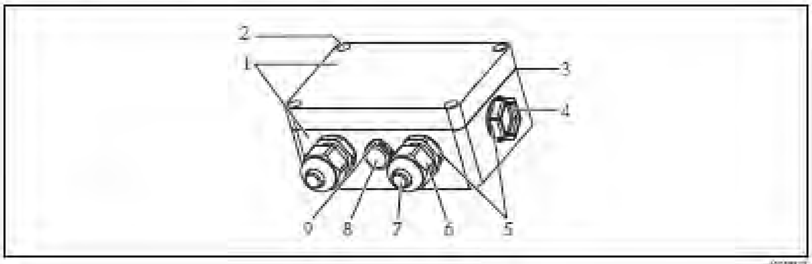
Component part		Weight
Level probe, outer diameter 22 mm (0.87 in)		344 g (12.133 oz)
Level probe, outer diameter 42 mm (1.65 in)		1376 g (48.532 oz)
Level probe, outer diameter 29 mm (1.14 in)		394 g (13.896 oz)
Extension cable	▪ PE ▪ PUR ▪ FEP	▪ 52 g/m (0.035 lbs/1 ft) ▪ 60 g/m (0.040 lbs/1 ft) ▪ 108 g/m (0.072 lbs/1 ft
Mounting clamp		170 g (5.996 oz)
Extension cable mounting screw G 1½" A		770 g (27.158 oz
Extension cable mounting screw NPT 1½"		724 g (25.535 oz)
Terminal box		235 g (8.288 oz)
Temperature head transmitter TMT182		40 g (1.411 oz)
Additional weight		300 g (10.581 oz)
Testing adapter		39 g (1.376 oz)

Material



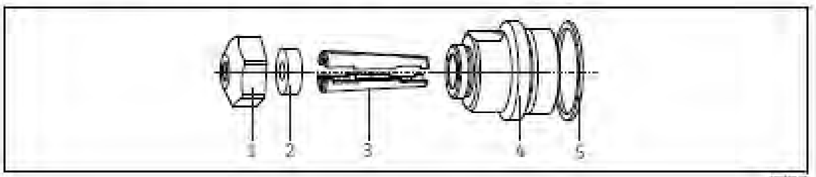
Material in contact with process		
Position number	Component part	Material
1	A: Level probe, outer diameter 22 mm (0.87 in) B: Level probe, outer diameter 42 mm (1.65 in) C: Level probe, outer diameter max. 29 mm (1.14 in)	316L (1.4404/1.4435)
1.1	Sensor sleeve	PPS (polyphenylene sulfide)
1.2	Heat-shrink sleeve	Polyolefin and hot-melt adhesive
	The heat-shrink sleeve at the level probe acts as an insulation. It prevents electrical contact between the probe and the tank. Electrochemical corrosion is thus avoided.	
2	Protection cap ▪ A and C: with outer diameter 22 mm (0.87 in) and 29 mm (1.14 in) ▪ B: with outer diameter 42 mm (1.65 in)	▪ PPO (Polyphenylenoxid) ▪ PFA (Perfluoralkoxy)
3	Process ceramic	Al_2O_3 (aluminum oxide ceramic)
4	Seal	EPDM or FKM Viton
5	Extension cable insulation For more information → 25	Either: ▪ PE-LD (low-density polyethylene) ▪ FEP (fluorinated ethylene propylene) ▪ PUR (polyurethane)
Material not in contact with process		
6	Pressure compensation tube	PA
7	Heat-shrink sleeve	Polyolefin

Terminal box (not in contact with process)



Position number	Component part	Material
1	Housing	PC
2	Mounting screws (4 x)	A2
3	Seal	CR (Chloropren-Unvulcanized rubber)
4	Dummy plug M20x1.5	PBT-GF30
5	Cable gland M20x1.5	PE-HD
6		PA6
7		PA6-GF30
8	Pressure compensation tube	PA6-GF10, ePTFE
9	Pressure compensation tube O-ring	Silicone (VMQ)

Cable mounting screw (not in contact with process)

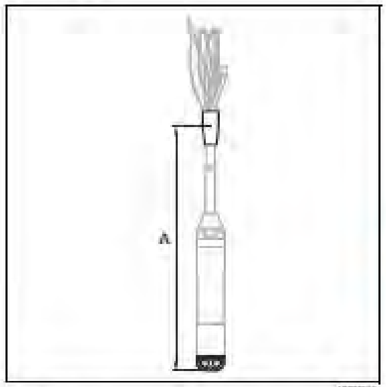


Position number	Component part	Material
1	Cover cable gland	304 (1.4301)
2	Seal	NBR
3	Klemmhülsen	PA66-GF35
4	Anschlussstück cable gland G 1½" A, NPT 1½"	304 (1.4301)
5	Seal → only for G 1½" A	EPDM

Extension cable

PE	PUR	FEP
▪ Abrasion-resistant extension cable with Dynema strain-relief members ▪ Shielded with aluminum-coated film ▪ Insulated with polyethylene (PE), black ▪ Copper wires, twisted ▪ Pressure compensation tube with Teflon filter	▪ Abrasion-resistant extension cable with Dynema strain-relief members ▪ Shielded with aluminum-coated film ▪ Insulated with polyurethane (PUR), black ▪ Copper wires, twisted ▪ Pressure compensation tube with Teflon filter	▪ Abrasion-resistant extension cable ▪ Shielded with galvanized steel wire netting ▪ Insulated with fluorinated ethylene propylene (FEP), black ▪ Copper wires, twisted ▪ Pressure compensation tube with Teflon filter

Cable length



A Cable length

- Please refer also to "Load" (→ 12).
- Cable lengths that can be ordered
  - Customer-specific length in meters or feet (→ 28, "Ordering information")
  - Limited cable length when performing installation with freely suspended device with extension cable mounting screw or mounting clamp, as well as for hazardous areas: max. 300 m (984 ft).

When using the measuring device in hazardous areas, installation must comply with the applicable national standards and regulations and the Safety Instructions (XAs) or the Installation or Control Drawings (ZDs) "Documentation"

Cross-section
- Total outer diameter: 8.0 mm (0.31 in) ±0.25 mm (±0.01 in)
- FMX21: 3 x 0.227 mm^2 (3 x 26 AWG) + pressure compensation tube with Teflon filter
- FMX21 with Pt100 (optional): 7 x 0.227 mm^2 (7x 26 AWG) + pressure compensation tube with Teflon filter
- Pressure compensation tube with Teflon filter:
  outer diameter 2.5 mm (0.1 in), internal diameter 1.5 mm (0.06 in)

Cable resistance
per wire: ≤ 0.09 Ω/m

Further technical data
- Minimum bending radius: 120 mm (4.72 in)
- Tensile strength: max. 950 N (213.56 lbf)
- Cable extraction force (= necessary tensile force to extract the cable from the level probe):
  - PE, FEP: typical ≥ 400 N (89.92 lbf), PUR: typical ≥ 150 N (33.72 lbf)
  - for use in hazardous areas: ≥ 100 N (73.75 lbf)
- Resistance to UV light
- PE: Usage in drinking water

Terminals

- Three terminals as standard in the terminal box
- 4-terminal strip can be ordered as an accessory, Order No: 52008938
  Conductor cross-section 0.08 to 2.5 mm^2 (28 to 14 AWG)

The 4-terminal strip is not intended for use in hazardous areas incl. CSA GP.

Operability

FieldCare	FieldCare is Endress+Hauser's plant asset management tool based on FDT technology. You can use FieldCare to configure all Endress+Hauser devices as well as third-party devices which support the FDT standard. FieldCare supports the following functions: ▪ Configuration of transmitters in offline and online mode ▪ Loading and saving device data (upload/download) ▪ Documentation of the measuring point Connection options: ▪ Via Commubox FXA195 and the USB port of a computer ▪ Via Fieldgate FXA520 For further information and free download of FieldCare see → www.endress.com → Download → Search: FieldCare
Field Xpert SFX	Field Xpert is an industrial PDA with integrated 3.5" touchscreen from Endress+Hauser based on Windows Mobile. It communicates via wireless with the optional VIATOR® Bluetooth® modem connected to a HART device point-to-point or wireless via WiFi and Endress+Hauser's Fieldgate FXA520. Field Xpert also works as a stand-alone device for asset management applications. For details refer to BA00060S/00/EN.

Certificates and approvals

CE mark	The device meets the legal requirements of the applicable EC Directives. Endress+Hauser confirms successful testing of the device by affixing to it the CE mark.
Ex approval	▪ ATEX ▪ CSA C/US ▪ FM ▪ IEC ▪ NEPSI ▪ INMETRO ▪ The approvals to apply only for Waterpilot FMX21 without Pt100 and without TMT182. ▪ Waterpilot FMX21 is only available for use in hazardous areas with the FKM Viton seal. ▪ All explosion protection data are given in separate documentation which is available upon request. The Ex documentation is supplied as standard with all devices approved for use in explosion hazardous areas (→ 32).
Drinking water approval	For FMX21 with outer diameter 22 mm (0.87 in) ▪ KTW certificate ▪ NSF 61 approval ▪ ACS approval
Marine certificate	▪ GL (Germanischer Lloyd) ▪ ABS (American Bureau of Shipping) ▪ LR (Lloyds Register) ▪ BV (Bureau Veritas) ▪ DNV (Det Norske Veritas)
Standards and guidelines	The European standards and guidelines that have been applied are listed in the associated EC Declarations of Conformity. In addition, the following standards were also applied for the Waterpilot FMX21: ▪ DIN EN 60770 (IEC 60770): Transmitters for use in industrial process control systems Part 1: Methods for performance evaluation ▪ DIN 16086: Electrical pressure measuring instruments, pressure sensors, pressure transmitters, pressure measuring instruments, concepts, specifications on data sheets ▪ EN 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements ▪ EN 61010-1 (IEC 61010-1): Safety requirements for electrical equipment for measurement, control and laboratory use ▪ IEC 60529: Degrees of protection provided by enclosures

Ordering information

FMX21

You can enter the versions for the specific feature in the following table. The versions entered make up the complete order code. Options which are mutually exclusive are not marked.

10		**Approval:**
	AA	Non-hazardous area
	BE	ATEX II 2 G Ex ia IIC T6
	BD	ATEX II 3 G Ex nA IIC T6
	FE	FM IS, Cl. I Division 1, Groups A – D; AEx ia, zone 1
	CE	CSA C/US IS Cl. I Division 1, Groups A – D, Ex ia, zone 1
	CD	CSA General Purpose
	IC	IEC Ex ia IIC T6 Gb
	MA	INMETRO Ex ia IIC T6
	NA	NEPSI Ex ia IIC T6
20		**Output:**
	2	4-20 mA HART
45		**Probe tube:**
	1	Outer diameter d = 22 mm, AISI 316L
	2	Outer diameter d = 42 mm, flush-mounted, AISI 316L
	5	Outer diameter d = 29 mm, AISI 316L, PPS/polyolefin for saltwater applications
70		**Sensor range:**
		Measuring range
	1C	100 mbar/10 kPa/1.5 psi gauge, 1 m H_2O/3 ft H_2O/40 in H_2O
	1D	200 mbar/20 kPa/3 psi gauge, 2 m H_2O/6 ft H_2O/80 in H_2O
	1F	400 mbar/40 kPa/6 psi gauge, 4 m H_2O/13 ft H_2O/160 in H_2O
	1G	600 mbar/60 kPa/9 psi gauge, 6 m H_2O/20 ft H_2O/240 in H_2O
	1H	1 bar/100 kPa/15 psi gauge, 10 m H_2O/33 ft H_2O/400 in H_2O
	1K	2 bar/200 kPa/30 psi gauge, 20 m H_2O/67 ft H_2O/800 in H_2O
	1M	4 bar/400 kPa/60 psi gauge, 40 m H_2O/133 ft H_2O/1600 in H_2O
	1P	10 bar/1 MPa/150 psi gauge, 100 m H_2O/333 ft H_2O/4000 in H_2O
	1Q	20 bar/2 MPa/300 psi gauge, 200 m H_2O/667 ft H_2O/8000 in H_2O
	2K	2 bar/200 kPa/30 psi absolute, 20 m H_2O/67 ft H_2O/800 in H_2O
	2M	4 bar/400 kPa/60 psi absolute, 40 m H_2O/133 ft H_2O/1600 in H_2O
	2P	10 bar/1 MPa/150 psi absolute, 100 m H_2O/333 ft H_2O/4000 in H_2O
	2Q	20 bar/2 MPa/300 psi absolute, 200 m H_2O/667 ft H_2O/8000 in H_2O
80		**Reference accuracy:**
	D	Platinum
	G	Standard
90		**Calibration, unit:**
	A	Sensor range; %
	B	Sensor range; mbar/bar
	C	Sensor range; kPa/MPa
	D	Sensor range; mm/mH_2O
	E	Sensor range; in H_2O/ft H_2O
	F	Sensor range; psi
	J	Customized pressure; see additional specification
	K	Customized level; see additional specification
FMX21-		Order code

→ Ordering information for continued on next page

FMX21 (continued)

100		**Probe connection:**
	10	10 m cable, shortable, PE
	11	20 m cable, shortable, PE
	15	..... m cable, shortable, PE
	20	30 ft cable, shortable, PE
	21	60 ft cable, shortable, PE
	25	..... ft cable, shortable, PE
	30	10 m cable, shortable, FEP
	31	20 m cable, shortable, FEP
	35	..... m cable, shortable, FEP
	40	30 ft cable, shortable, FEP
	41	60 ft cable, shortable, FEP
	45	..... ft cable, shortable, FEP
	50	10 m cable, shortable, PUR
	51	20 m cable, shortable, PUR
	55	..... m cable, shortable, PUR
	60	30 ft cable, shortable, PUR
	61	60 ft cable, shortable, PUR
	65	..... ft cable, shortable, PUR
190		**Seal:**
	A	FKM Viton
	H	EPDM
FMX21-		Order code

Additional ordering information (optional)

550		**Calibration**
	F1	Works calib. certificate 5-point
570		**Service**
	IA	Adjusted min alarm current
	IB	Adjusted HART Burst Mode PV
	IR	... m cable marking>installation
	IS	... ft cable marking>installation
	I9	Special version
590		**Additional approval**
	LE	GL Marine certificate
	LF	ABS Marine certificate
	LG	LR Marine certificate
	LH	BV Marine certificate
	LI	DNV Marine certificate
	LQ	KTW potable water approval
	LR	NSF potable water approval
	LS	ACS potable water approval
610		**Accessories mounted**
	NB	Temperature sensor Pt100, 4-wire
620		**Accessories enclosed**
	PO	Suspension clamp, 316L
	PQ	Cable mounting screw G1½", 304
	PR	Cable mounting screw NPT1½", 304
	PS	Terminal box IP66/67
	PT	Temperature head transmitter TMT182, 2-wire, 4-20 mA, −20 to 80 °C
	PU	Additional weight, 316L
	PV	Adapter, function test
	PW	Shortening kit, extension cable
895		**Marking**
	Z1	Tagging (TAG)
FMX21-		Order code

Accessories

Mounting clamp

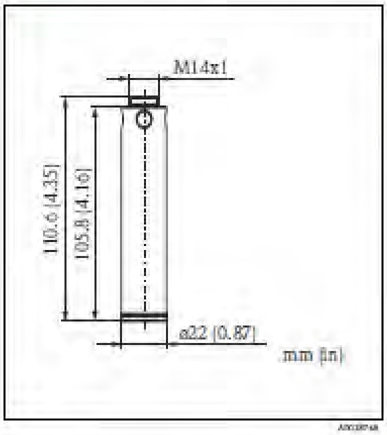
- Endress+Hauser offers a mounting clamp for easy FMX21 mounting (→ 20).
- Material: 316L (1.4404) and fiberglass reinforced PA (polyamide)
- Order number 52006151, "Ordering information" (→ 28)

Terminal box

- IP66/IP67 terminal boxes with GORE-TEX® filter incl. 3 integrated terminals.
  The terminal box is also suitable for installing a TMT182 temperature head transmitter or for four additional terminals (Order No. 52008938) → 21, "Ordering information" (→ 28).

The terminal box is not intended for the FMX21 with Ex nA explosion protection in the hazardous area. When using the terminal box in hazardous areas, installation must comply with the corresponding national standards and regulations and the Safety Instructions or Installation or Control Drawings.

Additional weight



For FMX21 with outer diameter of 22 mm (0.87 in) or 29 mm (1.14 in)

- Endress+Hauser offers additional weights to prevent sideways movement that results in measuring errors, or to make it easier to lower the device in a guide tube.
  You can screw several weights together. The weights are attached directly to the FMX21. For FMX21 with an outer diameter of 29 mm (1.14 in) a maximum of 5 weights may be attached. In combination with the Ex nA approval, for FMX21 with an outer diameter of 29 mm (1.14 in) a maximum of 1 additional weight may be attached.
- Material: 316L (1.4435)
- Weight: 300 g (10.581 oz)
- Order number 52006153, "Ordering information" (→ 28)

TMT182 temperature head transmitter (4 to 20 mA HART)

- 2-wire temperature head transmitter, configured for a measuring range from −20 to +80 °C (-4 to +158 °F). This setting offers a temperature range of 100 K which can be easily mapped. Please note that the Pt100 resistance thermometer is designed for a temperature range from −10 to +70 °C (−14 to +176 °F) → 22.
- Order number: 51001023, Ordering information (→ 28)

The TMT182 temperature head transmitter is not intended for use in hazardous areas incl. CSA GP.

Extension cable mounting screw

Endress+Hauser offers extension cable mounting screws to ease FMX21 mounting and to seal the measuring aperture (→ 21).

- Order number for extension cable mounting screw:
  - 52008264 (G 1½" A)
  - 52009311 (NPT 1½")
- Material (→ 23)

Terminals

- Four terminals in strip for terminal box, suitable for wire cross-section: 0.08 to 2.5 mm^2 (28 to 14 AWG)
- Order number: 52008938

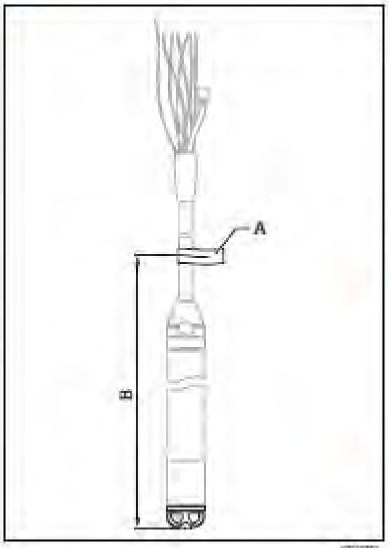
The 4-terminal strip is not intended for use in hazardous areas incl. CSA GP.

Cable shortening kit

- The cable shortening kit is used to easily and professionally shorten a cable.
- Order Number: 71222671, "Ordering information" and the documentation SD00552P/00/A6 (→ 28)

The cable shortening kit is not intended for the FMX21 with FM/CSA approval.

Cable marking



A Cable marking
B Cable marking tolerance

- To make installation easier, Endress+Hauser offers a mark on the extension cable for a customer-specific length, see also → 28, "Ordering information".
- Cable marking tolerance (distance to the lower end of the cable probe):
  Cable length < 5 m (16 ft): ±17.5 mm (0.69 in)
  Cable length > 5 m (16 ft): ±0.2 %
- Material: PET, Adhesive: acrylic
- Immunity to temperature change: −30 to +100 °C (−22 to +212 °F)

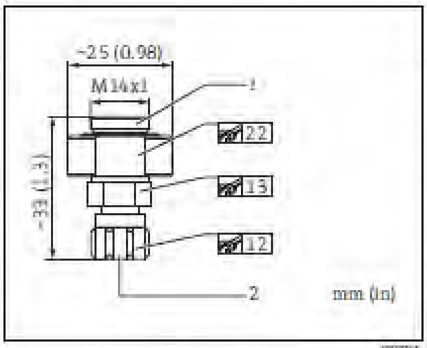
NOTICE

The mark is for installation purposes only.

- It must be thoroughly removed without trace in the case of devices with drinking water approval. The extension cable must not be damaged in the process

Not for use in hazardous areas.

Testing adapter



1 FMX21 level probe connection
2 Compressed air hose connection, internal diameter of quick coupling piece 4 mm (0.16 in)

For FMX21 with outer diameter of 22 mm (0.87 in) and 29 mm (1.14 in)

- Endress+Hauser offers a testing adapter to ease function-testing of the level probes.
- Observe the maximum pressure for the compressed air hose and the maximum overload for the level probe (→ 11).
- Maximum pressure of the quick coupling piece supplied: 10 bar (145 psi)
- Adapter material: 304 (1.4301)
- Quick coupling piece material: anodized aluminum
- Adapter weight: 39 g (1.376 oz)
- Order number 52011868 (→ 28)

Documentation

The following document types are also available in the Download Area of the Endress+Hauser website: www.endress.com → Download

Field of activities

- Pressure measurement: FA00004P/00/EN
- Recording technology: FA00014R/09/EN
- System components: FA00016K/09/EN

Technical Information

- Waterpilot FMX167 with 4 to 20 mA analog output: TI00351P/00/EN
- Deltapilot M: TI00437P/00/EN
- Temperature head transmitter iTEMP HART TMT182: TI00078R/09/EN

Operating Instructions

- Waterpilot FMX21: BA00380P/00/EN
- Cable shortening kit: SD00552P/00/A6
- Field Xpert: BA01211S/04/EN

Safety instructions

Safety Instructions (XA) are supplied with the device depending on the approval. These instructions are anintegral part of the Operating Instructions.

Approval	Feature in Order code	Types of protection	Category	Documentation
ATEX	BD	Ex ia IIC	II 2 G	XA00454P
ATEX	BE	Ex nA IIC	II 3 G	XA00485P
IECEx	IC	Ex ia IIC	n/a	XA00455P
CSA C/US	CE	Ex ia IIC	n/a	ZD232P (960008976)
FM	FE	AEx ia IIC	n/a	ZD231P (960008975)
NEPSI	NA	Ex ia IIC	n/a	XA00456P
INMETRO	MA	Ex ia IIC	n/a	XA01066P

The nameplate provides information on the Safety Instructions (XA) that are relevant for the device.

Drinking water approval

- SD00289P/00/A3 (NSF)
- SD00319P/00/A3 (KTW)
- SD00320P/00/A3 (ACS)

Patents

This product is protected by at least one of the following patents. Further patents are pending.

- US 6,427,129 B1 ≙ EP 0 892 249 B1
- US 6,703,943 A1
- DE 203 13 744.2 U1

Configuration data sheet

Level

The following configuration data sheet has to be filled in and included with the order if the option "K: customized level" has been selected in feature "090: Calibration; unit" in the product structure.

Pressure Engineering Unit

☐ mbar	☐ mmH_2O	☐ mmHg	☐ hPa
☐ bar	☐ mH_2O		☐ kPa
	☐ ftH_2O		☐ MPa
☐ psi	☐ inH_2O	☐ kgf/cm^2	

Output Unit (Scaled unit)

Mass	Length	Volume	Volume	Percent
☐ kg	☐ m	☐ l	☐ gal	☐ %
☐ t	☐ dm	☐ hl	☐ Igal	
☐ lb	☐ cm			
	☐ mm	☐ m^3		
		☐ ft^3		
	☐ ft	☐ in^3		
	☐ inch			

Empty calibration [a]: low pressure value (empty)	______________ [pres.eng.unit]	Empty calibration [a]: low level value (empty)	______________ [scaled unit]
Full calibration [b]: high pressure value (full)	______________ [pres.eng.unit]	Full calibration [b]: high level value (full)	______________ [scaled unit]

Damping

Damping: ___________ sec

Pressure

The following configuration data sheet has to be filled in and included with the order if the option "J: customized pressure" has been selected in feature "090: Calibration; unit" in the product structure.

Pressure Engineering Unit

☐ mbar	☐ mmH_2O	☐ mmHg	☐ Pa
☐ bar	☐ mH_2O		☐ kPa
	☐ ftH_2O		☐ MPa
☐ psi	☐ inH_2O	☐ kgf/cm^2	

Calibration Range / Output

Low range value (LRV) _________________ [pressure engineering unit]
Upper range value (URV): _________________ [pressure engineering unit]

Damping

Damping: ___________ sec

Endress+Hauser SE+Co.
2340 Endress Place
Greenwood, In. 46143-9772

Final Inspection Report /Endprüfprotokoll

The manufacturer confirms that all measuring equipment used to assure the quality of the products has been calibrated and is traceable to national (e.g. DKD/DAkkS, NIST, NABL...) or international standards.

Der Hersteller bestätigt, dass die zu Qualitätsprüfungen des Erzeugnisses eingesetzten Messmittel gültig kalibriert waren und auf nationale (z.B. DKD/DAkkS, NIST, NABL...) bzw. internationale Normale rückführbar sind.

Waterpilot HART

TAG number	Messstellen-Nummer	
Order code	Bestellcode	FMX21-6FF0/0
Serial number	Seriennummer	NB00D915122
Extended order code	Erweiterter Bestellcode	FMX21-FE211HGE25A+PO
Sensor range	Sensor-Messbereich	0...400 inH2O
Adjusted measuring range	Eingestellter Messbereich	0...400 inH2O
Maximum permissible error	Max. zulässige Messabweichung	± 0.2 %
Output type	Ausgang	4-20 mA HART
Software version	Softwareversion	01.00
Output mode	Ausgangsmodus	linear

HAMPTON ROADS SANITATION DISTRICT HRSD

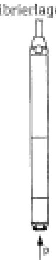
Customer order number	Auftragsnummer des Kunden	34884
E+H sales order number	E+H Auftragsnummer	3019367181000010
Internal order number	Interne Auftragsnummer	3003840583/0010
Ambient temperature	Umgebungs-Temperatur	22.2°C (± 1 °C)
Ambient humidity	Umgebungs-Luftfeuchte	27.9 %rel.F (± 10 %rel.F)
Ambient pressure	Umgebungs-Luftdruck	980.8 mbar (± 0.2 mbar)

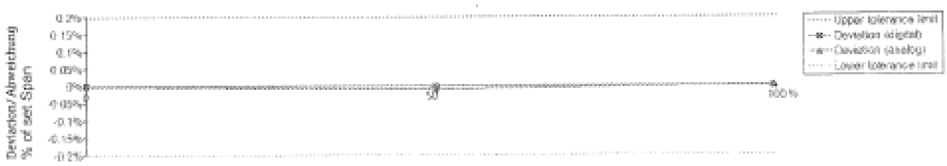
Calibrated according to fix point method IEC 60770. Prüfung nach Grenzpunktmethode gemäß IEC 60770.

Measuring results / Messergebnisse

Calibration point / Kalibrierpunkt	Nominal value ($p_{Ref.}$) / Sollwert ($p_{Ref.}$)	Measured value (digital readout) / Istwert (Digitaler Wert)	Deviation (digital) / Abweichung (digital)	Nominal value (I_{Out} calculated) / Sollwert (I_{Out} berechnet)	Current output (analog) / Istwert Stromausgang (analog)	Rel. deviation (analog) / Rel. Abweichung (analog)
%	inH2O	inH2O	% of Span	mA	mA	%
0	0.00000	0.00040	0.00010	4.00000	3.99994	-0.00036
51	202.402	202.394	-0.00197	12.09608	12.09430	-0.01115
99	397.580	397.586	-0.00056	19.90362	19.90399	0.00295

Calibration orientation
Kalibrierlage





Calibration carried out in output mode linear/
Kalibration erfolgte im Ausgangsmodus linear.

Measuring point in % of adjusted measuring range/
Messpunkt in % vom eingestellten Messbereich

We confirm that all tests, according to the Quality Plan (QP), have been performed successfully. At the time of verification, the measuring points of the device indicated above were in compliance to the published valid technical specification (TI).

Wir bestätigen, dass alle Tests aus dem Qualitätsplan (QP) erfolgreich durchgeführt wurden. Das Gerät entsprach zum Zeitpunkt der Prüfung an den aufgeführten Messpunkten den gültigen technischen Spezifikationen (TI).

TI 431P

This document was generated electronically and is valid without signature.

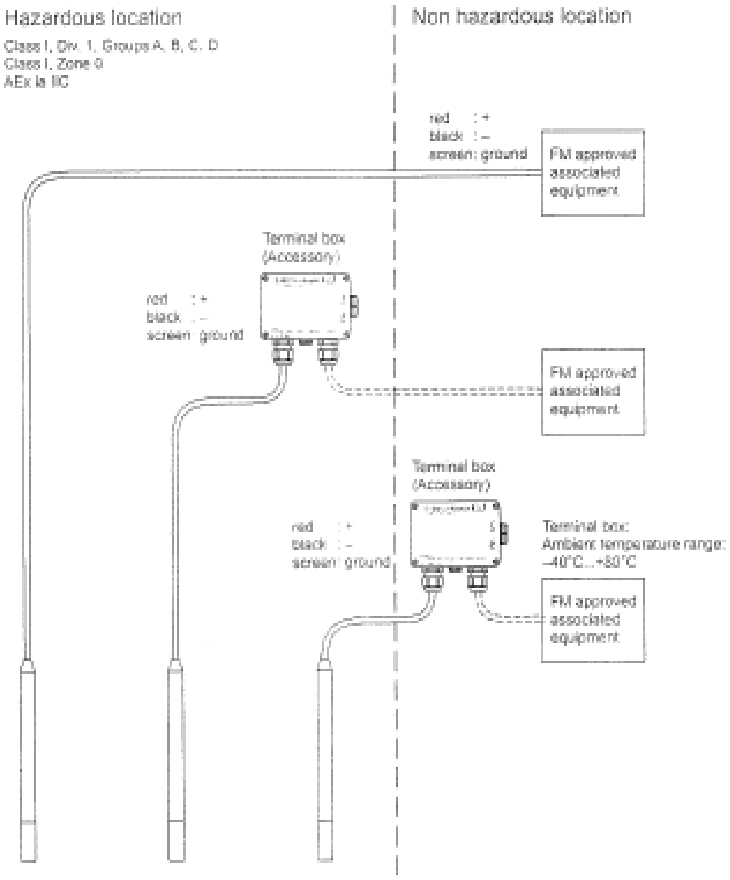
Dieses Dokument wurde elektronisch erzeugt und ist ohne Unterschrift gültig.

Endress+Hauser
People for Process Automation

Date of inspection/ Prüfdatum 26. Nov 2018

71089244/250082797-C

- End of document -
- Ende des Dokumentes -



Intrinsically safe (entity), Class I, Div. 1, Groups A, B, C, D or Zone 0, IIC Hazardous Location Installations

1. FM approved apparatus must be installed in accordance with manufacturer instructions.
2. Control room equipment must not use or generate over 250 V.
3. The installation must be in accordance with the National Electric Code ANSI / NFPA 70 and ANSI / ISA-RP 12.06.01.
4. Sensor entity parameters: Vmax = 30 V DC, Imax = 133 mA, Pmax = 1 W Ci and Li per following table:

Length of sensor cable	Ci (10.3 nF + 180 pF/m)	Li (1 µH/m)
5 m	11.3 nF	5 µH
10 m	12.2 nF	10 µH
20 m	14.0 nF	20 µH
30 m	15.8 nF	30 µH
50 m	19.4 nF	50 µH
100 m	28.4 nF	100 µH
200 m	46.4 nF	200 µH
300 m	64.4 nF	300 µH

5. FM approved associated equipment must meet following conditions:
Voc or Vt ≤ Vmax; Isc or Io ≤ Imax; Po ≤ Pmax;
Ca ≥ Ci + Ccable; La ≥ Li + Lcable.
Install associated equipment in accordance with the manufacturer instructions
6. Use supply wires suitable for 5°C above surrounding ambient.
7. Avoid friction and impact sparks. Anchor sensor if necessary, secure against swinging.
8. WARNING: Avoid electrostatic charging of plastic surfaces. Do not rub. Do not use in media or environments which may generate electrostatic charges on plastic surfaces.
9. WARNING: Substitution of components may impair intrinsic safety.
10. Do not remove or move terminal blocks, fastening elements or insulation plates of the terminal box. Do not build in additional components.
11. Connect cable screen to earth ground of the installation.

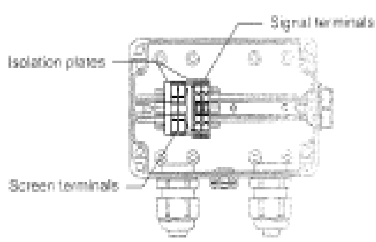
Sensor

Temperature class	Ambient temperature range
T4	–10°C ≤ Ta ≤ +70°C
T5	–10°C ≤ Ta ≤ +55°C
T6	–10°C ≤ Ta ≤ +40°C

Terminal box

Temperature class	Ambient temperature range
T6	–40°C ≤ Ta ≤ +80°C

Terminal box (Accessory):



[Click here to return to Strategic Automation Configuration (DCS))]

XIII. Exhibit R

Hampton Roads Sanitation District
Strategic Automation Configuration Guide

Automation Standards

January 26, 2021

Introduction

Software, hardware, and network standards must be defined before any distributed control system (DCS) design effort can be undertaken. Such standards benefit the DCS development team by providing a consistent design and an organized implementation plan. This, in turn, benefits the final user in the form of an efficient DCS operation and maintenance environment. This document details the DCS automation standards for the Hampton Roads Sanitation District, and future projects.

This Automation Standards document is intended to be a living document, and as such, will be continuously updated. Changes will occur more frequently as new plants are added, and new types of control are defined.

This volume is ordered into sections which provide a broad-brush approach to standards, guidelines, and best practices. For each plant or pump station, a second volume will be developed, having additional tabbed sections containing standards that are unique to that specific plant or pump station.

Due to the necessity to restrict access to sensitive information about HRSD's network infrastructure, control details, database, etc., the original Automation Manual has been split into two sections. The first of which is intended to provide a detailed overview of the OVATION system and recommended practices, that would be of use to an Architect Engineer in understanding the OVATION system. The second manual mirrors the first in section numbers, etc. This manual contains details of the control systems' networking set up, program details, and protocols used. This second manual will be used for internal purposes only by HRSD to configure the system.

GUIDE
SPECIFICATION
SECTION 40 94 23
DISTRIBUTED CONTROL SUBSYSTEM (DCS)

PART **1** **GENERAL**

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): X3.5, Flow Charts Symbols and Usage.
2. Instrumentation, Systems, and Automation Society (ISA):
   a. S5.2, Binary Logic Diagrams for Process Operations.
   b. S5.4, Instrument Loop Diagrams.
   c. S5.5, Graphic Symbols for Process Displays.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (10,000 Volts Maximum).

1.2 SUMMARY

A. This section covers requirements for Distributed Control Subsystem (DCS) and is in addition to requirements in Section 40 90 10, Process Instrumentation and
Control Systems (PICS). Key technical definitions and requirements for DCS are given in Section 40 90 10, Process Instrumentation and Control Systems (PICS).

B. DCS functions include data acquisition, process control, historical data storage, text and graphical data display, alarming, data analysis, and report generation. Requirements listed, identify minimum acceptable system performance. Provide hardware and software features required to allow configuring of a fully operational system, with convenient operator interface and efficient equipment use.

****

****

C. DCS Overview: The complete Distributed Control System shall be the latest version of the Ovation System, manufactured and supplied by Emerson Process Management (EMR). The system shall include the following components and features as shown on the DCS System

Block Diagram:

1. All DCS communications modules and cables shall be redundant.
2. All DCS power supplies shall be redundant.
3. Interface gateway to Allen-Bradley PLC SLC.
4. All DCS hardware shall be powered from "true on-line double conversion" type UPS units provided by the DCS supplier. All UPS units shall be monitored by the DCS for faults and low battery conditions. UPS units shall be located in communication cabinets in control room locations and in separate enclosures for RIO units.
5. All I/O modules shall be provided with field termination units with factory interconnect cable.
6. All DCS equipment shall be powered through shielded isolation transformers. Transformers and associated circuit breaker panels shall be sized and provided by DCS supplier.

D. Configuring of Applications Software shall be provided by EMR.

1.3 *DEFINITIONS*

A. Abbreviations:

1. As specified in Section 40 90 10, Process Instrumentation and Control Systems (PICS).
2. CPU: Central Processing Unit.
3. EMR: Emerson Process Management (DCS Supplier).
4. EWS: Engineering Workstation.
5. PMCS: Process Monitoring and Control Software.
6. LAN: Local Area Network.
7. DCU: Digital Control Unit.
8. PLC: Programmable Logic Controller.
9. RTU: Remote Terminal Unit.
10. ACC: Area Control Center.
11. CAD: Computer Aided Design.

B. Terms:

1. Circular Files: Files in which each latest record written to file replaces oldest record in file.
2. Log a Message: Print a message on an alarm/status printer.
3. OIS: Includes computer with standard operator station software, operator's keyboard, and CRT monitor.

C. Types of Variables:

1. Calculated Analog Points (CA): Analog variables computed from DCU inputs, manual inputs, calculated discrete points, and other calculated analog points.
2. Calculated Discrete Points (CD): Discrete variables computed from DCU inputs, manual inputs, calculated analog points, and other calculated discrete points.
3. Manual Inputs (MI): Variables whose values are manually entered, e.g., laboratory data.
4. Process Variables (PV): Analog variables from DCU analog inputs and calculated analog points.
5. Report Variables: Variables computed by report generator.

1.4 SUBMITTALS

A. Action Submittals:

1. DCS block diagram and overview description.
2. Bill of Materials:
   a. Breakdown to level of individual plug in modules.
   b. Information: Name of part, manufacturer, model number, options included, and quantity. Organize by ACC, and within ACC organize by enclosure and component (for example, DCU, EWS, OIS).
3. Room Layout Drawings: For each ACC, show to scale enclosure, furniture, DCS equipment, and service area requirements.
4. Power Connection Diagram: For DCS equipment, show interconnection from power sources through uninterruptible power supplies and power distribution panels to DCS equipment.
5. Grounding Diagram: For DCS equipment, show grounding philosophy and implementation.
6. Interconnecting Wiring and Cabling Diagrams: For DCS equipment, identify terminal receptacles, cable ID tags, actual cable lengths, and maximum distance limitations between cabinets or components.
7. Component Submittal: For each DCS component:
   a. General data and description.
   b. Engineering Specifications and data sheets.
   c. Scaled drawings and mounting arrangements.
   d. Equipment weights.
   e. Power and grounding requirements.
   f. External electrical interconnection and interface definitions.
8. Shop Drawings for Specifically Assembled DCS Equipment:
   a. A complete connection diagram.
   b. Data sheets on each major item, annotated as necessary to describe specific items furnished.
   c. Scaled Layout and Fabrication Drawings:
      1) Cable access areas and cable routing.
      2) Power termination and ground lug location.
      3) Data cable termination points.
      4) Field signal termination points.
      5) Anchor bolt size and location.
   d. Installation and mounting detail drawings.
   e. Equipment weights.

9. Input/Output (I/O) Point List for All I/O Points: Information in the list shall include all items shown on the I/O lists in these documents and the following information where applicable:
    a. Point names and descriptions.
    b. Point addresses, tag numbers, functions, ranges, and engineering units.
    c. Wire and cable assignments.
    d. DCU card layout, module and block number.
    e. Field wiring termination assignments.
10. Power Consumption and Heat Dissipation Summary for DCS Equipment: Voltages, current, phase(s), and maximum heat dissipations in Btu/hr.

B. Software Shop Drawings:

1. System Software Documentation: Complete reference information for system users. Detailed descriptions including features, limitations, and use of System Software.
    a. Operating System and Utilities:
        1) Base Documentation: For day-to-day users of tasks, including editing files and using command procedures.
        2) General User Documentation:
            a) Using files, directories, command language, and text editors.
            b) Alphabetic list of errors, warning and informational messages including explanation and response required.
        3) System Manager Documentation:
            a) Setting up systems.
            b) Maintaining system and files.
            c) Optimizing performance.
            d) Networking features.
        4) Programming Documentation:
            a) Linking, loading, running, and debugging tasks.
            b) Screen management.
            c) Librarian and file management.
            d) Device support and device drivers.
    a. Programming Language. Syntax, execution, use and reference capabilities.
    b. Online and Offline Diagnostics: How they are used, and various execution options available.
    c. Communications with DCS and PLC equipment. Describe configuration, operation, limitations, and diagnostics for LANs, data highway, serial links, and other communication

paths. Provide sufficient documentation to allow third parties to troubleshoot communications problems with devices connected to DCS.

2. PMCS Documentation: Detailed technical reference manuals and user level manuals.
    a. Types of Manuals:
        1) System Manager Documentation:
            a) Initial system setup.
            b) Data base and file structures.
            c) Communication with field devices.
            d) Maintaining system and files.
            e) Troubleshooting system problems.
            f) Optimizing performance.
        2) System Engineer Documentation:
            a) Configuring applications software.
            b) Documenting applications software.
        3) Operator Documentation: Using the PMCS with configured applications software.
    b. PMCS Functions Covered:
        1) Process data base.
        2) Communication with field devices.
        3) Calculated analog points and calculated discrete points.
        4) Input processing.
        5) Message logging.
        6) DCS diagnostic alarms.
        7) Alarm handling.
        8) Control processor.
        9) Restart program.
        10) Man-machine interface-general functions.
        11) Graphics display generator.
        12) Types of displays.
        13) Alarm/status log history.
        14) Historical data collection.
        15) Data retrieval.
        16) Trending.
        17) Report generator.

C. Informational Submittals:

1. Testing related Submittals.
2. O&M Manuals-Hardware:
    a. Updated version of hardware Shop Drawings.
    b. Component Manufacturers' O&M Manuals: Instructions for installation, operation, maintenance, troubleshooting,

and calibration.

c. Bill of materials for parts. Separate list of installed parts from lists for spare parts and expendables provided.

d. List of additional spare parts recommended.

3. Reproducible Hardware Drawings:

a. DCS block diagram.

b. Power and grounding interconnection diagrams.

c. Interconnection wiring and cabling diagrams.

4. O&M Manuals-Software Documentation:

a. Updated version of software Shop Drawings described under Article Submittals.

b. For system software that is not a product of the DCS manufacturer, include manufacturer's original disks and manuals with hardware shipments.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Control Room: NEMA 1.

B. Other Locations: As noted.

1.06 SEQUENCING AND SCHEDULING

A. Refer to Section 40 90 10, Process Instrumentation and Control Systems (PICS).

1.7 MAINTENANCE

A. Maintenance Service Agreement: Services provided following system acceptance.

1. Service Agreement:
   a. Duration: 2 years.
   b. Demand Maintenance: As requested by Owner.
   c. Manufacturer's recommended preventive maintenance, checking system error counters, and installing required engineering changes.
   d. Remote Monitoring and Diagnostic Service: Direct telephone line link between DCS and DCS manufacturer's maintenance center. Service supports connection of DCS to remote equipment at DCS manufacturer's service center, which can be used to diagnose hardware and software problems with all DCS equipment.
2. Telephone Support Service:
   a. Duration: 2 years.
   b. Available during normal business week.
   c. Provided by persons thoroughly familiar with DCS supplied.
3. Software Update Service:
   a. Duration: 4 years.
   b. Coverage: Standard software, including both system software and PMCS.
   c. Include new software versions, documentation updates, newsletters, user notes, software performance reports, interim software updates, revisions, releases, and fixes, etc.

1.8 EXTRA MATERIALS

A. Spare Parts:

1. When computing percentages for spare parts, round up fractions to nearest whole number.
   a. Modules and Power Supplies: For all DCS equipment except printers, and personal computer portion of engineering workstations and OISs:
      1) 2 of each size and type of power supply used.
      2) 1 of each type of electronic circuit board or electronic module used, except for process I/O modules.
      3) 2 of each type of process I/O module required to handle the points shown in I/O lists in Supplements at end of

this section.

b. Engineering Workstation: One.

c. Fuses: 20 percent, but no less than 10 of each type and current rating used.

PART 2 PRODUCTS

2.1 SYSTEM PERFORMANCE

A. Availability: 99.999 percent minimum.

B. Capacity:

1. Provide DCS with sufficient capacity to handle specified equipment and functions required by Contract Documents and equipment listed under paragraph Future Components, and still have specified spare capacity. Except for software configuring, implementing listed future components shall not require addition of DCS hardware or software to the DCS equipment supplied under this contract, other than the listed future components.
2. For example, provide I/O racks, power supplies, processor capacity and inter-rack cables in each DCU supplied under this contract, for DCU future I/O.
3. *Refer to following items as an indication of complexity of applications software that DCS will be required to support:*
   a. Drawings: Process and Instrumentation Diagrams.
   b. Section 40 90 10, Process Instrumentation and Control Systems (PICS): Supplements, Functional Descriptions, DCS Special Functions.
   c. Input/Outputs List in Supplements at end of this section.
4. Capacity refers to required physical size, storage capacity, and processing throughput of DCS hardware and software. DCS changes required to implement listed future components shall be limited to "configuring" data base tables and system parameters to allow system to recognize the additional equipment.

C. Response Times:

1. Basis for Response Times:
   a. All DCUs and OISs are in operation.
   b. Each EWS and OIS has been configured with 5,000 tags.
   c. Spare slots in DCUs have been used to implement I/O points in table under paragraph DCU Spare Plug-In Slots, under Article Spare Parts.
   d. Process graphic displays have 20 active points minimum, and points distributed between DCUs.

2. OIS Response Time: Number of seconds from when an operator requests a new OIS display until that display is fully presented on screen with active data displayed. For each type of display, table lists maximum allowable times in seconds for:
   a. Average: Average time to call up display.
   b. Worst: Worst case call up time.
   c. Refresh: Rate at which data on display is updated.

Display Type	**Average**	**Worst**	**Refresh**
Group Display	1.0	2.0	1.0
Process displays	2.0	2.0	1.0
Alarm summary	1.0	1.0	1.0
Historical trends, four process variables minimum			
30 minutes	1.0	1.0	--
1 hour	2.0	2.0	--
8 hours	2.0	2.0	--
1 day (24 hours)	3.0	3.0	--

Display Type	**Average**	**Worst**	**Refresh**
1 week (7 days)	5.0	5.0	--
30 days	10.0	10.0	

3. Viewing Input Changes:
   a. Given following conditions:
      1) Operator is viewing a process graphic display.
      2) A displayed point's field input to a DCU changes its value.
   b. Time From Field Input Change Until New Value Appears on Process Graphic Display: 2 seconds, maximum.
4. End-to-End Response Time for DCUs:
   a. Given following conditions:
      1) Operator is viewing a process graphic display.
      2) Operator gives command through OIS to change status of DCU discrete output point from ON to OFF.
      3) At DCU discrete output point is wired back into a

discrete input point.

4) Discrete input is displayed on process graphic display being viewed.

b. Time from operator command to change discrete output until new value of discrete input appears on graphic display: 3 seconds, maximum.

5. End-to-End Response Time for PLCs:

a. Conditions: Same as for end-to-end timing for DCUs.

b. Time From Operator Command to Change Discrete Output Until New Value of Discrete Input Appears on Graphic Display:

15 seconds, maximum.

D. DCU Input Scan Rate:

1. Analog Inputs: 2 seconds, maximum.
2. Discrete Inputs: 1 second, maximum.

E. Redundancy and Reliability:

1. No single failure of any DCS equipment, including data highway or power supplies, shall cause loss of any functions except as noted for failure of the following items.

a. DCU with Redundant Processors: No loss of function.

b. Any OIS: Loss of function limited to use of that OIS.

c. Any Engineering Workstation: Loss of function limited to use of that engineering workstation.

d. Any Process I/O Card: Limited to loss of functions dependent on signals from/to that card.

2. Provide means to manually switch functions of failed OISs to another unit.

2.2 SYSTEM SOFTWARE

A. Operating System: General purpose, multiuser, multiprocessing operating system:

1. Multiprocessing support for simultaneous execution of process monitoring, and control software tasks, and system support tasks.
2. Batch processing operating under control of command files.
3. Priority task scheduler with provisions for job initiation on time of day, elapsed time, hardware interrupt, process event, request from another task, or operator request.

4. Schedule I/O operations on a priority basis with all I/O carried out concurrently with program execution.
5. Device independent input/output system using online reassignable logical unit numbers for peripheral devices and file names for disk and tape files.
6. Ability to delete, replace, or add process control task or system support while online.
7. Multilevel password protection scheme to control access to different system support tasks and disk-based data structures.
8. Systems Generation: Allow configuring of an operating system to meet specific requirements of hardware and software configuration.
9. All software on system should have the appropriate number of licenses for the hardware the system was shipped with.
10. Licensing for the Historical points on the Historian (Drop 160) should be 50% greater than when the system is shipped for future expansion purposes.

B. Programming Languages: Provide compilers each programming language used by DCS.

C. Utilities:

1. File Management: General-purpose file system supporting dynamic creation, extension, and deletion of disk files from source programs, object programs, and data files.
2. Network Communications: General-purpose network communications software to support local area network connection between DCS central processing units and with personal computers. Allows for exchange of disk files between computer systems.
3. Debugging Aids: Online and offline debugging aids for high and low level language environments.
4. Disk Backup and Reload: Operator-initiated utility for maintaining backup copy using the latest technology.

D. Diagnostics:

1. Online Diagnostics: Complete system of diagnostic software to monitor, isolate, identify, tabulate, and alarm system hardware malfunctions and software failures.

E. Additional Software Tools: For each OWS provide current versions of manufacturer’s standard software tools.

F. Transportable Applications: While applications software is being developed and tested offsite, each OIS, EWS, and DCU may be temporarily substituted for a similar unit. For example, applications software for EWSs, DCUs, and OISs for one ACC may be developed and tested using equipment for a different ACC. Allow applications software for one unit to be transported to other units of same type. Provide software, software licenses, and hardware needed to support this type of transporting and substitution, whether or not these software, software licenses or hardware will actually be used in final configuration.

G. Capacity to Handle Software Upgrades: Provide DCS hardware able to adequately run major software upgrades introduced by DCS manufacturer the life of DCS product line.

2.3 PROCESS MONITORING AND CONTROL SOFTWARE (PMCS)

A. Types of PMCS Software:

1. Control: Executes on DCUs.
2. Monitoring and Supervisory Control of DCUs: Executes on OISs and EWS.
3. Configuring of Applications Software: Executes on EWS and OIS. Includes utilities and configuring aids in either online or offline modes.
4. Communications: Executes on DCUs, OISs, and EWS.

B. Types of Displays:

1. Index Displays: Alphanumeric display with major and minor indexes that identify access to all subsequent displays.
2. Overview Displays: Alphanumeric displays that show a summary of the group and process graphic displays. Includes the display names and descriptions./
3. Group Displays:
   a. Detailed information on a number of analog control loops, analog indications, discrete sequencing functions, and discrete status indicators, in any configurable combination.
   b. Groups of analog controller and indicator displays. "Faceplate" type displays having all the operator interface features normally provided by conventional electronic analog controllers and indicators. These features include display of ranges, units, pacing constants, AUTO/MANUAL status, tag numbers, service descriptions, bar graph representation and numeric values of process variables, outputs, and set

points.

c. Discrete sequence step indications, time value indications, AUTO/MANUAL mode indications, tag numbers, and service descriptions.
d. Discrete status indications including ON/OFF status of discrete inputs and outputs, AUTO/MANUAL status of discrete outputs, software selector switch position indications, tag numbers, service descriptions, Boolean, integer, real, and string parameter values.
e. Detail Displays: Configuration parameters associated with an individual loop or process 1/0 point, such as, controller tuning constants, timer values, scaling constants, alarm settings, etc.

4. Trend Displays: Provide functions described under paragraph Trending.
5. Alarm Summary Display: Shows all existing alarms and unacknowledged alarms. Refer to paragraph Alarm Handling.
   a. Display format similar to messages logged on alarm/status printer.
   b. Retains last 1,000 alarms, minimum.
   c. Include time of day at which alarm was detected.
   d. Alarms grouped by priority, highest priority first.
   e. Within priority groupings, alarms listed in reverse chronological order.
   f. Unacknowledged alarm messages shall be displayed in reverse video.
   g. Single-key acknowledgement of all alarms shown on a currently displayed page of alarm summary display.
6. Process Graphic Displays: Configurable.
   a. Display Objects:
      1) Process Flow streams: Labeled and color coded.
      2) Process Structures: Basins, tanks, wet wells, channels, etc.
      3) Major Equipment Items: Pumps, blowers, drives, compressors, etc.
      4) Major Control Devices: Gates, valves, etc.
      5) Instruments.
      6) Targets to allow quick access associated process graphic displays.
7. Diagnostic Displays:
   a. DCS Diagnostic Display: Graphic display showing operational status of DCS, including data highway and OIS.

C. Historical Data Collection Files:

1. Periodically save designated variables for trending, report generation, and historical records. Allow any process variable to be selected for saving in data collection files.
2. Data Entry for Manual Inputs:
    a. Direct entry into historical files of data values for manual input variables.
    b. Data entered through menus based on configurable groups of related manual inputs.
3. Disk Files:
    a. High Resolution Data:
        1) Sample Interval: Adjustable from 1 second to 15 minutes.
        2) Period Covered: Multiple day, adjustable.
        3) Content: Time of day, date, and values of designated process variable. Value saved may be either instantaneous value or average over sample interval.
    b. Hourly Data:
        1) Sample Interval: 1 hour.
        2) Period Covered: Multiple day, adjustable.
        3) Content: Time of day, date, average, maximum, minimum, and totalized hourly values of designated process variables.
    c. Daily Data:
        1) Sample Interval: 1 day.
        2) Period Covered: Multiple day, adjustable.
        3) Content:
            a) For Designated Process Variable:
                (1) Daily minimum and maximum values.
                (2) Time occurrence of daily minimum and maximum values.
                (3) Average daily value.
                (4) Daily total (for flow and other rate type variables).
            b) End of day values for designated run time counters and cycle counters.
            c) Daily values for designated report variables and manual inputs.
        1) In case DCS is down at midnight, allow manual initiation of this file update at a later time.
3. Historical Archive File: Maintains permanent record of data saved in daily data disk file. On command, copy 1 month of data from daily

data disk file to historical archive tape file. Provide operator selectable commands for both manual initiation and automatic timed initiation of this archival operation. Copy operation does not alter disk files. Disk data continues to be available for data retrieval functions.

D. Trending:

1. General Features:
    a. Trending is a special case of previously specified Data Retrieval function.
    b. Simultaneous trending of different sets of variables on different trend output devices.
    c. OIS Trend Resolution: Pixel level.
    d. Variables Per Trend: User selectable, one to four minimum, all displayed in same trend window.
2. Trend Types:
    a. Real-Time: Continuous plotting of variables as a function of time.
        1) Plottable Variables: Any process variable, report variables, discrete variable, and manual input defined in process data base.
        2) Minimum Plot Sample Interval: Same as scan rate.
    b. Historical: Plotting any variables from Historical Data Collection files as a function of time.
3. Retrieval Parameters: Specific variables, data types, retrieval period, sample interval, process variable scales, and output device. Refer to paragraph Data Retrieval.
4. Process Variable Scales:
    a. Independent selection for each variable of low scale and high scale values in engineering units of process variable axis. For example, if scales for variables A and B are 0.00 to 1.00 and 100 to 200 respectively, and if A=0.50 and B=l 50, both A and B would plot
       at exactly the same point (the mid-point of process variable axis).
    b. Display individual, engineering units' scales for each variable being trended.
    c. Readout Cursor: Adjustable by user over range of time scale. Values are displayed in engineering units of each trended variable intersected by readout cursor.
    d. Point Descriptions: Tag number and description are shown for each trended variable.
4. Trend Groups: Aid requesting of frequently used trends. Each Trend Group contains all data retrieval parameters needed to specify trend display for up to four variables.
    a. Provide a minimum of 10 trend groups.
    b. Allow operator to create custom trend groups as desired.

E. Utility Programs: Software that helps in the configuring of applications, including but not limited to database format translations (to and from dBase, EXCEL), checking and verification of control configuration, configured blocks, and display configuration.

H. PMCS Manufacturer: EMR.

2.4 DCS COMMUNICATIONS

A. General: High speed masterless communication system linking all DCS stations as shown on DCS block diagrams in the Drawings. DCS stations are defined as DCUs, OISs, EWSs, printers, and gateway modules.

B. DCU Data Highway Performance:

1. Communication Speed: 100 Mbps, minimum.
2. Operating Length: 5,000 feet, minimum.
3. Stations Supported per Highway: 100, minimum.

C. Redundancy and Reliability:

1. Communications system fully redundant; no single failure of communications component results in loss of communications to any DCS station.
2. Redundant Components: Including, but not limited to, communications controllers, modems, power supplies, data highway cables, and cable connectors.
3. Redundant data highway cable lengths: Different cable lengths (paths) for each highway cable shall not affect operation.
4. Automatic detection of communications system component failure.
5. Automatic switchover from failed communications system component to backup component without any interruptions to normal operations. Alarm switchover and identify failed component in alarm message.
6. Communication system not affected by connection, disconnection, and failure of DCS stations.

D Peer-to-Peer Communications: Direct communication over data highway between DCUs. Allows DCUs to exchange data base values. Communication not dependent on OISs or EWSs. Allow at least 10 percent of any DCS database values to be exchanged with other DCUs on a regular basis without degrading system performance.

C. Applications Software Transfers: For stations connected to communications system:

1. *Download control logic from EWSs to DCUs.*
2. Upload control logic from database server.

3. Download monitoring and display configurations from EWSs to OISs and other EWSs.
4. Upload monitoring and display configurations from database server.

D. DCS/PLC Communications:

1. Periodically read all discrete and analog inputs and outputs for each PLC.
2. On demand, read from and write to internal PLC registers including individual timers, counters, timer/counter preset values, control loop set points, high/low limits, computed variables, control loop tuning constants, status indicators, and sequence START/STOP commands.
3. DCS Capacity to Read and Write PLC Data: DCS able to read all PLC inputs and write all PLC outputs at least once every 15 seconds.

2.5 HARDWARE-GENERAL

A. DCS Block Diagram: Refer to control system functional block diagram in Drawings. Interconnecting lines shown on block diagram imply information flow and not necessarily wiring.

B. DCS Manufacturer: Emerson Process Management (EPM); Ovation System, latest version.

C. Control Room Layout: Refer to Drawings.

D. Equipment Mounting: Unless otherwise noted, mount all DCS components in NEMA rated cabinets.

E. Color: Manufacturer's standard.

F. Cables Required:

1. For interconnection between all DCS components, except where leased telephone lines are shown.
2. Fiber Optics Cables: As shown on Drawings, for interconnection between DCS components.
3. Data Highway and Local Area Network:
    a. Media: Fiber optics, coaxial, meeting DCS manufacturer's specifications.
4. Cables Under 50 Feet in Length: Prefabricated with connectors and factory tested with DCS.
5. Furnish and install communications cables.

G. Special signal conditioning/repeating equipment as required for proper operation of DCS.

H. Isolation Transformers: Provide for all DCS equipment to protect DCS from damage by electrical transients induced in cables by lighting discharges or electrical equipment.

I. . Power to DCS Equipment:

1. From isolation transformers and uninterruptible power supply (UPS) units provided under this section.
2. Supplied from dual feed circuits.
3. Provide circuit breaker panelboard at each DCU and RIO location.

J. Power Failure Detection and AUTO Restart:

1. Prevents errors due to power failure or short-term power fluctuations that occur when UPS is not operating.
2. Power Failure: Voltage variations more than plus or minus 10 percent of normal for a duration of 0.5 second or longer. Causes DCS equipment to automatically shut down as required to prevent introducing errors on disk.
3. Short-Term Power Fluctuations: Voltage variations more than plus or minus 10 percent of normal for durations of 0.5 second to 1 millisecond. DCS shuts down as above or is buffered to prevent fluctuations from causing errors.
4. DCS executes restart program and return to normal operation when power is restored. Battery backed-up real-time clock used by DCS during automatic restart to set time and date.

J. I/O Lists:

1. DCU Input/Output List: Covers I/O points directly connected to DCS process I/O modules.

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XII. ******************************

a. POINT TAG (OLD): Existing point tag in the old PLC based control system.
b. POINT TAG (NEW): New point tag to be used in the DCS software. This tagging system must follow the new HRSD standards. If new tag is not given, create tag in accordance with standards.
c. POINT DESCRIPTION: Point name to be used in the DCS software.
d. DCU/RIO: DCU or RIO number where point is to be terminated.
e. UP: Unit Process that the point is associated with.
f. DI: Discrete input signal, 24V dc.
g. DO: Discrete output signal, 24V dc.
h. AI: Analog input signal, 24V dc, 4 to 20 mA dc current signal.
i. AO: Analog output signal, 24V dc, 4 to 20 mA dc current signal. May be powered: from DCS or from field power supply.
j. TC: Thermocouple input signal, type K unless otherwise indicated.
k. SET (Contact Closed): Condition when the input device is closed or energized.
1. RESET (Contact Opened): Condition when the input device is not closed or energized.

m. SENSOR RANGE (Signal Range): Analog sensor and/or signal range.
n. AI POWER (DCS/FIELD): For analog inputs only, indicates loop power from either the DCS cabinet (DCU or RIO) or from a field power supply. FIELD also applies to typical 4 wire devices such as magnetic flow meters which do not need a powered 4 to
20 mA dc loop. If not indicated default is FIELD.
o. TERMINAL NO.: First terminal number in interface cabinet, field panel or other interface point. This will generally be the positive terminal.
p. TERMINAL NO.: Second terminal number in interface cabinet, field panel or other interface point. This will generally be the negative or common terminal if
q. TERMINAL NO. SHIELD: Terminal number for cable shield when needed with shielded cables.
r. REFERENCE DRAWING: Number or designation of the existing equipment drawing where interface terminals are shown.
s. P&ID: Process and Instrumentation Drawing where the equipment and signals are shown.
t. TOT: Total number of required active I/O points for each DCU or RIO unit. This includes DI, DO, AI, AO and TC signals.
u. COMMENTS: Any additional pertinent or clarifying information that may be included for reference or general information.

L. DCS Component: Provide all components required for a complete operational DCS system.

M. DCU and RIO Enclosures:

1. Number of standard cabinets as required for each DCU or RIO.
2. HRSD prefers back-to-back style cabinets with modules in front and corresponding termination units in back. If this cannot be accommodated due to limited floor space, then side by side cabinets will be acceptable.
3. Doors: Hinged doors for front and back access.
4. DCU/RIO Enclosure (Front half cabinet):
    a. DCU modules mounted in front.
    b. No field cables brought into cabinet.
    c. Sufficient rack space to accommodate specified future input/outputs, and associated power supplies, processors, communications and interface modules.
5. DCU/RIO Interface Cabinet (Rear half or side cabinet):

a. All field terminations in cabinet.
b. Houses all interface relays, timers, distribution breakers, fuses and miscellaneous items.
c. Cabinet divided by 11-gauge, minimum, mounting panel allowing equipment to be mounted both sides of panel.
d. Sufficient space in cabinets for terminations of specified spare I/O points and associated interface relays, timers, distribution breakers, fuses and miscellaneous items.

6. Typical Wiring Schematic: See Drawings.
7. DCU Spare Plug-In Slots: For each DCU/RIO, provide sufficient spare space in wired module cages plus sufficient terminals, power supplies, interfacing relays, and cabling to permit future addition of process I/O modules to bring total I/O point counts to those shown in following table. Numbers in parenthesis are remote I/O. Figures in table include required spares.
8. HRSD prefers Top Hat Enclosures on top of DCU/RIO's so conduits can penetrate it instead of DCU/RIO's. Inside of Top Hat enclosures two 4 inch knockouts can be made one for analog wiring and one for digital wiring. These knockouts should be centered in between the terminal connections.

2.6 HARDWARE-DCS COMPONENT LIST

A. Distributed Control Unit: Provide sufficient control processors, but no fewer than the number listed, for each DCU such that each control processor shall have 50 percent spare capacity when control functions have been configured.

B. Process Input/Output Modules:

1. I/O List: Provide sufficient I/O modules to handle the points shown in the I/O lists in Supplements at end of this section.
2. Spares: Refer to Article Spare Parts for additional requirements.
3. Remote I/O Modules: Mount all remote I/O modules within a given ACC in a cabinet that is separate from the DCU cabinet for that ACC.

C. Operator Interface Station: Manufacturer's standard with one or two monitors as shown.

D. Engineering Workstation: Manufacturer's standard.

E. Historical Data Processor: Provide one of the following options for historical data collection, archival, and retrieval:

1. Historical functions implemented by OISs. To provide redundancy, multiple OISs simultaneously handle these functions.
2. Historical functions implemented through dedicated historical processors. For redundancy, provide a minimum of two such processors.

F. Gateway Modules for Interface with Non-DCS Equipment:

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XIII. **********************************

1. PLCs: Allen-Bradley, Modicon, GE.
2. Where possible, use Modbus over Ethernet protocol.
3. Except with Allen Bradley PLC. Use native protocol.

7. HARDWARE-FURNITURE

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XIV. **********************************

A. Control Room Console:

1. Provide 3-position console.
2. Integrated multiple bay enclosures suitable for sit down operation. House OISs, EWSs, printers, communications processors, data highway communications equipment, and power supplies.
3. Units made of high impact, durable plastic top. Desktops capable of supporting 400 pounds, minimum, on extended surfaces. Bushed holes for power and signal cables to devices located on desktop. Edges of desktops beveled or rounded. Forms feed slots in desktops for printer paper. Cupboards below printers with shelves to hold feed paper.
4. Operator Station Layouts: Provide layouts for each operator station as shown on drawings and listed below. Bays are listed from left to right as **operator views console.**
   a. Types of Bays: Following abbreviations are used to identify required bays:
      1) OIS or EWS.
      2) Printer: Console printer surface.
      3) Work: Console work surface.
      4) Wedge: Console wedge section.
5. Colors: As selected by Owner.
6. Manufacturer and Product: Evans; Series 200, or equal.

B. Chairs:

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XV. ******************************

1. Quantity: 8.
2. Type: Mid-back desk chair with five-arm base, T-arms, back height adjustment, back angle adjustment, seat angle adjustment, arm height
   adjustment, pneumatic height adjustment, and electrostatic discharge (ESD) option.
3. Castors:
   a. ESD soft, dual-wheel for use on hard floors.
   b. ESD hard-composition, dual-wheel for use on carpet.
4. Finish: Approved by chair manufacturer for use with ESD option. Custom color selected by Owner.
5. Manufacturer: Steelcase Inc. Criterion series 453-5500.

2.8 HARDWARE COMPONENT SPECIFICATIONS

A. Distributed Control Unit (DCU):

1. Independent units completely fabricated, with components installed and wired at factory.
2. Implement control logic (applications software) configured through the EWS.
3. Capable of continuing to execute control logic to maintain control over process even if all other stations are down and data highways are nonfunctional.
4. Primary Components:
   a. Control processors (redundant).
   b. I/O modules.
   c. Redundant data highway communications processors.
   d. Power supplies.
5. Control Processors:
   a. Execute control logic compiled by EWS.
   b. Communicate with I/O modules, data highway, other control processors and PLCs.
6. Redundant Control Processors:
   a. Required for all units.
   b. Both control processors receive and process information simultaneously. Faults detected by processors themselves without the need for data highway to be available. When fault is detected, non-defective processor assumes control without affecting normal operation.

c. Allow online configuration of control processors without interruption to process control functions.

7. Power Supplies:
   a. No interruption of operation due to single failure of any power supply.
   b. Capable of providing 24V dc power from DCU to field instruments.
8. Transportable Applications: Applications software developed offline on EWS can be downloaded to control processors. Control processors can

emulate one another and applications software developed and debugged on one control processor can be saved, and later downloaded to a different control processor without additional modification.

B. Process Input/Output Modules:

1. Common Requirements:
   a. Surge Withstand Capability: ANSI/IEEE C37.90A.
   b. Discrete Output Fuses: Points individually fused either on I/O module or in field termination unit.
   c. Each I/O module shall be replaceable without disturbing the field

      I/O wiring connected to it.
   d. Provide a separate field termination unit and factory interconnect cable for each I/O module.
1. Analog Inputs (Isolated 4 to 20 mA dc):
   a. Type: Isolated 4 to 20 mA dc signals conforming to ISA S50.l.
   b. Input Range: 4 to 20 mA dc, minimum.
   c. Accuracy: Plus, or minus 0.1 percent of span.
   d. Resolution: 12 bits, minimum.
   e. Transmitter Power: 24V dc at 20 mA.
   f. Isolation: 300V minimum between points.
   g. Common Mode Rejection: 90 dB, minimum.
   h. Normal Mode Rejection: 33 dB, minimum, for frequencies of 60-Hz and above.
   i. Analog-to-Digital Converter: No more than eight inputs per converter.
3. Analog Outputs (Isolated 4 to 20 mA dc):
   a. Type: Isolated 4 to 20 mA dc signals conforming to ISA S50.l.
   b. Accuracy: Plus or minus 0.1 percent of span.
   c. Resolution: 12 bits, minimum.
   d. Isolation: 300V minimum between points.
4. Discrete Inputs (Contact Sense 24V dc):
   a. Type: 24V dc supplied by DCU impressed on external contacts

to sense their OPEN/CLOSE status.

b. Isolation: 300V minimum between points.

c. Maximum Current for Turn On: 3 mA.

d. LED ON/OFF status indicators for each point.

5. Discrete Outputs (Voltage Output 24V dc):

a. Type: DCU supplies 24V dc to operate relays in external control panels.

b. Isolation: 300V minimum between all output points.

c. Maximum Load Current: 2 amps.

d. LED ON/OFF status indicator for each point.

C. Uninterruptible Power Supplies (UPS): Manufacturer's standard continuous on-line type sized for a minimum of 30 minutes operation at full load conditions.

D. Isolation Transformers: Manufacturer's standard.

E. Circuit Breaker Panels: Manufacturer's standard.

2.9 SOURCE QUALITY CONTROL

A. Factory Demonstration Tests:

1. Scope: For all DCS equipment. See Section 40 90 10, Process Instrumentation and Control Systems (PICS).
2. Location: DCS manufacturer's factory.
3. Loop Specific Functions: See Section 40 90 10, Process Instrumentation and Control Systems (PICS).
4. Non-Loop Specific Functions:

a. Input/output point generation and point processing.

b. Control strategy generation.

c. Message logging and alarm handling.

d. Process control display generation and configuration.

e. OIS displays and user entries.

f. Power up, startup, and system restart.

g. Printing/plotting functions.

h. Failure mode and backup procedures including power failure, auto restart, and disk backup, and reload.

i. Data base configuration and use.

j. Historical data collection and retrieval.

k. Creation of a typical report and production of specified reports.

PART 3 **EXECUTION**

3.1 FIELD QUALITY CONTROL

A. Operational Readiness Test: Refer to Section 40 90 10, Process Instrumentation and Control Systems (PICS).

B. Performance Acceptance Test: Include the same types of testing that are specified for factory demonstration test.

3.2 MANUFACTURER'S SERVICES

A. General: Provide experienced personnel and management in field (Staging Site, and Plant Site) to coordinate and complete: installation, termination, adjustment, testing, training, and startup assistance.

B. Startup and Testing Team: Provide onsite, a team of at least two persons experienced in DCS systems engineering, hardware maintenance, and software configuring during the total period required to:

1. Check the installation, termination, and adjustment of all subsystems and their components.
2. Perform and complete onsite tests.
3. Provide startup assistance.

3.5 SUPPLEMENTS

A. Supplements listed below follow "End of Section," are a part of this Specification.

1. DCS Equipment Schedule.
2. DCS Input/Output List, included with Contract Drawings.

END OF SECTION

Hampton Roads Sanitation District Strategic Automation Configuration Guide

Software and HMI Standards

January 8, 2015

1 Introduction

Software, Hardware and Network standards must be defined before any Distributed Control System (DCS) design effort can be undertaken. Such standards benefit the DCS development team by providing a consistent design and an organized implementation plan. This, in turn, benefits the final user in the form of an efficient DCS operation and maintenance environment. This document details the DCS automation standards for the Hampton Roads Sanitation District projects.

This Automation Standards document is intended to be a living document, and as such, will be continuously updated. Changes will occur more frequently as new plants are added, and new types of control are defined.

This Volume is ordered into sections which provide a broad brush approach to standards, guidelines and best practices. For each plant or pump station, a second Volume will be developed, having additional tabbed sections containing standards that are unique to that specific plant or pump station.

2 Database

The Input/Output (I/O) database is the most important information required for a DCS project. Not only does it assist in the definition of control strategies and custom graphics, but it also provides point details that almost every standard software package on the DCS system uses. A successful DCS project starts with an I/O database that is 100% complete and accurate in both functional definition and record field content.

The following three sections define the core database record fields. The first section defines fields that are common to all data types. The remaining two sections define fields based upon whether the data type is analog or digital. Some of these fields are included for informational purposes only. Also, many of these fields will not necessarily appear in all of the published project I/O listings.

Emerson's Database Initial Definition Tool (DBID) is an offline pc-based utility that can be used to enter this essential database information for the DCS. Once the information is entered, the utility produces a file that can be imported into the actual Ovation DCS equipment.

<u>References</u>

- Appendix I – Database Field Entry
- Appendix II - Word and Phrase Abbreviations
- Ovation Record Types Reference Manual – REF_1140
- Ovation I/O Reference Manual - REF_1150

1. Common Fields

- Point Name is a unique identifier that is assigned to each field input and output. This identifier is coded with information pertaining to the plant, unit process, ISA and loop information associated with the I/O point.

- English Description is a functional definition of the Point Name, and appears in various system displays and listings. These rules are followed when assigning this field:

    - English Description is limited to 30 characters.

    - To benefit all users, English Description terminology, abbreviations and acronyms are consistent. Abbreviations are assigned so that their interpretations are as intuitive as possible, within the 30 character limit. Note that abbreviations are usually, but not necessarily unique, and that the context of the full description may provide the interpretation of what an abbreviation or acronym represents.

    - English Description specifically defines which device is being referenced. For example, "PUMP 1" is not an acceptable specific description, whereas 'TANK 1 GRIT PUMP 1" is an acceptable specific description.

- I/O Type defines the four distinct data types used in the database:

    - Analog Input (AI) is a continuous process or status input reading over a measured range.

    - Analog Output (AO) is a continuous control output signal, typically used to control a VFD or modulating valve.

    - Digital Input (DI) is a two-state reading of a device state, process state or device position.

    - Digital Output (DO) is a two-state control output signal, typically used to energize an interposing relay that starts a motor or drives a valve.

- Xmtr defines the communication method used between the DCS and the field device. The following communication methods are defined:

    - 4-20 mA - Specifies an Analog Input or Analog Output with a milliamp signal level that is directly proportional to a measured range or control range.

    - 2W - Specifies the use of a serial communication link (e.g. a PLC or valve communications link). Any I/O Type can use this communication method.

    - 24VDC - Specifies a digital signal that switches a 24 volt DC potential when reading a state or energizing a relay.

    - 120VDC - Specifies a digital signal that switches a 120 volt AC potential when reading a state or energizing a relay.

    - TC – Specifies an Analog Input with a millivolt signal level that is a function of sensed temperature.

- History defines which points should be archived. Analog points also require a historical deadband, which defines the incremental change required before a new analog value is archived. The default deadband value for an analog I/O point or calculated value is 1%., whereas critical points would be assigned a 0.5% value, and other points are not configured to be archived at all.

- P&ID references where the device can be found in the project specification P&ID or Electrical Plan drawing.

- DCU is a term used to describe a redundant control processor and it's supporting hardware.

- Alarm Priority (AP) is intended to inform the Operator of the urgency of an alarm. HRSD assigns alarm priority level definitions.

- Point Alias is an auxiliary database field that has been designated to hold the Old Point Tag, as designated in the project database.

- Characteristics are assigned to allow the User to assign console destinations for alarm points, and also as a sorting mechanism used with the Ovation Point Review utility.

- Security is assigned as a 32 bit field that defines which Users have access to the various control and tuning functions associated with each point.

2. Analog Fields

- AI Power specifies whether a 4-20 mA signal is powered locally at the DCU (DCS) or from a field power source (FIELD). Note that shields for all analog signal cabling will be grounded at the DCS.

- Top Bar (TB) is the maximum scale value of the point represented in engineering units. This attribute determines the scaling used for bar graphs and trend lines.

- Bottom Bar (BB) is the minimum scale value of the point represented in engineering units. This attribute determines the scaling used for bar graphs and trend lines.

- Range combines the TB and BB fields into a single field, for clarity.

- Engineering Units (EU) is the unit of measure that point value represents. Examples of Engineering Units would be PPM, MGD, GPM, PSI, etc. This description is limited to six characters.

- Decimal Places (FM) defines the number of decimal places that will be shown in the Point Information screen and by default on Graphics (unless otherwise defined within the graphic code).

- High Sensor (HS) is the maximum electrical range of the instrument providing the point value. For example, if an instrument operates within a 4-20 mA range, HS would be 20 mA. Likewise, if the instrument operates within a 1-5 VDC range, HS would be 5 VDC. Only enter the numerical value in the field; 5 in the last example. Note that for 4-20 mA signals, the high sensor alarm setting will be set at 20.4 mA.

- Low Sensor (LS) is the minimum electrical range of the instrument providing the point value. For example, if an instrument operates within a 4 to 20 mA range, LS would be 4 mA. Likewise, if the instrument operates within a 1 to 5 VDC range, LS would be 1 VDC. Only enter the numerical value in the field; 1 in the last example. Note that for 4-20 mA signals, the low sensor alarm setting will be set at 3.6 mA.

- High Alarm (HL) is the value at which an alarm is generated on increasing signal.

- Low Alarm (LL) is the value at which an alarm is generated on decreasing signal.

- Deadband (DB) minimizes the occurrence of nuisance alarming when a signal oscillates near a High Limit or Low Limit setting. Once a point has exceeded either threshold, the alarm will remain active until the signal passes back through the threshold by the amount specified in Deadband.

- Deadband Algorithm represents the units of the Deadband (DB) value indicated above (standard, percentage range, ratio, etc.)

- Top Output Scale (TW) represents the maximum value of an Analog Output in Engineering Units.

- Bottom Output Scale (BW) represents the minimum value of an Analog Output in Engineering Units.

3. Digital Fields

- Reset Description (RS) describes the state of a device or command when a Digital Input or Digital Output contact is opened.

- Set Description (ST) describes the state of a device or command when a Digital Input or Digital Output contact is closed.

- Alarm State (AR) specifies which logic state should be alarmed for a digital point, contact closed (AR = 1) or contact opened (AR = 0).

- Alarm is an alternative method used to display the Alarm State on a database listing and is positioned to indicate whether the Reset Description or the Set Description is the alarm state of the signal.

3 DCS Control Philosophy

The Ovation DCS offers a wide variety of hardware configurations and software tools, allowing the user maximum flexibility in the implementation of control applications. Like any software-based program, Ovation control applications follow stringent guidelines that dictate the programming structure and control logic flow. Implementation of such guidelines is critical to the efficient development of the control logic, successful installation of the DCS and ease of software maintenance for years to come.

The following sections summarize the DCS control application program structure, typical of the logic flow required for HRSD process control applications.

<u>References</u>

- Appendix IX – Level 1 Control Templates
- Appendix X – DCU Software Mapping
- Appendix XI – Sample Control Strategy
- Ovation Algorithms Reference Manual – REF_1100

3.1 Process Control Programming Structure

HRSD process control applications require two distinct layers of automation. Each layer requires a specific set of I/O signals and provides a limited level of automation. These levels can be summarized as follows.

Level 1 Control

This is the lowest level of automation, and provides manual start/stop/open/close control and monitoring of devices such as valves, pumps, breakers, etc. From a software standpoint, this layer of control is designed in a modular logic format since most devices require the same basic control functions. Provisions are also made to accept commands from higher levels of automation.

Devices that require continuous control signals such as modulating valves and variable speed drives are also considered as Level 1 control. The control for these devices is typically unique in nature and, therefore, is omitted below to simplify the discussion of control layering. Modulating control is specifically addressed later in this document.

Level 2 Control

This level of automation provides automatic control of multiple devices within a single process. Examples of logic functions included at this level are:

- Equipment sequencing
    - Lead/lag priority assignment
- Automatic equipment alternation of parallel devices

Much of this software is designed in a modular format.

3.1.1 Level 1 Control Automation

Level 1 control automation provides manual control/monitoring of devices such as valves, pumps, breakers, etc. This is the software equivalent of the type of hardwired controls that normally appear at a control panel or MCC. Features that appear at this level of software include:

- Operator interface
- Equipment protection interlocks
- Process interlocks

- Commands from other automation levels
- Device fail alarms

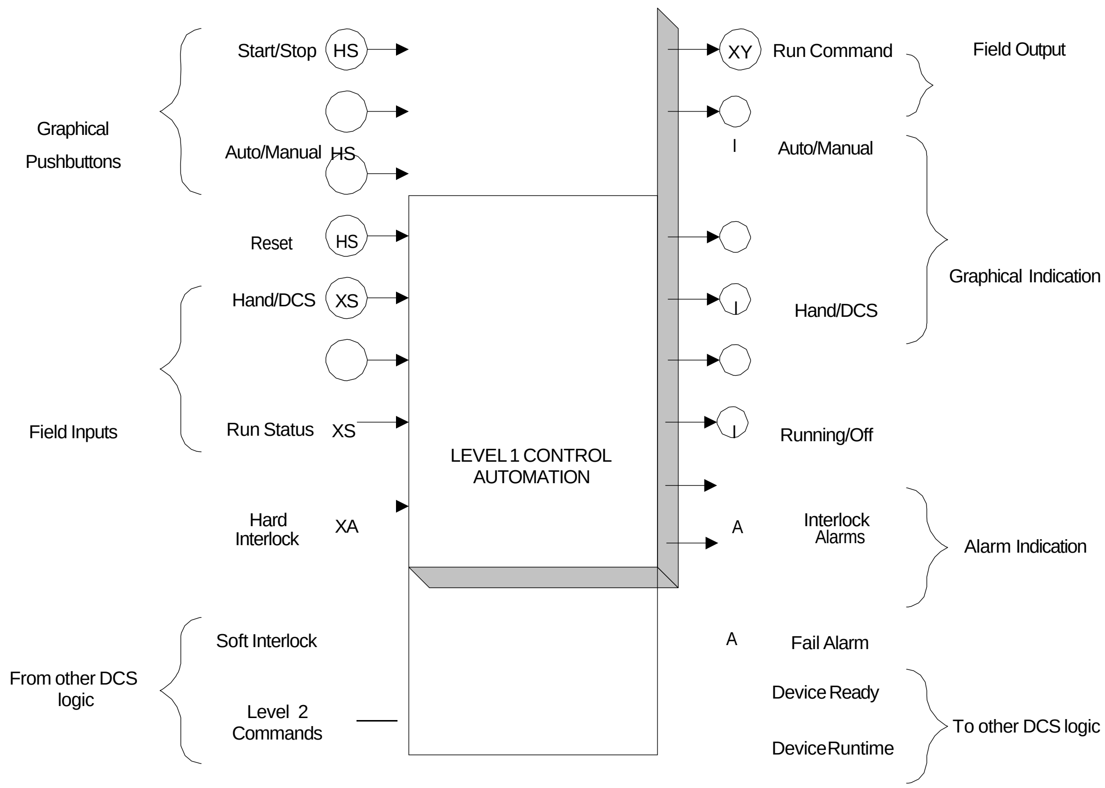


Figure 3.1.1 – Level 1 Control Automation Software Module

Figure 3.1.1 depicts a software module that controls an individual device such as a motor or breaker. This example generates one maintained control output based upon various Operator, I/O and DCS input signals. The module is designed to accommodate the worst case logic requirements of all field devices that utilize one maintained control output. For any device that does not match the requirements of the worst case device, all non-applicable input/output signals are disabled or ignored at the software module.

Other modules are developed for each type of control output requirement, e.g., one momentary output, two maintained outputs, two momentary outputs, etc. All modules have the same general characteristics:

- Operator Inputs – Graphical Pushbuttons
    - Start/Stop or Open/Close pushbuttons are provided to allow manual control from the DCS.
    - Auto/Manual pushbuttons are provided for any device that also has Level 2 control automation.
    - Reset pushbuttons are provided to allow the Operator to reset failure alarms.
- Field/DCS Inputs – Status and Interlock
    - Hand/DCS status is used to determine when the device is available for DCS control. Manual control pushbuttons are defeated when a device is in Hand control.

    - Device status provides the control feedback that is necessary to determine that the device is properly responding to the control output. A failure alarm is generated when the device does not respond properly to the DCS commands.
    - Hard (field) and soft (DCS) interlocks are used in permissive/interlock logic, providing equipment/safety protection.
    - Level 2 automation normally provides start/stop commands to Level 1 automation for control such as device sequencing, lead/lag operations and automatic device alternation.
- Operator Display – Status and Alarms
    - Operator control interface to Level 1 automation is normally depicted as a Manual/Auto (M/A) control station. The M/A station displays all status and alarm information, enabling the Operator to control, monitor and troubleshoot device operation from one graphic display.
- Field/DCS Outputs – Command Outputs and Device Ready Status
    - Command outputs drive the I/O that provides the DCS with the means to control the device.
    - In order to make control decisions without duplicating Level 1 logic, Level 2

automation requires a Device Ready status from the associated Level 1 automation. Device Ready status is a single signal that indicates that a device is in DCS control, is in DCS Auto, and has all interlocks cleared.

3.1.2 Level 2 Control Automation – Process Control

This portion of Level 2 control automation provides automatic control of multiple devices. This type of automation typically replaces repetitive or scheduled Operator functions that involve multiple pieces of equipment. Features that appear at this level of software include:

- Operator interface
- Process interlocks
- Process startup, shutdown and normal control
- Command/status from other automation levels
- Process fail alarm

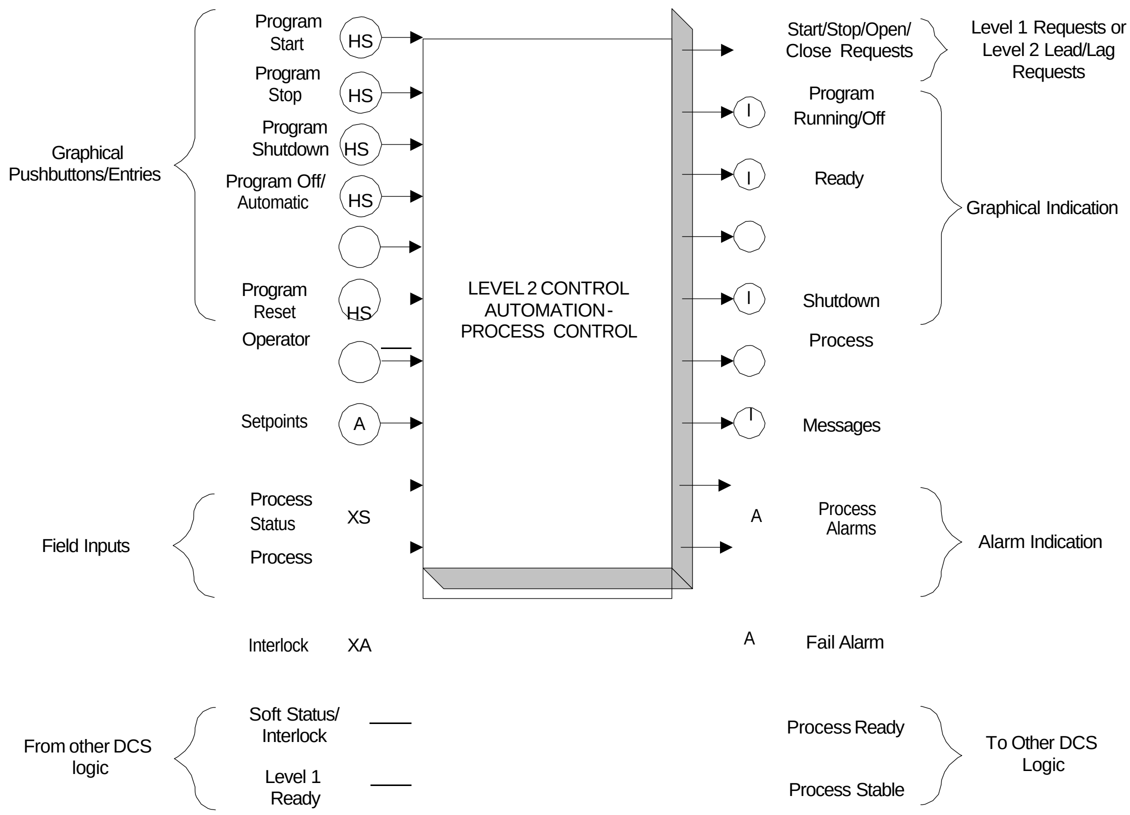


Figure 3.1.2 – Level 2 Control Automation Software Process Control Module

Figure 3.1.2 depicts a software module that controls multiple devices in response to process conditions and a predetermined program. This example generates multiple start/stop/open/close requests to other software modules. The interface to the Operator and to other software modules may be standardized, however the control program is customized based upon the process control requirements.

Other modules are developed for each specific process requirement. All modules have the same general characteristics:

- Operator Inputs – Graphical Pushbuttons/Entries
    - Program Start and Stop pushbuttons are provided for Operator initiation of the process. A Program Off pushbutton is provided to reset a sequence to its first step, when applicable. Process setpoints and timer settings are also typically required. A Program Reset is also provided as a means to reset any sequence FAIL event before reinitiating the sequence. A Program Shutdown pushbutton may also be required, which provides an immediate shutdown of the associated equipment.
- Field/DCS Inputs – Status and Interlock
    - Process status provides the control feedback that is necessary to determine that the process is properly responding to the control requests. A fail alarm is generated when the process does not respond properly.
    - Hard (field) and soft (DCS) interlocks are used in startup/shutdown permissive

logic, providing process protection. Equipment/safety protection is provided at the Level 1 control automation.

- Level 1 control automation provides Device Ready status information to Level 2 automation. This allows the Level 2 automation to determine which devices are available to control the process.

- Operator Display – Status and Alarms

    - Operator control interface to Level 2 automation is normally depicted on an entire graphical display or a single control window, depending on the complexity of the process control. The graphic displays all status and alarm information and provides the Operator with informational messages that are unique to the process. This enables the Operator to control, monitor and troubleshoot the process operation from one graphic display. Level 1 M/A stations are also sometimes accessible from this display.

- Field/DCS Outputs – Control Requests and Process Ready Status

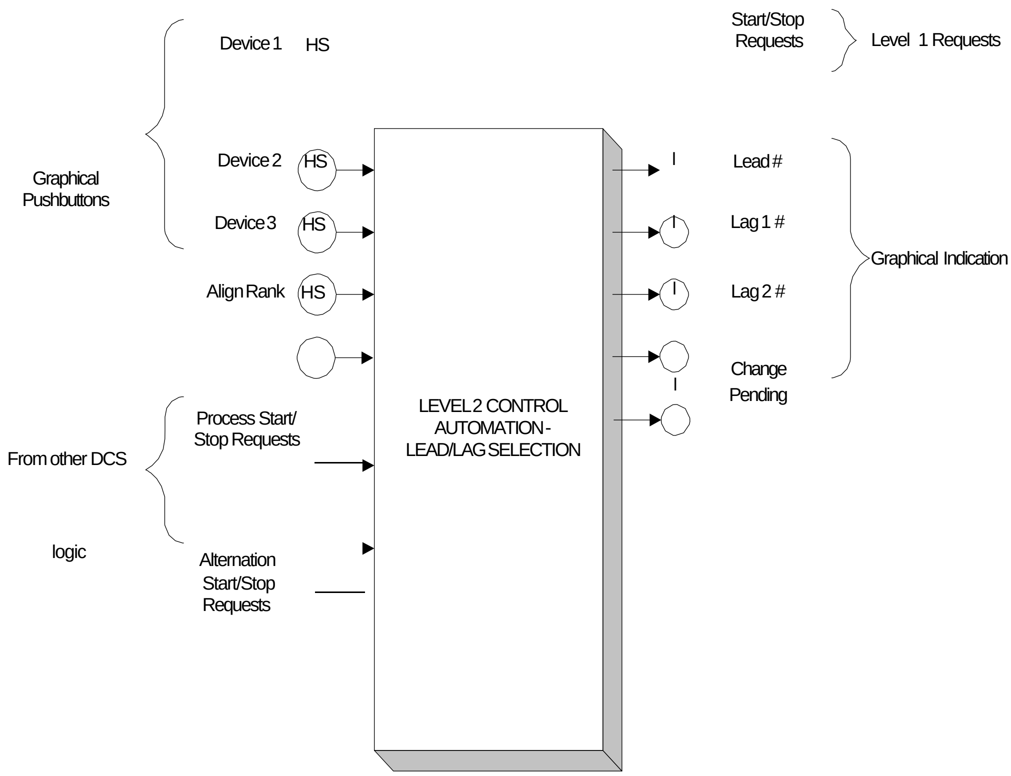
    - Control requests drive other software modules such as Level 2 Lead/Lag, Level 2 Alternation or Level 1.

3.1.3 Level 2 Control Automation – Lead/Lag Selection

This portion of Level 2 control automation accommodates the manual start/stop prioritization of multiple devices. Features that appear at this level of software include:

- Operator interface

- Manual start/stop prioritization



- Commands from/to other automation levels

Figure 3.1.3 – Level 2 Control Automation Software Lead/Lag Selection Module

Figure 3.1.3 depicts a software module that determines the specific selection of the next Level 1 device to start/stop. This example generates a control request for each device based upon various Operator and DCS input signals. The final selection is based on a predetermined order that is set manually. The module is designed to accommodate the worst case logic requirements of all processes that utilize a Lead/Lag type of selection. For any process that does not match the requirements of the worst case process, all non-applicable input/output signals are disabled or ignored at the software module.

Other modules may be developed for various types of control output requirement, e.g., Active/Standby, Lead1/Lead2/Lag, etc. All modules have the same general characteristics:

- Operator Inputs – Graphical Pushbuttons
    - Device pushbuttons are provided to allow manual order selection from the DCS. The Operator determines this by pressing the Device pushbuttons in the desired order.
    - The Align Rank pushbutton enables the Operator to execute an automatic re-alignment of the devices to match a new device order. Here, the highest priority devices are automatically started, and lower priority devices are stopped until the device statuses match the selected order.
- DCS Inputs – Status and Commands
    - This control module processes all requests from the Level 2 Process Control Module, and from the Level 2 Automatic Alternation Module when applicable.
- Operator Display – Status
    - Selection orders are displayed so that the Operator is aware of which device will be selected next.
    - The Operator may select a new device order if all devices are in the DCS Manual mode. Once an assignment is made for each device, a Pending Change message informs the Operator that the desired devices may again be placed in DCS Auto, then the Align Rank pushbutton will rotate the devices to match the new order.
- DCS Outputs – Control Requests
    - Control requests drive the associated Level 1 control automation.

3.1.4 Level 2 Control Automation – Automatic Alternation

This portion of Level 2 control automation requests the alternation of parallel devices based on one of several specified criteria:

- Runtime comparison to a manually set cycle timer
    - On start of alternating devices
- On device with least accumulated runtime, when device start is requested.

Features that appear at this level of software include:

- Operator interface
- Device current runtime comparison

- Commands to other automation levels

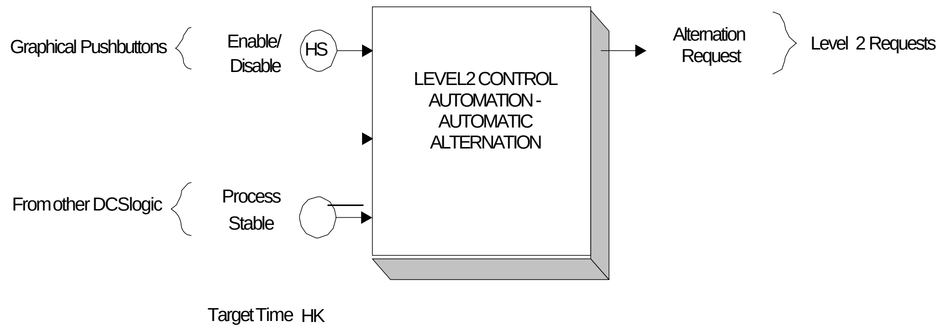


Figure 3.1.4 – Level 2 Control Automation Software Automatic Alternation Module

Figure 3.1.4 depicts a software module that determines when Level 1 devices need to be alternated. This example generates a control request to a Level 2 Lead/Lag Selection module based upon various DCS input signals. The output command is triggered based on equipment current runtime comparison to a manually set cycle timer. The module is designed to accommodate the worst case logic requirements of all processes that require automatic alternation. For any process that does not match the requirements of the worst case process, all non-applicable input/output signals are disabled or ignored at the software module. This module has the following general characteristics:

- Operator Inputs – Graphical Pushbuttons
    - Enable/Disable selections activate/deactivate the automatic control.
- DCS Inputs – Status and Commands
    - In this example, the device's current runtime is compared to a target (elapsed) time setpoint to determine when the equipment should alternate. Device current runtimes are calculated at Level 1.
    - When applicable, Level 2 automation only permits equipment alternation when the process is stable.
- DCS Outputs – Control Requests
    - Control requests drive the associated Level 2 Lead/Lag Selection Module.

3.1.5 Control Automation

Figure 3.1.5 summarizes the general handshaking requirements between Level 1 and Level 2 controls:

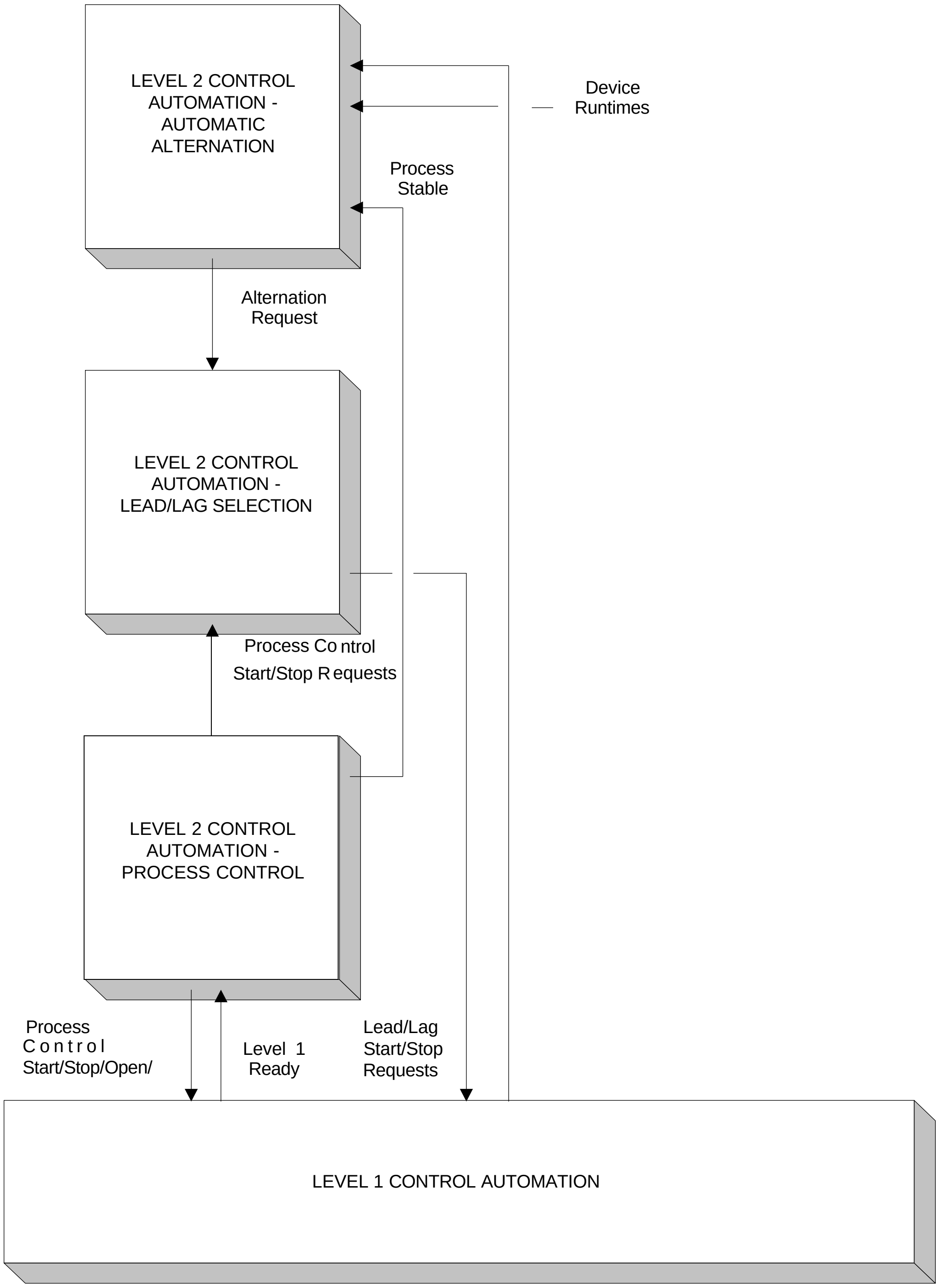


Figure 3.1.5 – Level 1/2 Control Automation Command/Status Flow

3.2 Failure and Availability Modes

The following alarms and failure modes will be provided for the indication of abnormal conditions of the equipment controlled by the DCS. This logic is provided to alert the operator of abnormal conditions that affect the DCS controls, and to provide the automatic controls with the information required to adapt to the same abnormal conditions. Note that upper case terms are used to represent control pushbuttons and indications that are integrated onto the Operator/Engineer displays.

3.2.1 General Failure and Availability Modes

- DATA LINK FAILURE - The DCS and PLC application programs combine to create a simple pulse train, or watchdog signal, for each DCS/PLC data link. If the pulse train ceases alternating between logic 0 and logic 1 states, then a DATA LINK FAILURE alarm is set. After a communication between the DCS and the PLC is reestablished, this alarm will be cleared automatically and after a predefined time delay all the DCS control functions will be restored.

- READY - The DCS continuously monitors the status and alarm condition of each controlled device. A device is defined as READY under the following conditions:

    - The local HAND/DCS switch is in DCS position, and

    - The device INTERLOCK flag is reset (if applicable), and

    - The device PERMISSIVE flag is reset (if applicable), and

    - DATA LINK FAILURE flag is reset (if applicable), and

    - None of the DCS originated alarms described below and specified for each type of the controlled device are active, e.g., drive FAIL TO START, drive FAIL TO STOP, valve FAIL TO OPEN, valve FAIL TO CLOSE, etc.

- AVAILABLE - This flag is used by Level 2 software to determine the equipment availability. A device is defined as AVAILABLE for strategy under the following conditions:

    - device READY flag is set, and

    - The device is selected to DCS AUTO mode

3.2.2 Drive Failure Modes

- INTERLOCK - This signal combines a complete list of DCS signals, which are defined as interlock criteria for a running drive that is controlled by the DCS, e.g., drive OVERLOAD, pump DISCHARGE PRESSURE HIGH, etc. The number and types of alarms included in drive INTERLOCK is specific for each type of controlled device and is defined at the database level or derived from other DCS logic. All signals, which are included in a drive INTERLOCK are displayed at the M/A station. Under occurrence the DCS commands the drive to STOP, prevents it from starting and sets the drive FAILED alarm.

- PERMISSIVE - This signal combines a complete list of DCS signals, which are defined as start-up permissive criteria for a drive that is controlled by the DCS. The number and types of alarms included in drive PERMISSIVE is specific for each type of controlled device and is defined at the database level or derived from other DCS logic. All signals, which are included in a drive PERMISSIVE are displayed at the M/A station. Under occurrence the DCS commands the drive to STOP and prevents it from starting.

- FAIL TO START - When a stopped electrical drive is commanded to start by the DCS in either MANUAL or AUTO mode and a running feedback is not received within a preset time, the Operator will receive a FAIL TO START alarm for the drive. This alarm is latched at the DCS and can be either manually reset by the Operator at the respective M/A station or is automatically reset when the drive HAND/AUTO switch is turned to HAND position. If the drive is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- FAILED - If a running electrical drive (e.g., pump, blower, etc.) stops while commanded to run by the DCS in either MANUAL or AUTO mode or if the drive INTERLOCK signal is set for such a drive, the Operator will receive a FAILED alarm for the drive. This alarm is latched at the DCS and can be either manually reset by the Operator at the respective M/A station or is automatically reset when the drive HAND/AUTO switch is turned to HAND position. If the drive is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- FAIL TO STOP - When a running electrical drive is commanded to stop by the DCS in either MANUAL or AUTO mode and a stop feedback (removed running feedback) is not received within a preset time, the Operator will receive a FAIL TO STOP alarm for the drive. This alarm is latched at the DCS and can be either manually reset by the Operator at the respective M/A station or is automatically reset when the drive HAND/AUTO switch is turned to HAND position. If the drive is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- SPEED DEVIATION - This alarm will be activated at the DCS for a variable speed pump if, for a preset amount of time the actual pump speed differs from the required pump speed by more than a preset value.

3.2.3 Valve Failure Modes

- INTERLOCK - This signal combines a complete list of DCS signals, which should interlock a controlled valve, i.e., valve JAMMED, valve HIGH TORQUE, etc. The number and types of alarms included in valve INTERLOCK is specific for each type of controlled device and is defined at the database level, or derived from other DCS logic. All signals, which are included in a valve INTERLOCK are displayed at the M/A station.

- FAIL TO OPEN - When a valve is commanded to open by the DCS in either MANUAL or AUTO mode and an open feedback is not received within a preset time, the Operator will receive a FAIL TO OPEN alarm for the valve. This alarm is latched at the DCS and can be either manually RESET by the Operator at the respective M/A station or is automatically reset when the valve HAND/AUTO switch is turned to HAND position. If the valve is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- FAIL TO CLOSE - When a valve commanded to close by the DCS in either MANUAL or AUTO mode and a close feedback is not received within a preset time, the Operator will receive a FAIL TO CLOSE alarm for this valve. This alarm is latched at the DCS and can be either manually RESET by the Operator at the respective M/A station or is automatically reset when the valve HAND/AUTO switch is turned to HAND position. If the valve is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- SWITCH FAILURE - If at any time both OPEN and CLOSE limit switch signals are received by the DCS at the same time, the SWITCH FAILURE alarm will be set. This alarm is latched at the

DCS and can be only manually RESET by the Operator at the respective M/A station. If the valve is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- POSITION DEVIATION - This alarm will be activated at the DCS for a modulating valve if, for a preset amount of time the actual valve position differs from the required valve position for more than an preset value.

(a) 4 Custom Graphics and HMI Configuration

Custom graphics are the most important interface tool provided with the DCS. These graphics, combined with the Ovation Human/Machine Interface (HMI) software packages, provide the monitoring and control access required for the Plant Operations and Maintenance (O&M) staff to perform their daily tasks. Development of an efficient, user-friendly HMI environment enhances the performance of the user and the resulting Plant operation.

Like any user interface, graphics design and HMI configuration must consider “human factors”. These factors include:

- Consistency
- Navigation
- Presentation (e.g., colors, blinking, shapes)
- Control accessibility
- Uniformity between different applications

The purpose of this Section is to define the approach used for the design and development of DCS control and monitoring graphics, and how they are integrated into the HMI environment. Specific concepts, examples and programming notes are included in various Sections of this document to assist the software development and maintenance efforts.

<u>References</u>

- Appendix III – Graphic Hierarchy
- Appendix IV – Graphic Navigation
- Appendix V – Graphic Display Elements
- Appendix VI – Process Colors
- Appendix VII – Graphic Macro List
- Appendix VIII – Sample Graphic Types
- Operator Station User Guide – OW331-20
- Operator Station Configuration Guide – OW331-21
- Graphics Builder Use Guide for Ovation 3.3 – OW331-90
- ISA 101 standards.

4.1. Graphics Hierarchy

4.1.1 General

- Graphics should follow ISA 101 standards.

A graphics hierarchy defines the “road map” for the organization and navigation of the DCS graphics. An effective graphic hierarchy provides the user with a consistent and an intuitive interface to the DCS monitoring and control functions.

The following general design concepts must first be established:

- Graphic Types – Most graphic types should mimic the appearance of project mechanical, architectural, electrical and instrumentation drawings. Standard formats are established for each type based upon desired levels of monitoring and control functionality, giving the user an immediate "feel" for the content and control accessibility of each graphic. In addition, each graphic type should appear somewhat similar to the other types. These standardized appearances also aid in identifying the hierarchical location of each graphic, resulting in more intuitive navigation actions by the user.

- Functional Areas – Functional Areas are established based upon plant-specific areas, unit processes and auxiliaries. Related piping, structures and equipment are grouped together on a graphic or set of graphics, to the extent allowed by the density limitations of the graphic type being used. Note that pan and zoom features are available as part of the standard viewing system, and their use should be considered when evaluating Functional Areas and graphic density. However, because of the number of user actions required to pan and zoom, its use should not be relied upon for normal user activities.

- Navigation – Paging symbols and Pop-Up windows are used to guide the user through the hierarchical map. Standard symbol locations and consistent graphic types result in more intuitive paging actions by the user. Paging symbols are also sometimes assigned for process lines that are continued between graphics.

- Pop-Up Windows - Pop-Up Windows provide a powerful alternative to using full-size graphics for paging, monitoring and control functions, significantly reducing the required number of user mouse actions.

4.2 Graphic Types

4.2.1 Plant Overview Graphics

Plant Overview graphics provide the highest level of display for the user’s DCS operation. These graphics summarize the equipment layout and process status for multiple Functional Areas on a single graphic.

Three types of Plant Overview graphics are designed:

4.2.2 Display Menu – This provides a one-page summary of all custom mainscreen graphics provided with the system. This graphic is normally shown in a format that shows the hierarchical arrangement of the graphics.

4.2.3 Plant Overview - This provides a simplified P&ID diagram of the entire plant process and includes dynamic information for major plant process variables and equipment statuses.

4.2.4 Multi-Process Overview – This provides a simplified P&ID diagram of several related plant unit processes on a single graphic and includes dynamic information for major process variables and equipment statuses.

5 Unit Process Overview Graphics

Four types of Unit Process Overview graphics are designed:

5.1 P&ID graphics provide status update and high level control of multiple related devices within a Plant Functional Area. These graphics inherently can become very dense; therefore process and equipment representations are kept simple, may not always provide a true representation of equipment orientation, and look similar to the process and instrumentation drawings (P&ID) found in the project plans. Functional process layout is shown, along with related process variables, statuses, alarms and controls.

5.2 Electrical Single Line graphics are specific to electrical equipment arrangements and are similar to the one-line drawings found in the project plans. Functional electrical layout is shown, along with related process variables, statuses, alarms and controls.

- DCS System Status graphics represent the DCS network architecture and provide a constant update of the control system hardware status.

- Tabular graphics provide a summary of miscellaneous dynamic information that does not have an efficient graphical representation or would otherwise clutter another graphic. Information is presented in functionally grouped tables.

6 Unit Process Graphics

Two types of Unit Process graphics are designed:

- P&ID graphics provide individual control of devices related to a specific area or process. Process and equipment representations utilize a two-dimensional style of symbols. Functional process layout is shown, along with related process variables, statuses, alarms and controls.

- Electrical Single Line graphics are specific to electrical equipment arrangements and are similar to the one-line drawings found in the project plans. Functional electrical layout is shown, along with related process variables, statuses, alarms and controls.

7 Graphic Functional Areas

Graphic Functional Areas are established based upon plant-specific areas, unit processes and auxiliaries. Definition of these areas establishes the graphic display hierarchy. The following guidelines are used in the assignment of Functional Areas:

- Related process flow and plant areas are grouped.

- Processes should be separated from common plant auxiliary systems such as plant air and water. This causes less confusion and congestion on potentially dense graphics.

- Related graphics should be combined when sufficient space exists, thus minimizing the total number areas and simplifying navigation.

- Control for any specific device should appear in the fewest possible areas to minimize confusion.

- A specific range of graphic numbers is assigned to each area.

8 Graphic Navigation

With the proper design of Graphic Types and Functional Areas, most Graphic Navigation should inherently exist. The following guidelines are used in the assignment of Graphic Navigation:

- Navigation symbols should appear in consistent locations from graphic to graphic. When navigation symbols are grouped, their order (left/right/top/bottom) should reflect the process flow, which should also reflect the graphic hierarchy.

- Each graphic should contain a mechanism (drop-down menus or "shortcut keys") that enables immediate access to other graphics.

- Process lines may include paging symbols when the lines connect to other graphics.

- Extraneous paging symbols should be avoided since there is no location consistency from graphic to graphic. This tends to confuse the user and also uses valuable graphic space. Instead, the hierarchical design should already provide an intuitive means for the user to quickly display any graphic.

- Paging between different graphic types tends to be confusing and should be avoided.

9 Pop-Up Windows

Pop-Up Windows should be used extensively to facilitate user monitoring and control actions, and to reduce the number of user paging actions. Size should be considered when designing these windows, since it may be undesirable for the window to cover a substantial portion of the main graphic, however some applications require that no limit be defined. Predefined symbols locate the "poke field" areas that call up the windows from the mainscreen graphics. The following are uses for Pop-Up windows:

- Manual/Auto Control Stations - Analog/digital control stations are the most common application for Pop-Up Windows. Standard station sizes are defined, as well as the maximum number of stations per window. Equipment symbols are used to designate the associated poke field areas.

- Strategy Windows - Start/Stop strategy, Lead/Lag selection, value entry, sequence initiation and sequence step displays are typical functions applied to Strategy Windows. The possible combinations of these functions should be predefined, which would in turn define the number of user actions required to initiate a typical control. Due to the wide variation of possible control combinations, these windows typically have no predefined sizes. Text or equipment symbols are used to designate the associated poke field areas.

- Paging Menu - These "drop-down" windows allow the user to quickly navigate between graphics.

10. Base Workstation Features

10.1 General

When designing custom graphics, consideration must be given to the user interaction with the base workstation features. Custom graphic elements and related workstation functions should have a similar appearance and "feel". Note that it is not in the scope of this Section to define the specific workstation parameters, but only to summarize the relation of the graphic interface to standard workstation functions.

The following base workstation features must be considered when implementing the custom graphic design:

- Alarm List
- Trend Package
- Custom Graphic Menus
- Custom Keypad
- Keyboard Paging Arrows
- Diagram Display
- Navigation and Control
- Security Levels
- Operating System Commands

10.2 Workstation/Custom Graphic Interaction

- Alarm List.
  - Alarms should follow ISA 18 recommendations. The Alarm List provides a centralized interface for the user to manage all process and control system alarms. Custom graphics can provide a similar interface:

- Dynamic Display Elements - Any graphic display element can be designed to change color and/or blink based upon its associated alarm statuses. Implementing these dynamics on the custom graphics provides the user with the same information presented on the Alarm List, with the benefit of specifying only the subset of alarms that is associated with the graphic being displayed. Any combination of color and blink dynamics can be used on the custom graphics.

- Alarm List Invocation - The Alarm List appears in a window that is independent from the custom graphic viewing system, with the call-up icon being located on the workstation desktop. Custom graphics can be designed to call up the Alarm List from an icon coded within the graphic.

- Bell Silence and Alarm Acknowledge Control - These controls are standard functions on the Alarm List window and can be replicated on the custom graphics. Subject to alarm filtering parameters, the Operator may Silence or Acknowledge any DCS alarm from any workstation.

11 Trend Package

The Trend Package provides trending capability for 600 groups of points, each group having a maximum of 8 points apiece. Trend Groups appear in windows that are independent from the custom graphic viewing system. Custom graphics can be designed to call any specific trend group window without having to use the standard trend group menu function.

12. Diagram Display

The workstation's Operating System includes a program that displays any custom graphic by entering/selecting the assigned graphic number. This function is intended as a development/troubleshooting aid only and should not be made available to most users.

13 Navigation and Control

The workstation provides various means to navigate the cursor and activate control functions. Most users will use the mouse/trackball for as many functions as the interface is designed to accommodate, therefore the majority of custom graphic designs encourage the use of the mouse/trackball to select and activate the controls.

14 Security Levels

The workstation provides security controls through the use of the Ovation user login identification. Ovation Control and Engineering Function accessibility is enabled/disabled through the Ovation workstation security tools. Custom graphics may be viewed at any security level; however, control, engineering and maintenance functions are normally restricted.

15 Operating System Commands

Custom graphics have the capability of executing any Operating System command that is accessible by the user's security level. Typically, users of custom graphics have little need for such a feature to be included (except for convenience), since most programs available to the user are already accessible by other methods via the workstation's Operating System menus.

16. Base Graphic Standards

16.1 General

All graphics should follow ISA 101 standards.

Base graphic standards provide the foundation from which all custom graphic designs evolve. Like any project, these standards must be developed before any programming begins, and its associated documentation must be updated as the project progresses. Strict enforcement of such standards provides a consistent design, as well as a product that is cost-effective to develop and maintain. The following general categories of information must be defined:

- Graphic Window Parameters
- Graphic Layout Guidelines
- Plant-Specific Information
- Graphic Element Appearance

16.2 Graphic Window Parameters

Primary consideration must be given to the graphic dimensions, it's call-up location and the background color of the graphic window. The following parameters are configurable for each graphic:

- Design Size - Graphics are normally designed with a single, standard dimension that does not cover the entire desktop. This provides consistency and allows quick access to desktop icons for base workstations functions such as the Alarm List and the Trend Package.

- Fixed/Default Size and Location - These parameters determine whether each graphic is called up in a fixed size and location, or whether it should simply assume the previously displayed graphic's size and location. As with any desktop arrangement, users typically find it annoying for the system to resize and rearrange their windows, therefore fixed parameters are normally discouraged here.

- Resize/Zoom - These parameters are typically enabled to allow the user to fit more windows on the screen, and to enable the user to obtain a clearer view of the area of interest on the graphic. Note, however, that graphics should not be designed to require the user to zoom/pan the graphic window.

- Background Color - A single, dark background color should be chosen for all graphics, thus reducing eye strain for the user. The design should also allow for sections of a graphic to have another background color, thus furnishing a means to highlight a group of related devices.

- Grid - When possible, custom graphics should be designed on a fixed grid map. This simplifies graphic development and maintenance, and results in a better design.

17 Graphic Layout Guidelines

All custom graphics, no matter which type is chosen, are normally designed with some common display elements. These elements are typically placed in one of five areas, with the same information appearing in the identical location from graphic to graphic:

- Header Area (top)

- Footer Area (bottom)
- Left Margin
- Right Margin
- Corners

The following types of information are typically assigned to these areas. Care must be taken to minimize the amount of graphic space assigned to these areas, considering that the body of the graphic may need to consume all available space.

- Graphic Number - This information is helpful for development and troubleshooting, as well as for general reference needs in the project documentation.
- Graphic Title - In normal discussion, graphics are referenced by description instead of by number, therefore a concise title is appropriate for each.
- Navigation - These areas are ideal locations for the implementation of hierarchical graphics paging pop-up windows and shortcut keys.
- Time/Date - This information is sometimes useful for reference on graphic screen dumps, showing process variable values at a specific time and date.
- Process Variable Information - These areas are ideal locations for the display of major process information, such as Plant Influent Flow or Unit Megawatts.
- Plant/DCS Specific Information - Other important information such as plant location or DCS status can be placed here.
- Access to Base Workstation Features - Normally, graphics are sized in such a manner that desktop icons are readily accessible. In cases where graphics are designed to cover the majority of the desktop, access to base workstation features may be required in these areas.
- People are conditioned to read information in fixed directions. For example, in the United States, the typical user tends to read from left to right, and from top to bottom. Graphic designers must consider this natural user response when arranging screen content, and processes should tend to flow in these directions. Note that in this same example, the expected flow also favors a clockwise direction over a counter-clockwise direction.

18 Plant-Specific Information

As installations vary from company to company, and industry to industry, there are limitless possibilities of plant-specific information that may be required to be included on the custom graphics. The minimum required information is outlined below. Normally this information can be found in the project plans and specifications.

- Process Colors - Many installations color code the physical plant piping to facilitate the tracing of pipes. The custom graphics should follow a similar color scheme.

19 Base Graphic Elements

All custom graphic content consists of one or more base graphic elements that have stand-alone functionality, and act as building blocks for more complex graphic elements. Base static and dynamic features must be pre-defined and passed into the design of complex graphic elements.

19.1 Base Graphic Element Appearance

Ergonomic guidelines must be followed when choosing colors, blink attributes and fonts:

- Bright colors should be avoided, as well as large blank areas of light coloring on a dark background.

- When choosing a color, always consider the background color on which the associated element will appear and check for an acceptable degree of contrast.

- The overall graphic design should reduce the possibility of having too many different colors on a single graphic. Too many colors make the graphic look "busy" since the user's mind will subconsciously attempt to interpret each color.

- The exclusive use of color to convey specific information should be avoided since the user may suffer from some degree of color-blindness.

- Large blinking elements should be avoided, as well as elements that always blink.

- Font sizes and styles should be consistent between like functions.

- The number of different font sizes and styles should be minimized.

- Because of the density requirements of a typical set of custom graphics, it is difficult to avoid using small font sizes. Graphic designers should preview all font choices on a CRT that has the minimum size and resolution that will be used on the installed system.

- Center text on both the X and Y axis when the background is a colored bar. When using blank spaces to center text, and an odd number of spaces are available, put the extra space on the right side of the text (e.g. --center---, not ---center--).

- Capital letters should be used for most text to make the graphics more readable.

19.2 Base Graphic Element Functions

Pre-defining the base function of each type of graphic element results in consistent custom graphics and simplifies their development and maintenance. Base functional definitions should include size, color, and dynamic behavior.

- Text - Text is the most used graphic element, and default system text sizes should be used. Graphics designers must take into consideration that the size of most other graphic elements will be affected by the text sizes that are chosen.

- Lines - Lines are commonly used for piping, table construction and as pointing mechanisms. Line types and widths are chosen from system default menus. The use of different line types should be limited, since only a few different types are easily distinguishable on the typical graphic display.

- Polygons - Polygons are commonly used for piping and structural graphic representations. One advantage that polygons have over lines is that they have the option of including an outline color.

- Rectangles - Regular rectangles are used as needed. OL rectangles are normally used as background elements for 3-D representations.

- Shapes - A shape library provides pre-defined symbols for use throughout the graphics. Often, however, macros are instead used for this purpose because of their flexibility in including other graphic elements and complex dynamics.

- Filled Areas - Fills are used to paint areas within a specific boundary. Often, however, polygons are favored because the fill boundary rules are sometimes difficult to implement, and because fills tend to consume more of the workstation's processor resources.

- Process Points - Process points display analog values in a wide variety of formats. Quality indications are often included to display when a value may be invalid or not updating.

- Bargraphs - Bargraph indicators are used in a manner similar to that provided by hardened control panels. Bargraphs are useful in providing a more physical representation of an analog value. This is normally applied to a display such as tank level, or where related values are displayed side by side, as in the case of an M/A station.

- Poke Fields - Poke fields provide the user with the ability to interact with the graphics and process controllers. Typical applications include navigation and control. Unique symbols are used to indicate where poke fields are available.

- Entry Fields - Entry fields provide the user with the means to input data into the control system Typical applications include tuning adjustments and equipment start/stop prioritization.

19.3 Macros

- In order to simplify programming, graphic elements can be combined into library elements called macros. Macros feature a fill-in-the-blanks approach to programming simple or complex display elements.

Appendix I – Database Field Entry

General

This Appendix describes various database entry guidelines. The enclosed listings provide the User with the pre-defined options that are available for each entry. Refer to Section 2 of this document for general database information and references.

I/O Point Names

This Appendix describes the point naming scheme for I/O points. I/O point names are limited to 16 characters in length, and some non-alphanumeric characters are not allowed. When assessing I/O point naming lengths, internal point naming standards must also be considered.

Plant and Pump Station Naming Standards

I/O points must have a unique name on a single DCS network. Identical point names on different networks are not recommended since it can cause confusion when data is drawn from multiple networks. The first three characters will describe the Plant or Pump Station with which the point is associated.

Unit Process Standards

To facilitate data sorting and identification, the fourth and fifth characters of the point name will represent a Plant Unit Process. For consistency, Unit Process designations will match between different Plants, and pre-defined HRSD designators (two-digit numbers) will be used.

Function Designator

The third designator in the point naming scheme will consist of a four character representation that most closely describes the point function, generally following ISA standards.

Loop Designator

The fourth designator in the point naming scheme will consist of a four digit loop identifier, and typically represent a single device or group of related devices. Loop assignments are defined in the project database.

Loop Suffix Designator

For devices that have the same Plant/UP/ISA/Loop designators, a provision is made to differentiate point names through the addition of an alphabetic (A-Z) loop suffix.

Typical Point Name

Using the aforementioned schemes, a typical point name will appear as in the following example:

ABP12FITX2013

This point name represents a flow indicating transmitter at the Army Base Treatment Plant, Unit Process 12, and identified by loop number 2013.

All DCU and RIO cabinet alarms shall be included in unit process 99 and be tagged as follows:

UPS summary alarm	ABP99YAAXxxyy
UPS low battery	ABP99YABXxxyy
UPS on battery	ABP99ONBTxxyy
UPS on bypass	ABP99ONBYxxyy
UPS ON STATUS	ABP99ONSTxxyy
Cabinet door closed	ABP99CLSSxxyy

Where xx = Drop and yy = RIO. Examples: ABP99YAEX0100 is Drop 1 UPS is bypassed, ABP99YABX2221 is RIO 21 UPS low battery, which is controlled by drop 22.

Internal Point Names

Internal point names are added to the DCS as required to implement the control logic. These can be Analog, Digital or Packed points, and will follow a pattern similar to that used for I/O points, with the following exceptions:

Internal Function Standards

The third designator in the point naming scheme will consist of a four digit pseudo-ISA representation that most closely describes the internal point function.

Fourteenth Character

In order to quickly identify internal points, the fourteenth character will be a dash "- ".

Internal Point Suffix

A two-character suffix is added to the last two positions, thus allowing multiple internal points to be assigned to a single control function.

Typical Internal Point Name

Using the aforementioned schemes, typical internal point names will appear as in the following examples:

ABP01B00X1036-00

ABP01FCLS1036-00

The first point name would represent internally generated packed status bits, while the second represents a FAIL TO CLOSE alarm for the same unit process 1 device at the Army Base Treatment Plant, identified by loop number 1036.

Alarm Priority and Color Standards – Follow ISA18

Any point designated as an alarm must be assigned a priority and a color for display on the DCS Alarm List. The Ovation system provides for up to 8 alarm priorities, 1-8 (most critical to least critical). Note that the color assignment made here will also be used on the custom graphic displays, as applicable.

Alarm Destination Standards

At the HMI, the User can select Normal or Priority Mode for alarm list display. Typically, the Normal Mode is configured to show all alarms. Priority Mode is typically configured to display User-specific or Location-specific alarms. Alarm destination is used to assign each point to these alarm configurations. Note that 26 categories of alarm destination are available, and one is reserved for DCS-related alarms.

Point Characteristics Standards

At the HMI, the User is provided with a utility to sort thru the system database points for various status information. Point Characteristics provides the sorting mechanism. Eight characters are assigned to each point to categorize the possible sort combinations. Note that the first Point Characteristic is always the alarm destination designator.

HRSD Functional Tag Standards and Conventions

Tag	Function	Initiating Device
AAHH	Analyzer Alarm High High	Gas Monitoring System
AAHX	Analyzer Warning High	Gas Monitoring System
AALX	Analyzer Alarm Low	Gas Monitoring System
AITX	Analysis Indicator Transmitter	Analysis Transmitter or System
CLSC	Valve/Slide Gate Close Command	DCS
CLSP	Valve/Slide Gate Close Permissive	DCS
CLSS	Valve/Slide Gate Close Status	Field Device
EAHX	Voltage Alarm High	Generator System
EALL	Voltage Alarm Low Low	Generator System
EALX	Voltage Alarm Low	Generator System
EITX	Voltage Indicator	Generator System
FALX	Flow Alarm Low	DCS
FITQ	Flow Indicator Transmitter Totalizer	Flow Transmitter (pulse)
FITX	Flow Indicator Transmitter	Flow Transmitter
FSLX	Flow Switch Low	Flow Switch
HSAS	Hand Switch in Auto Status	HOA Selector Switch
HSHS	Hand Switch Hand Status	HOA Selector Switch
HSOS	Hand Switch Off Status	HOA Selector Switch
IITX	Current Indicator	Generator System
JHXX	Power Demand High	Power Transmitter
JITX	Power Indicator	Generator System
HBCX	Heartbeat Output	DCS
KQIX	Run Time Indicator	Field Equipment
HBIX	Heartbeat Input	PLC
LAHH	Level Alarm High High	Field Equipment
LAHX	Level Alarm High	Field Equipment
LALL	Level Alarm Low Low	Field Equipment
LALX	Level Alarm Low	Field Equipment
LITX	Level Indicator Transmitter	Level Transmitter
LSHH	Level Switch High High	Level Switch or System
LSHX	Level Switch High	Level Switch or System
LSLL	Level Switch Low Low	Level Switch or System
LSLX	Level Switch Low Limit	Level Switch or System
LSXX	Switch	Field Equipment

NAHH	Torque Alarm High	High	Torque Monitoring System
NAHX	Torque Alarm High		Torque Monitoring System

HRSD Functional Tag Standards and Conventions

Tag	Function	Initiating Device
NIXX	Torque Indication Torque	Torque Monitoring System
NSHH	Switch Fail Not Running	Torque Monitoring System
OFST	Status (OFF) Running	MCC, AFD, Control Panel
ONST	Status (ON) Running	MCC, AFD, Control Panel
ONSF	Forward Running Reverse	MCC, AFD, Control Panel
ONSR		MCC, AFD, Control Panel
OPNC	Open Command	DCS
OPNP	Open Permissive	DCS
OPNS	Open Status	DCS
PAHH	Pressure Alarm High High	Control Panel
PAHX	Pressure Alarm High	Control Panel
PALL	Pressure Alarm Low Low	Contro Panel
PALX	Pressure Alarm Low	l Panel
		Control
PDAH	Differential Pressure Alarm High	DCS
PDAL	Differential Pressure Alarm Low	DCS
PDHH	Differential Pressure Alarm/Switch High High	DCS/Differential Pressure Switch
PDLL	Differential Pressure Alarm/Switch Low Low	DCS/Differential Pressure Switch
PDSH	Differential Pressure Switch High	Differential Pressure Switch
PDSL	Differential Pressure Switch Low	Differential Pressure Switch
PDIT	Pressure Differential Indicating Transmitter PITX PSXX PSHH PSHX PSLL	Differential Pressure Transmitter

PSL	Pressure Limit Switch
X	Pressure Switch High High Pressure Switch High Pressure Switch Low Low
Pressure	Pressure Switch Low

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Switch

QITX	Power Factor Indicator Transmitter	Electrical Systems
RUNC	RUN Command FORWARD	DCS
RUNF	Run Command	DCS
RUNP	Run Permissive	DCS
RUNR	Run REVERSE Command	DCS
SAHX	Overspeed Alarm	Generator System
SIXX	Speed Indication Pump	VFD panel
SCXX	SPEED Command Speed	DCS
SSLX	Switch Low	Zero Speed Switch

HRSD Functional Tag Standards and Conventions

Tag	Function	Initiating Device
TAHH	Temperature Alarm High High	Generator System
TAHX	Temperature Alarm High	Generator System
TCTX	Temperature Sensor	Thermocouple Temp
TITX	Temp Indicator Transmitter	Device Field
VAHX	Vibration Alarm High	Equipment
VITX	Vibration Transmitter Weight	Vibration Transmitter or System
WITX	Indicating Transmitter Event	Weight Transmitter
YAAX	Alarm No 1	MCC AFD, Control Panel
YABX	Event Alarm No 2	, AFD, Control Panel
YACX	Event Fail Alarm Common	MCC, AFD, Control Panel
YADX	Event Alarm No 3	MCC, AFD, Control Panel
		MCC,
YAXX	Emergency Stop Position	Field Equipment
ZCXX	Command Position	DCS
ZIXX	Indication	Position Transmitter

NOTE: Any required point type tags that are cannot be expressed using this list must be approved for use by HRSD and Emerson.

Appendix II - Word and Phrase Abbreviations

General

This Appendix describes the Plant equipment abbreviation standards. The following lists set forth the abbreviation convention for all Plant structures, equipment and devices that appear in the DCS and its related documentation. For general use, two lists are included, one sorted by word/phrase, and the other sorted by abbreviation. A third list is provided for the point Set/Reset fields.

Abbreviations are required for every aspect of a DCS project, from database definition to Alarm Lists, Trend Groups and custom graphics. Abbreviation standards are vital; however, they are difficult to enforce on large projects with many people, and with many software packages having different text length limitations. Other complications are that multiple words may require the same abbreviation, and that not all possible words can always be pre-defined in an abbreviations list.

The following guidelines shall be used when adding new abbreviations:

- For multiple words, use a common acronym, or create an acronym using the first letter of each word.
- For single words, abbreviations should be constructed to provide unique representation without need for context and intuitive interpretation for the user.
- Periods (.) should never be used in abbreviations, and other extraneous punctuation should be avoided.

Appendix III – Graphic Hierarchy

Graphics Standards are being updated to comply with ISA 101

General

This Appendix describes the Plant graphic hierarchy. The graphic hierarchy list presented on the following pages does not necessarily represent a final design, as requirements change during project approval and development. Graphic numbering is spaced for future expansion, and to provide numbering consistency between Plants. These numbers are pre-assigned and may change. Note that the graphics hierarchy and paging menus are designed such that the Operator need not be concerned with recognizing or memorizing graphic numbers.

Graphics Hierarchy

HRSD Graphics Hierarchy

Menu Name	Graphic No.	Graphic Title	Graphic Style
	Main Window	Overview	ISA 101 Level 1
Top Level Process - appears on all menus			
	2000	Plant Overview	ISA 101 Level 2
	2010	Plant Overview Table	ISA 101 Level 2
	2020	Liquid Process Overview	ISA 101 Level 2
	2030	Biosolids Process Overview	ISA 101 Level 2
	2040	Program Status Overview	Tabular
PRELIMINARY			
	2100	Preliminary Treatment Overview	ISA 101 Level 2
	2110	Influent Screening System	2D
	2120	Plant Influent Pumping System	2D
	2130	Grit Removal System	2D
	2150	Bio Solids / Septage receiving/Handling	2D
PRIMARY			
	2200	Primary Treatment Overview	ISA 101 Level 2
	2210	Primary Clarification 1/2/3	2D
	2220	Primary Clarification 4/5/6	2D
	2230	Primary Scum System	2D
	2250	Intermediate Pumping	2D

HRSD Graphics Hierarchy

Menu Name	Graphic No. Main Window	Graphic Title	Graphic Style
SECONDARY			
	2300	Secondary Treatment Overview	ISA 101 Level 2
	2310	Aeration Basins 1/2	2D
	2320	Aeration Basins 3/4	2D
	2330	Nitrate and Anoxic Recycle Pumps	2D
	2340	Aeration Blowers	2D
	2350	Secondary Clarifiers	2D
	2360	RAS and WAS	2D
	2370	Foam Removal/ Scum Pumping	2D
CONTACT TK/EFFL			
	2500	Contact Tank/Effluent Overview	ISA 101 Level 2
ODOR CONTROL			
	2700	Odor Control Overview	ISA 101 Level 2
	2710	Odor Control Station	2D

CHEMICAL

2860

2870

2800

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Chemical Systems Overview Hypochlorite System Bisulfite System Caustic System

Primary Treatment Polymer System Secondary Treatment Polymer System Methanol |

Storage and Pumping

Ferric Chloride system

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HRSD Graphics Hierarchy

Menu Name	Graphic No. Main Window	Graphic Title	Graphic Style
Thickening			
	2900	Thickening Overview	ISA 101 Level 2
	2910	Thickener 1	2D
	2920	Thickeners 2	2D
	2970	Thickening Polymer System	
DEWATERING			
	3000	Dewatering Overview	ISA 101 Level 2
	3010	Primary Biosolids Storage and Pumping	2D
	3020	Waste Activated Biosolids Storage and Pumping	2D
	3030	Norfolk Water Solids	2D
	3040	Centrifuges Dewatering	2D
	3070	Polymer System	2D
INCINERATION			
	3100	Incineration Overview	ISA 101 Level 2D
	3110	Biosolids Conveying/FBS	2D
	3120	Incinerator 1	2D
	3140	Incinerator 2	2D
	3160	Ash Handling System	2D
NITRIFICATION			
	3195	Nitrification Enhancement Overview	ISA 101 Level 2

3200	Auxiliary System Overview	ISA 101 Level 2

SAFETY/SECURITY

3300	Safety/Security	Tabular
3310	Overview Gas Monitoring	Tabular

Menu Name

Graphic No. Main Window	Graphic Title	Graphic Style

ELECTRICAL

3400	Electrical System Overview	One-line
3410	Emergency Generation Overview	One-line
3420	Generator 1	2D
3430	Generator 2	2D
3440	Generator 3	2D
3450	Generator Auxiliary Systems	2D

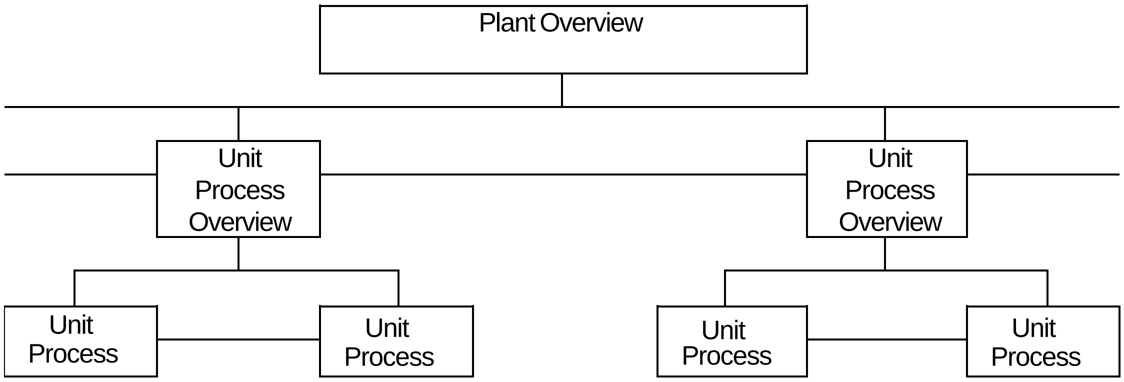
DCS

1800	DCS Status Overview	One-line

Appendix IV - Graphic Navigation

General

The general navigational structure between Plant Overview graphics, Unit Process Overview graphics and Unit Process graphics can be diagrammed as follows:



Other navigational guidelines are as follows:

- Up/Down/Left/Right paging is supplied on the graphic window's menu bar. Up/Down paging “rolls over” to stay within a single Unit Process graphic set, whereas the Left/Right paging links to other Unit Process graphic sets.

- Drop-down menu based paging is included on each graphic to allow "two-click" access to any other graphic.

- Flow lines are provided with poke field paging that connects to other graphics.

- The Top Level Paging Menu (Diagram 1000) provides a site map to the system’s mainscreen graphics and is depicted in manner similar to a GUI file folder structure.

Appendix V – Graphic Display Elements

General

This Appendix describes the details of the graphic static and dynamic elements, in table format. This is followed by several examples of how these elements are combined to form standard graphic layouts.

Graphic Windows Parameters

Parameter	Comment
Design Size	1100w X 770h
Fixed/Default Size and Location	Default size and position for all main screens and pop-up windows
Resize/Zoom	Resize and zoom enabled, but not considered as normal an operator function when laying out the graphic design
Background Color	Gray40 for all main screens, gray70 for pop-up windows
Base Font	Standard ovation vector-based font
Grid	Minimum allowable size

Table V.1 - Graphic Windows Parameters

<u>Graphic Layout Guidelines</u>

Header Area	Comment
Title Bar	Graphic title and graphic number
Top Left Corner	Plant name, time/date
Top Right Corner	Shortcut bar with Display Menu access and Help file (.pdf) access
Custom Buttons	Pop-up graphic menu access. Menu groupings are based on graphic hierarchy.

Table V.2 - Graphic Layout Guidelines

Base Graphic Element Functions - Static Text

Function	Size	FG Color	BG Color	Comment
Engineering Units - Process Points	2	White	Same as graphic	
Engineering Units - M/A Station	1	Same as process bargraph	Same as graphic	
General Main Screen Text	1 or 2	White	Same as graphic	
Header Title Bar - Graphic Number	1	Darkgreen	Gray60	
Header Title Bar - Graphic Title	5	Darkgreen	Gray60	
Header Title Bar - Plant Name	5	Darkgreen	Gray60	
M/A Station - General Labels	2	White	Same as graphic	
M/A Station or Strategy - Control PB Labels	2	Black	Gray70	
M/A Station or Strategy - Title Line 1&2	2	Darkgreen	Gray60	
Strategy Window - Text	2	White	Same as graphic	
Table Headings and Labels	2	White	Same as graphic	

Table V.3 - Base Graphic Element Functions - Static Text

Base Graphic Element Functions - Dynamic Text

Function	Size	Text	FG Color	BG Color	Comment
Process Point	2	Dynamic Value	Green	Same as graphic	Alarm colors match the colors defined for the alarm list. Quality alarm is FG red, except for Timed Out which is FG magenta.
Main Screen or Control Window - Alarm Text or M/A Interlock	2	Derived from English Description	Gray shade varies based on BG color, normally 10 shades lighter.	Same as graphic	Alarm colors match the colors defined for the alarm list.
Main Screen - Running/ Stopped Status	2	R S	White Black	Red Green	Device shapes also turn yellow upon FAIL.
Main Screen - Open/ In Travel/ Close	2	O I C	White Black Black	Red White Green	Device shapes also turn yellow upon FAIL.
Main Screen - Open/ Close	2	O C	Black White	Green Red	Device shapes also turn yellow upon FAIL.
Main Screen - Not Ready/ Running/ Ready Sequence Status	2	N R D	Black White Black	Magenta Red Green	None None None
Main Screen - Hand/DCS Mode	2	H D	White White	Red Blue	None None
M/A Station - Manual/ Auto	2	MANUAL AUTO	White White	Red Blue	None None

Function	Size	Text	FG Color	BG Color	Comment
M/A Station - Device Status	3	STOPPED RUNNING FAIL TO START FAIL TO STOP FAIL	White Black Black Black Black	Red Green Yellow Yellow Yellow	None None See 2nd note. See 2nd note. See 2nd note.
M/A Station - Hand/DCS	2	HAND DCS	White White	Red Blue	None None
M/A Station Manual Reject	2	MREJ	White	Red	None
M/A Station Track	2	TRACK	White	Blue	None
M/A Station - Valve Status	2	OPENED IN TRAVEL CLOSED FAIL TO OPEN FAIL TO CLOSE SWITCH FAIL	White Black Black Black Black Black	Red White Green Yellow Yellow Yellow	None None None See 2nd note. See 2nd note. See 2nd note.
M/A Station - Breaker Status	2	OPENED CLOSED FAIL TO OPEN FAIL TO CLOSE SWITCH FAIL	Black White Black Black Black	Green Red Yellow Yellow Yellow	None None See 2nd note. See 2nd note. See 2nd note.
Strategy Control Window - Device Availability	2	Device Name (available) Device Name (not available)	White Gray50	Same as window Same as window	None None

Function	Size	Text	FG Color	BG Color	Comment
General Dynamic Message	2	Message specific	Black	White	None
Strategy Control Window - Status	2	NOT READY	Black	Magenta	None
		RUNNING	White	Red	None
		READY	Black	Green	None
		FAIL	Black	Yellow	None
Sequence Step Window - Sequence Ready/ Not Ready/ Failed/ Selected/ Active/ Done	2	READY N	Black	Green	None
		READY	Black	Magenta	None
		FAILED	Black	Yellow	None
		SELECTED	Black	Green	None
		ACTIVE	White	Red	None
		DONE	Black	White	None

Table V.4 - Base Graphic Element Functions - Dynamic Text

Notes:

- Functions that are identical between Windows and Main Screens have identical dynamics.
- For unacknowledged alarms, the display element is reverse-video. When in alarm and acknowledged, the reverse video changes to normal, with the appropriate alarm color. No blinking is used for alarms.
- Device symbols include color dynamics that match those described for the associated dynamic text.
- Bargraphs are included on main screens where dynamic levels are displayed, and on M/A Stations. Bargraph colors match the associated process color (Appendix VI) on main screens, and match the process point colors on M/A Stations (PV - Darkgreen, SP/Bias - White, Output – Dodgerblue4, Feedback - Blue).

Base Graphic Element Functions - Lines

Function	Size	Type	FG Color	BG Color	Comment
General Use	1	Solid	White	None	None
Tables	1	Solid	White	None	None.

Table V.5 - Base Graphic Element Functions - Lines

Notes:

- Process lines follow the color standard set forth in Appendix VI. Where polygons are used as process lines, they also have a black outline.

Appendix VI - Process Colors

General

This Appendix details the standard process flow descriptions, abbreviations and associated graphic colors. Note that the Base Color specified herein is a description of the approximate color being used. In actual practice, the graphics are coded with the Custom Color Name listed. Through the operating system's "rgb.txt" color palette definition, each Custom Color Name can be modified as needed to finalize the actual RGB properties of the color to be used. These properties can be adjusted at any time, providing a simple method of fine-tuning the graphic colors for the final working environment.

The custom colors that are added to the library have the following RGB values. Cut and paste this information into the system rgb.txt file if it needs to be recreated:

58 95 205	air1
255 255 0	gas1
255 165 0	hazard1
0 245 255	sewage1
139 69 19	solids1
0 139 139	water1

Appendix VII – Graphic Macro List

General

Macro details are provided in their respective Graphic Builder source codes. The enclosed list provides a summary of the HRSD custom macros. Usage examples are provided in the form of final system main screen and Graphic Builder source codes.

Appendix VIII – Sample Graphic Types

Graphics Standards are being updated to comply with ISA 101

Appendix IX – Level 1 Control

Templates

General

Control template details are provided in their respective Control Builder ACAD drawings. The following list provides a summary of the HRSD control templates. Implementation examples are provided as part of the DCS Automation Standards – Proprietary Volume.

Control Template Types:

- MOTOR/DEVICE WITH SINGLE MOMENTARY OUTPUT
- MOTOR/DEVICE WITH SINGLE MAINTAINED START COMMAND
- MOTOR/DEVICE WITH TWO MAINTAINED START COMMANDS (TWO SPEED MOTORS REVERSABLE MOTOR)
- M/A STATION – ANALOG
- M/A STATION – PULSE
- VALVE WITH SINGLE OPEN COMMAND
- VALVE/GATE WITH TWO MAINTAINED OUTPUTS
- VALVE/GATE WITH TWO MAINTAINED OUTPUTS AND MANUAL STOP
- VALVE WITH TWO MOMENTARY OUTPUTS

Appendix X – DCU Software Mapping

General

DCU software, like many significant project activities, requires planning and coordination between multiple developers. This Appendix provides an example of DCU software mapping, which defines where each major section of control software resides.

Each Ovation DCU (controller or drop) provides the User with 999 “sheets” of control logic capacity. Once programmed and loaded into the controller, each sheet can be viewed dynamically on the DCS workstation. Each sheet is therefore subject to ergonomic guidelines and programming efficiency guidelines.

Ergonomic and programming efficiency guidelines include:

- Analog control should generally flow in a top-to-bottom/left-to-right logic flow.
- Digital control should generally flow in a left-to-right/top-to-bottom logic flow.
- Sheet I/O connectors should be kept on the edges of the sheet, except where significant programming efficiencies would result.
- Similar controls should look similar from sheet to sheet. Sheets should be copied whenever possible.
- Control loops (strategies) should be grouped. Within a group, control types should flow as follows:
    - Common logic
    - Sequential logic
    - Analog (PID) logic
    - Digital (motors, valves, etc.) logic

The enclosed listing is an example of the grouping of control loop software. A similar map shall be developed for the HRSD projects in order to provide an optimal software development environment and an ergonomic final product.

Appendix XI – Common Control Functions

(b) 1 Common Control Functions

The following sections describe some of the common control functions provided in the DCS. These functions include the base logic required to manually control any device, as well as other miscellaneous controls and calculations used in process control applications. The descriptions in this chapter are derived from the HRSD Automation Standards document. Refer to that document for more detailed descriptions, as well as sample control logic drawings.

1. Continuous Control

- This type of control provides the Operator with the capability of positioning a device throughout its full controllable range. Typical applications include modulating valve controls and VFD speed controls.

- The device can be placed in either MANUAL or AUTO mode of operation. The current selection is displayed at the respective M/A station and can be changed by pressing the respective M/A station's pushbuttons at any time, subject to the following exceptions:

  - The device is rejected to MANUAL mode when quality of the Process Variable (PV) signal is set to BAD (e.g., due to I/O card failure or input signal out of range).

  - The device is rejected to MANUAL if the LOCAL/DCS switch is not in DCS position.

  - For devices controlled via serial link, the device mode is rejected to MANUAL mode when the DATA LINK FAILURE alarm is active.

  - Specific MANUAL REJECT conditions are defined for each device (see the lists presented in each strategy section labeled "DCS Manual Control"). Upon a MANUAL REJECT condition, the DCS issues an alarm (if applicable), and the device mode is rejected to MANUAL.

- Specific TRACKING conditions are also defined for each device (see the lists presented in each strategy section labeled "DCS Manual Control"). Upon a TRACKING condition, the DCS issues an alarm (if applicable), and the Operator is not able to manually adjust the associated DCS output signal. Note that devices are able to TRACK in both the AUTO and MANUAL modes.

  - In case of speed control applications, when the device is not running, the speed is tracked to zero.

- If the respective LOCAL/DCS switch is in DCS position and the AUTO/MANUAL graphical switch at the workstation is in MANUAL mode, then subject to TRACKING conditions, the position can be directly adjusted from the DCS at the discretion of the Operator.

- If the respective LOCAL/DCS switch is in DCS position and the AUTO/MANUAL graphical switch at the workstation is in AUTO mode, then subject to TRACKING conditions, the position will typically be controlled by a PID controller, which adjusts the output based on an error signal calculated as a difference between an Operator-entered setpoint and the PV value.

- The following tracking rules are provided in order to ensure bum pless transitions between the following modes:

  - While switching from AUTO to MANUAL mode, the output will be set to the last value calculated in AUTO mode, until changed by the Operator.

APPENDIX XI - COMMON CONTROL FUNCTIONS

  - While MANUAL mode is selected, the PID algorithm's output will equal the manually entered output value, allowing for a bumpless transition from MANUAL to AUTO mode.

  - While the device LOCAL/DCS switch is not in DCS position, the DCS will track the applicable device feedback signal (typically valve position or drive speed percentage) and set algorithm's output equal to that signal.

  - For devices controlled via serial link, upon recovering from a DATA LINK FAILURE, the DCS will track the applicable device feedback signal and set algorithm's output equal to that signal.

- Application-specific tracking conditions may also apply based on the type of automatic control that is provided. A common example of this type of device tracking occurs when a higher level sequential control attempts to position a device based upon the requirements of the sequence. Refer to strategy sections labeled "DCS Automatic Control" for any applicable details.

- The device DEVIATION alarm will be activated at the DCS if, after a preset amount of time (initial value 30 seconds, Engineer adjustable) if the device feedback signal differs from the demand for more than a preset amount (initial value 5 percent, Engineer adjustable).

- When required, the M/A station output value will be characterized in order to adjust the DCS output to a specific device response curve, thus providing a linear control system response to the process.

2. Open/Stop/Close Control

- This type of control provides the Operator with the capability of basic OPEN and CLOSE functions for devices such as valves, gates or breakers. STOP functionality is included only when the associated I/O is available, allowing the Operator to select intermediate valve/gate positions.

- The device can be placed in either MANUAL or AUTO mode of operation via the graphical switch at the workstation. AUTO mode of operation enables the device to work in conjunction with a higher-level sequential control, when applicable. Note that for devices controlled via serial link, the device mode is not rejected to MANUAL when the DATA LINK FAILURE alarm is active.

- If the respective LOCAL/DCS switch is in DCS position and the AUTO/MANUAL graphical switch at the workstation is in MANUAL mode, then subject to OPEN PERMISSIVES, CLOSE PERMISSIVES and TRIPS, the device can be opened and closed from the workstation at the discretion of the Operator.

- Specific OPEN PERMISSIVE and CLOSE PERMISSIVE signals are defined for each device (see the lists presented in each strategy section labeled "DCS Manual Control"). If the PERMISSIVE is not met, then the device may not be opened or closed further.

- If the device is commanded to open by the DCS and an OPENED feedback is not received within a preset time (Engineer adjustable), the Operator will receive a FAIL TO OPEN alarm for the device. This alarm is latched at the DCS and must be RESET before the device can be opened from the DCS.

- If the device is commanded to close by the DCS and a CLOSED feedback is not received within a preset time (Engineer adjustable), the Operator will receive a FAIL TO CLOSE alarm for this device. This alarm is latched at the DCS and must be RESET before the device can be closed from the DCS.

- If at any time both OPEN and CLOSE limit switch signals are received by the DCS at the same time, the SWITCH FAILURE alarm will be set. This alarm is latched at the DCS, and this condition must be cleared before the alarm can be RESET by the Operator at the respective M/A station.

- When the RESET pushbutton is selected to clear an alarm, the device will be switched from AUTO to MANUAL mode of operation.

- For devices controlled via serial link, upon recovering from a DATA LINK FAILURE, the current device position will be tracked and the DCS command will be set accordingly to maintain the device position. Also, the device FAIL TO OPEN, FAIL TO CLOSE and SWITCH FAILURE alarms will be disabled during a DATA LINK FAILURE.

- For devices with no OPENED and/or CLOSED status feedback, the corresponding FAIL TO OPEN, FAIL TO CLOSE and SWITCH FAILURE alarms are disabled where the DCS cannot verify the device position.

3. Start/Stop Control

- This type of control provides the Operator with the capability of basic START and STOP functions for a two state device.

- The device can be placed in either MANUAL or AUTO mode of operation via the graphical switch at the workstation. AUTO mode of operation enables the device to work in conjunction with a higher level sequential control, when applicable. Note that for devices controlled via serial link, the device mode is not rejected to MANUAL when the DATA LINK FAILURE alarm is active.

- If the respective LOCAL/DCS switch is in DCS position and the AUTO/MANUAL graphical switch at the workstation is in MANUAL mode, then subject to PERMISSIVE and TRIP conditions, the device can be started and stopped from the workstation at the discretion of the Operator.

- Specific PERMISSIVE and TRIP conditions are defined for each device (see the lists presented in each strategy section labeled "DCS Manual Control"). PERMISSIVE conditions are defined as startup criteria for the device, whereas TRIP conditions are defined as running criteria for the device. In addition, either signal may incorporate an Engineer adjustable delay, as required. If the PERMISSIVE condition is not met, the DCS issues an alarm (if applicable) and prevents the device from running. However, the PERMISSIVE condition has no effect on a running device. Upon a TRIP condition, the DCS issues an alarm (if applicable), commands the device to STOP.

- If a stopped device is commanded to start by the DCS and a running feedback is not received within a preset time (initial value 5 seconds, Engineer adjustable), the Operator will receive a FAIL TO START alarm for the device. This alarm is latched at the DCS and must be RESET before the device control functions will be enabled at the DCS.

- If a running device stops while commanded to run by the DCS, the Operator will receive a FAIL TO RUN alarm for the device. This alarm is latched at the DCS and must be RESET before the device control functions will be enabled at the DCS.

- When the RESET pushbutton is selected to clear an alarm, the device will be switched from AUTO to MANUAL mode of operation.

- If a running device is commanded to stop by the DCS, and a stop feedback (removed running feedback) is not received within a preset time (Engineer adjustable), the Operator will receive a FAIL TO STOP alarm for the device. This alarm is latched at the DCS and must be RESET before the device control functions will be enabled at the DCS.

- For devices with no RUNNING status feedback, the appropriate FAIL TO RUN, FAIL TO STOP and FAIL TO START alarms are disabled since the DCS cannot verify the device status.

- After the device is stopped, the DCS imposes a RESTART DELAY to prevent the restart of that device for a preset time period (Engineer adjustable).

- The DCS provides a runtime algorithm for the device which calculates the following values:

- Total runtime - This indicates the device total accumulated runtime and cannot be RESET by the Operator.

- Current on time - This indicates the accumulated run time since the device was started for the last time. This value remains unchanged after the device is stopped and is reset when the device starts again. This calculation is for internal use, and therefore does not appear on the custom graphics.

- Maintenance runtime - This indicates the accumulated runtime since the last manual RESET by the Operator.

- For devices controlled via serial link, upon recovering from a DATA LINK FAILURE, the current device status will be tracked and the DCS command will be set accordingly to maintain the device status. Also, the device FAIL TO START, FAIL TO STOP and FAIL TO RUN alarms will be disabled during a DATA LINK FAILURE.

4. Flow Totalizer

The flow totalizer logic accumulates a flow reading over a time period, thus providing the Operator with a volume calculation for that time period.

DCS flow totalizer logic calculates three different outputs:

- Total flow - The flow value accumulated over time period since the last manual RESET initialized by the Engineer.
- Current 24 hr. flow - The flow value accumulated since last automatic RESET, which occurs at the last shift change of the day.
- Previous 24 hr. flow - The frozen flow value accumulated during previous day, which is saved when the Current 24 hour flow total is reset.

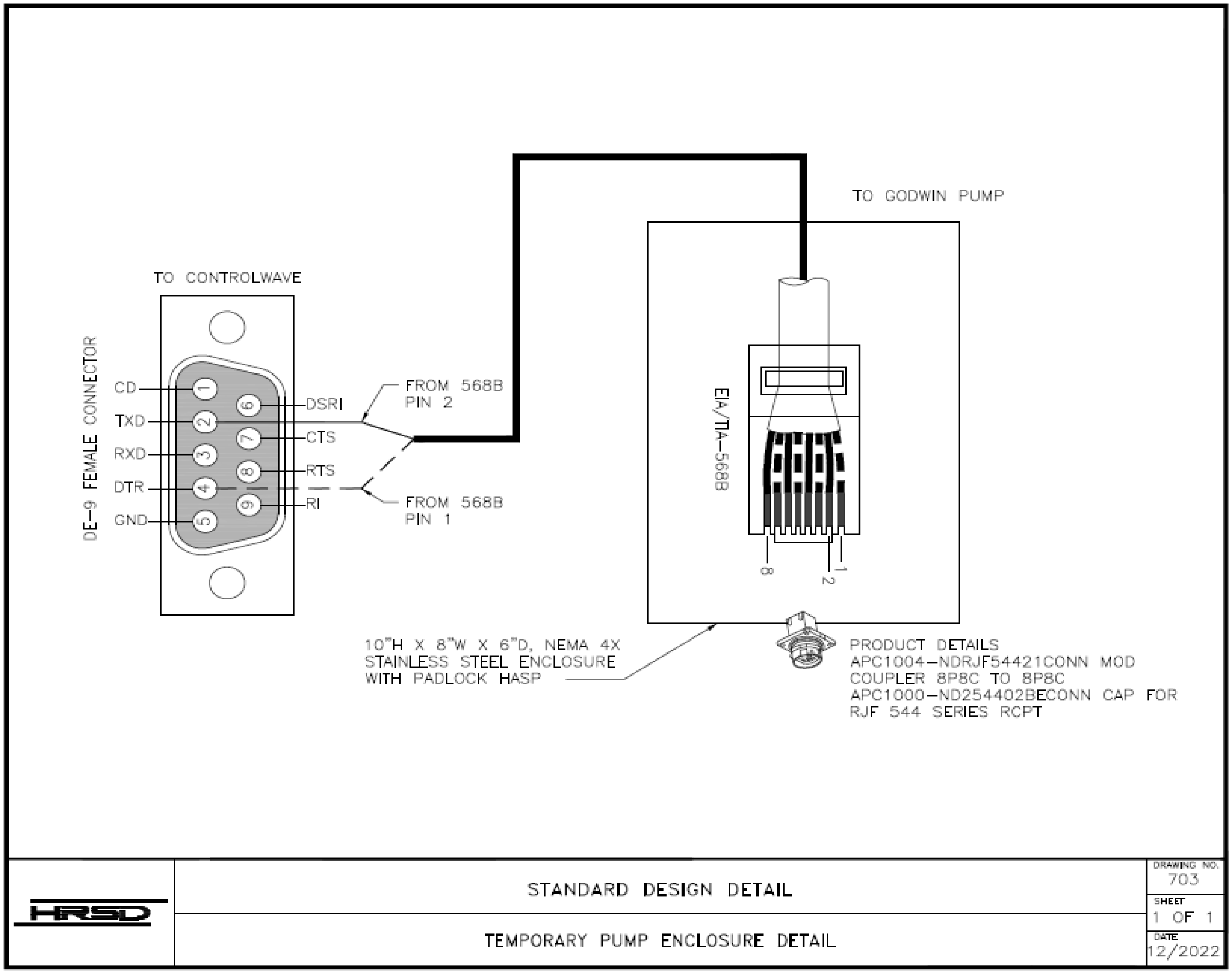
The algorithm stops accumulating flow when:

- The quality of the flow signal is set to BAD (i.e., due to I/O card failure or input signal is out of range), or
- The flow signal carries only insignificant noise, i.e., the value of the signal is lower than 5% of the signal's range (Engineer adjustable).

Click here to return to Controlwave (PSs)

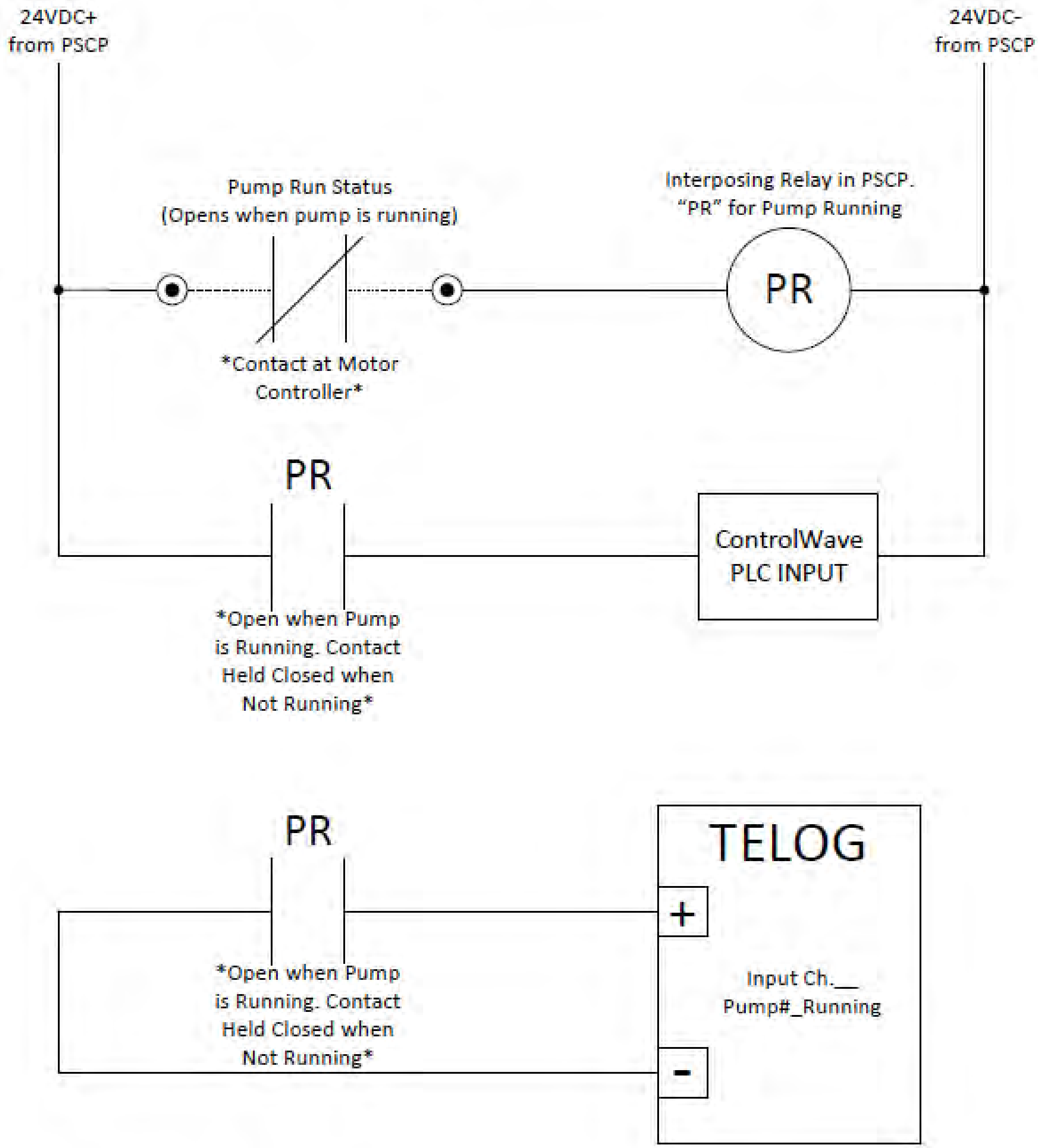
Click here to return to Controlwave (TPs)

EXHIBIT S



Elementary Pump Station Wiring Schematic for:

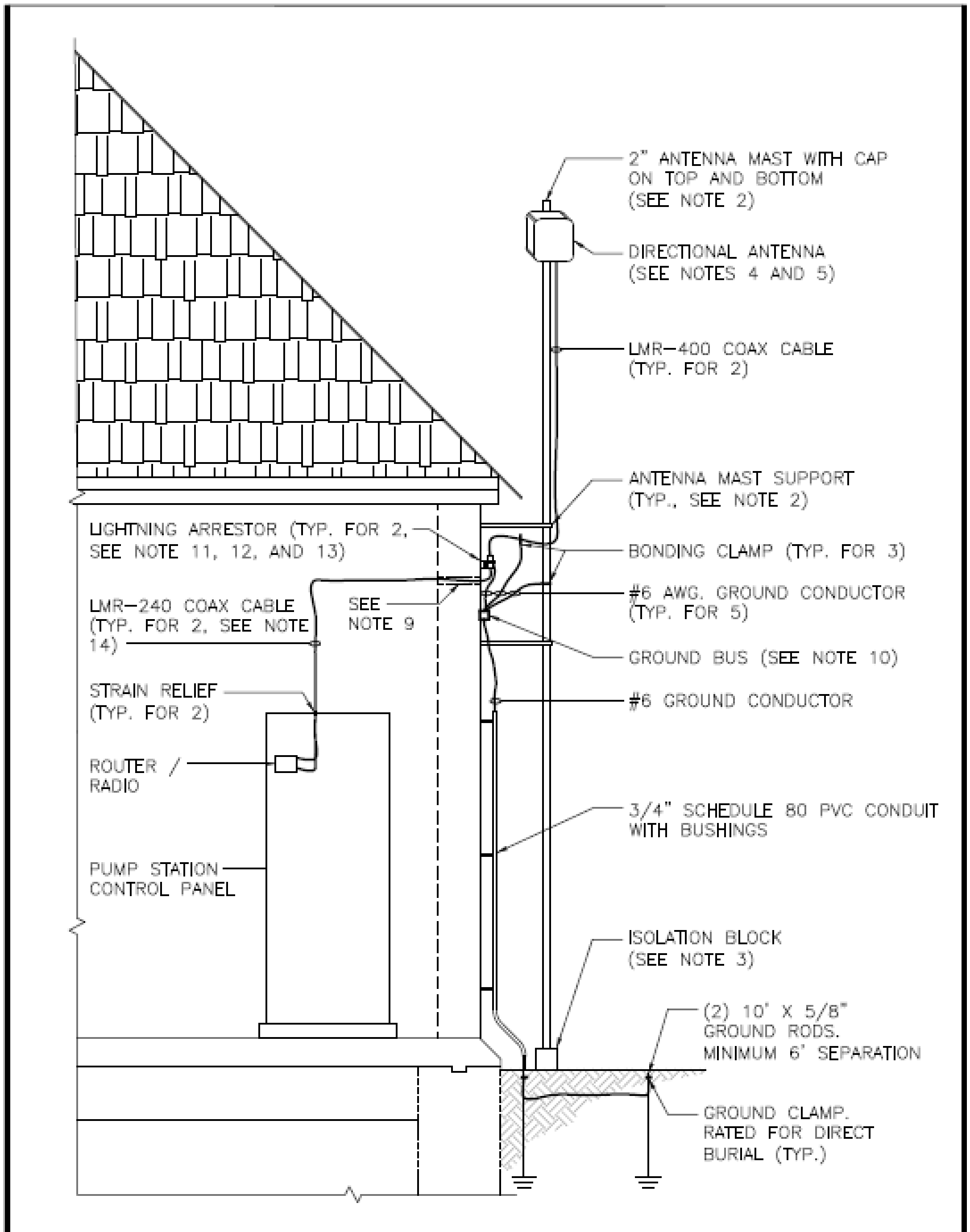
Pump Running Status to Local PLC (Control Wave) and Telog



Click here to return to Antenna (PSs)

Click here to return to Antenna (TPs)

EXHIBIT T



HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 701A
		SHEET 1 OF 2
	ANTENNA INSTALLATION DETAIL	DATE 12/2022

NOTES:

1. ANY DEVIATIONS FROM THIS DETAIL SHALL BE COORDINATED WITH HRSD OR HRSD'S REPRESENTATIVE.

2. ALL FASTENERS AND MOUNTING HARDWARE USED FOR INSTALLATION OF ELECTRICAL ITEMS SHALL BE OF THE SAME MATERIAL, GALVANIZED STEEL OR STAINLESS STEEL.

3. GALVANIZED STEEL ANTENNA MASTS SHALL NOT COME IN DIRECT CONNECT WITH THE GROUND. PROVIDE A BLOCK FOR ISOLATION IF REQUIRED.

4. DIRECTIONAL ANTENNA SHALL BE INSTALLED AT THE PROPER HEIGHT AND AZIMUTH ACCORDING TO THE SITE SURVEY.

5. DIRECTIONAL ANTENNA SHALL BE MOBILE MARK #PND10–700/2700.

6. COAX CABLE CONNECTORS SHALL BE INSTALLED PER MANUFACTURER REQUIREMENTS. SOLDERED CONNECTIONS ARE PREFERRED, CRIMP AND CAPTIVATED CONNECTIONS WILL BE ACCEPTED WHEN NECESSARY.

7. COAX CABLE CONNECTORS SHALL BE WEATHERPROOFED USING HEAT SHRINK OR COLD SHRINK TUBING, ELECTRICAL TAPE IS NOT ACCEPTABLE.

8. SUPPORT CONDUIT, COAX CABLE, AND GROUND CONDUCTORS AS REQUIRED PER THE NEC.

9. THROUGH WALL PENETRATION SHALL INCLUDE A SUITABLE SLEEVE. SEAL BETWEEN WALL AND SLEEVE. SEAL INTERIOR OF SLEEVE AFTER INSTALLATION OF THE COAX CABLES.

10. RUN A #6 GROUND CONDUCTOR FROM THE GROUND BUS TO THE BUILDING GROUNDING ELECTRODE SYSTEM. CONNECTION TO A SUPPLEMENTAL GROUND IS NOT ACCEPTABLE.

11. LIGHTNING ARRESTORS SHALL BE POLYPHASER #TSX–DFF OR #TSX–NFF MOUNTED ON THE OUTSIDE OF THE PUMP STATION NEAREST TO THE COAX CABLE POINT OF ENTRY USING AN APPROVED MOUNTING BRACKET.

12. GROUND CONDUCTORS FROM THE LIGHTNING ARRESTOR TO THE GROUND BUS SHALL NOT EXCEED 36 INCHES.

13. LIGHTNING ARRESTORS TO BE MOUNTED ON OUTSIDE OF BUILDING.

14. LMR–240 CABLE SHALL NOT EXCEED 75 LINEAR FEET.

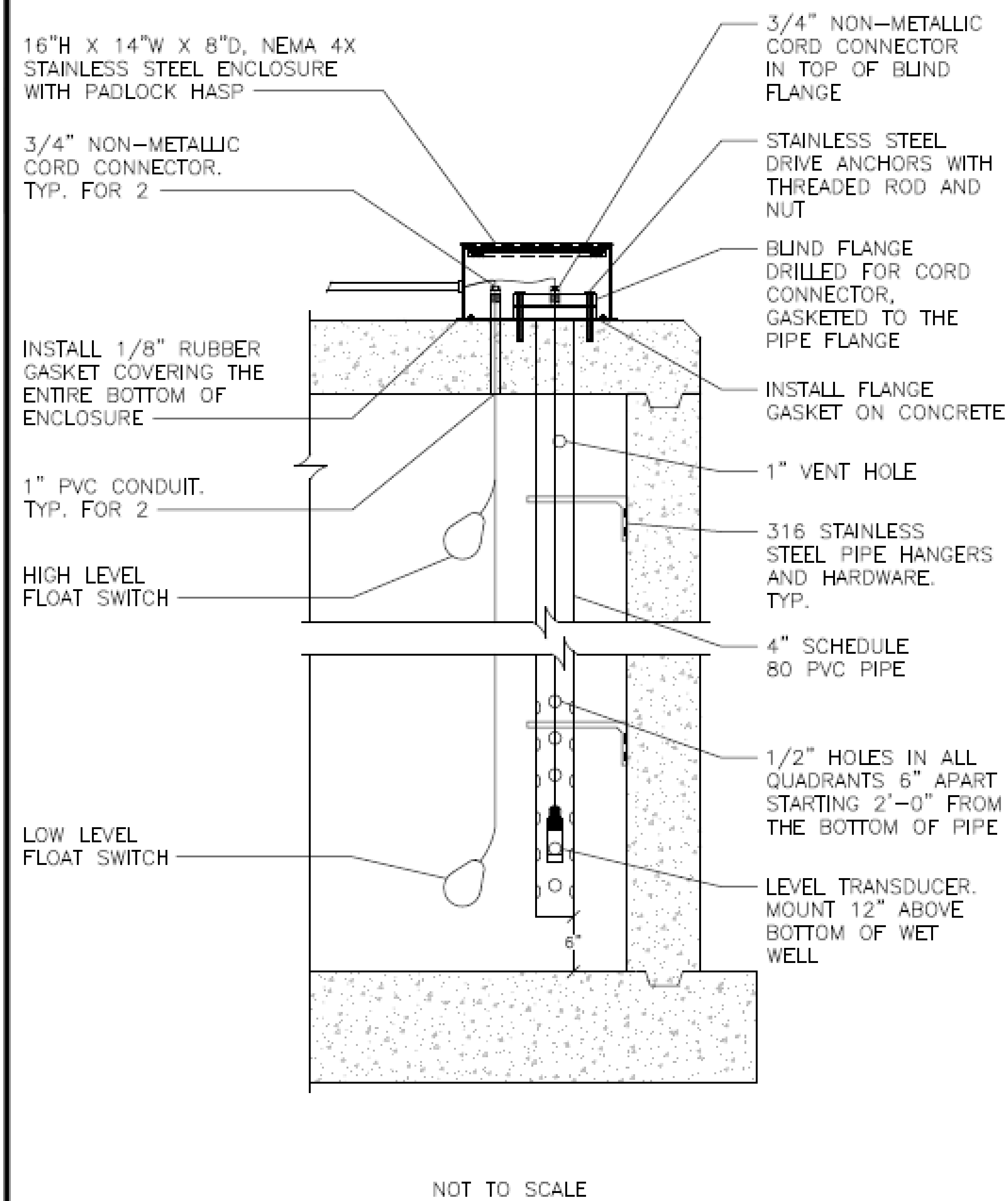
15. COAX CABLE CONNECTORS AT THE ROUTER / RADIO SHALL BE TNC MALE CONNECTORS.

HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 701B
		SHEET 2 OF 2
	ANTENNA INSTALLATION DETAIL	DATE 12/2022

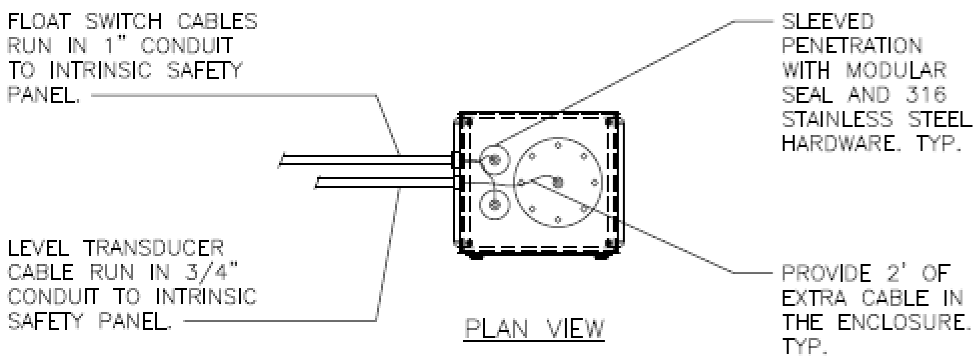
[Click here to return to Wet Well Detail (PSs)](#)

[Click here to return to Wet Well Detail (TPs)](#)

EXHIBIT U



HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 707A
	WET WELL INSTRUMENTATION INSTALLATION DETAIL	SHEET 1 OF 2
		DATE 12/2022



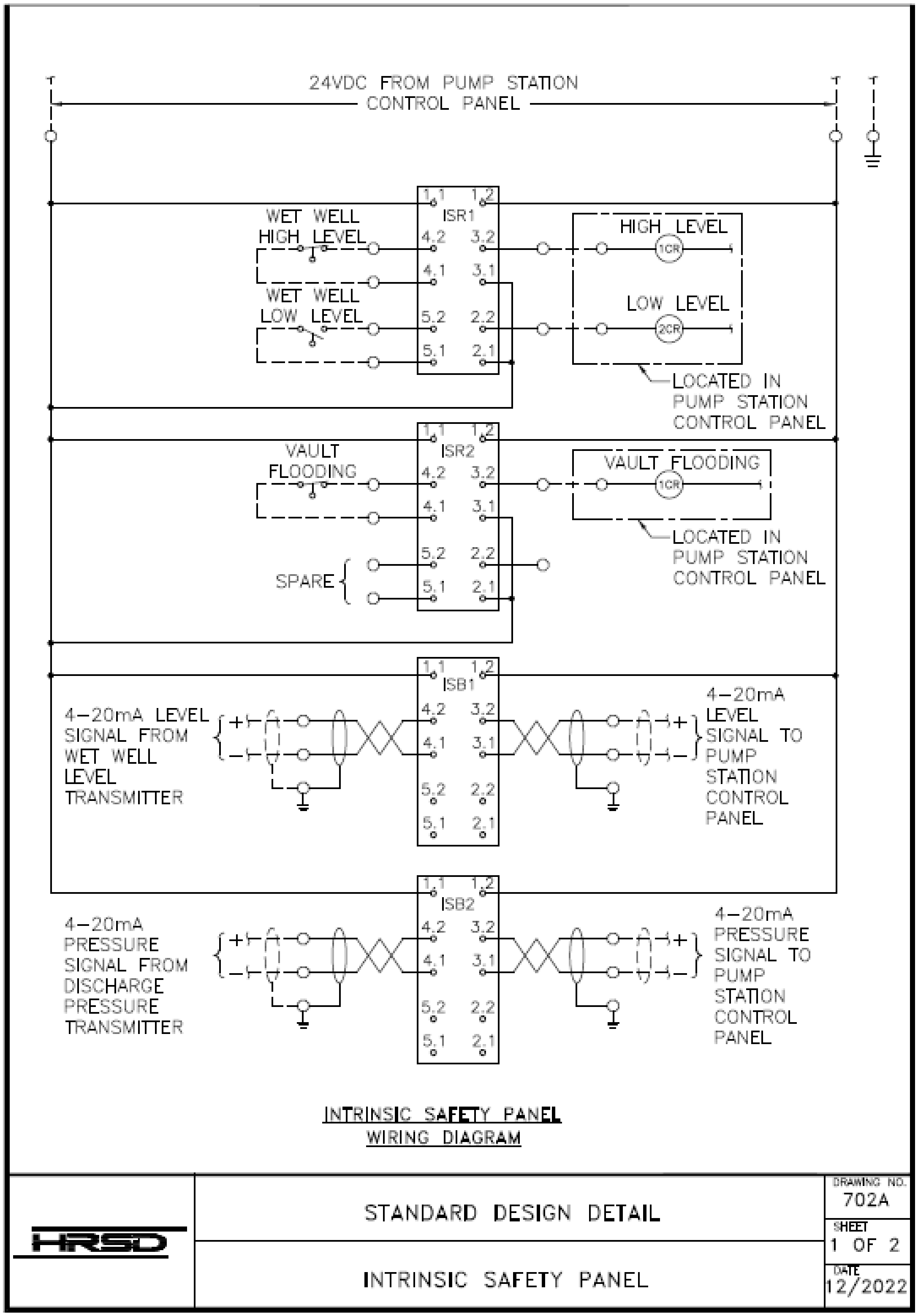
NOT TO SCALE

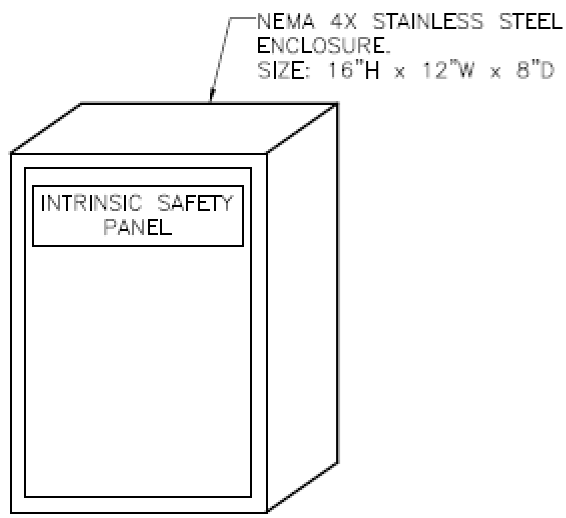
HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 707B
	WET WELL INSTRUMENTATION INSTALLATION DETAIL	SHEET 2 OF 2
		DATE 12/2022

Click here to return to Intrinsic Safety Panel (PSs)

Click here to return to Intrinsic Safety Panel (TPs)

EXHIBIT V





INTRINSIC SAFETY PANEL
PANEL LAYOUT

NOTES:

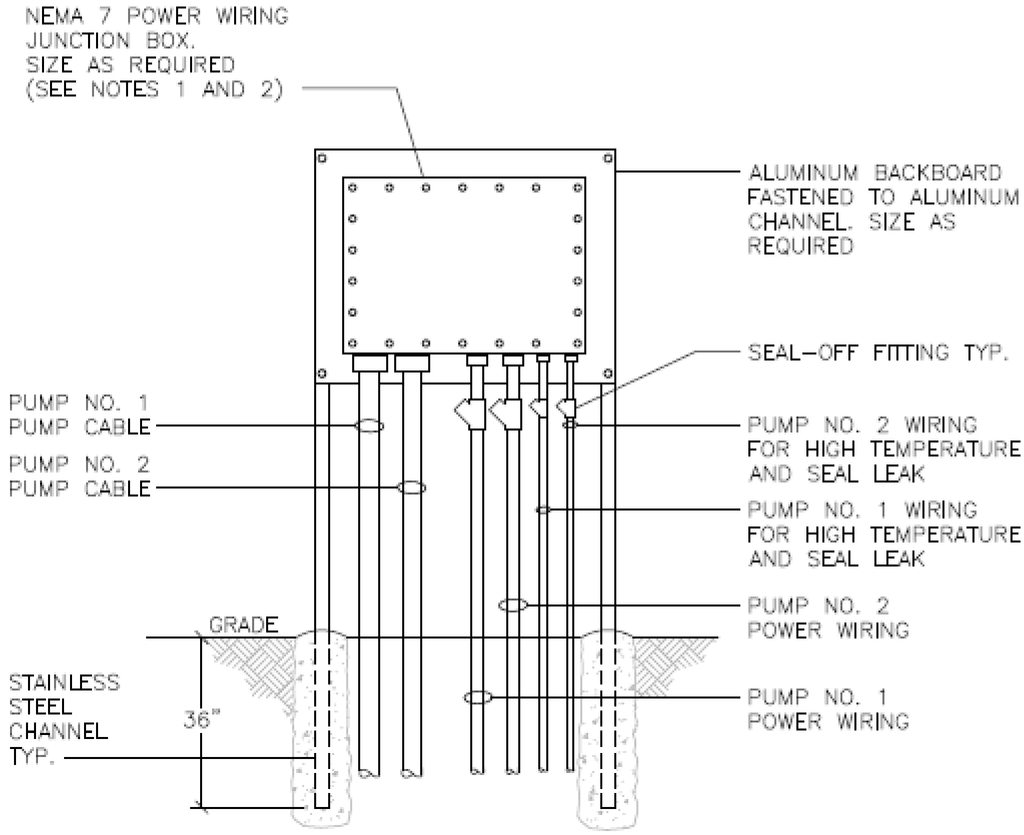
1. INTRINSIC SAFETY PANEL SHALL BE MOUNTED ON OUTSIDE OF BUILDING OR EQUIPMENT RACK.
2. CONDUITS FROM TRANSDUCER AND FLOAT SWITCH CABLES ENTERING INTRINSIC SAFETY PANEL REQUIRE NO SEAL OFF FITTINGS.
3. CONDUITS LEAVING INTRINSIC SAFETY PANEL GOING TO PUMP CONTROL PANEL SHALL HAVE SEAL OFF FITTINGS.

HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 702B
		SHEET 2 OF 2
	INTRINSIC SAFETY PANEL	DATE 12/2022

Click here to return to Junction Box (PSs)

Click here to return to Junction Box (TPs)

EXHIBIT W



NOTES:

1. PUMP CABLE WIRES SHALL BE SPLICED IN THE POWER WIRING JUNCTION BOX USING INSULATED MECHANICAL LUGS.
2. PROVIDE A MINIMUM OF 2' OF CABLE SLACK IN THE JUNCTION BOX.
3. THE INSTRUMENT VAULT AND VALVE VAULT ARE CLASSIFIED AS A CLASS 1, DIVISION 2, GROUP D AREA IN ACCORDANCE WITH NFPA 820. THE INSTALLATION OF ALL ELECTRICAL EQUIPMENT AND CONDUIT SHALL BE PERFORMED IN ACCORDANCE WITH THIS CLASSIFICATION.
4. ALL CONDUIT PENETRATIONS THROUGH CONCRETE STRUCTURES SHALL BE INSTALLED THROUGH SLEEVED PENETRATIONS WITH MODULAR SEALS AND 316 STAINLESS STEEL HARDWARE.

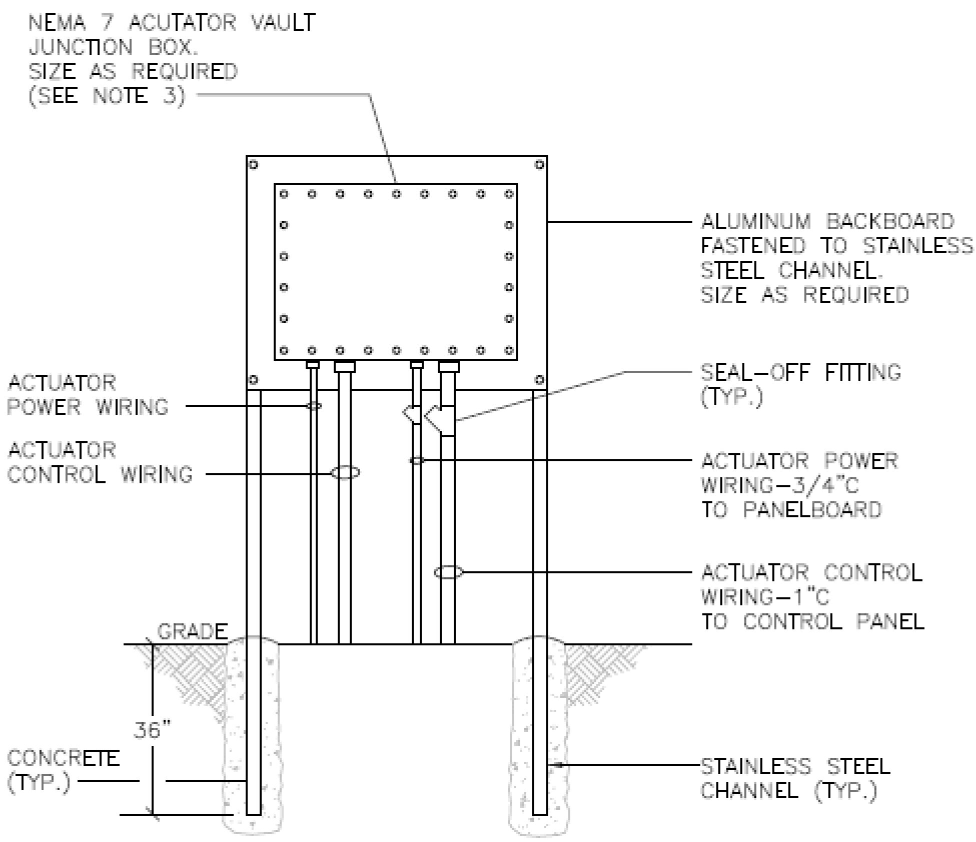
NOT TO SCALE

HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 700
		SHEET 1 OF 1
	WET WELL PUMP WIRING ELECTRICAL BACKBOARD DETAIL	DATE 12/2022

Click here to return to Vault Plans (PSs)

Click here to return to Vault Plans (TPs)

EXHIBIT X



NOTES:

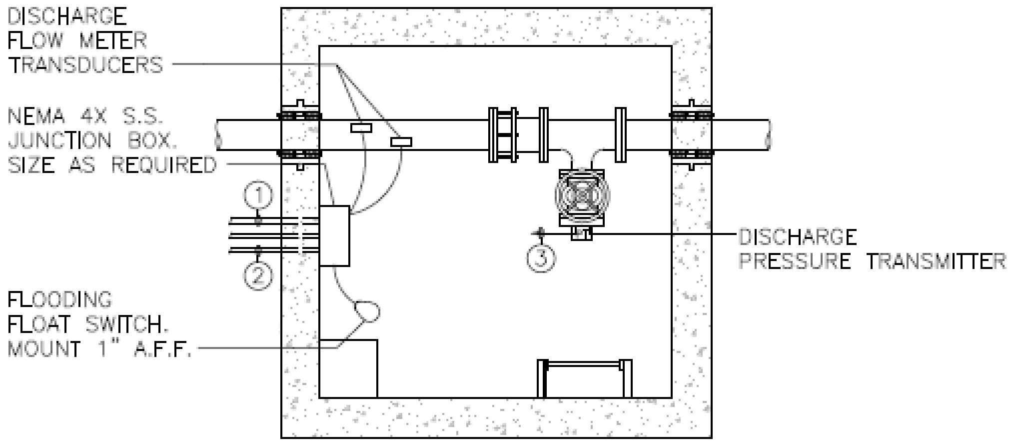
1. THE INSTRUMENT VAULT AND VALVE VAULT ARE CLASSIFIED AS A CLASS 1, DIVISION 2, GROUP D AREA IN ACCORDANCE WITH NFPA 820. THE INSTALLATION OF ALL ELECTRICAL EQUIPMENT AND CONDUIT SHALL BE PERFORMED IN ACCORDANCE WITH THIS CLASSIFICATION.

2. ALL CONDUIT PENETRATIONS THROUGH CONCRETE STRUCTURES SHALL BE INSTALLED THROUGH SLEEVED PENETRATIONS WITH MODULAR SEALS AND 316 STAINLESS STEEL HARDWARE.

3. PROVIDE A BARRIER BETWEEN POWER AND CONTROL WIRING.

NOT TO SCALE

HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 704
		SHEET 1 OF 1
	ACTUATOR VAULT ELECTRICAL BACKBOARD DETAIL	DATE 12/2022



WIRING LEGEND:

1. DISCHARGE FLOW METER TRANSDUCER CABLES–1"C TO DISCHARGE FLOW METER TRANSMITTER

2. 2#14–3/4"C TO INTRINSIC SAFETY PANEL

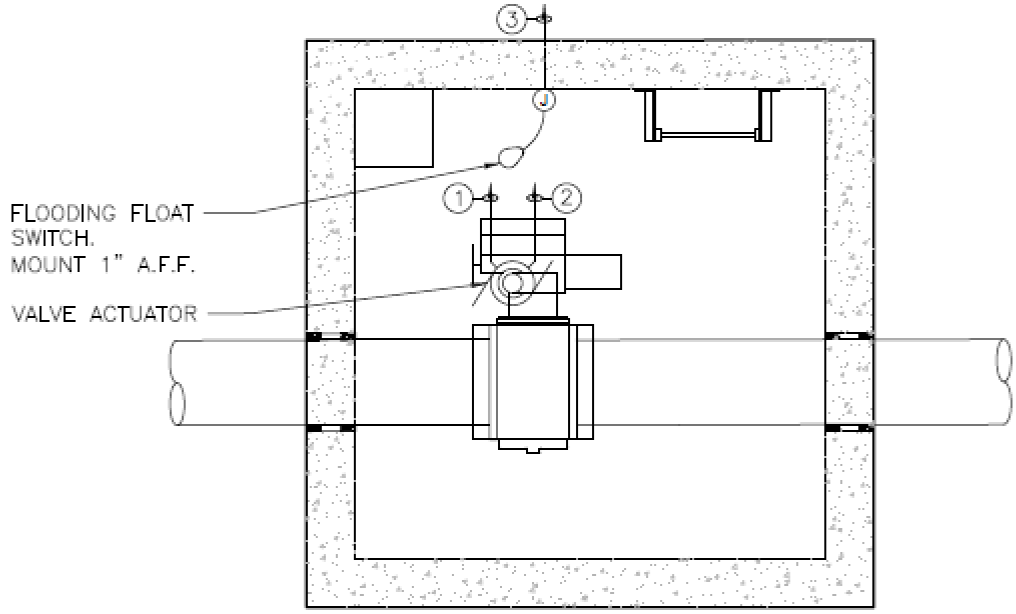
3. 1 PR. #18 SHLD. TO INTRINSIC SAFETY PANEL. RUN IN 3/4"C TO JUNCTION BOX IN INSTRUMENT VAULT AND IN 3/4" TO INTRINSIC SAFETY PANEL

NOTES:

1. THE INSTRUMENT VAULT AND VALVE VAULT ARE CLASSIFIED AS A CLASS 1, DIVISION 2, GROUP D AREA IN ACCORDANCE WITH NFPA 820. THE INSTALLATION OF ALL ELECTRICAL EQUIPMENT AND CONDUIT SHALL BE PERFORMED IN ACCORDANCE WITH THIS CLASSIFICATION.
2. ALL CONDUIT PENETRATIONS THROUGH CONCRETE STRUCTURES SHALL BE INSTALLED THROUGH SLEEVED PENETRATIONS WITH MODULAR SEALS AND 316 STAINLESS STEEL HARDWARE.
3. PROVIDE A BARRIER BETWEEN POWER AND CONTROL WIRING.

NOT TO SCALE

HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 705
		SHEET 1 OF 1
	INSTRUMENT VAULT ELECTRICAL PLAN	DATE 12/2022



WIRING LEGEND:

1. ACTUATOR POWER WIRING–3/4"C TO ACTUATOR VAULT JUNCTION BOX
2. ACTUATOR CONTROL WIRING–1"C TO ACTUATOR VAULT JUNCTION BOX
3. 2#14–3/4"C TO INTRINSIC SAFETY PANEL

NOTES:

1. THE INSTRUMENT VAULT AND VALVE VAULT ARE CLASSIFIED AS A CLASS 1, DIVISION 2, GROUP D AREA IN ACCORDANCE WITH NFPA 820. THE INSTALLATION OF ALL ELECTRICAL EQUIPMENT AND CONDUIT SHALL BE PERFORMED IN ACCORDANCE WITH THIS CLASSIFICATION.
2. ALL CONDUIT PENETRATIONS THROUGH CONCRETE STRUCTURES SHALL BE INSTALLED THROUGH SLEEVED PENETRATIONS WITH MODULAR SEALS AND 316 STAINLESS STEEL HARDWARE.
3. PROVIDE A BARRIER BETWEEN POWER AND CONTROL WIRING.

NOT TO SCALE

HRSD	STANDARD DESIGN DETAIL	DRAWING NO. 706
		SHEET 1 OF 1
	ACTUATOR VAULT ELECTRICAL PLAN	DATE 12/2022

Click here to return to Building Classification (PSs) | Click here to return to Building Classification (TPs)

EXHIBIT Y

Table 4.2.2 Collection Systems

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area	*NEC* Area Electrical Classification (All Class I, Group D)	Materials of Construction[c]	Fire Protection Measures
1		MATERIALS USED IN REHABILITATION, RECONSTRUCTION, OR SLIP-LINING OF SEWERS	N/A	N/A	N/A	N/A	In accordance with 8.3.5	N/A
2		INDUSTRIAL SEWER Sewer transporting industrial wastewater only (no sanitary wastewater)	Not included within the scope of this standard					
3		STORM SEWER Sewer transporting storm water only (no sanitary wastewater)	Possible ignition of flammable gases and floating flammable liquids	NNV	Inside of sewer	Division 2	In accordance with 8.3.5	NR
4		STORM WATER PUMPING STATION WET WELLS Liquid side of pumping station serving only a storm sewer system	Possible ignition of flammable gases and floating flammable liquids	NNV	Entire room or space	Division 2	NC, LC, or LFS	NR
5	a	STORM WATER PUMPING STATION DRY WELLS Dry side of a pumping station serving only a storm sewer system and physically separated from wet well	Buildup of vapors from flammable or combustible liquids	D	Entire dry well	Division 2	NC, LC, or LFS	FE
	b			C	Entire dry well	Unclassified	NC, LC, or LFS	FE
6		PRESSURE SEWER (Force main) Sewer under pressure (flooded discharge pipe from pump or tank)	Not included within the scope of this standard					
7		BUILDING SEWER (Lateral sewer or drain) Sewer serving a house or single building (plumbing)	Not included within the scope of this standard					
8		INDIVIDUAL RESIDENTIAL SEWER Sewer serving one or more individual residences with a total flow of not more than 1500 gallons per day (gpd)	N/A	NNV	Within enclosed space	Unclassified	NR	NR
9		INDIVIDUAL RESIDENTIAL PUMPING UNITS Pumping units serving one or more individual residences with a total flow of not more than 1500 gallons per day (gpd) (e.g., grinder pumps, septic tank effluent pumps, ejector pumps)	N/A	NNV	Within enclosed space	Unclassified	NR	NR
10	a	RESIDENTIAL SEWER Sewer transporting primarily residential wastewater	Possible ignition of flammable gases and floating flammable liquids	NNV	Within enclosed space	Division 2	In accordance with 8.3.5	NR
	b			B	Within enclosed space	Unclassified	In accordance with 8.3.5	NR

(continues)

Table 4.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area	*NEC* Area Electrical Classification (All Class I, Group D)	Materials of Construction[c]	Fire Protection Measures
11	a	RESIDENTIAL WASTEWATER PUMPING STATION WET WELL Pumping station transporting primarily residential wastewater	Possible ignition of flammable gases and floating flammable liquids	A	Entire room or space	Division 2	NC, LC, or LFS	CGD
	b			B	Entire room or space	Unclassified	NC, LC, or LFS	CGD
12	a	RESIDENTIAL WASTEWATER PUMPING STATION DRY WELL Dry side of a pumping station transporting primarily residential wastewater	Buildup of vapors from flammable or combustible liquids	D	Entire room or space	Division 2	NC, LC, or LFS	FE
	b			C	Entire room or space	Unclassified	NC, LC, or LFS	FE
13		OUTFALL SEWER Final discharge pipe from a treatment plant, transporting treated wastewater	N/A	NNV	N/A	Unclassified	NR	NR
14	a	SANITARY SEWER Sewer transporting domestic, commercial, and industrial wastewater	Possible ignition of flammable gases and floating flammable liquids	NNV	Inside of sewer	Division 1	In accordance with 8.3.5	NR
	b			B	Inside of sewer	Division 2	In accordance with 8.3.5	NR
15	a	COMBINED SEWER Sewer transporting domestic, commercial, and industrial wastewater and storm water	Possible ignition of flammable gases and floating flammable liquids	NNV	Inside of sewer	Division 1	In accordance with 8.3.5	NR
	b			B	Inside of sewer	Division 2	In accordance with 8.3.5	NR
16	a	WASTEWATER PUMPING STATION WET WELLS Liquid side of a pumping station serving a sanitary sewer or combined system	Possible ignition of flammable gases and floating flammable liquids	A	Entire room or space	Division 1	NC, LC, or LFS	CGD required if mechanically ventilated or opens into a building interior
	b			B	Entire room or space	Division 2	NC, LC, or LFS	CGD
17	a	BELOWGRADE OR PARTIALLY BELOWGRADE WASTEWATER PUMPING STATION DRY WELL Pump room physically separated from wet well; pumping of wastewater from a sanitary or combined sewer system through closed pumps and pipes	Buildup of vapors from flammable or combustible liquids	C	Entire space or room	Unclassified	NC, LC, or LFS	FE
	b			D	Entire space or room	Division 2	NC, LC, or LFS	FE
18		ABOVEGRADE WASTEWATER PUMPING STATION Pump room physically separated with no personnel access to wet well; pumping of wastewater from a sanitary or combined sewer system through closed pumps and pipes	N/A	NR	N/A	Unclassified	NC, LC, or LFS	FE

(continues)

Table 4.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area	*NEC* Area Electrical Classification (All Class I, Group D)	Materials of Construction[c]	Fire Protection Measures
19	a	ABOVEGRADE WASTEWATER PUMPING STATION Pump room not physically separated from wet well; pumping of wastewater from a sanitary or combined sewer system through closed pumps and pipes	Possible ignition of flammable gases and floating flammable liquids	A	Entire space or room	Division 1	NC	FE
	b			B	Entire space or room	Division 2	NC, LC, or LFS	FE
20	a	ODOR-CONTROL AND VENTILATION SYSTEMS SERVING CLASSIFIED AREAS	Leakage and ignition of flammable gases and vapors	D	Entire area if enclosed	Division 2	NC, LC, or LFS	CGD and FDS
	b			C	Areas within 0.9 m (3 ft) of leakage sources such as fans, dampers, flexible connections, flanges, pressurized unwelded ductwork, and odor-control vessels	Division 2	NC, LC, or LFS	CGD and FDS
	c			C	Areas beyond 0.9 m (3 ft)	Unclassified	NC, LC, or LFS	CGD and FDS
	d			Not enclosed, open to the atmosphere	Areas within 0.9 m (3 ft) of leakage sources such as fans, dampers, flexible connections, flanges, pressurized unwelded ductwork, and odor-control vessels	Division 2	NC, LC, LFS	FE
	e			Not enclosed, open to the atmosphere	Areas beyond 0.9 m (3 ft)	Unclassified	NC,LC, LFS	FE
21	a	MAINTENANCE HOLES Access to sewer for personnel entry	Possible ignition of flammable gases and floating flammable liquids	NNV	Inside	Division 1	In accordance with 8.3.5	NR
	b			B	Inside	Division 2	In accordance with 8.3.5	NR
22	a	JUNCTION CHAMBERS Structure where sewers intersect	Buildup of vapors from flammable or combustible liquids	NNV	Inside	Division 1	In accordance with 8.3.5	NR
	b			B	Open and above grade or inside and ventilated	Division 2	In accordance with 8.3.5	NR
23		INVERTED SIPHONS Depressed section of gravity sewer	Possible ignition of flammable gases and floating flammable liquids	NNV	Interior of inlet and outlet structures	Division 1	NC	NR
24		CATCH BASINS (Curb inlet) Inlet where street water enters a storm or combined sewer	Buildup of vapors from flammable or combustible liquids	NNV	Enclosed space	Division 1	In accordance with 8.3.5	NR

(continues)

Table 4.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area	*NEC* Area Electrical Classification (All Class I, Group D)	Materials of Construction[c]	Fire Protection Measures
25	a	RESIDENTIAL DIVERSION STRUCTURES Enclosed structures where residential wastewater can be diverted	Buildup of vapors from flammable or combustible liquids	NNV	Enclosed space	Division 2	In accordance with Chapter 8	NR
	b			B	Enclosed space	Unclassified	In accordance with Chapter 8	NR
26	a	RESIDENTIAL BELOWGRADE VALVE VAULT With an exposed residential wastewater surface	Possible ignition of gases and floating flammable liquids	NNV	Enclosed space	Division 2	In accordance with 8.3.5	NR
	b			B	Enclosed space	Unclassified	In accordance with 8.3.5	NR
27	a	RESIDENTIAL CONTROL STRUCTURES Enclosed structures where residential wastewater flow is regulated	Buildup of vapors from flammable or combustible liquids	A	Enclosed space	Division 2	In accordance with Chapter 8	NR
	b			B	Enclosed space	Unclassified	In accordance with Chapter 8	NR
28	a	RESIDENTIAL BELOWGRADE METERING VAULT With an exposed residential wastewater surface	Possible ignition of flammable gases and floating flammable liquids	NNV	Enclosed space	Division 2	In accordance with 8.3.5	NR
	b			B	Enclosed space	Unclassified	In accordance with 8.3.5	NR
29	a	DIVERSION STRUCTURES Enclosed structures where wastewater can be diverted	Buildup of vapors from flammable or combustible liquids	NNV	Enclosed space	Division 1	In accordance with Chapter 8	NR
	b			B		Division 2	In accordance with Chapter 8	NR
30		ABOVEGRADE VALVE VAULT Physically separated from the wet well; valves in vault in closed piping system	N/A	NR	N/A	Unclassified	NC, LC, or LFS	NR
31	a	BELOWGRADE VALVE VAULT Physically separated from the wet well and with closed piping system	Buildup of vapors from flammable or combustible liquids	NNV	Enclosed space	Division 2	NC, LC, or LFS	NR
	b			C	Enclosed space	Unclassified	NC, LC, or LFS	NR
32	a	BELOWGRADE VALVE VAULT With an exposed wastewater surface	Possible ignition of gases and floating flammable liquids	NNV	Enclosed space	Division 1	NC	NR
	b			B	Enclosed space	Division 2	NC, LC, or LFS	NR
33	a	CONTROL STRUCTURES Enclosed structures where wastewater or storm water flow is regulated	Buildup of vapors from flammable or combustible liquids	A	Enclosed space	Division 1	In accordance with Chapter 8	NR
	b			B	Enclosed space	Division 2	In accordance with Chapter 8	NR
34	a	WASTEWATER HOLDING BASINS Enclosed structures temporarily holding untreated or partially treated wastewater	Possible ignition of flammable gases and floating flammable liquids	A	Enclosed space	Division 1	NC	NR
	b			B	Enclosed space	Division 2	NC, LC, or LFS	NR

(continues)

Table 4.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area	*NEC* Area Electrical Classification (All Class I, Group D)	Materials of Construction[c]	Fire Protection Measures
35		WASTEWATER HOLDING BASINS, LINED OR UNLINED Open structures holding storm water, combined wastewater, untreated or partially treated wastewater	NR	NR	NR	NR	NR	NR
36	a	BELOWGRADE METERING VAULT Physically separated from the wet well and with closed piping system	Buildup of vapors from flammable or combustible liquids	NNV	Enclosed space	Division 2	NC, LC, or LFS	NR
	b			C	Enclosed space	Unclassified	NC, LC, or LFS	NR
37	a	BELOWGRADE METERING VAULT With an exposed wastewater surface	Possible ignition of flammable gases and floating flammable liquids	NNV	Enclosed space	Division 1	NC	NR
	b			B	Enclosed space	Division 2	NC, LC, or LFS	NR
38		COARSE AND FINE SCREEN FACILITIES *(See "Coarse and Fine Screen Facilities" in Table 5.2.2.)*						

Note: The following codes are used in this table:
A: No ventilation or ventilated at less than 12 air changes per hour
B: Continuously ventilated at 12 changes per hour
C: Continuously ventilated at six air changes per hour
CGD: Combustible gas detection system
D: No ventilation or ventilated at less than six air changes per hour
FDS: Fire detection system
FE: Portable fire extinguisher
LC: Limited-combustible material
LFS: Low flame spread index material
N/A: Not applicable
NC: Noncombustible material
NEC: In accordance with *NFPA 70*
NNV: Not normally ventilated
NR: No requirement

[a]The "Row" and "Line" columns are used to refer to specific figures in A.4.2 and specific requirements for each location and function.

[b]This column indicates the ventilation requirements for processes. Additional ventilation requirements are provided in Chapter 9. Ventilation signaling and alarm requirements are provided in Chapter 7.

[c]This column indicates the materials of construction for processes. Materials of construction for buildings in which these processes are housed are in accordance with the applicable building code and construction requirements provided in Chapter 8.

Click here to return to Building Classification (PSs)

Click here to return to Building Classification (TPs)

EXHIBIT Z

Table 5.2.2 Liquid Stream Treatment Processes

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area[c]	NEC Area Electrical Classification (All Class I, Group D)[d]	Materials of Construction[e]	Fire Protection Measures
1	a	DIVERSION AND CONTROL STRUCTURES Not preceded by primary treatment	Possible ignition of flammable gases and floating flammable liquids	A	Enclosed—entire space	Division 1	NC	FE, H; CGD if enclosed in building
	b			B	Enclosed—entire space	Division 2	NC, LC, or LFS	FE, H; CGD if enclosed in a building
	c			Not enclosed, open to atmosphere	Within a 3 m (10 ft) envelope around equipment and open channel	Division 2	NC, LC, or LFS	FE and H
2	a	COARSE AND FINE SCREEN FACILITIES Removal of screenings from raw wastewater	Possible ignition of flammable gases and floating flammable liquids	A	Enclosed— entire space	Division 1	NC	FE, H, CGD
	b			B	Enclosed— entire space	Division 2	NC, LC, or LFS	FE, H, CGD
	c			Not enclosed, open to atmosphere	Within a 3 m (10 ft) envelope around equipment and open channel	Division 2	NC, LC, or LFS	FE, H
3		PUMPING STATIONS, DIVERSION STRUCTURES AND CONTROL STRUCTURES (See Table 4.2.2.)						
4	a	FLOW EQUALIZATION TANKS Storage of raw or partially treated wastewater	Possible ignition of flammable gases and floating flammable liquids	A	Enclosed— entire space	Division 1	NC	FE, H;CGD if enclosed in a building
	b			B	Enclosed— entire space	Division 2	NC, LC, or LFS	FE, H; CGD if enclosed in a building
	c			Not enclosed, open to atmosphere	Within a 3 m (10 ft) envelope around equipment and open channel[f,g]	Division 2	NC, LC, or LFS	FE, H
5	a	GRIT REMOVAL TANKS Separation of grit from raw wastewater	Possible ignition of flammable gases and floating flammable liquids	A	Enclosed— entire space	Division 1	NC	FE, H;CGD if enclosed in a building
	b			B	Enclosed— entire space	Division 2	NC, LC, or LFS	FE, H; CGD if enclosed in a building
	c			Not enclosed, open to atmosphere	Within a 3 m (10 ft) envelope around equipment and open channel[f,g]	Division 2	NC, LC, or LFS	FE, H
6	a	PRE-AERATION TANKS Conditioning of wastewater prior to further treatment	Possible ignition of flammable gases and floating flammable liquids	A	Enclosed— entire space	Division 1	NC	H;CGD if enclosed in a building
	b			B	Enclosed— entire space	Division 2	NC, LC, or LFS	H; CGD if enclosed in a building
	c			Not enclosed, open to atmosphere	Within a 3 m (10 ft) envelope around equipment and open channel[f,g]	Division 2	NC, LC, or LFS	H

(continues)

Table 5.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area[c]	*NEC* Area Electrical Classification (All Class I, Group D)[d]	Materials of Construction[e]	Fire Protection Measures
7	a	PRIMARY SEDIMENTATION TANKS Separation of floating or settleable solids from raw wastewater	Possible ignition of flammable gases and floating flammable liquids	A	Enclosed— entire space	Division 1	NC	H;CGD if enclosed in a building
	b			B	Enclosed— entire space	Division 2	NC, LC, or LFS	H; CGD if enclosed in a building
	c			Not enclosed, open to atmosphere	Interior of the tank from the minimum operating water surface to the top of the tank wall; envelope 0.46 m (18 in.) above the top of the tank and extending 0.46 m (18 in.) beyond the exterior wall; envelope 0.46 m (18 in.) above grade extending 3 m (10 ft) horizontally from the exterior tank walls	Division 2	NC, LC, or LFS	H
8		AERATION BASIN, POND, LAGOON, OXIDATION DITCH, AEROBIC SUSPENDED GROWTH SYSTEMS, SEQUENCING BATCH REACTORS Aerobic treatment of wastewater open to the atmosphere	N/A	NR		Classified (see Primary Sedimentation) Unclassified if process is preceded by primary sedimentation	NR	H

(continues)

Table 5.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area[c]	NEC Area Electrical Classification (All Class I, Group D)[d]	Materials of Construction[e]	Fire Protection Measures
9	a1	ENCLOSED AERATION BASIN, AEROBIC OR SUSPENDED GROWTH SYSTEMS, MEMBRANE BIOLOGICAL REACTORS Aerobic treatment not preceded by primary treatment	Possible ignition of flammable gases or floating flammable liquids	A (Interior of tank)	Entire enclosed space or tank of system	Division 1	NC	NR
	a2			A (Interior of tank)	Exterior of enclosed space or tank, installed in a building	Division 2	NC, LC, or LFS	NR
	a3			A (Interior of tank)	Exterior of enclosed space or tank, installed outdoors; envelope 0.46 m (18 in.) surrounding tank	Division 2	NC, LC, or LFS	NR
	b1			B (Interior of tank maintained at negative pressure)	Entire enclosed space or tank of system	Division 2	NC, LC, or LFS	NR
	b2			B (Interior of tank maintained at negative pressure)	Exterior of enclosed space or tank, installed in a building	Unclassified	NC, LC, or LFS	NR
	b3			B (Interior of tank maintained at negative pressure)	Exterior of enclosed space or tank, installed outdoors	Unclassified	NC, LC, or LFS	NR
	c			Not enclosed, open to atmosphere	Interior of tank from the minimum operating water surface to the top of the tank wall; envelope 0.46 m (18 in.) above the top of the tank and extending 0.46 m (18 in.) beyond exterior wall; envelope 0.46 m (18 in.) above grade and extending 3 m (10 ft) horizontally from the exterior tank walls	Division 2	NC, LC, or LFS	NR
10	a1	RESIDENTIAL ENCLOSED AERATION BASIN, AEROBIC OR SUSPENDED GROWTH SYSTEMS, MEMBRANE BIOLOGICAL REACTORS Aerobic treatment not preceded by primary treatment, serving one but not more than five dwellings	Possible ignition of flammable gases or floating flammable liquids	A (Interior of tank)	Entire enclosed space or tank of system	Division 2	NC	NR
	a2			A (Interior of tank)	Exterior of enclosed space or tank, installed in a building	Unclassified	NC, LC, or LFS	NR
	a3			A (Interior of tank)	Exterior of enclosed space or tank, installed outdoors	Unclassified	NC, LC, or LFS	NR

(continues)

Table 5.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area[c]	*NEC* Area Electrical Classification (All Class I, Group D)[d]	Materials of Construction[e]	Fire Protection Measures
11		ENCLOSED AERATION BASIN, AEROBIC OR SUSPENDED GROWTH SYSTEMS, MEMBRANE BIOLOGICAL REACTORS Aerobic treatment of wastewater preceded by primary treatment	N/A	NR	Entire enclosed space	Unclassified	NC, LC, or LFS	NR
12		TRICKLING FILTER, BIO-TOWER, AEROBIC FIXED-FILM SYSTEMS Aerobic biological treatment of wastewater	Not normally a significant hazard; however, these processes might contain materials that are combustible under certain conditions	NR	N/A	Classified (*See Primary sedimentation*) Unclassified if unit process is preceded by primary sedimentation	NR	H
13	a	ANAEROBIC TOWERS, ANAEROBIC FIXED-FILM SYSTEM Anaerobic biological treatment if sealed from atmosphere	Normally produces combustible gas as treatment process by-product	N/A	Tank interior	Division 1	NC	FE and H
	b			N/A	3 m (10 ft) envelope around tank	Division 2	NC, LC, or LFS	FE and H
14	a	GAS-HANDLING SYSTEMS FOR LIQUID TREATMENT PROCESSES	Combustible gas, often under pressure	A	Enclosed— entire space	Division 1	NC	FE and H
	b			B	Enclosed— entire space	Division 2	NC, LC, or LFS	FE and H
	c			Not enclosed, open to atmosphere	Within a 3 m (10 ft) envelope around equipment[f]	Division 2	NC, LC, or LFS	FE and H
15		OXYGEN AERATION TANKS Tanks for aerobic treatment of wastewater using high-purity oxygen rather than air	Ignition of flammable gases and floating flammable liquids in an oxygen-enriched environment	N/A	Enclosed space	Division 2 (If unit process is not preceded by primary sedimentation, see Primary sedimentation Tanks in Table 5.2.2 for classification.)	Any equipment or material within the reactor space shall be safe for exposure to volatile in an oxygen-enriched atmosphere	Special provision for LFL monitoring and automatic isolation of equipment and oxygen supply
16		INTERMEDIATE, SECONDARY, OR TERTIARY SEDIMENTATION TANKS Separate floating and settleable solids from wastewater at various treatment stages	N/A	NR	N/A	Classified (*See Primary sedimentation*) Unclassified if unit process is preceded by primary sedimentation	NR	H
17		FLASH MIXER OR FLOCCULATION TANKS Tanks for mixing various treatment chemicals with wastewater	N/A	NR	N/A	Classified (*See Primary sedimentation*) Unclassified if unit process is preceded by primary sedimentation	NR	H
18		NITRIFICATION AND DENITRIFICATION TANKS Tertiary treatment of wastewater to reduce or remove nitrogen	N/A	NR	N/A	Classified (*See Primary sedimentation*) Unclassified if unit process is preceded by primary sedimentation	NR	H

(continues)

Table 5.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area[c]	*NEC* Area Electrical Classification (All Class I, Group D)[d]	Materials of Construction[e]	Fire Protection Measures
19		BREAKPOINT CHLORINATION TANKS AND CHLORINE CONTACT TANKS Application of chlorine in aqueous solution to wastewater	N/A	NR	N/A	Unclassified	NR (These unit processes use corrosive chemicals that require the use of specific materials of construction. Special consideration shall be given to these materials of construction.)	H
20		AMMONIA STRIPPING TOWERS	*(See Trickling filter in Table 5.2.2.)*	N/A	N/A	Unclassified	NR (These unit processes use corrosive chemicals. Special consideration shall be given to these materials of construction.)	H
21		INTERMEDIATE OR FINAL PUMPING STATIONS AND OTHER UNIT PROCESSES AND STRUCTURES NOT SPECIFICALLY ADDRESSED IN THIS TABLE. Preceded by primary treatment	N/A	NR	N/A	Unclassified	NR	H
22		GRAVITY AND PRESSURE FILTERS Filtering of treated wastewater through sand or other media	N/A	NR	N/A	Unclassified	NR	H
23		CARBON COLUMN OR TANKS Vessels containing carbon for tertiary treatment of wastewater	Significant hazard from combustible carbon material	N/A	N//A	Unclassified	NR	H
24		ON-SITE OZONE GENERATION SYSTEM AND OZONE CONTACT TANKS Ozone generation and purification for disinfection of wastewater	Similar to oxygen generation with addition of being highly corrosive *(See Table D.1.1)*	N/A	N/A	Not covered in this standard	NR	NR
25		BACKWASH WATER AND WASTE BACKWASH WATER HOLDING TANKS Tanks for temporary storage of backwash water	N/A	N/A	N/A	Unclassified	NR	H
26		ULTRAVIOLET DISINFECTION UNIT Disinfection of wastewater effluent by ultraviolet radiation	N/A	NR	N/A	Unclassified	NR	H

(continues)

Table 5.2.2 *Continued*

Row[a]	Line[a]	Location and Function	Fire and Explosion Hazard	Ventilation[b]	Extent of Classified Area[f]	*NEC* Area Electrical Classification (All Class I, Group D)[d]	Materials of Construction[e]	Fire Protection Measures
27		EFFLUENT STRUCTURES Various structures conveying treated wastewater away from treatment processes	N/A	NR	N/A	Unclassified	NR	H
28	a	ODOR-CONTROL AND VENTILATION SYSTEMS SERVING CLASSIFIED AREAS *(See Table 4.2.2)*						
	b							
	c							

Note: The following codes are used in this table:
A: No ventilation or ventilated at less than 12 air changes per hour
B: Continuously ventilated at 12 air changes per hour in accordance with Chapter 9.
C: Continuously ventilated at six air changes per hour in accordance with Chapter 9.
CGD: Combustible gas detection system.
D: No ventilation or ventilated at less than six air changes per hour.
FDS: Fire detection system.
FE: Portable fire extinguisher.
H: Hydrant protection in accordance with 7.2.4.
LC: Limited-combustible material.
LFS: Low flame spread index material.
N/A: Not applicable.
NC: Noncombustible material.
NEC: In accordance with *NFPA 70*.
NR: No requirement.

[a]The "Row" and "Line" columns are used to refer to specific figures in A.5.2 and specific requirements for each location and function.
[b]This column indicates the ventilation requirements for processes. Additional ventilation requirements are provided in Chapter 9. Ventilation signaling and alarm requirements are provided in Chapter 7.
[c]Open channels and open structures upstream from the unit processes are classified the same as the downstream processes they supply.
[d]These unit processes use corrosive chemicals that can have a deteriorating effect on conductors and equipment. Electrical equipment shall be identified for use in the operating environment.
[e]This column indicates the materials of construction for processes. Materials of construction for buildings in which these processes are housed are in accordance with the applicable building code and construction requirements provided in Chapter 8.
[f]The area beyond the envelope is unclassified.
[g]Where liquid turbulence is not induced by aeration or other factors, the following criteria apply: (1) interior of the tank from the minimum operating water surface to the top of the tank wall; (2) envelope 0.46 m (18 in.) above the top of the tank and extending 0.46 m (18 in.) beyond the exterior wall; (3) envelope 0.46 m (18 in.) above grade extending 3 m (10 ft) horizontally from the exterior tank walls.

Click here to return to Air Purification (PSs)

Click here to return to Air Purification (TPs)

EXHIBIT AA

Packaged Filter Unit (PFU)

PureAIR FILTRATION

Basic Information:

- Main Function: protecting mission critical electronics from hardware failure, including in control rooms at wastewater and water treatment plants, refineries and paper plants, and data centers, improving indoor air quality, & commercial odor control
  - Our PFU Mobile and PFU Mini units, explained later in this section, are the smallest versions of the PFU model
- Complete, self contained, vertical airflow configuration
- Free standing and very compact unit which can provide continuous high efficiency purification at airflows between 500 and 3,000 CFM
- Multiple media stages for chemical adsorbent media
- Multiple sizes and customizable options explained later in section

Benefits of PFU System:

- Self contained and compact, especially relative to airflow capacity
- Free standing, energy efficient, and quiet
- Positive seal prevents air bypass for highest filtration efficiency
- Produces pressurization, recirculation, or both
- Easy access to internal parts and adsorbent media for maintenance and changeout
- Integrated particulate filter

Customizable Options:

- Multiple power input configurations
- Options for construction material
- Various sizes available depending on footprint, airflow, and other customer requirements- See model selection guide on next page
- Media selection for multiple media cartridges- see adsorbent media section for options
- Further options for pre and final filters, as well as other features- see remainder of this section for full details on customizable options

Packaged Filter Unit (PFU)

PureAIR FILTRATION

Model Nomenclature:

PFU - XXXX - B

Model — Airflow in CFM — Number of Banks (1 or 2)

PFU MODEL NO	AIRFLOW RANGE CFM (CMH)	MOTOR SIZE HP (KW)	MEDIA VOLUME FT^3 (M^3)	SHIPPING WEIGHT LBS (KG)	OPERATING WEIGHT LBS (KG)
PFU-1000-2	500-1000 (850-1700)	1 (0.75)	4 (0.11)	530 (240)	730 (330)
PFU-2000-2	1000-2000 (1700-3400)	2 (1.5)	8 (0.23)	980 (445)	1380 (625)
PFU-3000-2	1500-3000 (2550-5100)	3 (2.3)	12 (0.35)	1220 (555)	1820 (825)

Two of the PFU Units are Mobile and Have Different Nomenclature:

Mobile PFU MODEL NO	AIR RANGE CFM (CMH)	MOTOR SIZE HP (kW)	MEDIA VOLUME FT^3 (M^3)	SHIPPING WEIGHT LBS (KG)	OPERATING WEIGHT LBS (KG)
PFU-Mobile	500 - 1,000 (850-1700)	0.8 (0.6)	4 (0.11)	280 (127)	440 (200)
PFU-Mini	250 - 500 (425-850)	0.3 (0.2)	1 (0.03)	190 (86)	270 (122)

*Note that these units were previously called the DC-1 and DC-mini. They have been renamed to portray their similarities to the PFU model as well as their many applications.

Selecting Standard Options

- Construction Material - Painted/coated steel, aluminized steel, FRP, 316 or 304 grade stainless steel, or aluminum options
    - ◊ Painted/Coated Steel Standard
- Particulate Filter Options
    - ◊ Options for First Filter- protects downstream system components and improves life of media
        - Standard- 2", 30% MERV 8 filter
        - Optional 95%+ filters are available to prevent small particulates blinding media
        - Magnehelic or photohelic differential pressure gauges available to determine when or cleaning is necessary
    - ◊ Final Filter - removes any fine dust which may be released during media changeout or initial start-up, standard for industrial customers
        - 6", 95% MERV 13 filter with extruded aluminum tracks and positive air seals to prevent air bypass
        - Magnehelic or photohelic differential pressure gauges available to determine when changeout or cleaning is necessary
- Blower- internal direct drive or belt drive blower standard. Discuss vendor and factory options with PureAir Representative
    - ◊ Redundant blowers available
- Multiple available power configurations
- Adsorbent Media- up to 2 media stages available
    - ◊ Types of Adsorbent Media to fill media banks- see media section

Packaged Filter Unit (PFU)

PureAIR FILTRATION

Additional Features & Options

- Intake Louver
- Intake Hood
- Inlet Isolation Damper
- Insulated / Double Walled
- Internal Plenum Fan or External Scroll Fan
- Sound Enclosure
- Outlet Silencer
- No-Loss stacks

Our team is proud to offer fully customizable solutions with various standard features described- ask our team about any additional options in which you may be interested.

Packaged Filter Unit (PFU)

PFU-Mobile and PFU-Mini

Protect Critical and Valuable Servers from Polluted Air

PureAir's PFU-mobile and PFU-mini units are self-contained, moveable units that recirculate the air in controlled environments like control rooms and data centers. As the air passes through PureAir's gas adsorbent media, harmful corrosive gases are captured and permanently bound. Purified air is sent out the top of the unit where it is used to cool servers and computer components without harming electrical components. The unit has low energy consumption and noise, and installation is a snap in your existing server cabinets, plugging into standard electrical sockets. The PFU-mobile unit provides protection for up to 5000 square feet (approximately 500 M2). Airflow is variable, controllable up to 1000 cfm (1700 CMH), and differential pressure gauges indicate filter changes for easy maintenance. Other information and details include:

- Variable airflow
- Low EMF brushless AC blower motor
- Low noise and energy consumption
- Available in 110-230 V and 50/60 V options
- MERV 7 (G4) Dust prefilter
- MERV 13 (F7) Dust final filter
- Optional differential pressure gauges to indicate dust filter change
- PureAir chemical adsorbent media filled in low pressure holding frames

	Room Air Volume Capacity by Model	
Air Quality	PFU-Mini	PFU-Mobile
G2	20000 ft3 (600 M^3)	40000 ft3 (1200 M^3)
G3	10000 (300 M^3)	20000 ft3 (600 M^3)
GX	5000 ft3 (150 M^3)	10000 ft3 (300 M^3)
Based on ISA S71.4 or ASHRAE TC9.9 recommendations		

Packaged Filter Unit (PFU)

PureAIR FILTRATION

Additional Features & Options

- Intake Louver
- Intake Hood
- Inlet Isolation Damper
- Insulated / Double Walled
- Internal Plenum Fan or External Scroll Fan
- Sound Enclosure
- Outlet Silencer
- No-Loss stacks

Our team is proud to offer fully customizable solutions with various standard features described- ask our team about any additional options in which you may be interested.

Packaged Filter Unit (PFU)

PureAIR FILTRATION

PFU-Mobile and PFU-Mini

Protect Critical and Valuable Servers from Polluted Air

PureAir's PFU-mobile and PFU-mini units are self-contained, moveable units that recirculate the air in controlled environments like control rooms and data centers. As the air passes through PureAir's gas adsorbent media, harmful corrosive gases are captured and permanently bound. Purified air is sent out the top of the unit where it is used to cool servers and computer components without harming electrical components. The unit has low energy consumption and noise, and installation is a snap in your existing server cabinets, plugging into standard electrical sockets. The PFU-mobile unit provides protection for up to 5000 square feet (approximately 500 M2). Airflow is variable, controllable up to 1000 cfm (1700 CMH), and differential pressure gauges indicate filter changes for easy maintenance. Other information and details include:

- Variable airflow
- Low EMF brushless AC blower motor
- Low noise and energy consumption
- Available in 110-230 V and 50/60 V options
- MERV 7 (G4) Dust prefilter
- MERV 13 (F7) Dust final filter
- Optional differential pressure gauges to indicate dust filter change
- PureAir chemical adsorbent media filled in low pressure holding frames

	Room Air Volume Capacity by Model	
Air Quality	PFU-Mini	PFU-Mobile
G2	20000 ft3 (600 M^3)	40000 ft3 (1200 M^3)
G3	10000 (300 M^3)	20000 ft3 (600 M^3)
GX	5000 ft3 (150 M^3)	10000 ft3 (300 M^3)
*Based on ISA S71.4 or ASHRAE TC9.9 recommendations		

PureAIR FILTRATION

Packaged Filter Unit (PFU)

Case Study - Christie's

The Problem:

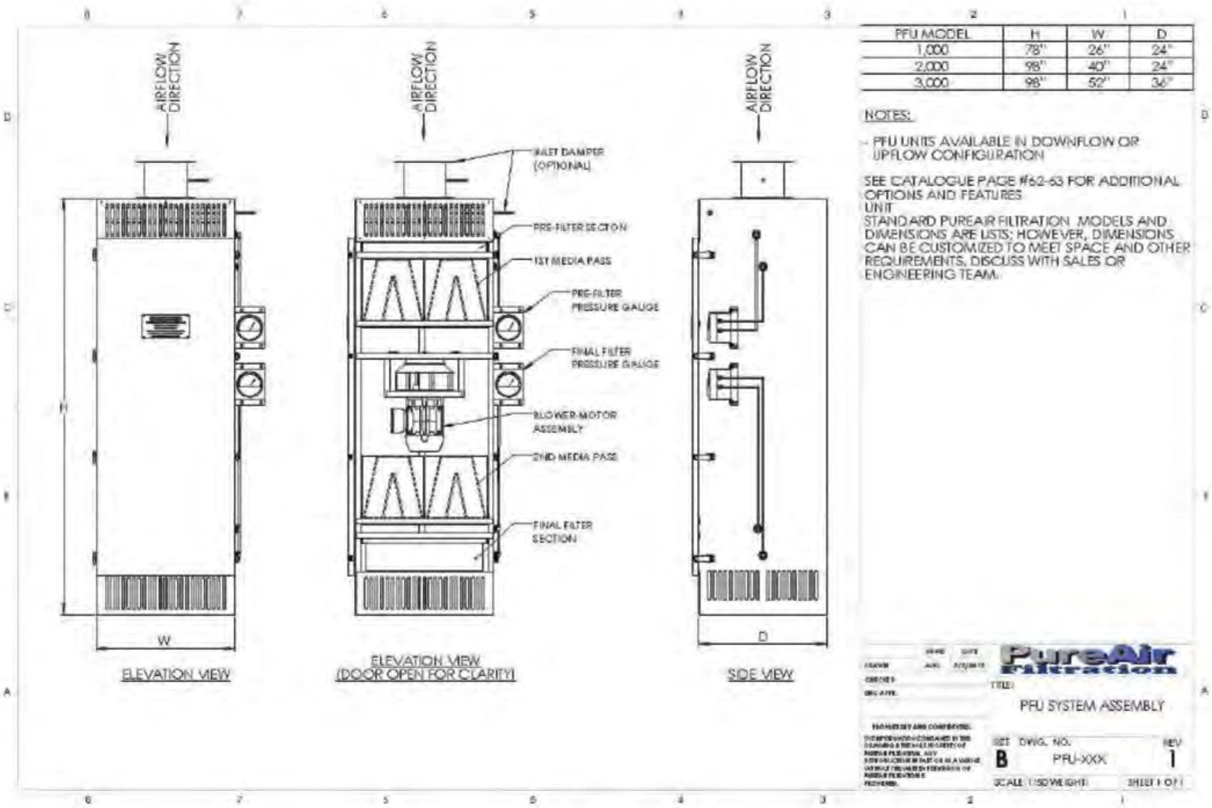
Christie's Auction House has sold precious pieces of artwork and estate for hundreds of years. The first US auction was held in 1977 in Rockefeller Center, New York, and since that time, the US Branch has continued to host numerous priceless artifacts for sale. In 2015, sales totaled $7.4 billion. Needless to say, Christie's must take extra precautions to protect these valuable pieces of artwork. Even the slightest amount of pollution in the air can tarnish delicate artifacts, so it is incredibly important to keep the air inside the auction house free of all contaminants. Christie's looked to the air purification market for a solution to super-purify the air in its facilities.

The Solution:

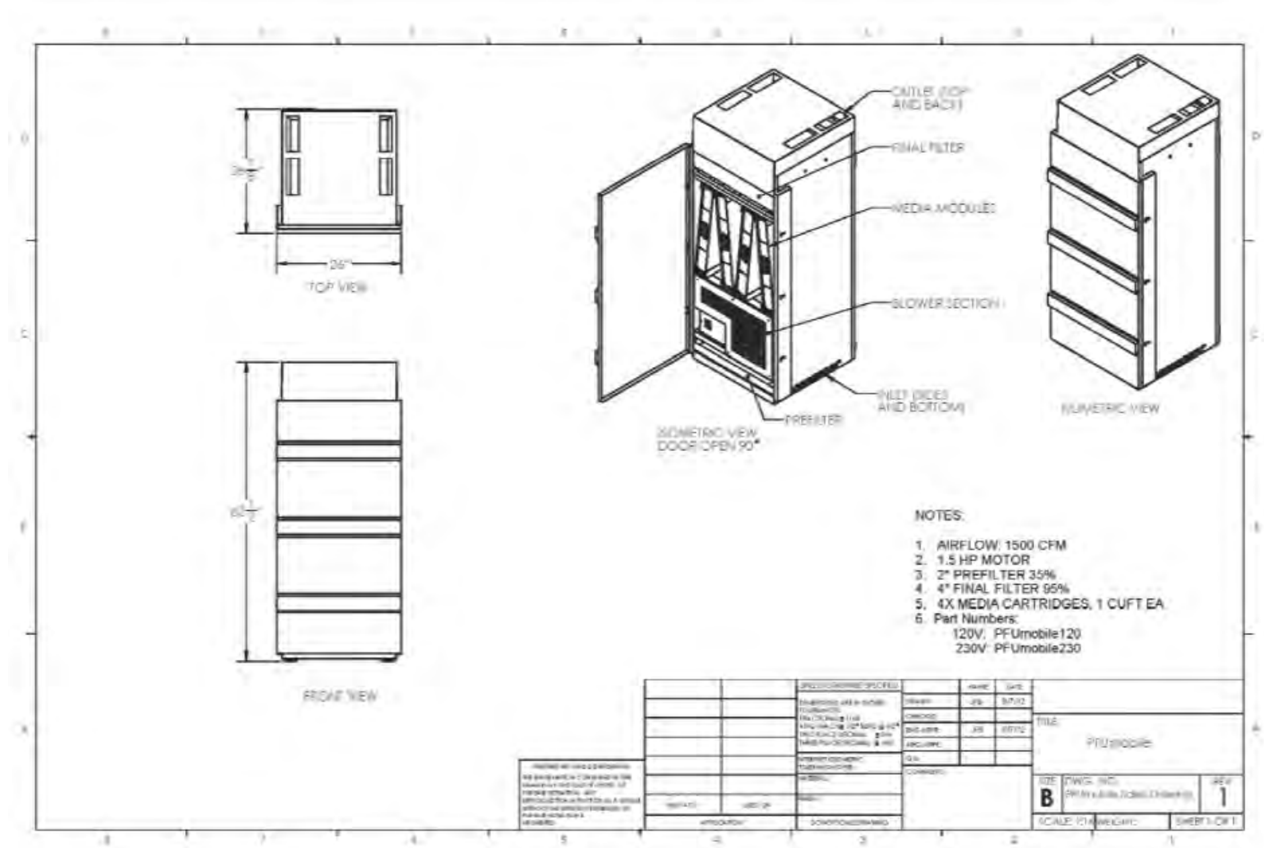
Christie's contacted PureAir Filtration to see if a solution to their problem could be provided. Familiar with applications requiring super purification in an urban commercial environment, the engineers at PureAir recommended four Packaged Filter Units to handle the job. The model chosen was the PFU-6000, and details of the units included:

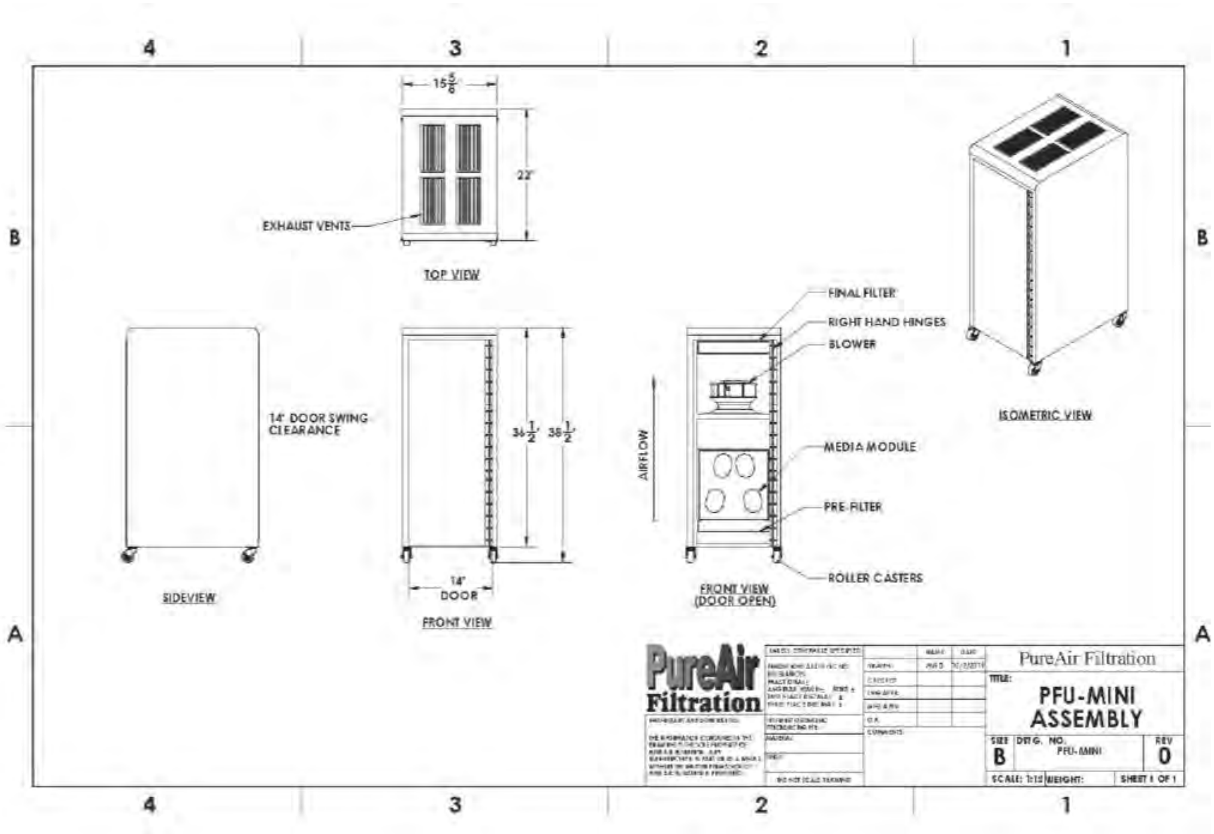
- Galvanized steel double wall construction
- Internal aluminum plenum fan with 10 Hp
- MERV 6 prefilter and MERV 13 final filter
- PureAir CP blend media in PP12 refillable modules

The units and media have been successful in protecting the priceless pieces of artwork from pollutant corrosion.



AIRFLOW DIRECTION
AIRFLOW DIRECTION
AIRFLOW DIRECTION
INLET DAMPER (OPTIONAL)
PRE-FILTER SECTION
1ST MEDIA PASS
PRE-FILTER PRESSURE GAUGE
FINAL FILTER PRESSURE GAUGE
BLOWER-MOTOR ASSEMBLY
2ND MEDIA PASS
FINAL FILTER SECTION
H
W
D
ELEVATION VIEW
ELEVATION VIEW (DOOR OPEN FOR CLARITY)
SIDE VIEW
PFU MODEL | H | W | D
1,000 | 78" | 26" | 24"
2,000 | 98" | 40" | 24"
3,000 | 98" | 52" | 36"
NOTES:
- PFU UNITS AVAILABLE IN DOWNFLOW OR UPFLOW CONFIGURATION
SEE CATALOGUE PAGE #62-63 FOR ADDITIONAL OPTIONS AND FEATURES
UNIT
STANDARD PUREAIR FILTRATION MODELS AND DIMENSIONS ARE LISTS; HOWEVER, DIMENSIONS CAN BE CUSTOMIZED TO MEET SPACE AND OTHER REQUIREMENTS, DISCUSS WITH SALES OR ENGINEERING TEAM.
PureAir Filtration
TITLE:
PFU SYSTEM ASSEMBLY
SIZE
DWG. NO.
REV
B
PFU-XXX
1
SCALE
WEIGHT
SHEET 1 OF 1


OUTLET (TOP AND BACK)
FINAL FILTER
MEDIA MODULES
BLOWER SECTION
INLET (SIDES AND BOTTOM)
PREFILTER
ISOMETRIC VIEW DOOR OPEN 90°
TOP VIEW
FRONT VIEW
ISOMETRIC VIEW
NOTES:
1. AIRFLOW: 1500 CFM
2. 1.5 HP MOTOR
3. 2" PREFILTER 35%
4. 4" FINAL FILTER 95%
5. 4X MEDIA CARTRIDGES, 1 CUFT EA
6. Part Numbers:
120V: PFUmobile120
230V: PFUmobile230
PFU mobile
B
1



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