1 Introduction and Safety

1.1 Introduction

Purpose of the manual

The purpose of this manual is to provide necessary information for working with the unit. Read this manual carefully before starting work.

Read and keep the manual

Save this manual for future reference, and keep it readily available at the location of the unit.

Intended use

WARNING:

Operating, installing, or maintaining the unit in any way that is not covered in this manual could cause death, serious personal injury, or damage to the equipment and the surroundings. This includes any modification to the equipment or use of parts not provided by Xylem. If there is a question regarding the intended use of the equipment, please contact a Xylem representative before proceeding.

Other manuals

See also the safety requirements and information in the original manufacturer's manuals for any other equipment furnished separately for use in this system.

1.2 Safety terminology and symbols

About safety messages

It is extremely important that you read, understand, and follow the safety messages and regulations carefully before handling the product. They are published to help prevent these hazards:

- Personal accidents and health problems
- Damage to the product and its surroundings
- Product malfunction

Hazard levels

Hazard level	Indication
 DANGER:	A hazardous situation which, if not avoided, will result in death or serious injury
 WARNING:	A hazardous situation which, if not avoided, could result in death or serious injury
 CAUTION:	A hazardous situation which, if not avoided, could result in minor or moderate injury
NOTICE:	Notices are used when there is a risk of equipment damage or decreased performance, but not personal injury.

Special symbols

Some hazard categories have specific symbols, as shown in the following table.

Electrical hazard	Magnetic fields hazard
 Electrical Hazard:	 CAUTION:

1.3 User safety

All regulations, codes, and health and safety directives must be observed.

The site

- Observe lockout/tagout procedures before starting work on the product, such as transportation, installation, maintenance, or service.
- Pay attention to the risks presented by gas and vapors in the work area.
- Always be aware of the area surrounding the equipment, and any hazards posed by the site or nearby equipment.

Qualified personnel

This product must be installed, operated, and maintained by qualified personnel only.

Protective equipment and safety devices

- Use personal protective equipment as needed. Examples of personal protective equipment include, but are not limited to, hard hats, safety goggles, protective gloves and shoes, and breathing equipment.
- Make sure that all safety features on the product are functioning and in use at all times when the unit is being operated.

1.4 Ex-approved products

Follow these special handling instructions if you have an Ex-approved unit.

Personnel requirements

These are the personnel requirements for Ex-approved products in potentially explosive atmospheres:

- All work on the product must be carried out by certified electricians and Xylem-authorized mechanics. Special rules apply to installations in explosive atmospheres.
- All users must know about the risks of electric current and the chemical and physical characteristics of the gas, the vapor, or both present in hazardous areas.
- Any maintenance for Ex-approved products must conform to international and national standards (for example, IEC/EN 60079-17).

Xylem disclaims all responsibility for work done by untrained and unauthorized personnel.

Product and product handling requirements

These are the product and product handling requirements for Ex-approved products in potentially explosive atmospheres:

- Only use the product in accordance with the approved motor data.
- The Ex-approved product must never run dry during operation. The volute must be filled with liquid during operation. Dry running during service and inspection is only permitted outside the classified area.
- Before you start work on the product, make sure that the product and the control panel are isolated from the power supply and the control circuit, so they cannot be energized.
- Do not open the product while it is energized or in an explosive gas atmosphere.

- Intrinsically safe circuits are normally required for the automatic level-control system by the level regulator if mounted in zone 0.
- The yield stress of fasteners must be in accordance with the approval drawing and the product specification.
- Do not modify the equipment without approval from an Ex-approved Xylem representative.
- Only use original Xylem spare parts that are provided by an Ex-approved Xylem representative.
- The thermal detectors that are fitted to the stator windings must be connected correctly to a separate motor control circuit and in use. The detectors disconnect the power supply to the motor timely. This action prevents the rise of temperatures above the temperature value for the approval classification.
- The width of flameproof joints is more than the values specified in the tables of the IEC 60079–1 standard.
- The gap of flameproof joints is less than the values specified in Table 1 of the IEC 60079–1 standard.
- The flameproof joints are NOT intended to be repaired.

Guidelines for compliance

Compliance is fulfilled only when you operate the unit within its intended use. Do not change the conditions of the service without the approval of an Ex-approved Xylem representative. When you install or maintain explosion proof products, always comply with the directive and applicable standards (for example, IEC/EN 60079–14).

Minimum permitted liquid level

See the dimensional drawings of the product for the minimum permitted liquid level according to the approval for explosion proof products. If the information is missing on the dimensional drawing, the product must be fully submerged. Level-sensing equipment must be installed if the product can be operated at less than the minimum submersion depth.

Monitoring equipment

For additional safety, use condition-monitoring devices. Examples of condition-monitoring devices include, but are not limited to, the following:

- Level indicators
- Temperature detectors in addition to the stator thermal detectors

Any thermal detectors or thermal protection devices delivered with the pump must be installed and in use at all times.

1.5 Special hazards

1.5.1 Biological hazards

The product is designed for use in liquids that can be hazardous to your health. Observe these rules when you work with the product:

- Make sure that all personnel who may come into contact with biological hazards are vaccinated against diseases to which they may be exposed.
- Observe strict personal cleanliness.

WARNING: Biological Hazard

Infection risk. Rinse the unit thoroughly with clean water before working on it.

1.5.2 Wash the skin and eyes

Follow these procedures for chemicals or hazardous fluids that have come into contact with your eyes or your skin:

Condition	Action
Chemicals or hazardous fluids in eyes	1. Hold your eyelids apart forcibly with your fingers. 2. Rinse the eyes with eyewash or running water for at least 15 minutes. 3. Seek medical attention.
Chemicals or hazardous fluids on skin	1. Remove contaminated clothing. 2. Wash the skin with soap and water for at least 1 minute. 3. Seek medical attention, if necessary.

1.6 Protecting the environment

Emissions and waste disposal

Observe the local regulations and codes regarding:

- Reporting of emissions to the appropriate authorities
- Sorting, recycling and disposal of solid or liquid waste
- Clean-up of spills

Exceptional sites

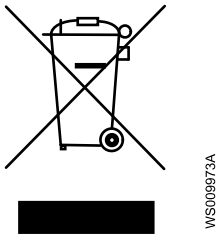
CAUTION: Radiation Hazard

Do NOT send the product to Xylem if it has been exposed to nuclear radiation, unless Xylem has been informed and appropriate actions have been agreed upon.

1.7 End of life product disposal

Handle and dispose of all waste in compliance with local laws and regulations.

EU only: Correct disposal of this product – WEEE Directive on waste electrical and electronic equipment



This marking on the product, accessories or literature indicates that the product should not be disposed of with other waste at the end of its working life.

To prevent possible harm to the environment or human health from uncontrolled waste disposal, please separate these items from other types of waste and recycle them responsibly to promote the sustainable reuse of material resources.

Waste from electrical and electronic equipment can be returned to the producer or distributor.

1.8 Spare parts

CAUTION:

Only use the manufacturer's original spare parts to replace any worn or faulty components. The use of unsuitable spare parts may cause malfunctions, damage, and injuries as well as void the warranty.

1.9 Warranty

For information about warranty, see the sales contract.

2 Transportation and Storage

2.1 Examine the delivery

2.1.1 Examine the package

1. Examine the package for damaged or missing items upon delivery.
2. Record any damaged or missing items on the receipt and freight bill.
3. If anything is out of order, then file a claim with the shipping company.

   If the product has been picked up at a distributor, make a claim directly to the distributor.

2.1.2 Examine the unit

1. Remove packing materials from the product.

   Dispose of all packing materials in accordance with local regulations.
2. To determine whether any parts have been damaged or are missing, examine the product.
3. If applicable, unfasten the product by removing any screws, bolts, or straps.

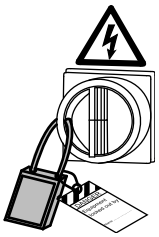
   Use care around nails and straps.
4. If there is any issue, then contact a sales representative.

2.2 Transportation guidelines

2.2.1 Precautions

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.



Position and fastening

The unit can be transported either horizontally or vertically. Make sure that the unit is correctly fastened during transportation, and cannot roll or fall over.

Horizontal position

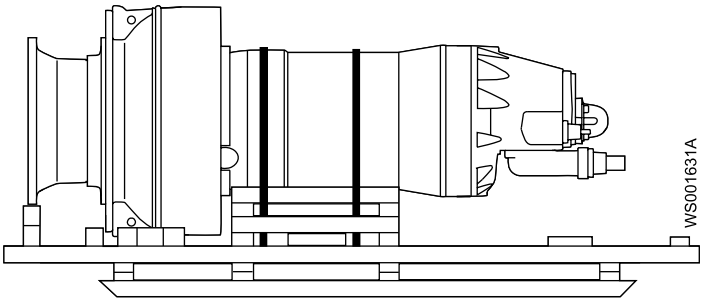


Figure 1: Horizontal position for transport

If the unit is transported in the horizontal position, then the propeller must be locked during transportation.

Vertical position

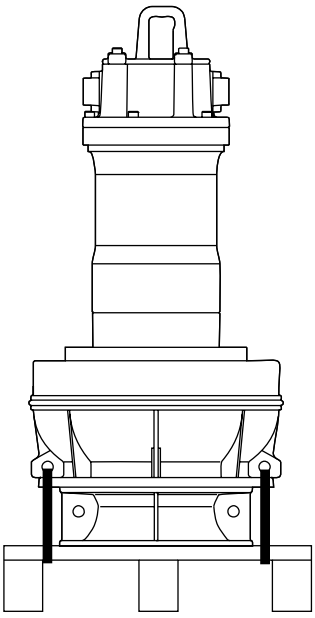


Figure 2: Vertical position for transport

The impeller or propeller must also be locked during transportation. Units with drive units 605, 615, 665 or 675 are not equipped with the locking device.

2.2.2 Lifting

Always inspect the lifting equipment and tackle before starting any work.

WARNING: Crush Hazard

1) Always lift the unit by its designated lifting points. 2) Use suitable lifting equipment and ensure that the product is properly harnessed. 3) Wear personal protective equipment. 4) Stay clear of cables and suspended loads.

NOTICE:

Never lift the unit by its cables or hose.

Lifting equipment

Lifting equipment is always required to handle the unit. The lifting equipment must fulfill the following requirements:

- The minimum height between the lifting hook and the floor must be sufficient to lift the unit. Contact a Xylem representative for more information.
- The lifting equipment must be able to hoist the unit straight up and down, preferably without the need for resetting the lifting hook.
- The lifting equipment must be correctly anchored and in good condition.
- The lifting equipment must support the weight of the entire assembly. Only authorized personnel may use the lifting equipment.
- Two sets of lifting equipment must be used to lift the unit for repair work.
- The lifting equipment must be dimensioned to lift the unit with any remaining pumped media in it.
- The lifting equipment must not be oversized.

CAUTION: Crush Hazard

Over-dimensioned lifting equipment can lead to injury. A site-specific risk analysis must be done.

2.2.3 Lifting link placement for vertical lifting

Use the following lifting link configurations to lift the pump in the vertical position.

The arrow indicates placement of the lifting link when lifting the drive unit only, or the complete unit, with 605–675 drive units.

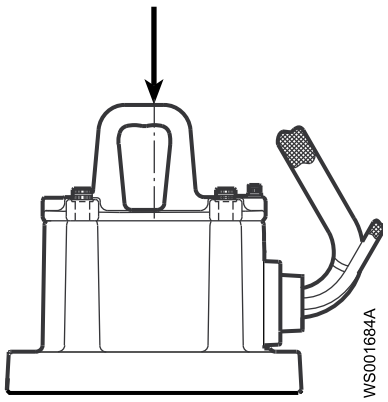


Figure 3: Drive units 605–675

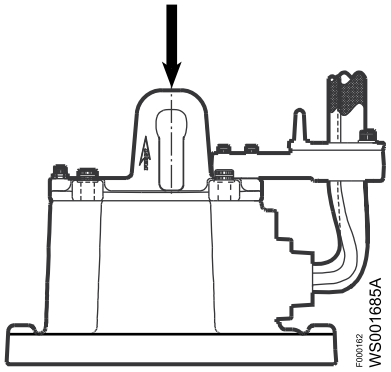


Figure 4: Drive units 705–776

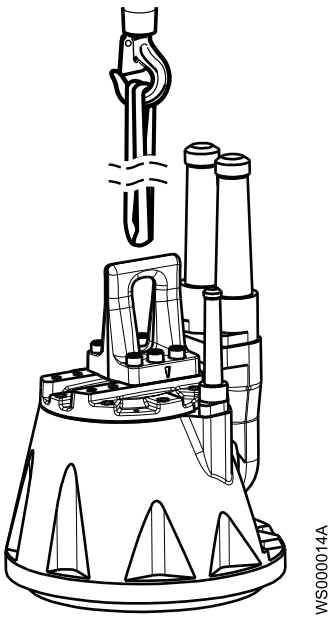
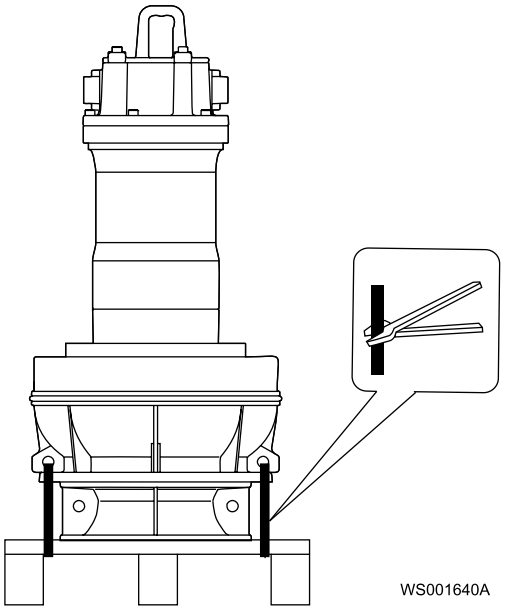


Figure 5: Drive units 805–998

For 805–998 drive units, the lifting link must be put so that the complete unit hangs forward with an incline of 0–2° in relation to the vertical axis.

2.2.4 Lift pump from vertical position and remove transport pallet

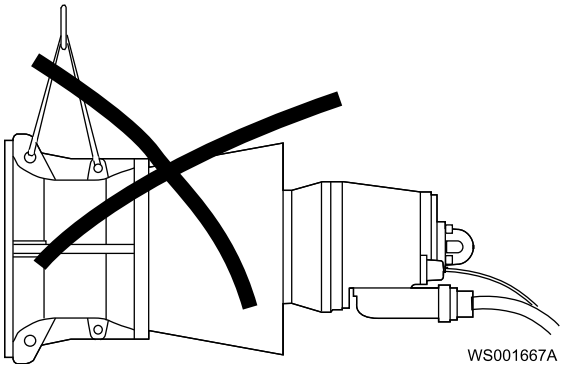
1. Fit a lifting strap or sling to the lifting eye on the top of the drive unit.
2. Cut the transportation strap.



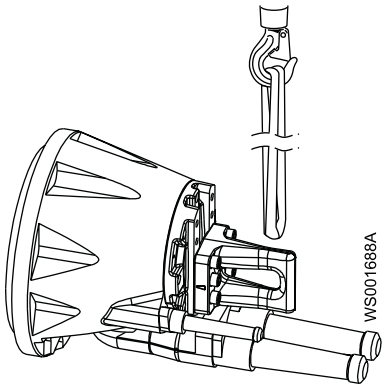
3. Lift the pump with correct lifting equipment.
4. Put the pump upright on a rigid horizontal surface so that it cannot fall over.

2.2.5 Lift pump from horizontal position and remove transport pallet

NOTICE:
An assembled pump must never be lifted by the holes in the hydraulic unit.

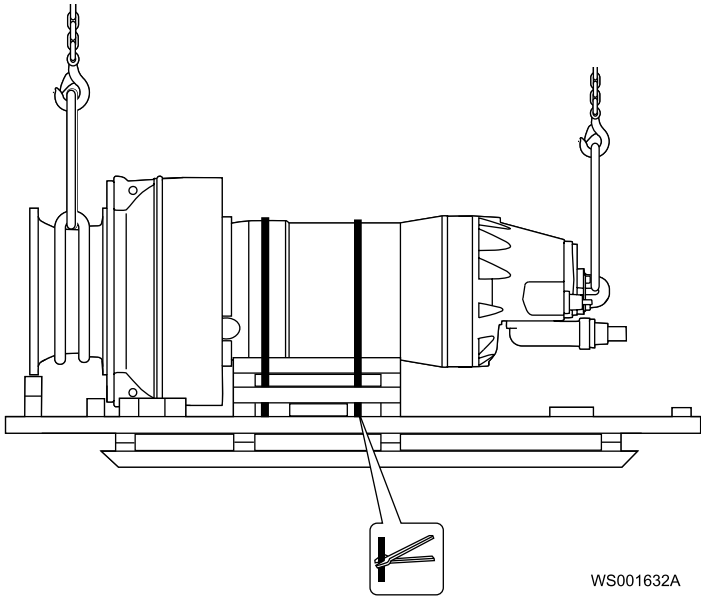


NOTICE:
When handling the unit to and from horizontal position, the unit should always be lifted by the lifting link. Use a suitable lifting sling/strap.

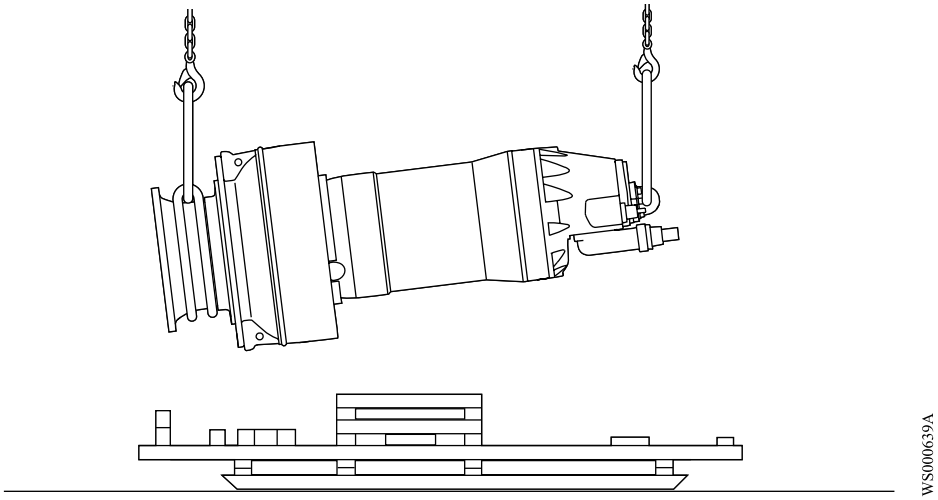


Lift with two lifting devices (recommended)

1. Attach a lifting sling or strap to the lifting eye on the top of the drive unit. Attach the sling to the first lifting device.
   See *Lifting* on page 9.
2. Attach a sling around the hydraulic unit. Attach the sling to the second lifting device.



3. Remove the straps securing the unit to the transport pallet.
   The transport pallet is custom-made for the pump and can be stored for future use.
4. Lift the unit.



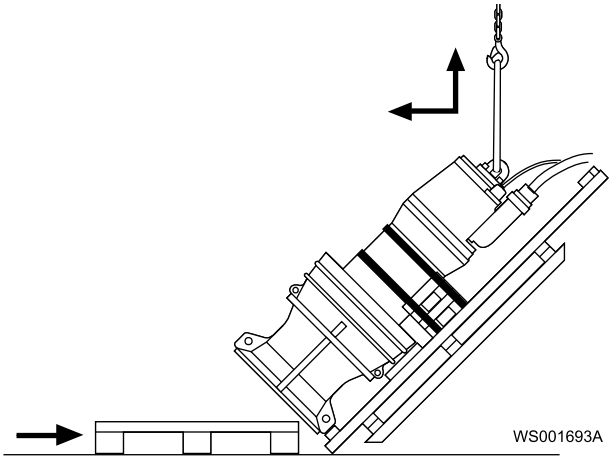
5. Put the unit upright on a rigid horizontal surface so that it cannot fall over.

Lift with one lifting device

1. Attach a lifting sling or strap to the lifting eye on the top of the drive unit.
2. Lift the unit until it is halfway upright.

   The unit is attached to the transport pallet at this point.
3. Slide a pallet or similar object under the inlet section.

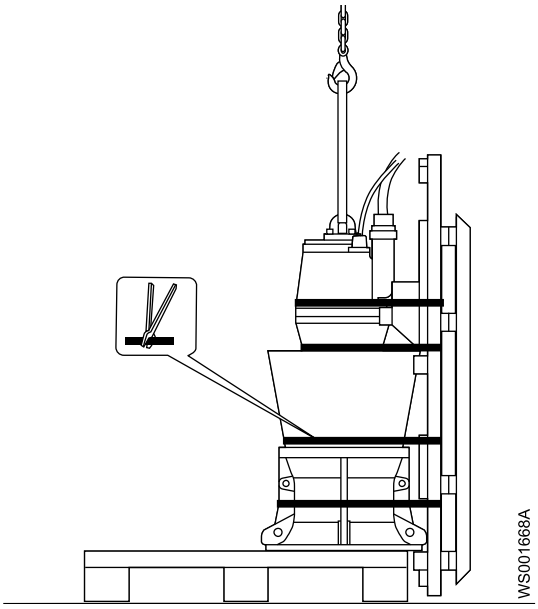
   The pallet minimizes the jolt which can occur later in the lifting, when the unit is almost fully upright.



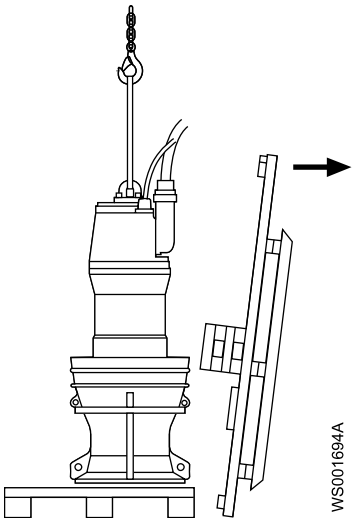
4. Continue raising the unit until it is upright.

   The unit can jolt or sway near the end of the lifting operation.
5. Remove the straps holding the unit to the transport pallet.

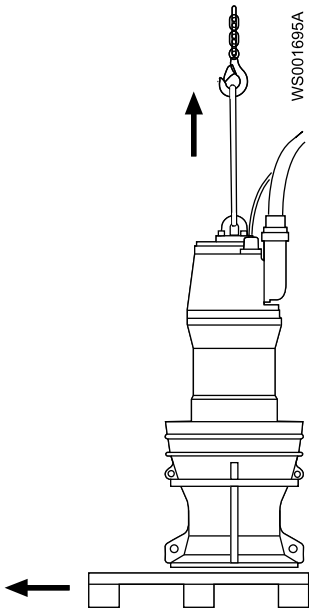
Location of straps can vary. Figure shows a generic impeller or propeller unit.



6. Remove the transport pallet.
   The transport pallet is custom-made for the pump and can be stored for future use.



7. Lift the unit and remove the support pallet.



8. Put the unit upright on a rigid horizontal surface so that it cannot fall over.

2.3 Temperature ranges for transportation, handling and storage

Handling at freezing temperature

At temperatures below freezing, the product and all installation equipment, including the lifting gear, must be handled with extreme care.

Make sure that the product is warmed up to a temperature above the freezing point before starting up. Avoid rotating the impeller/propeller by hand at temperatures below the freezing point. The recommended method to warm the unit up is to submerge it in the liquid which will be pumped or mixed.

NOTICE:

Never use a naked flame to thaw the unit.

Unit in as-delivered condition

If the unit is still in the condition in which it left the factory - all packing materials are undisturbed - then the acceptable temperature range during transportation, handling and storage is: –50°C (–58°F) to +60°C (+140°F).

If the unit has been exposed to freezing temperatures, then allow it to reach the ambient temperature of the sump before operating.

Lifting the unit out of liquid

The unit is normally protected from freezing while operating or immersed in liquid, but the impeller/propeller and the shaft seal may freeze if the unit is lifted out of the liquid into a surrounding temperature below freezing.

Follow these guidelines to avoid freezing damage:

1. Empty all pumped liquid, if applicable.
2. Check all liquids used for lubrication or cooling, both oil and water-glycol mixtures, for the presence of unacceptable amounts of water. Change if needed.

Water-glycol mixtures: Units equipped with an internal closed-loop cooling system are filled with a mixture of water and 30% glycol. This mixture remains a flowing liquid at temperatures down to –13°C (9°F). Below –13°C (9°F), the viscosity increases such that the glycol mixture will lose its flow properties. However, the glycol-water mixture will not solidify completely and thus cannot harm the product.

2.4 Storage guidelines

Storage location

The product must be stored in a covered and dry location free from heat, dirt, and vibrations.

NOTICE:

Protect the product against humidity, heat sources, and mechanical damage.

NOTICE:

Do not place heavy weights on the packed product.

Freezing precautions

The unit is frost-proof while operating or immersed in liquid, but the impeller/propeller and the shaft seal may freeze if the unit is lifted out of the liquid into a surrounding temperature below freezing.

Follow these guidelines to avoid freezing damage:

When	Guideline
Before storage	• The unit must be allowed to run for a short time after raising it to discharge remaining pumped liquid. This does not apply to impeller/propeller units. • The discharge opening must be covered in a suitable way, or placed facing down so that any still remaining pumped liquid runs out. • If present, the cooling jacket must be drained manually by opening the air vent screws at the top of the cooling jacket.
After storage	If the impeller/propeller is frozen, it must be thawed by immersing the unit in liquid before operating the unit. NOTICE: Never use a naked flame to thaw the unit.

Long-term storage

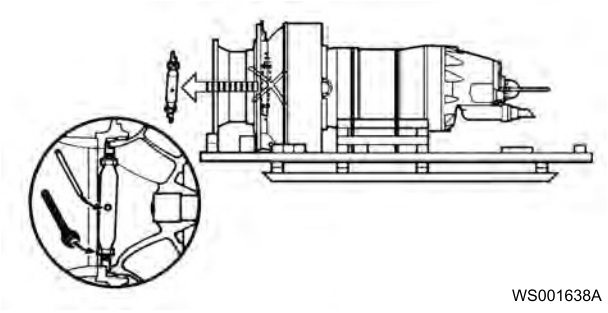
If the unit is stored more than six months, then the following apply:

- Before operating the unit after storage, it must be inspected with special attention to the seals and the cable entry.
- The impeller/propeller must be rotated every other month to prevent the seals from sticking together.

2.4.1 Reinstall the locking device

If the unit is transported in the horizontal position, then the impeller or propeller must be locked with the locking device during the transport.

1. Reinstall the locking device.



WS001638A

2. Clamp the locking device in place by turning and locking it by hand as tightly as possible.
3. For pumps with 700–, 800– and 900–series drive units: Tighten a further 1/6 to 1/3 of a turn according to the torque specified in the cross-sectional drawing in the Part List.

3 Product Description

3.1 Pump design

Intended Use

The product is intended for moving wastewater, sludge, raw and clean water. Always follow the limits that are given in *Application limits* on page 98. If there is a question regarding the intended use of the equipment, then contact a Xylem representative before proceeding.

DANGER: Explosion/Fire Hazard

Special rules apply to installations in explosive or flammable atmospheres. Do not install the product or any auxiliary equipment in an explosive zone unless it is rated explosion-proof or intrinsically-safe. If the product is EN/ATEX-, MSHA- or FM-approved, then see the specific EX information in the Safety chapter before taking any further actions.

NOTICE:

Do NOT use the unit in highly corrosive liquids.

3.1.1 Spare part requirements

The following applies when the unit is serviced or repaired:

- Modifications to the unit or installation must only be carried out after consulting with Xylem.
- Original spare parts and accessories that are authorized by Xylem are essential for compliance. The use of other parts can invalidate any claims for warranty or compensation. For more information, contact a Xylem representative.

3.2 Drive units

L3356

Voltage range	Standard drive units	Ex-proof drive units	Maximum number of starts per hour
Up to 1 kV	605	615	15
	665	675	15
Up to 1 kV	705	715	15
	735	745	15
	765	775	15
Up to 1 kV	706	716	10
	736	746	10
	766	776	10

L3400

Voltage range	Standard drive units	Ex-proof drive units	Maximum number of starts per hour
Up to 1 kV	705	715	15
	735	745	15
	765	775	15

Voltage range	Standard drive units	Ex-proof drive units	Maximum number of starts per hour
Up to 1 kV	706	716	10
	736	746	10
	766	776	10
Up to 1 kV	805	815	15
	835	845	15
	865	875	15
Up to 1 kV	806	816	10
	836	846	10
	866	876	10
1.2–6.6 kV	862	872	15
	882	892	10
1.2–6.6 kV	863	873	10
	883	893	10

L3602

Voltage range	Standard drive units	Ex-proof drive units	Maximum number of starts per hour
Up to 1 kV	735	745	15
	765	775	15
Up to 1 kV	736	746	10
	766	776	10
Up to 1 kV	805	815	15
	835	845	15
	865	875	15
Up to 1 kV	806	816	10
	836	846	10
	866	876	10
Up to 1 kV	905	915	10
	935	945	10
Up to 1 kV	906	916	10
	936	946	10
1.2–6.6 kV	862	872	15
	882	892	10
1.2–6.6 kV	863	873	10
	883	893	10

3.3 The MAS 801 monitoring equipment

3.3.1 FLS: float switch sensor

The float switches are leakage sensors.

The float switches are located in the lower part of the stator housing and in the junction box.

3.3.2 Vibration in three directions

A vibration sensor that is located in the PEM measures vibration speed in three directions.

Two adjustable alarm limits can be applied for each measurement direction:

- Early warning: “B”-alarm
- Pump stop: “A”-alarm

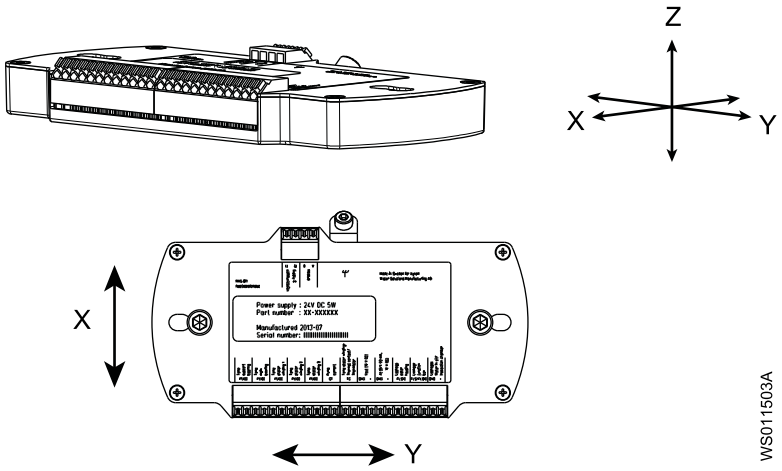


Figure 6: Vibration directions with reference to the PEM

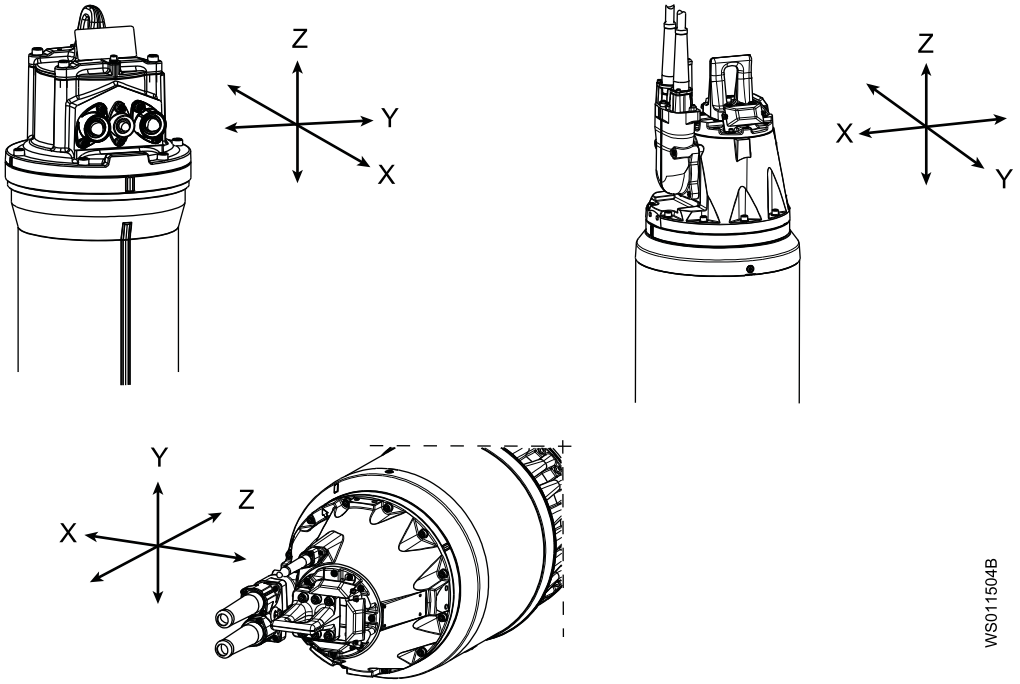


Figure 7: Vibration directions with reference to the pump

3.3.3 Bearing temperature measurement

Pt100 sensors monitor the bearing temperatures to protect the pump from the consequences of a bearing failure.

Main bearing

Main bearing temperature monitoring is standard in the MAS 711 and MAS 801. The Pt100 sensor is pressed by a spring against the outer ring of the ball bearing.

Support bearing

Support bearing temperature monitoring is an option in the MAS 711 and MAS 801. The Pt100 sensor is pressed by a spring against the outer ring of the roller bearing.

Alarms

Two adjustable alarm limits can be used:

- Early warning: "B"-alarm
- Pump stop: "A"-alarm

3.3.4 Stator temperature monitoring methods

The purpose of stator winding temperature monitoring is to make the motor shut off at high temperature. There are several monitoring methods, depending on the voltage of the motor, and types of thermal sensors chosen.

By using an analogue sensor, two adjustable alarm limits can be used, one for warning ("B"-alarm) and one for pump stop ("A"-alarm). The configurations which can be used for monitoring the stator winding temperature depend upon the voltage range of the drive unit. See *Drive units* on page 18 for the voltage range for each drive unit.

Up to 1 kV drive units

Table 1: Stator temperature monitoring configuration, up to 1 kV

Standard / Optional	Monitoring configuration description
Standard	• Three thermal contacts, connected in series, are incorporated in the coil ends of the stator winding. The contacts are normally closed, and open at 140°C (285°F). • One Pt100 sensor is incorporated in one of the windings.
	Or:
	• Three thermistors, PTC, connected in series, are incorporated in the coil ends of the stator windings. T_{Ref}=140°C (285°F). • One Pt100 sensor is incorporated in one of the windings.
Optional	• Three thermal contacts, connected in series, are incorporated in the coil ends of the stator winding. The contacts are normally closed, and open at 140°C (285°F). • Three Pt100 sensors, one for each phase, are incorporated in the windings.
	Or:
	• Three thermistors, PTC, connected in series, are incorporated in the coil ends of the stator windings. T_{Ref}=140°C (285°F). • Three Pt100 sensors, one for each phase, are incorporated in the windings.

1.2–6.6 kV drive units

Table 2: Stator temperature monitoring configuration, 1.2–6.6 kV

Standard / Optional	Monitoring configuration description
Standard	This configuration uses the following: • Three thermistors, PTC, connected in series, are incorporated in the coil ends of the stator windings. T_{Ref}=155°C (310°F) for medium-voltage drive units • Three Pt100 sensors, one for each phase, are incorporated in the windings. There are three extra thermistors, and three extra Pt100 sensors, already in position in the stator windings as reserves.

Stators used in the 1.2–6.6 kV drive units are equipped with three Pt100 sensors marked 19:20, 21:22, and 23:24. These sensors are connected at the plinth on the terminal plate. The stator is also equipped with a duplicate set of three Pt100 sensors, marked 19s:20s, 21s:22s, and 23s:24s. The duplicate set is not connected to the terminal plate as long as the first set of three Pt100 sensors function; it is kept in reserve as a back-up set. The ends of the reserve sensor leads are isolated, and leads bundled among the other cables, until the back-up Pt100 sensors are needed.

For pumps with drive units in voltage range 1.2–6.6 kV, the medium-voltage stator settings are shown in the following table.

Table 3: Stator alarm settings for 1.2–6.6 kV drive units

Stator Alarm	Setting
A	155°C
B	145°C

3.3.4.1 Temperature sensors

Table 4: Thermal contact

Description	Measured value	Fault values
The thermal contact is a normally closed contact.	0–3 ohm, unless the wires are long.	An infinite value (open circuit) indicates either high temperature or a fault. Examples of faults include a broken wire, or a bad contact in a connector.

Table 5: PTC thermistor

Description	Measured value	Fault values
The PTC thermistor is a semiconductor device.	Resistance at normal temperature: • 50–100 ohm (150–300 ohm for three in series).	• Above the tripping point, T_{Ref}, the resistance increases dramatically to several kilohm. • An infinite value (open circuit) indicates a fault. Examples of faults include a broken wire, or a bad contact in a connector. • A value close to zero indicates a short circuit in the wiring.

Table 6: Pt100 sensor

Description	Measured value	Fault values
The Pt100 sensor is a resistor changing value almost linearly with temperature.	Resistance: • 100 ohm at 0°C (32°F) • 107.79 ohm at room temperature (20°C, 68°F) • 138.5 ohm at 100°C (212°F) For resistance data between 0–160°C (32–320°F), see *Pt100 resistance* on page 99.	> 200 ohm (approximate) can indicate the following situations: • Broken sensor • Bad contact • Broken lead < 70 ohm (approximate) indicates: • Short circuit

NOTICE:

Never connect the Pt100 transducer to a voltage higher than 2.5 V.

For information on the various configurations of contacts, thermistors and sensors that are used to monitor stator winding temperature, see *Stator temperature monitoring methods* on page 26.

3.3.5 Pump current and power monitoring

Pump current

Pump current is an important parameter in itself, which the MAS 801 can also use to record running time, number of starts and other operating diagnostics. This information is fundamental for monitoring operation, maintenance planning, and fault diagnosis.

Pump current in one phase is standard with the MAS 801.

Pump current in three phases

Pump current in three phases is also possible with the MAS 801. To track pump current in three phases with the MAS 801, the following are needed:

- Three current transformers in the control cabinet
- The PAN 312 power analyzer

The current transformers are connected to the PAN 312. The PAN 312 transmits the data to the CU and the PEM in the MAS 801 system.

Power monitoring: PAN 312

The optional Flygt power analyzer PAN 312 allows the following parameters to be monitored:

- Three-phase power
- Power factor
- System voltage
- Voltage imbalance
- Pump current in three phases
- Current imbalance

3.3.6 CLS

This section applies to the following drive units:

- 605, 665
- 705, 735, 765
- 805, 835, 865, 885
- 862, 882
- 905, 935, 965
- 950, 985, 988

Table 7: Water-in-oil sensor (CLS)

Description	Measured value	Fault values
Capacitive leakage sensor located in the oil housing. This sensor issues an alarm if the water content reaches a concentration of approximately 30% or more.	Standard drive unit only. CLS must be connected to 12 V DC with correct polarity (+/–).	See table below.

CLS alarm is not a cause for stopping the pump. It is merely an indicator to check the oil and outer seal at the next planned service.

Table 8: CLS current measurements

Measuring result	Explanation
0 mA	Can indicate one of the following conditions: • The sensor has the wrong polarity. Check by changing plus and minus. • The cable/lead is broken.
4.0 to 8.0 mA	OK
27 to 33 mA	Alarm current
> 33 mA	Short circuit

3.4 The MAS 711 monitoring equipment

The MAS 711 system

MAS 711 (Monitoring and Status) is a monitoring system for Flygt pumps. It monitors and stores measurements from a number of sensors (temperature, leakage, and vibration). These are used to:

- Protect the pump by raising an alarm when undesirable events occur.
- Track operational data.

Alarm levels can be set so that the operator is notified when an alarm event has occurred. Depending on the alarm/event configuration, the MAS 711 system may stop the pump.

The base unit stores all measurement data on its embedded server.

The system also includes a pump memory module, storing identity data of the pump.

The parameters that are tracked are chosen by the customer, and may include the following:

- Temperature:
  - Main bearing
  - Support bearing
  - Stator winding
- Vibration
- Leakage:
  - In the stator housing or inspection chamber
  - In the junction box
  - Water in the oil chamber (if applicable)
- Power monitoring

For more information, see the MAS 711 Installation and User Manual.

Pump current

Pump current is an important parameter in itself, which the MAS 711 can also use to record running time, number of starts and other operating diagnostics.

Pump current is not measured using the 12/24 lead monitoring cable. To measure it, the control cabinet must be equipped with a current transformer. Alternatively the Flygt power analyzer PAN 312 is used, requiring three transformers. The measurement results are transmitted to MAS 711 over a serial link (Modbus).

This information is fundamental for monitoring operation, maintenance planning, and fault diagnosis.

Signal cables

The pump is delivered with the signal cable (also known as “auxiliary,” “control” or “pilot” cable) mounted. The following SUBCAB signal cables are available:

- 12x1.5 mm^2 (unscreened, also known as unshielded). Conductors 1-12.
- 24x1.5 mm^2 (unscreened, also known as unshielded). Conductors 1-24.
- S12x1.5 mm^2 (screened, also known as shielded). Conductors 1-12.
- S24x1.5 mm^2 (screened, also known as shielded). Conductors 1-24.

The number of conductors that are required to connect the sensors to the monitoring system depends on the number and type of sensors being used. Medium-voltage (1.2–6.6 kV) drive units always have 24 signal cable leads.

Sensors, drive units up to 1 kV

The drive units in this voltage range are shown in *Drive units* on page 18.

Table 9: Sensors for pumps using drive units up to 1 kV

Parameter Monitored	Sensor	Signal Cable, Number of Leads Required	Standard or Optional
Vibration	VIS 10	24	Optional
Leakage in the junction box	Float switch leakage sensor (FLS)	12	Standard
Stator winding temperature in one phase	Pt100 analog temperature sensor in one stator winding	12	Standard
Stator winding temperature	Thermal contacts (3), or	12	Standard
	PTC-thermistors (3)	24	Optional

Parameter Monitored	Sensor	Signal Cable, Number of Leads Required	Standard or Optional
Stator winding temperature in phases 2 and 3	Pt100 analog temperature sensors in two additional stator windings	24	Optional
Main bearing temperature	Pt100 analog temperature sensor	12	Standard
Leakage in the stator housing or inspection chamber	Float switch leakage sensor (FLS)	12	Standard
Water in oil: standard drive units only. (Not applicable for drive units with internal closed-loop cooling.)	Capacitive leakage sensor (CLS)	24	Optional
Support bearing temperature	Pt100 analog temperature sensor	24	Optional
Pump memory	Printed circuit board for pump memory includes a temperature sensor.	12	Standard
Pump current	A current transformer in the control cabinet is required.		
Power monitoring	Separate electronic instrument using three current transformers.		Optional

For more information on the stator temperature monitoring, see *Stator temperature monitoring methods* on page 26.

Sensors, drive units 1.2 – 6.6 kV

The drive units in this voltage range are shown in *Drive units* on page 18.

Table 10: Sensors for pumps using 1.2 – 6.6 kV drive units

Description	Sensor	Signal Cable, Number of Leads Required	Standard or Optional
Vibration	VIS 10	24	Optional
Leakage in the junction box	Float switch leakage sensor (FLS)	24	Standard
Stator winding temperature	PTC-thermistors (3+3)	24	Standard
Stator winding temperature in phases 1, 2 and 3	Pt100 analog temperature sensors in each stator winding (3+3)	24	Standard
Main bearing temperature	Pt100 analog temperature sensor	24	Standard
Leakage in the stator housing	Float switch leakage sensor (FLS)	24	Standard
Water in oil: standard drive units only. (Not applicable for drive units with internal closed-loop cooling.)	Capacitive leakage sensor (CLS)	24	Optional
Support bearing temperature	Pt100 analog temperature sensor	24	Optional
Pump memory	Printed circuit board for pump memory includes a temperature sensor.	24	Standard
Pump current	A current transformer in the control cabinet is required.		
Power monitoring	Separate electronic instrument using three current transformers.		Optional

For more information on the stator temperature monitoring, see *Stator temperature monitoring methods* on page 26.

1 6 total: 3 sensors are connected and 3 are built-in spares.
2 6 total: 3 sensors are connected and 3 are built-in spares.

3.4.1 FLS: float switch sensor

The float switches are leakage sensors.

The float switches are located in the lower part of the stator housing and in the junction box.

3.4.2 Vibration sensor (VIS10)

Description	Measured value	Fault values
The vibration sensor located in the junction box measures vibrations in one direction. The output is a 4-20 mA signal proportional to the vibration level.	Current, 4-20 mA	• >> 20 mA indicates a short circuit. • << 4 mA indicates a fault. • A zero value indicates a broken wire or bad contact in a connector.

3.4.3 Bearing temperature measurement

Pt100 sensors monitor the bearing temperatures to protect the pump from the consequences of a bearing failure.

Main bearing

Main bearing temperature monitoring is standard in the MAS 711 and MAS 801. The Pt100 sensor is pressed by a spring against the outer ring of the ball bearing.

Support bearing

Support bearing temperature monitoring is an option in the MAS 711 and MAS 801. The Pt100 sensor is pressed by a spring against the outer ring of the roller bearing.

Alarms

Two adjustable alarm limits can be used:

- Early warning: "B"-alarm
- Pump stop: "A"-alarm

3.4.4 Stator temperature monitoring methods

The purpose of stator winding temperature monitoring is to make the motor shut off at high temperature. There are several monitoring methods, depending on the voltage of the motor, and types of thermal sensors chosen.

By using an analogue sensor, two adjustable alarm limits can be used, one for warning ("B"-alarm) and one for pump stop ("A"-alarm). The configurations which can be used for monitoring the stator winding temperature depend upon the voltage range of the drive unit. See *Drive units* on page 18 for the voltage range for each drive unit.

Up to 1 kV drive units

Table 11: Stator temperature monitoring configuration, up to 1 kV

Standard / Optional	Monitoring configuration description
Standard	• Three thermal contacts, which are connected in series, are incorporated in the coil ends of the stator winding. The contacts are normally closed, and open at 140°C (285°F). • One Pt100 sensor is incorporated in one of the windings.
	Or:
	• Three thermistors, PTC, connected in series, are incorporated in the coil ends of the stator windings. T_{Ref}=140°C (285°F). • One Pt100 sensor is incorporated in one of the windings.

Standard / Optional	Monitoring configuration description
Optional	• Three thermal contacts, which are connected in series, are incorporated in the coil ends of the stator winding. The contacts are normally closed, and open at 140°C (285°F). • Three Pt100 sensors, one for each phase, are incorporated in the windings.
	Or:
	• Three thermistors, PTC, connected in series, are incorporated in the coil ends of the stator windings. T_{Ref}=140°C (285°F) • Three Pt100 sensors, one for each phase, are incorporated in the windings.

1.2–6.6 kV drive units

Table 12: Stator temperature monitoring configuration, 1.2–6.6 kV

Standard / Optional	Monitoring configuration description
Standard	This configuration uses the following: • Three thermistors, PTC, connected in series, are incorporated in the coil ends of the stator windings. T_{Ref}=155°C (310°F) for medium-voltage drive units • Three Pt100 sensors, one for each phase, are incorporated in the windings. There are three extra thermistors, and three extra Pt100 sensors, already in position in the stator windings as reserves.

Stators that are used in the 1.2–6.6 kV drive units are equipped with three Pt100 sensors marked 19:20, 21:22, and 23:24. The sensors are connected at the plinth on the terminal plate. The stator is also equipped with a duplicate set of three Pt100 sensors, marked 19s:20s, 21s:22s, and 23s:24s. This duplicate set is not connected to the terminal plate as long as the first set of three Pt100 sensors function. The duplicate set is kept in reserve as a back-up set. The ends of the reserve sensor leads are isolated, and leads bundled among the other cables, until the back-up Pt100 sensors are needed.

The MAS 711 has preset stator alarm settings. For pumps with drive units in voltage range 1.2–6.6 kV, the settings must be changed upon installation. The medium-voltage stator settings are shown in the following table.

Table 13: Stator alarm settings for 1.2–6.6 kV drive units

Stator Alarm	Setting
A	155°C
B	145°C

3.4.4.1 Temperature sensors

Table 14: Thermal contact

Description	Measured value	Fault values
The thermal contact is a normally closed contact.	0–3 ohm, unless the wires are long.	An infinite value (open circuit) indicates either high temperature or a fault. Examples of faults include a broken wire, or a bad contact in a connector.

Table 15: PTC thermistor

Description	Measured value	Fault values
The PTC thermistor is a semiconductor device.	Resistance at normal temperature: • 50–100 ohm (150–300 ohm for three in series).	• Above the tripping point, T_{Ref}, the resistance increases dramatically to several kilohm. • An infinite value (open circuit) indicates a fault. Examples of faults include a broken wire, or a bad contact in a connector. • A value close to zero indicates a short circuit in the wiring.

Table 16: Pt100 sensor

Description	Measured value	Fault values
The Pt100 sensor is a resistor changing value almost linearly with temperature.	Resistance: • 100 ohm at 0°C (32°F) • 107.79 ohm at room temperature (20°C, 68°F) • 138.5 ohm at 100°C (212°F) For resistance data between 0–160°C (32–320°F), see *Pt100 resistance* on page 99.	> 200 ohm (approximate) can indicate the following situations: • Broken sensor • Bad contact • Broken lead < 70 ohm (approximate) indicates: • Short circuit

NOTICE:

Never connect the Pt100 transducer to a voltage higher than 2.5 V.

For information on the various configurations of contacts, thermistors and sensors that are used to monitor stator winding temperature, see *Stator temperature monitoring methods* on page 26.

3.4.5 CLS

This section applies to the following drive units:

- 605, 665
- 705, 735, 765
- 805, 835, 865, 885
- 862, 882
- 905, 935, 965
- 950, 985, 988

Table 17: Water-in-oil sensor (CLS)

Description	Measured value	Fault values
Capacitive leakage sensor located in the oil housing. This sensor issues an alarm if the water content reaches a concentration of approximately 30% or more.	Standard drive unit only. CLS must be connected to 12 V DC with correct polarity (+/–).	See table below.

CLS alarm is not a cause for stopping the pump. It is merely an indicator to check the oil and outer seal at the next planned service.

Table 18: CLS current measurements

Measuring result	Explanation
0 mA	Can indicate one of the following conditions: • The sensor has the wrong polarity. Check by changing plus and minus. • The cable/lead is broken.
4.0 to 8.0 mA	OK

Measuring result	Explanation
27 to 33 mA	Alarm current
> 33 mA	Short circuit

3.4.6 Pump memory

The pump memory is located inside the junction box of the pump. The memory is loaded with data from the factory, which is then uploaded to the MAS system at first start-up.

The data that is uploaded contains the following features:

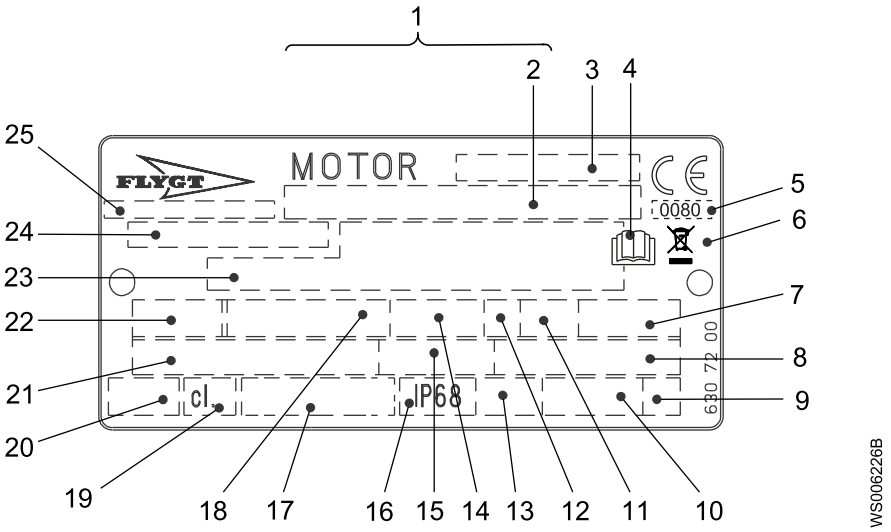
- Data plate information
- Sensor types and alarm settings recommended by the manufacturer
- Operational data and data to support service:
  - Histograms of temperatures, vibrations, and cycle length
  - Start and stop registration
  - Service log with a maximum of 200 lines of text
  - Conditions to prompt for service based on for example, running time, number of starts and stops or specific dates

For more information, see the MAS 711 Installation and User Manual.

3.5 The data plates

The data plates include key product specifications.

Drive unit

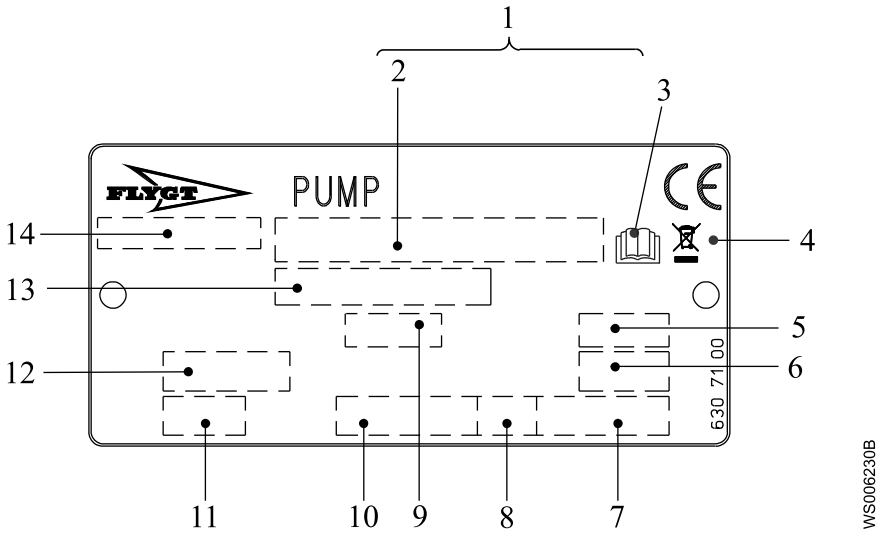


1. Serial number
2. Product code and number
3. Motor denomination
4. Read installation manual
5. Notified body, only for EN-approved Ex products
6. WEEE-Directive symbol
7. Maximum ambient temperature
8. Power factor
9. Locked rotor code letter
10. Product weight
11. Duty factor
12. Duty class
13. Maximum submergence
14. Rated speed
15. Rated current
16. Degree of protection
17. International standard
18. Rated shaft power
19. Thermal class
20. Thermal protection
21. Rated voltage
22. Phase; Type of current; Frequency
23. Additional information

24. Product number
25. Country of origin

Figure 8: The drive unit plate valid from 990101

Hydraulic unit



1. Serial number
2. Product code and number
3. Read installation manual
4. WEEE-Directive symbol
5. Impeller diameter
6. Propeller blade angle
7. Product weight
8. Direction of rotation: L=left, R=right
9. Impeller or Propeller code
10. Rated speed
11. Pressure class
12. Column diameter or Inlet and outlet diameter
13. Product number
14. Country of origin

Figure 9: The hydraulic unit plate

3.6 Approvals

Product approvals for hazardous locations

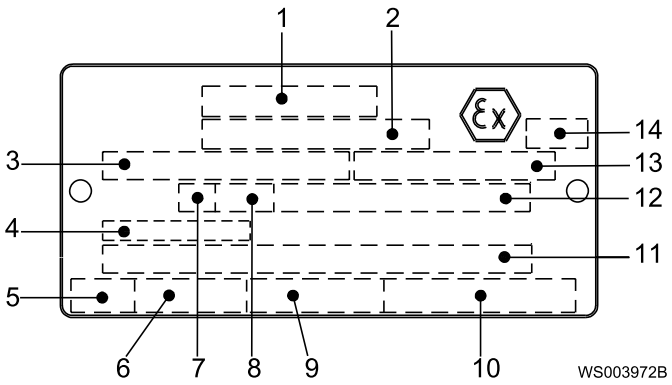
Table 19: Product approvals

Drive Unit	European Norm (EN)	IEC	FM (FM Approvals)	CSA Ex
615 675	• ATEX Directive • EN 60079-0:2012/A11:2013, EN 60079-1:2014, EN 13463-1:2009, EN 13463-5:2011 • Ⓔx II 2 G c Ex db IIB T3 Gb • Ⓔx II 2 G c Ex db IIB T4 Gb	• IECEx scheme • IEC 60079-0, IEC 60079-1 • Ex d IIB T3 Gb • Ex d IIB T4 Gb	• Explosion proof for use in Class I, Div. 1, Group C and D • Dust ignition proof for use in Class II, Div. 1, Group E, F and G • Suitable for use in Class III, Div. 1, Hazardous Locations	• Explosion proof for use in Class I, Div. 1, Group C and D
715 745 775	• ATEX Directive • EN 60079-0:2012/A11:2013, EN 60079-1:2014, EN 13463-1:2009, EN 13463-5:2011 • Ⓔx II 2 G c Ex db IIB T3 Gb • Ⓔx II 2 G c Ex db IIB T4 Gb	• IECEx scheme • IEC 60079-0, IEC 60079-1 • Ex d IIB T3 Gb • Ex d IIB T4 Gb	• Explosion proof for use in Class I, Div. 1, Group C and D • Dust ignition proof for use in Class II, Div. 1, Group E, F and G • Suitable for use in Class III, Div. 1, Hazardous Locations	• Explosion proof for use in Class I, Div. 1, Group C and D

Drive Unit	European Norm (EN)	IEC	FM (FM Approvals)	CSA Ex
716 746 776	• ATEX Directive • EN 60079-0:2012/A11:2013, EN 60079-1:2014, EN 13463-1:2009, EN 13463-5:2011 • ⟨Ex⟩ II 2 G c Ex db IIB T3 Gb	• IECEx scheme • IEC 60079-0, IEC 60079-1 • Ex d IIB T3 Gb	• Explosion proof for use in Class I, Div. 1, Group C and D • Dust ignition proof for use in Class II, Div. 1, Group E, F and G • Suitable for use in Class III, Div. 1, Hazardous Locations	• Explosion proof for use in Class I, Div. 1, Group C and D
815 845 872 875 892 895	• ATEX Directive • EN 60079-0:2012/A11:2013, EN 60079-1:2014, EN 13463-1:2009, EN 13463-5:2011 • ⟨Ex⟩ II 2 G c Ex db IIB T3 Gb	• IECEx scheme • IEC 60079-0, IEC 60079-1 • Ex d IIB T3 Gb	• Explosion proof for use in Class I, Div. 1, Group C and D • Dust ignition proof for use in Class II, Div. 1, Group E, F and G • Suitable for use in Class III, Div. 1, Hazardous Locations	• Explosion proof for use in Class I, Div. 1, Group C and D
816 846 873 876 893 896	• ATEX Directive • EN 60079-0:2012/A11:2013, EN 60079-1:2014, EN 13463-1:2009, EN 13463-5:2011 • ⟨Ex⟩ II 2 G c Ex db IIB T3 Gb	• IECEx scheme • IEC 60079-0, IEC 60079-1 • Ex d IIB T3 Gb	• Explosion proof for use in Class I, Div. 1, Group C and D	• Explosion proof for use in Class I, Div. 1, Group C and D
915 945 960 975 995 998	• ATEX Directive • EN 60079-0:2012/A11:2013, EN 60079-1:2014, EN 13463-1:2009, EN 13463-5:2011 • ⟨Ex⟩ II 2 G c Ex db IIB T3 Gb • ⟨Ex⟩ II 2 G c Ex db IIB T4 Gb (For T4, T_{amb} = 25°C.)	• IECEx scheme • IEC 60079-0, IEC 60079-1 • Ex d IIB T3 Gb • Ex d IIB T4 Gb (For T4, T_{amb} = 25°C.)	• Explosion proof for use in Class I, Div. 1, Group C and D • Dust ignition proof for use in Class II, Div. 1, Group E, F and G • Suitable for use in Class III, Div. 1, Hazardous Locations	• Explosion proof for use in Class I, Div. 1, Group C and D
916 946 961 976 996 997	• ATEX Directive • EN 60079-0:2012/A11:2013, EN 60079-1:2014, EN 13463-1:2009, EN 13463-5:2011 • ⟨Ex⟩ II 2 G c Ex db IIB T3 Gb • ⟨Ex⟩ II 2 G c Ex db IIB T4 Gb (For T4, T_{amb} = 25°C.)	• IECEx scheme • IEC 60079-0, IEC 60079-1 • Ex d IIB T3 Gb • Ex d IIB T4 Gb (For T4, T_{amb} = 25°C.)	• Explosion proof for use in Class I, Div. 1, Group C and D	• Explosion proof for use in Class I, Div. 1, Group C and D

EN approval plate

This illustration describes the EN approval plate and the information that is contained in its fields.

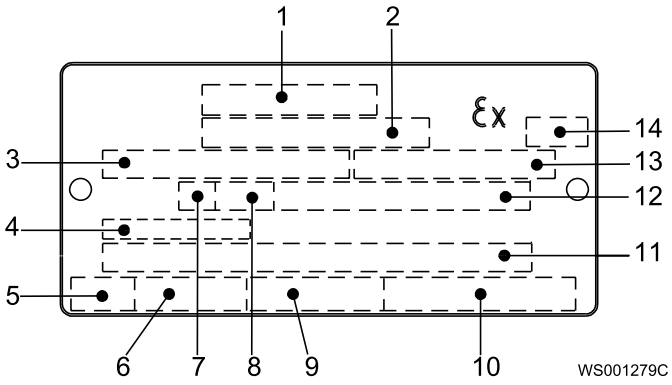


1. Approval
2. Approval authority and Approval number
3. Approved for drive unit
4. Cable entry temperature
5. Stall time
6. Starting current or Rated current
7. Duty class
8. Duty factor
9. Input power
10. Rated speed
11. Additional information
12. Maximum ambient temperature
13. Serial number
14. ATEX marking

IEC approval plate

This illustration describes the IEC approval plate and the information that is contained in its fields.

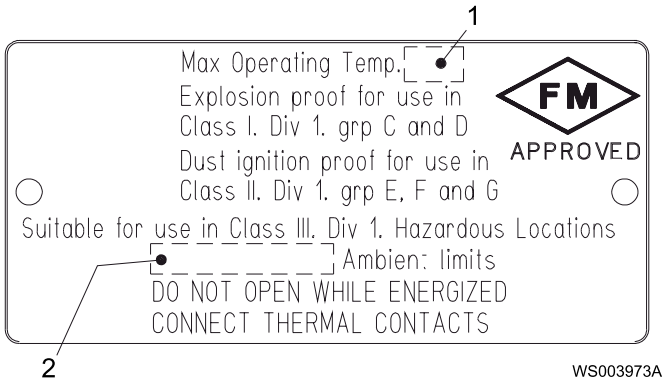
International Norm; not for EU member countries.



1. Approval
2. Approval authority and Approval number
3. Approved for drive unit
4. Cable entry temperature
5. Stall time
6. Starting current or Rated current
7. Duty class
8. Duty factor
9. Input power
10. Rated speed
11. Additional information
12. Maximum ambient temperature
13. Serial number
14. ATEX marking

FM approval plate

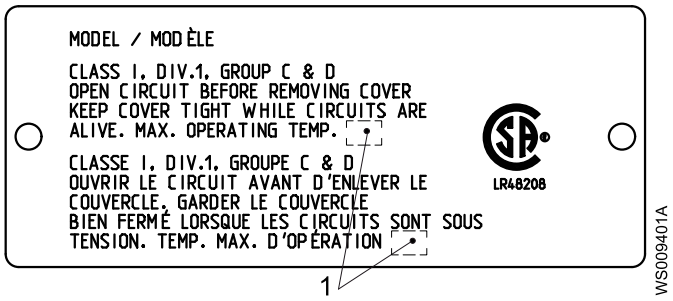
This illustration describes the FM approval plate and the information that is contained in its fields.



1. Temperature class
2. Maximum ambient temperature

CSA approval plate

This illustration describes the CSA approval plate and the information that is contained in its fields.



1. Temperature class

3.7 Product denomination

Reading instruction

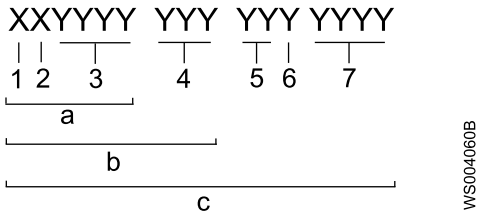
In this section, code characters are illustrated accordingly:

X = letter

Y = digit

The different types of codes are marked up with a, b, and c. Code parameters are marked up with numbers.

Codes and parameters



Type of Callout	Number	Indication
Type of code	a	Sales denomination
	b	Product code
	c	Serial number
Parameter	1	Hydraulic end
	2	Type of installation
	3	Sales code
	4	Drive unit
	5	Production year
	6	Production cycle
	7	Running number

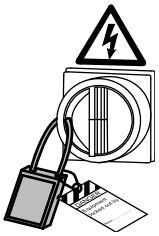
4 Installation

4.1 Precautions

Before starting work, make sure that the safety instructions in the chapter *Introduction and Safety* on page 4 have been read and understood.

DANGER: Electrical Hazard

Before starting work on the unit, make sure that the unit and the control panel are isolated from the power supply and cannot be energized. This applies to the control circuit as well.



DANGER: Explosion/Fire Hazard

Special rules apply to installations in explosive or flammable atmospheres. Do not install the product or any auxiliary equipment in an explosive zone unless it is rated explosion-proof or intrinsically-safe. If the product is EN/ATEX-, MSHA- or FM-approved, then see the specific EX information in the Safety chapter before taking any further actions.

DANGER: Inhalation Hazard

Before entering the work area, make sure that the atmosphere contains sufficient oxygen and no toxic gases.

Before installing the pump, do the following:

- Provide a suitable barrier around the work area, for example, a guard rail.
- Make sure that equipment is in place so that the unit cannot roll or fall over during the installation process.
- Check the explosion risk before you weld or use electric hand tools.
- Check that the cable and cable entry have not been damaged during transport.
- Always remove all debris and waste material from the sump before you install the pump.

Authority regulation

Vent the tank of a sewage station in accordance with local plumbing codes.

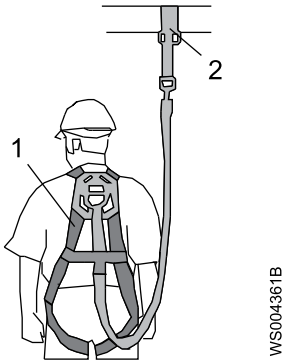
4.1.1 Falling

CAUTION: Fall Hazard

Slips and falls can cause severe injuries. Watch your step.

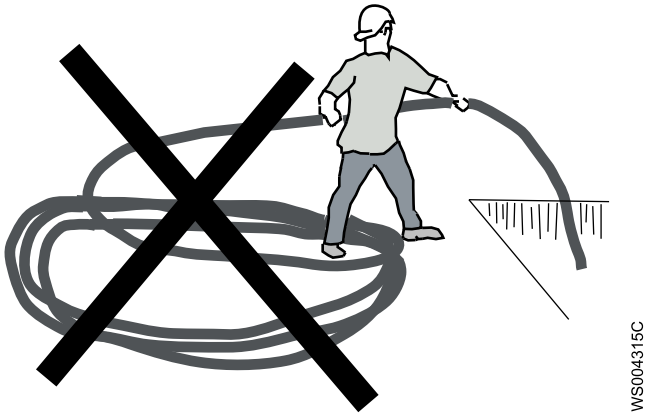
To minimize the risk of falling, observe the following:

- Use appropriate personal protection equipment when working in or near open basins, shafts, or trenches.



1. Fall protection harness
2. Anchoring point

- Make sure that all safety guards are in place and secure, and that there is a suitable barrier around the work area.
- Wear clean slip-resistant shoes.
- Make sure that any ladders or climbing equipment that is used is correctly sized and in good working condition.
- Never stand in coiled cables, ropes or wires, or between them and the open shaft or basin.



4.1.2 Hazardous atmospheres

DANGER: Explosion/Fire Hazard

Special rules apply to installations in explosive or flammable atmospheres. Do not install the product or any auxiliary equipment in an explosive zone unless it is rated explosion-proof or intrinsically-safe. If the product is EN/ATEX-, MSHA- or FM-approved, then see the specific EX information in the Safety chapter before taking any further actions.

WARNING: Explosion/Fire Hazard

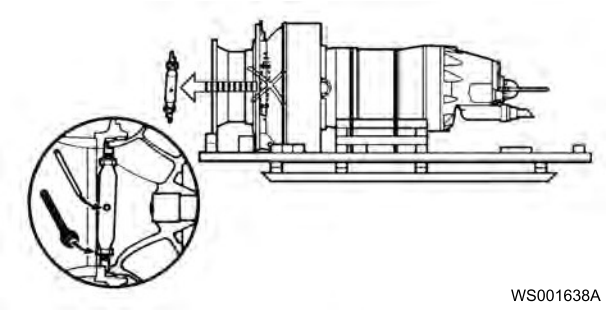
Do not install CSA-approved products in locations that are classified as hazardous in the National Electric Code(TM), ANSI/NFPA 70-2005.

Fasteners

- Only use fasteners of the correct size and material.
- Replace all corroded or damaged fasteners.
- Make sure that all the fasteners are correctly tightened and that there are no missing fasteners.

The locking device

Pumps delivered in the horizontal position have a locking device for the impeller/propeller. Before you install the pump, you must remove this locking device.



4.2 Cables

General requirements

- The voltage drop in a long cable must be taken into account. Always follow the local regulations for voltage drop.
- If a Variable Frequency Drive (VFD) is used, then the screened cable must be used according to the European CE and EMC requirements. For more information, contact a sales or authorized service representative (VFD-supplier).
- All unused conductors must be insulated.
- The cable entry seal sleeve and washers must conform to the outside diameter of the cable.

Cable condition

- The cable must not have any sharp bends, and not be pinched.

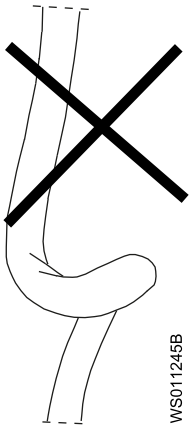


Figure 10: Kinked cable

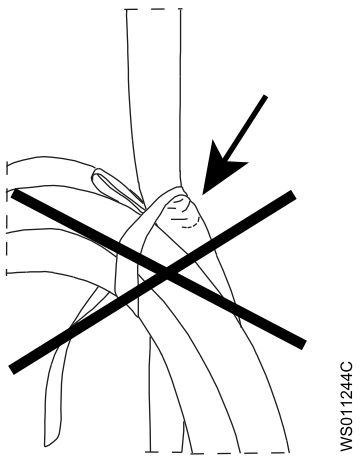


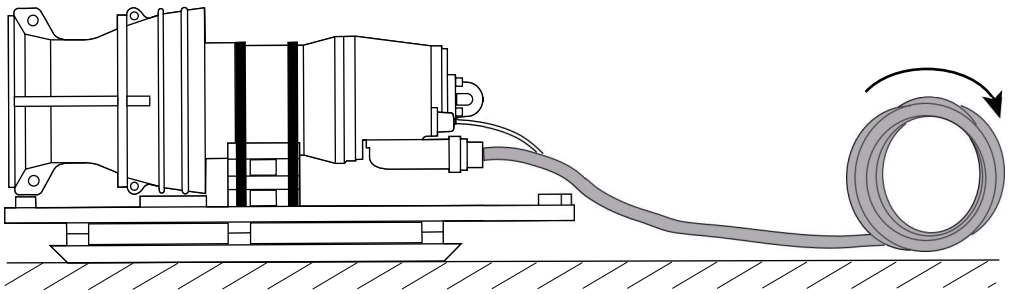
Figure 11: Pinched cable

- If the outer sheath of the cable is damaged, then replace the cable.
- The cable must not be damaged and must not have indentations or be embossed at the cable entry.
- If the cable has been used before, then a short piece must be peeled off when refitting it. This prevents the cable entry seal sleeve from closing around the cable at the same point.
- The cable must not be exposed for long periods to direct UV light. The cable ends must be protected from water during storage.

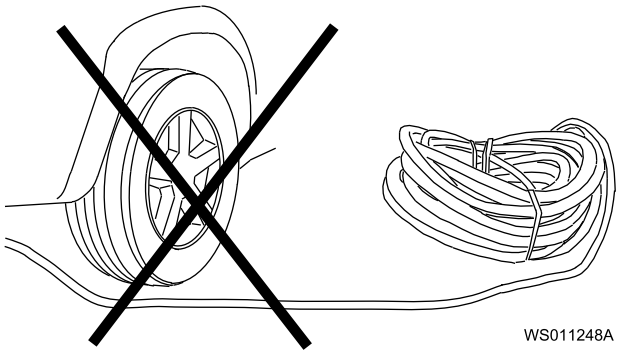
Cable handling

To install cables, follow these requirements:

- Start at the pump and carefully roll out the cable.



- When pulling the cable, do not exceed the maximum permissible tensile force.
- Do not bend the cable to a radius smaller than the recommended minimum bending radius.The recommended minimum bending radius is 10 times the diameter of the cable.
- Make sure that vehicles cannot run over the cable.



- All cables lose flexibility at lower temperatures. Use extra care when the cable is cold.Do not work with a cable whose temperature is below –30°C (–22°F).

4.3 Cable handling system

Cable system overview

When the pump is installed in a discharge tube, it is critically important that a correct cable support and protection system is used. This is especially important when using long power cables and closed discharge tubes. Characteristics of the cable handling system include:

- Cables must be supported in such a way, so that they do not come in contact with any hard surface which could abrade the cable sheathing. Examples of surfaces include pump and tube components, lifting cables or wires and any other hardware.
- Power cables should be bundled together, by using components that do not cut or abrade the cables.
- Correct strain relief and support at prescribed intervals must be provided.
- Spring-controlled tensioning and an integrated guide wire system are recommended for long cables.

Example of the Flygt cable handling system

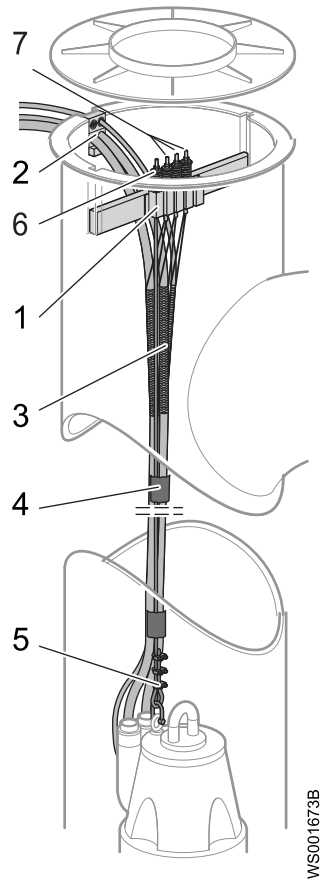


Figure 12: Example of the Flygt cable handling system

Number	Description
1	Support beam and cable holder
2	Cable entry unit
3	Cable support grips
4	Bundling kits
5	Wire unit
6	Lifting eye unit: wire
7	Lifting eye unit: cable

Instructions for installing the cable handling system

Instructions for installing the Flygt cable handling system are given in the document "Installation, Operation and Maintenance, Flygt Cable Handling System". For more information, contact the sales and service representative.

4.4 Install the pump

Consult the nearest local sales and service representative regarding the following:

- Sizing of the pump, piping station, and access frame
- Choice of auxiliary equipment
- Other aspects of installation

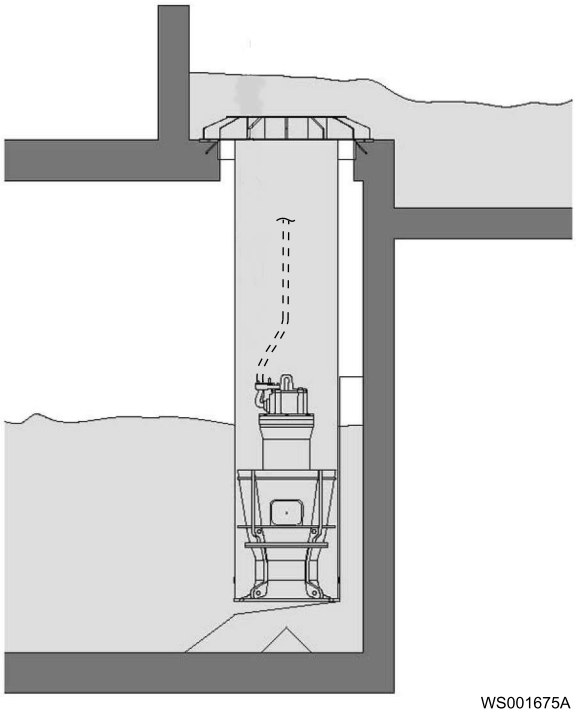
NOTICE:

Do not run the pump dry.

NOTICE:

Never force piping to make a connection with a pump.

The pump is usually installed in a vertical discharge tube on a pump seat, which is incorporated in the lower end of the tube. No anchoring is required because the weight of the pump is sufficient to keep it in position. The pumps are equipped with anti-rotation devices.



WS001675A

When the pump is installed in a discharge tube, the following must be considered:

- An appropriate cable support and protection system must be used.

Before installation, check the following:

- The propeller must rotate in the correct direction.

  If the rotation is not in the correct direction, then the pump can lift and start rotating inside the tube. This movement can seriously damage the equipment.
- The rubber seal ring underneath the pump is in position.
- There is no damage to, or debris on, the pump seat.
- There is no large construction debris under the pump tube, or at the pump intake. If debris is present, then there is a risk that it can get sucked into the pump and cause propeller damage.
- The pump control is set to turn off the pump at or above the minimum operating water level for this pump installation.

1. Secure the cables so that they can be fed into the column in a controlled manner.

   When the pump is lowered into the column, the cables must be fed into the column at the same speed as the pump is lowered.

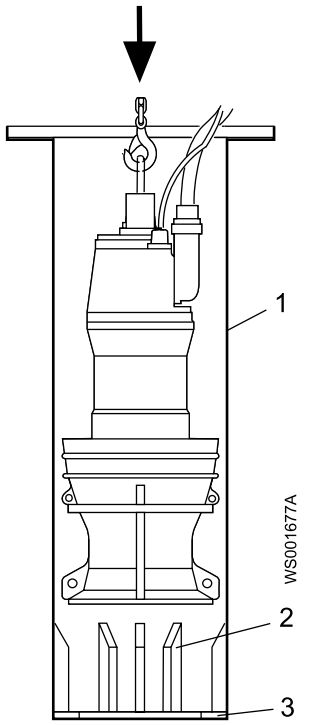
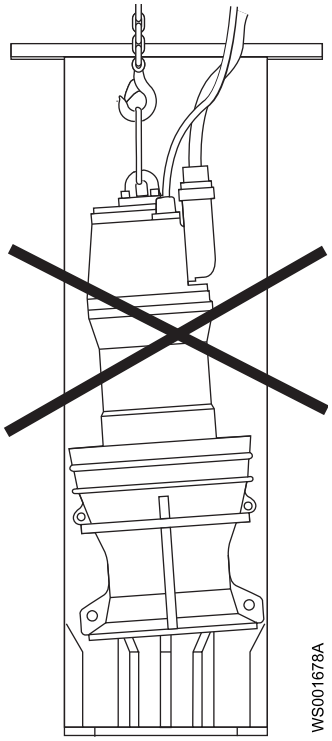
   See also the Installation, Operation, and Maintenance manual for the Flygt Cable Handling System.

2. Make sure that the lifting strap or chain for lowering the pump, is shorter than the length of the cables.

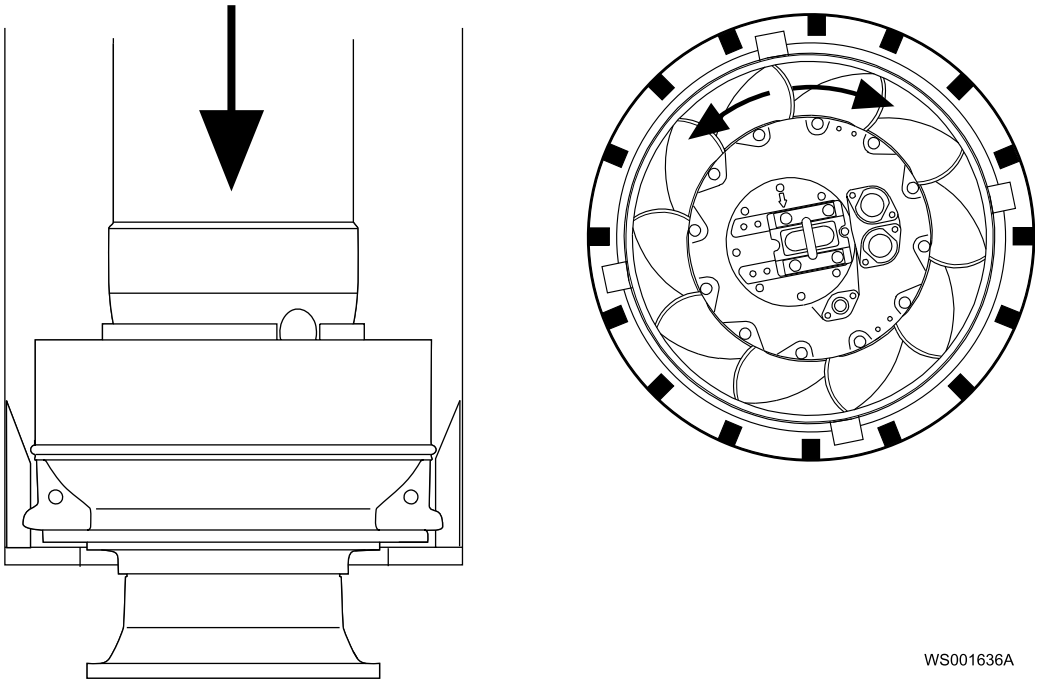
   Never lift the pump by its cables.

3. After cable preparation, lower the pump into the pump column.

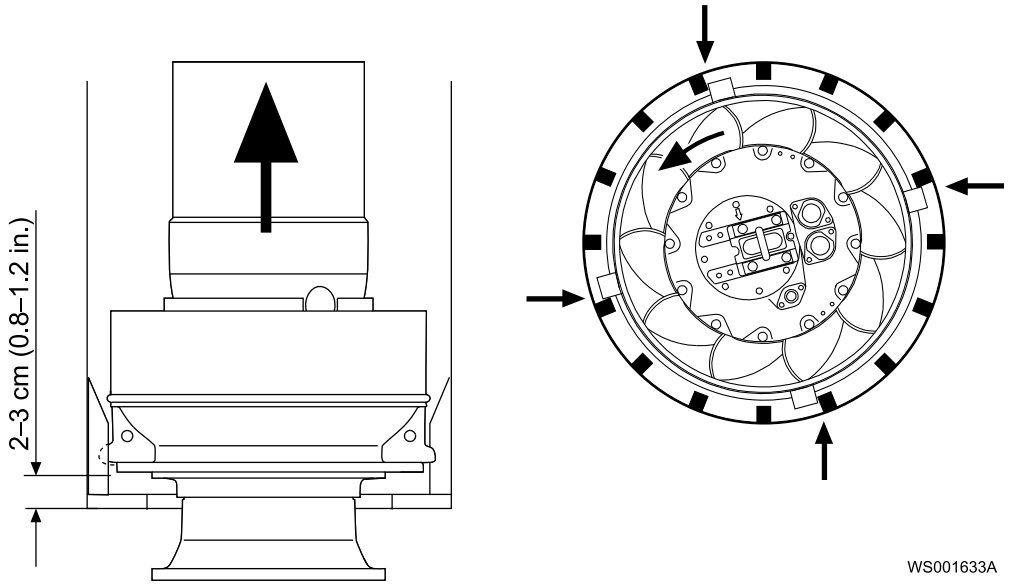
   Make sure that the pump does not tilt on the stop vanes, which are at the bottom of the column.

Correct	Incorrect
	
1 Discharge column 2 Antirotation gusset (stop vanes) 3 Pump seat	

4. Lower the pump to its bottom position, at the same time carefully moving it back and forth between the nearest anti-rotation gusset.

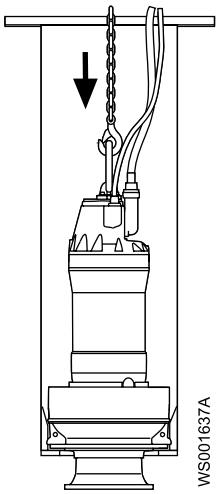


5. Lift the pump slightly again, approximately 2–3 cm (1 in.), and turn it counterclockwise until the anti-rotation device on the hydraulic end lands against the nearest adjacent vanes.



6. Lower the pump to its final bottom position.

   No additional anchoring of the pump is required. Maximum permissible submersion depth is 20 m (65 ft).



7. If the recommended cable handling system is used, then follow the instructions for finishing the cable connection. See the document "Mounting Instructions, Flygt Cable Handling System".
8. If the recommended cable handling system is not used, then attach the power cables on the cable holder, and run them to the electric junction box.

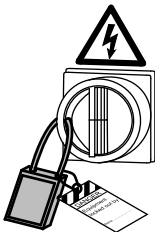
   Make sure that the cables have no sharp bends, are not pinched, and do not disturb the water flow.

4.5 Make the electrical connections

4.5.1 General precautions

DANGER: Electrical Hazard

Before starting work on the unit, make sure that the unit and the control panel are isolated from the power supply and cannot be energized. This applies to the control circuit as well.



WARNING: Electrical Hazard

Risk of electrical shock or burn. A certified electrician must supervise all electrical work. Comply with all local codes and regulations.

WARNING: Electrical Hazard

There is a risk of electrical shock or explosion if the electrical connections are not correctly carried out, or if there is fault or damage on the product. Visually inspect equipment for damaged cables, cracked casings or other signs of damage. Make sure that electrical connections have been correctly made.

WARNING: Crush Hazard

Risk of automatic restart.

CAUTION: Electrical Hazard

Prevent cables from becoming sharply bent or damaged.

NOTICE:

Leakage into the electrical parts can cause damaged equipment or a blown fuse. Keep the cable ends dry at all times.

Requirements

These general requirements apply for electrical installation:

- The supply authority must be notified before installing the pump if it will be connected to the public mains. When the pump is connected to the public power supply, it may cause flickering of incandescent lamps when started.
- The mains voltage and frequency must agree with the specifications on the data plate. If the pump can be connected to different voltages, then the connected voltage is specified by a yellow sticker close to the cable entry.
- The fuses and circuit breakers must have the proper rating, and the pump overload protection (motor protection breaker) must be connected and set to the rated current according to the data plate and if applicable the cable chart. The starting current in direct-on-line start can be up to six times higher than the rated current.

- The fuse rating and the cables must be in accordance with the local rules and regulations.
- If intermittent operation is prescribed, then the pump must be provided with monitoring equipment supporting such operation.
- The thermal contacts must be connected to a protection circuit in accordance with the product approvals.
- The thermal contacts/thermistors must be in use.
- The environment must be appropriate for medium-voltage (1.2–10 kV) cables and electrical work.
- For FM-approved pumps, a leakage sensor must be connected and in use in order to meet approval requirements.
- Specially-approved pumps must be earthed (grounded) at the external earthing (grounding) site on the outside of the drive unit, in order to meet approval requirements.

4.5.2 Grounding (earthing)

Grounding (earthing) must be done in compliance with all local codes and regulations.

DANGER: Electrical Hazard

All electrical equipment must be grounded (earthed). Test the ground (earth) lead to verify that it is connected correctly and that the path to ground is continuous.

WARNING: Electrical Hazard

If the power cable is jerked loose, then the ground (earth) conductor must be the last conductor to come loose from its terminal. Make sure that the ground (earth) conductor is longer than the phase conductors at both ends of the cable.

WARNING: Electrical Hazard

Risk of electrical shock or burn. You must connect an additional ground- (earth-) fault protection device to the grounded (earthed) connectors if persons are likely to come into contact with liquids that are also in contact with the pump or pumped liquid.

4.5.3 Connect the ground at the outside of the drive unit

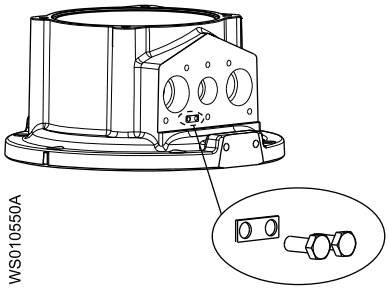
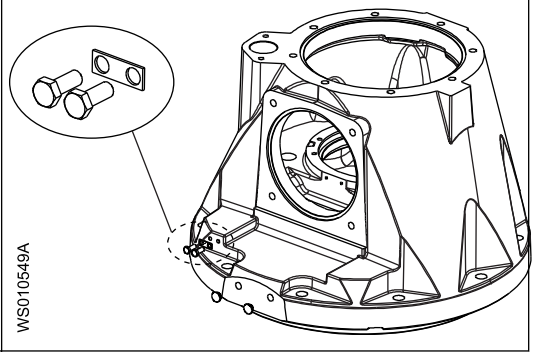
This section gives instructions for connecting the external earthing to the outside of the drive unit.

This procedure must be followed for:

- Pumps that are installed in an EX environment
- Medium voltage pumps.

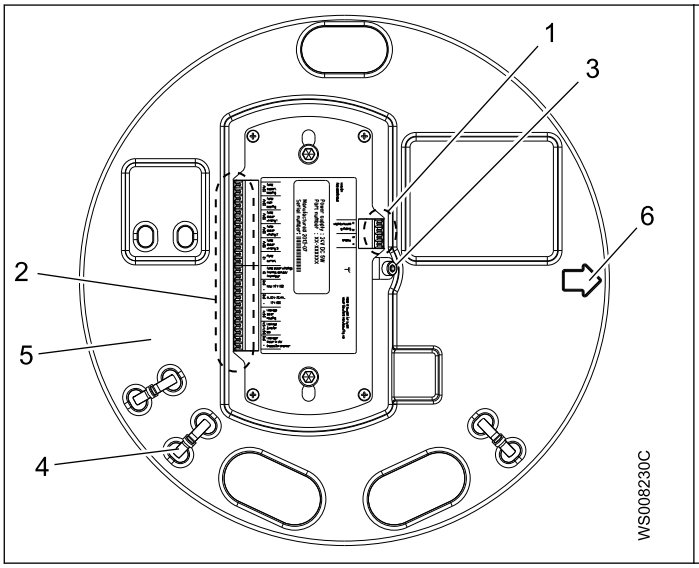
Other circumstances can also make this procedure applicable.

Connect the ground (earth) at the external grounding (earthing) site on the outside of the drive unit. See the following figures.

Small connection house	Large connection house
	

4.5.4 Connect the cables: Standard pumps with MAS 801

This procedure must not be used for Ex-proof applications. If the pump is Ex-proof, then use the procedure that is described in *Connect the cables: Ex-proof pumps with MAS 801* on page 48.

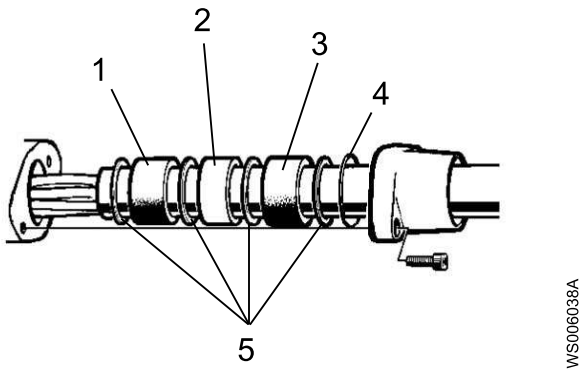


1. PEM communication terminals
2. PEM control terminals
3. Functional ground
4. Cable tie
5. Terminal plate
6. Index arrow. The index arrow on the terminal plate is aligned with the cable inlet.

1. Install the monitoring equipment. See the System Installation and Operation (SIO) Manual for the MAS 801 monitoring equipment.
2. Connect the two signal leads that are integrated in the SUBCAB® cable, T1 and T2, to the MAS BU.

   See the chapter “Installation” in the SIO Manual for the MAS 801 monitoring equipment.
3. If they are not already connected, then connect the T1 and T2 leads integrated in the SUBCAB cable to the PEM. See the illustration and table in *Terminals used in standard applications* on page 48.
4. If they are not already connected, then connect the power leads:
   a) Check the data plate to determine which connection is valid for the voltage supply.
   b) Connect the power leads to the terminal board connection U1, U2, V1, V2, W1, W2, and ground (earth) according to the cable chart.

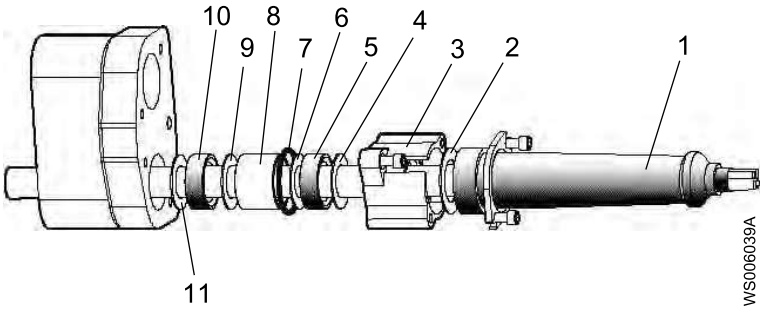
      See *Cable charts* on page 63.
5. Install the entrance flange:
   a) Fit the entrance flange parts according to the illustration for the correct drive unit.



1. Seal sleeve
2. Spacer ring
3. Seal sleeve

4. O-ring
5. Washer

Figure 13: Drive units 605–776



1. Protective sleeve
2. Washer
3. Connection flange
4. Washer
5. Seal sleeve
6. Washer
7. O-ring
8. Spacer ring
9. Washer
10. Seal sleeve
11. Washer

Figure 14: Drive unit 805–998

Pumps with drive units 605–776 are also equipped with a cable holder illustrated here.

Figure 15: Cable holder. Pumps equipped with MAS 801 do not have the auxiliary cable.

b) Fit the protective rubber sleeve onto the cable where it leaves the connection housing.

   The rubber sleeve must have the correct size to give the correct compression around the cable.

c) Attach the connection flange to the entrance flange.

   Make sure that the seal sleeve is not misaligned with the rubber sleeve. Check that the entrance flange supports the cable so that it cannot be excessively bent.

6. Connect the SUBCAB cable phase leads to the starter equipment according to the diagram in *Power cable phase sequence* on page 58.

7. Perform the system setup by using the Setup wizard and other commissioning procedures in the chapter “System Setup” in the SIO Manual for the MAS 801.
8. For pumps with drive units in voltage range 1.2–6.6 kV: Check that the stator alarm settings have been changed to the values in the following table.

Table 20: Stator alarm settings for 1.2–6.6 kV drive units

Stator Alarm	Setting
A	155°C
B	145°C

For more information, see the SIO Manual for the MAS 801. For drive unit voltage ranges, see *Drive units* on page 18.

4.5.4.1 Wiring for standard pumps

In standard pumps, thermal contacts or thermistors are connected to the PEM. All sensor signals are digitally transmitted through T1 and T2 in the SUBCAB™ power cable.

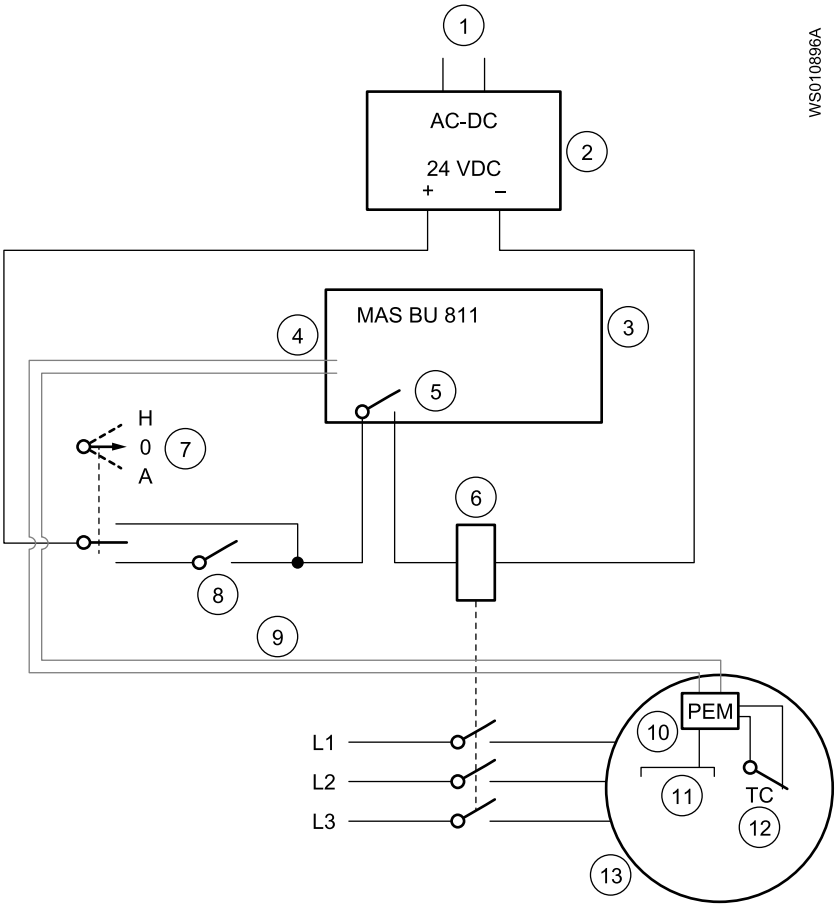
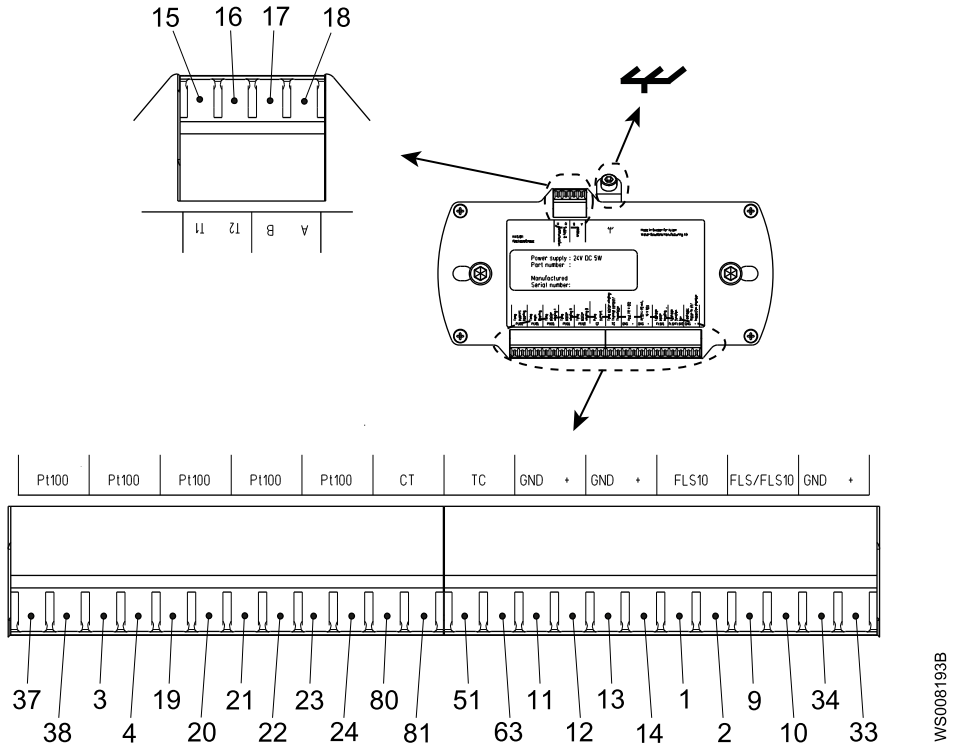


Figure 16: Thermal contacts or thermistors connections to the PEM

1. Power outlet, 100 VAC – 240 VAC	8. Pump control, on or off
2. AC/DC converter	9. T1 and T2 signal leads in SUBCAB™ power cable
3. Base unit	10. PEM
4. Pump electronic module communication	11. Pump sensors
5. GO contact	12. Thermal contact or thermistor
6. Contactor	13. Pump
7. Hand-Off-Auto (HOA) controller	

4.5.4.2 Terminals used in standard applications

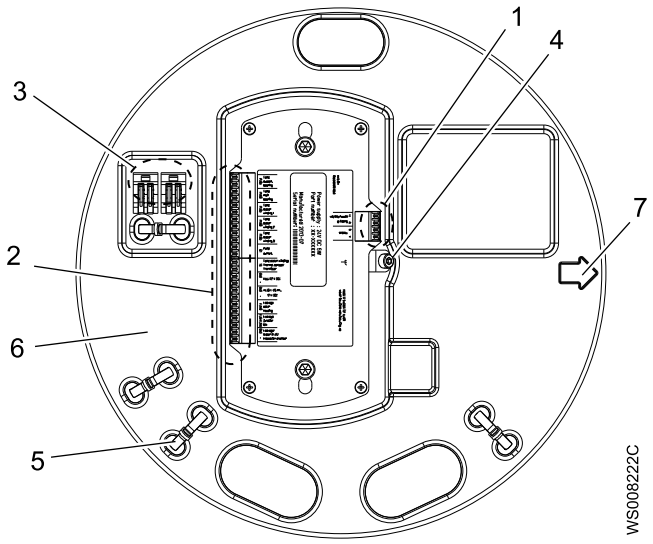


Terminal	Description	Terminal	Description
37, 38	Temperature support bearing, Pt100	13, 14	Analog input 0/4 -20 mA, +12 VDC, GND
3, 4	Temperature main bearing, Pt100	1, 2	Leakage: Inspection chamber or stator housing, FLS/FLS10
19, 20	Temperature stator winding 1, Pt100	9, 10	Leakage, junction box: FLS/FLS10
21, 22	Temperature stator winding 2, Pt100	34, 33	Leakage, inspection chamber: FLS10. Water in oil: CLS
23, 24	Temperature stator winding 3, Pt100	15	T1 power supply and communication
80, 81	Pump current, CT	16	T2 power supply and communication
51, 63	Temperature stator winding: Thermal contact or thermistor, TC	17	Not used
11, 12	V_{out} +12 VDC, GND	18	Not used

4.5.5 Connect the cables: Ex-proof pumps with MAS 801

For Ex-proof applications, the stator winding temperature sensors are not connected to terminals 51 and 63 on the PEM. They are connected to the T3 and T4 terminals on the separate plinth.

- Thermal contacts must be wired separately to break contactor circuit directly.
- Thermistors must be wired to a Safety Integrity Level (SIL)-approved thermistor relay.



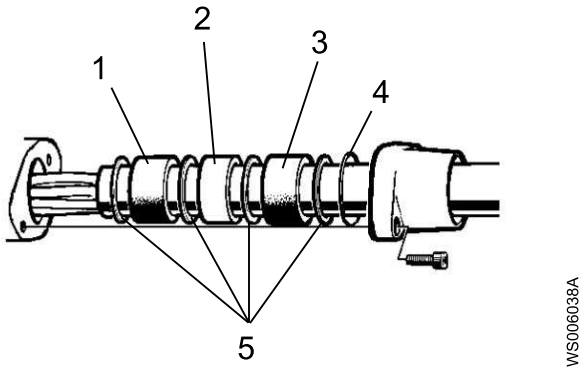
1. PEM communication terminals
2. PEM control terminals
3. Separate plinth with T3, T4 terminals
4. Functional ground
5. Cable tie
6. Terminal plate
7. Index arrow. The index arrow on the terminal plate is aligned with the cable inlet.

1. Install the monitoring equipment. See the System Installation and Operation (SIO) Manual for the MAS 801 monitoring equipment.
2. Connect the two signal leads that are integrated in the SUBCAB® cable, T1 and T2, to the MAS base unit.

   See the chapter "Installation" in the SIO Manual for the MAS 801 monitoring equipment.
3. Connect the T3 and T4 terminals to the auxiliary relay (thermal contacts) or the SIL-approved thermistor relay (thermistors). See *Wiring for Ex-proof application* on page 51.

   Do not connect the stator winding temperature sensor leads to PEM terminals 51 and 63.
4. If they are not already connected, then connect the T1 and T2 leads integrated in the SUBCAB cable to the PEM. See the illustration and table in *Terminals used in Ex applications* on page 53.
5. If they are not already connected, then connect the power leads:
   a) Check the data plate to determine which connection is valid for the voltage supply.
   b) Connect the power leads to the terminal board connection U1, U2, V1, V2, W1, W2, and ground (earth) according to the cable chart.

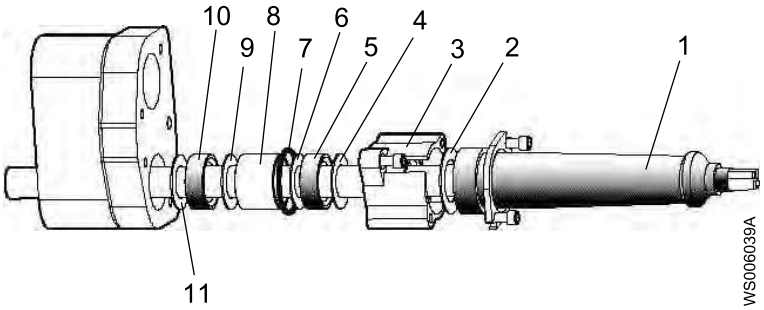
      See *Cable charts* on page 63.
6. Install the entrance flange:
   a) Fit the entrance flange parts according to the illustration for the correct drive unit.



1. Seal sleeve
2. Spacer ring
3. Seal sleeve

4. O-ring
5. Washer

Figure 17: Drive units 605–776



1. Protective sleeve
2. Washer
3. Connection flange
4. Washer
5. Seal sleeve
6. Washer
7. O-ring
8. Spacer ring
9. Washer
10. Seal sleeve
11. Washer

Figure 18: Drive unit 805–998

Pumps with drive units 605–776 are also equipped with a cable holder illustrated here.

Figure 19: Cable holder. Pumps equipped with MAS 801 do not have the auxiliary cable.

b) Fit the protective rubber sleeve onto the cable where it leaves the connection housing.

   The rubber sleeve must have the correct size to give the correct compression around the cable.

c) Attach the connection flange to the entrance flange.

   Make sure that the seal sleeve is not misaligned with the rubber sleeve. Check that the entrance flange supports the cable so that it cannot be excessively bent.

7. Connect the SUBCAB cable phase leads to the starter equipment according to the diagram in *Power cable phase sequence* on page 58.

8. Perform the system setup by using the Setup wizard and other commissioning procedures in the chapter “System Setup” in the SIO Manual for the MAS 801.
9. For pumps with drive units in voltage range 1.2–6.6 kV: Check that the stator alarm settings have been changed to the values in the following table.

Table 21: Stator alarm settings for 1.2–6.6 kV drive units

Stator Alarm	Setting
A	155°C
B	145°C

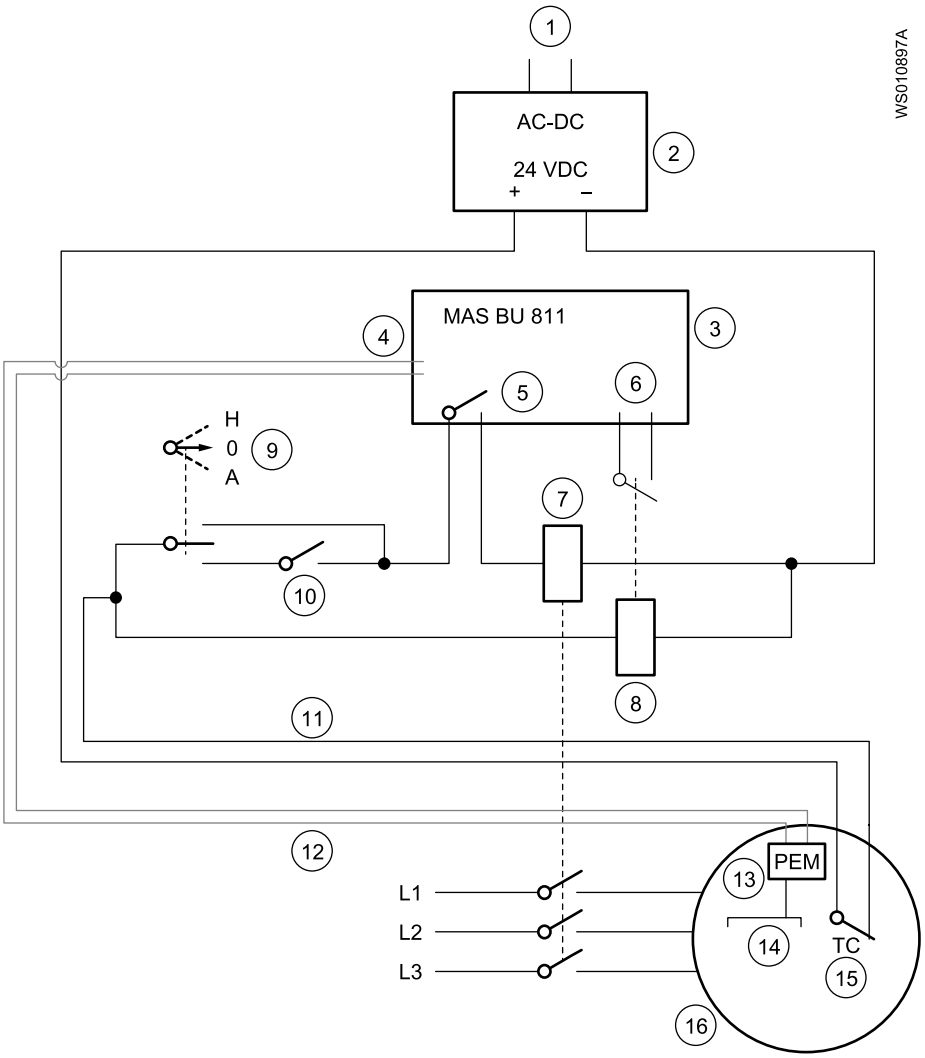
For more information, see the SIO Manual for the MAS 801. For drive unit voltage ranges, see *Drive units* on page 18.

4.5.5.1 Wiring for Ex-proof application

For Ex-proof applications, the stator winding temperature sensors are not connected to terminals 51 and 63 on the PEM. They are connected to the T3 and T4 terminals on the separate plinth.

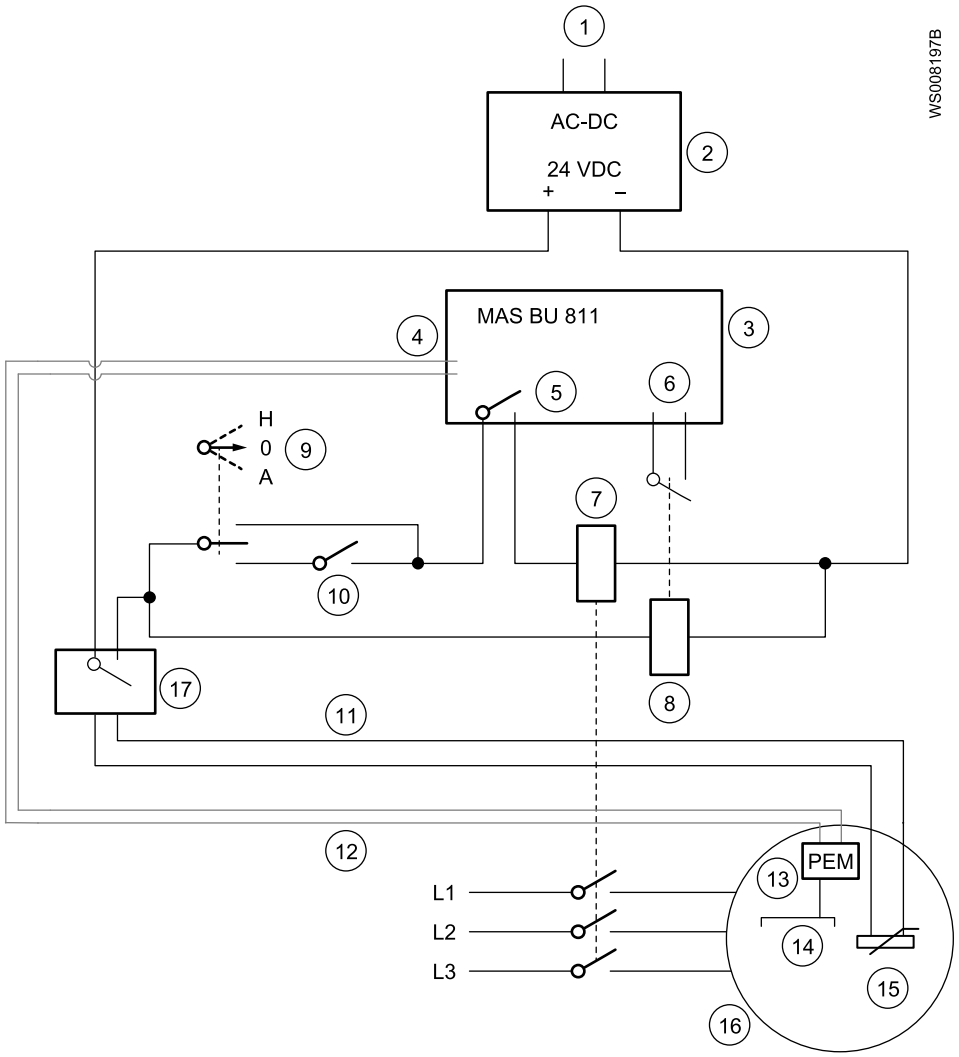
- Thermal contacts must be wired separately to break contactor circuit directly.
- Thermistors must be wired to a Safety Integrity Level (SIL)-approved thermistor relay.

Thermal contacts



1. Power outlet, 100–240 VAC	9. Controller • H – Hands • O – Off • A – Automatic
2. AC DC converter	10. Pump control: on or off
3. Base unit	11. T3 and T4 signal leads in SUBCAB® power cable
4. Pump electronic module communication	12. T1 and T2 signal leads in SUBCAB® power cable
5. GO -contact	13. Pump electronic module
6. Digital input	14. Pump sensors
7. Contactor	15. Thermal contact
8. R1 auxiliary relay	16. Pump

Thermistors



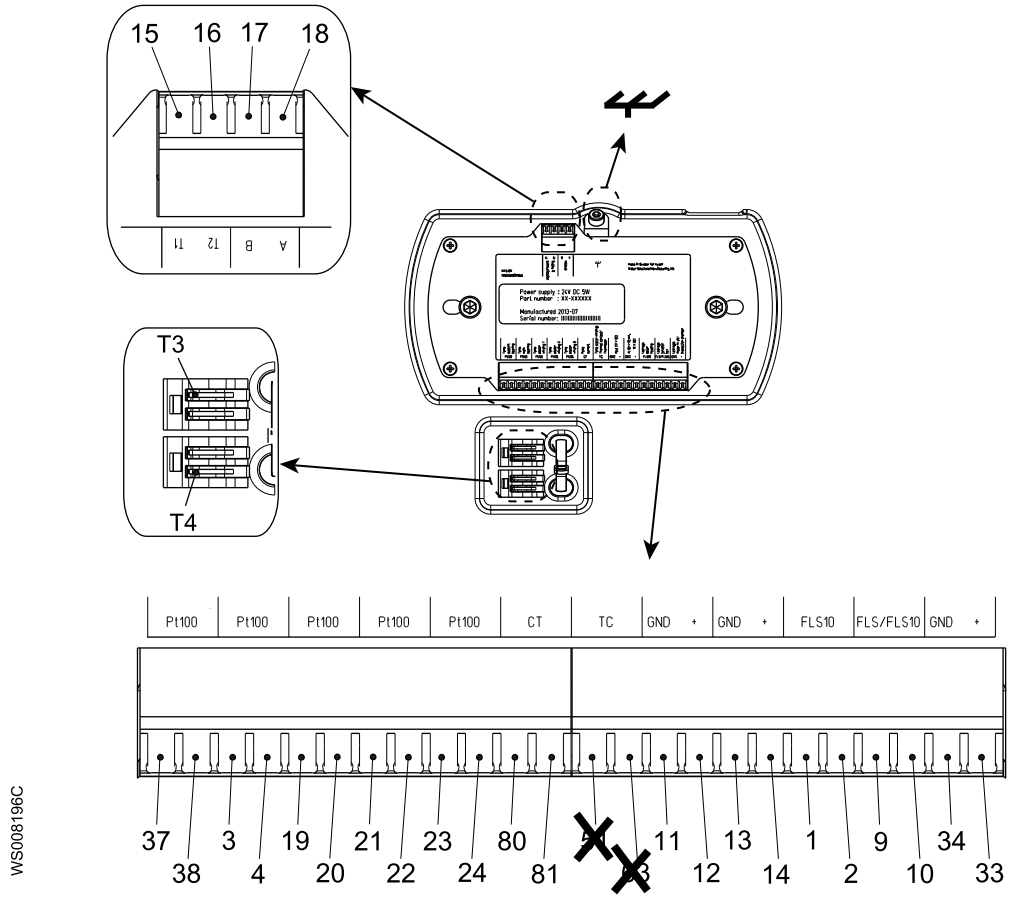
1. Power outlet, 100–240 VAC	9. Controller • H – Hands • O – Off • A – Automatic
2. AC DC converter	10. Pump control: on or off
3. Base unit	11. T3 and T4 signal leads in SUBCAB® power cable
4. Pump electronic module communication	12. T1 and T2 signal leads in SUBCAB® power cable

5. GO -contact	13. Pump electronic module
6. Digital input	14. Pump sensors
7. Contactor	15. Thermistors
8. R1 auxiliary relay	16. Pump
	17. Thermistor relay

4.5.5.2 Terminals used in Ex applications

For Ex applications, the stator winding temperature sensors are not connected to terminals 51 and 63 on the PEM. They are connected to the T3 and T4 terminals on the separate plinth.

- Thermal contacts must be wired separately to break contactor circuit directly.
- Thermistors must be wired to a Safety Integrity Level (SIL)-approved thermistor relay.



Terminal	Description	Terminal	Description
37, 38	Temperature support bearing, Pt100	1, 2	Leakage: Inspection chamber or stator housing, FLS/FLS10
3, 4	Temperature main bearing, Pt100	9, 10	Leakage junction box, FLS/FLS10
19, 20	Temperature stator winding 1, Pt100	34, 33	Leakage, inspection chamber: FLS10
21, 22	Temperature stator winding 2, Pt100	15	T1 power supply and communication
23, 24	Temperature stator winding 3, Pt100	16	T2 power supply and communication
80, 81	Pump current, CT	17	Not used
11, 12	V_{out} +12 VDC, GND	18	Not used
13, 14	Analog input 0/4 -20 mA, +12 VDC, GND	T3, T4	Temperature stator winding: Thermal contact or thermistor, TC

4.5.6 Connect the cables: Pumps with MAS 711

1. Connect the monitoring equipment.
2. Connect the cable to the terminal board:
   - If the MAS 711 system is used, then connect the cable to its terminal board according to the illustration and table in *MAS 711 sensor connections* on page 56.

   NOTICE:

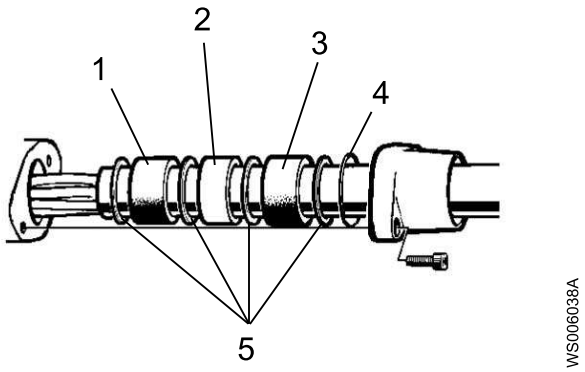
   As the cable ends are sealed to eliminate moisture entrainment during transport and storage, no wire markings for the sensors at the outlet end of the cable are made at the factory. Markings must therefore be carried out during installation of the unit.
3. Synchronize the MAS 711 base unit and the pump memory at the first installation:
   a) Check that the communication between the pump and the MAS base unit is activated.
   b) Upload the factory settings of sensors and related parameters by choosing the command "copy all from pump memory to MAS". For more information about the MAS installation, see the Installation and User Manual for the MAS 711 monitoring equipment.
4. For pumps with drive units in voltage range 1.2–6.6 kV: Change the preset to stator alarms to the values in the following table.

   Table 22: Stator alarm settings for 1.2–6.6 kV drive units

Stator Alarm	Setting
A	155°C
B	145°C

   For more information, see the Installation and User Manual for the MAS 711 monitoring equipment. For drive unit voltage ranges, see *Drive units* on page 18.
5. Connect the power cable:
   a) Check the data plate to determine which connection is valid for the voltage supply.
   b) Arrange the connection on the terminal board.
   c) Connect the power cable leads to the terminal board connection U1, U2, V1, V2, W1, W2, and ground (earth) according to the cable chart.

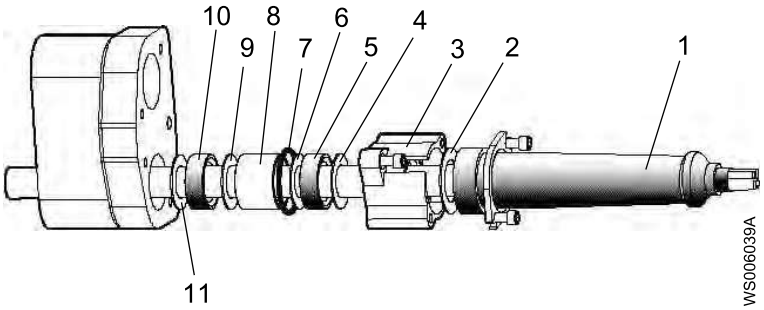
      See *Cable charts* on page 63.
   d) If control elements are present and not used, then cut and cap them.
6. Install the entrance flange:
   a) Fit the entrance flange parts according to the illustration for the correct drive unit.



1. Seal sleeve
2. Spacer ring
3. Seal sleeve

4. O-ring
5. Washer

Figure 20: Drive units 605-776



1. Protective sleeve
2. Washer
3. Connection flange
4. Washer
5. Seal sleeve
6. Washer
7. O-ring
8. Spacer ring
9. Washer
10. Seal sleeve
11. Washer

Figure 21: Drive unit 805-998

Pumps with drive units 605-776 are also equipped with a cable holder illustrated here.

Figure 22: Cable holder

b) Fit the protective rubber sleeve onto the cable where it leaves the connection housing.

   The rubber sleeve must have the correct size to give the correct compression around the cable.

c) Attach the connection flange to the entrance flange.

   Make sure that the seal sleeve is not misaligned with the rubber sleeve. Check that the entrance flange supports the cable so that it cannot be excessively bent.

7. Connect the starter equipment:
   a) Connect the power cable to the starter equipment according to the diagram in *Power cable phase sequence* on page 58.
   b) Connect the auxiliary cable to the starter equipment.

4.5.6.1 MAS 711 sensor connections

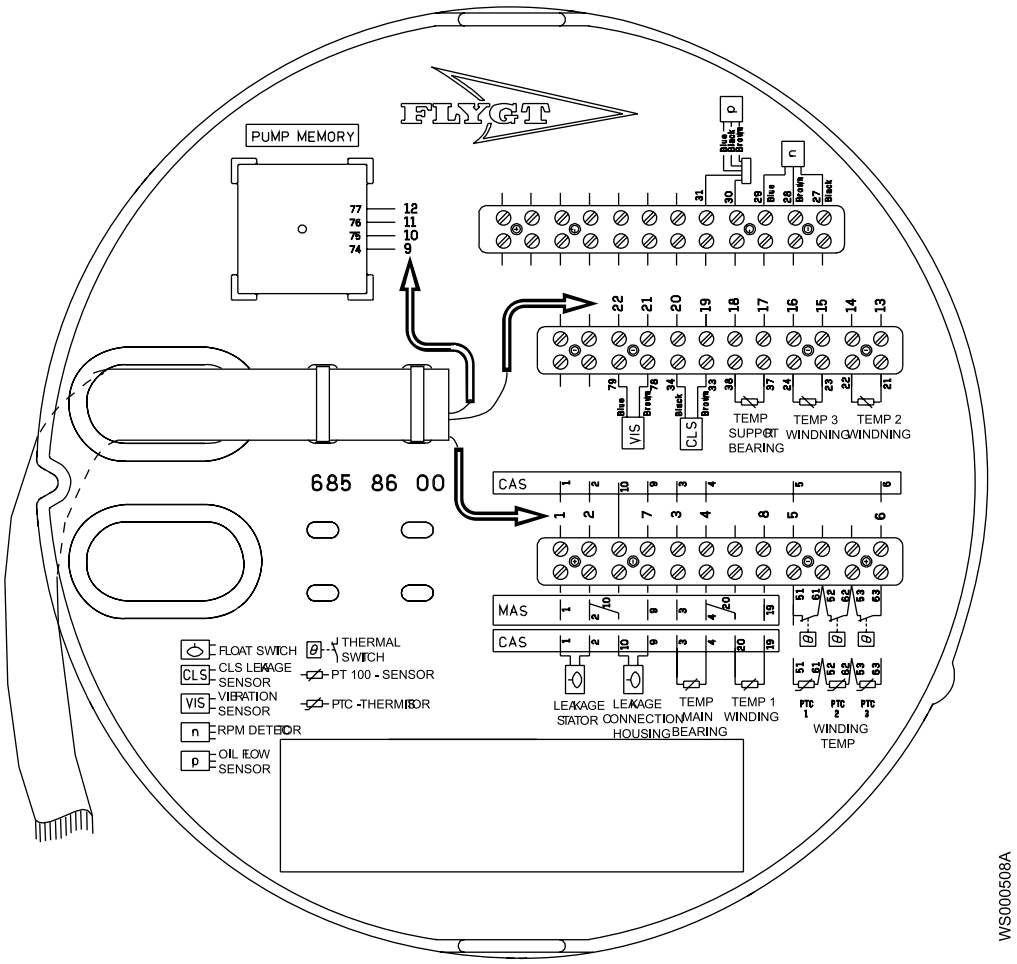


Figure 23: Connections at the product. Arrows indicate SUBCAB cable lead numbers.

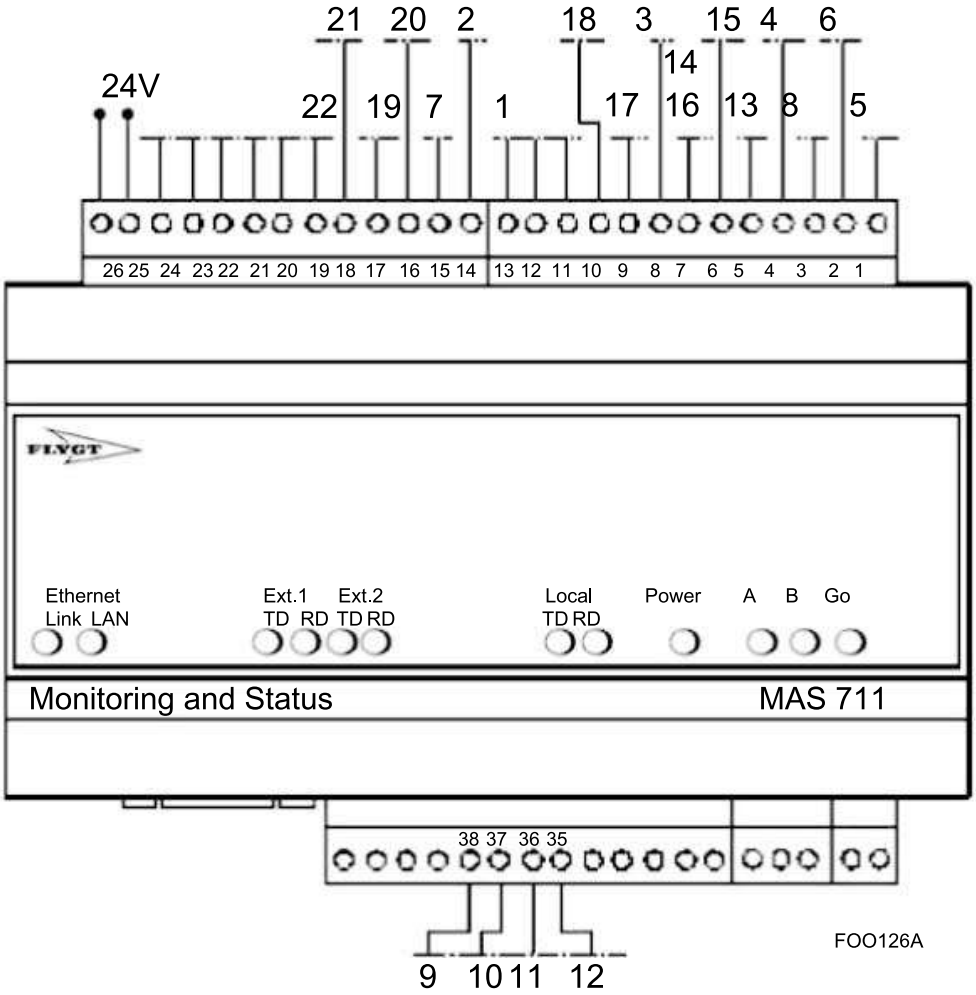


Figure 24: Connections at the MAS 711 base unit

This table shows how the conductors are connected to the different sensors.

Sensor		Terminal block	Conductor number for 12-lead cable	Conductor for 24-lead cable
Float switch in the stator house[3]		1	1	1
		2	2	2
Float switch in the junction box		9	7	7
		2	–	–
Pt100 in the main bearing[4]		3	3	3
		4	4	4
Pt100 in the support bearing		37	–	17
		38	–	18
Thermal switches or thermistors in the stator		5	5	5
		6	6	6
CLS sensor in the oil housing	+	33	–	19
	–	34	–	20

3 The leakage sensor in the stator housing and the leakage sensor in the junction box use the same terminal (terminal 2) on the terminal block.

4 The Pt100 sensors in the main bearing and the support bearing use the same terminal (terminal 4) on the terminal block.

Sensor		Terminal block	Conductor number for 12-lead cable	Conductor for 24-lead cable
Pt100 in the stator winding 1		19	8	8
		4	–	–
Pt100 in the stator winding 2		21	–	13
		22	–	14
Pt100 in the stator winding 3		23	–	15
		24	–	16
Memory module RS-485 B		74	9	9
Memory module RS-485 A		75	10	10
Memory module supply, ground (earth)		76	11	11
Memory module supply, 12 VDC+		77	12	12
Vibration sensor VIS 10	+	78	–	21
	–	79	–	22

4.5.7 Power cable phase sequence

In the following figure, the triangle marked “L1,” “L2” and “L3” shows the phase sequence.

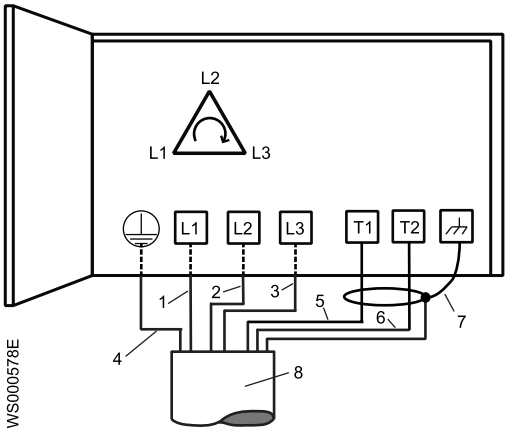
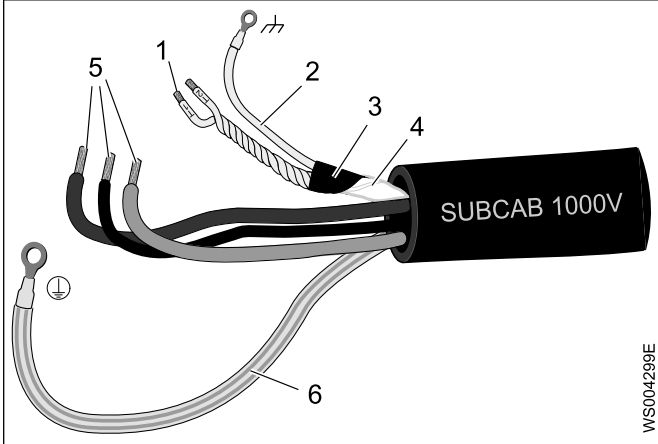
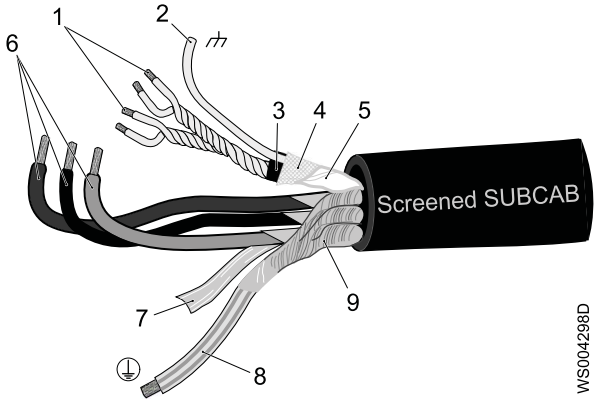


Figure 25: Correct phase sequence

Item	Description	
1	L1 cable lead	Brown
2	L2 cable lead	Black
3	L3 cable lead	Gray
4	Earth PE or ground lead cable	
5	T1 cable lead (control element)	In cables with both power cores and control element. MAS 801: See the SIO manual for T1, T2, and drain wire connections.
6	T2 cable lead (control element)	
7	Screen (drain wire)	
8	Power cable to unit	

4.5.8 Prepare the SUBCAB® cables

This section applies to SUBCAB® cables with twisted-pair control cores.

The prepared SUBCAB® cable	The prepared screened SUBCAB® cable
	
1. T1+T2 twisted pairs in control element 2. Drain wire in control element (bare aluminum wire) 3. Screened aluminum pt-foil 4. Insulation sheath (jacket) or PT-foil for control element 5. Power cores 6. Ground (earth) core	1. T1+T2 and T3+T4 twisted pairs in control element 2. Drain wire in control element (bare aluminum wire) 3. Screened aluminum pt-foil 4. Insulation sheath (jacket) for control element 5. Power cores 6. Aluminum foil 7. Ground (earth) core with green/yellow shrink hose 8. Uncovered screen/braided wire

1. Peel off the outer sheath at the end of the cable.
2. Prepare the control element:
   a) Peel the sheath (if applicable) and the aluminum foil.
      The aluminum foil is a screen and is conductive. Do not peel more than necessary, and remove the peeled foil.

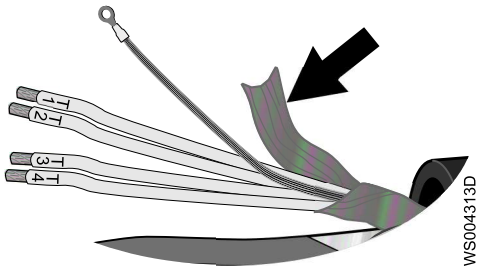


Figure 26: Aluminum foil on control element.

   b) Put a white shrink hose over the drain wire and the cable terminal.
   c) Fit a cable lug on the drain wire.
   d) Twist T1+T2 and T3+T4.
   e) Put a shrink hose over the control element.
      Make sure that the conductive aluminum foil and drain wire is covered.
3. Prepare the ground (earth) core for SUBCAB™ cable:
   a) Peel the yellow-green insulation from the ground (earth) core.
   b) Check that the ground (earth) core is at least 10% longer than the phase cores in the cabinet.
   c) If applicable, put a cable lug on the ground core.
4. Prepare the ground (earth) core for screened SUBCAB™ cable:
   a) Untwist the screens around the power cores.
   b) Put a yellow-green shrink hose over the ground (earth) core.
      Leave a short piece uncovered.
   c) If applicable, put a cable lug on the screened ground core.

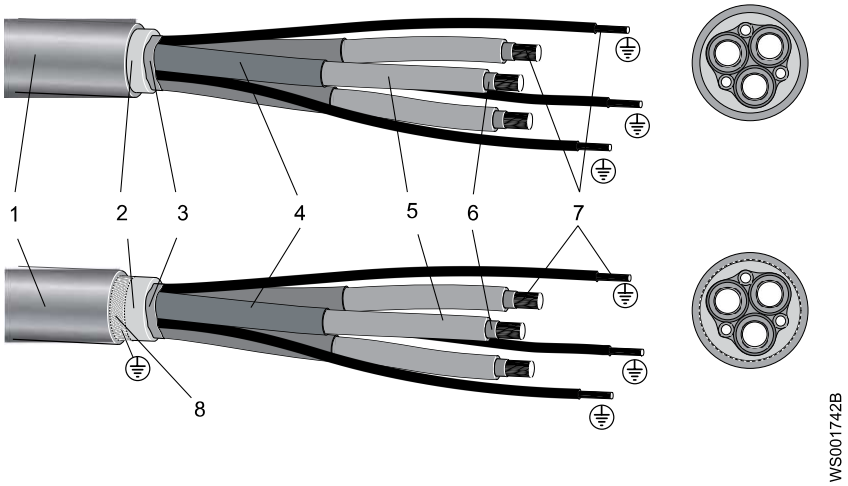
d) Twist all power core screens together to create a ground (earth) core and fit a cable terminal to the end.
e) Check that the ground (earth) core is at least 10% longer than the phase cores in the cabinet.

5. Connect to ground (earth):
   - Screw: Fit cable terminals to the ground (earth) core and the power cores.
   - Terminal block: Leave the core ends as they are.
6. Prepare the main leads:
   a) Remove the aluminum foil around each power core.
   b) Peel the insulation from each power core.

4.5.9 Prepare the medium-voltage cable

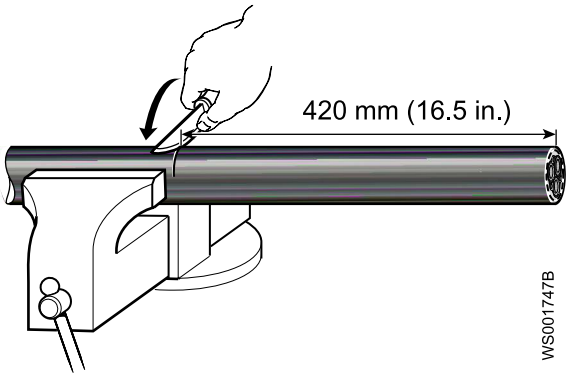
This instruction is for preparing medium voltage (1.2-15 kV) power cables prior to connecting them at the pump.

The upper illustration shows a cable without screen. The lower illustration shows a screened cable.

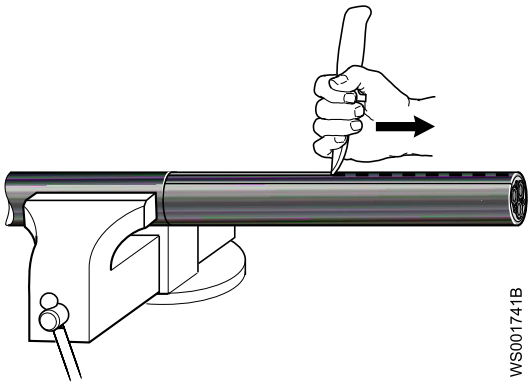


1. Outer cable sheath
2. Inner sheath
3. Conductive foil
4. Conductive layer
5. Conductor insulation
6. Conductive foil
7. Copper conductor
8. Shield wires

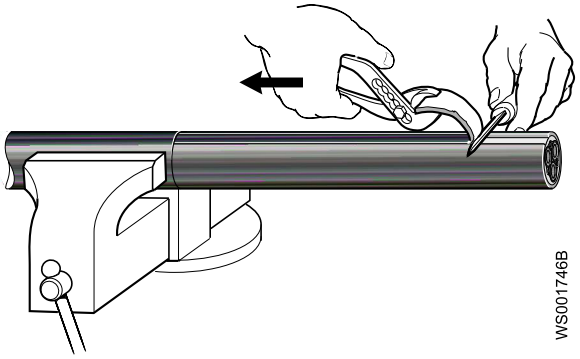
1. Peel off 420 mm of the cable casing at the connection end of the cable.
   a) Make the vertical cut.



   b) Make the horizontal cut.

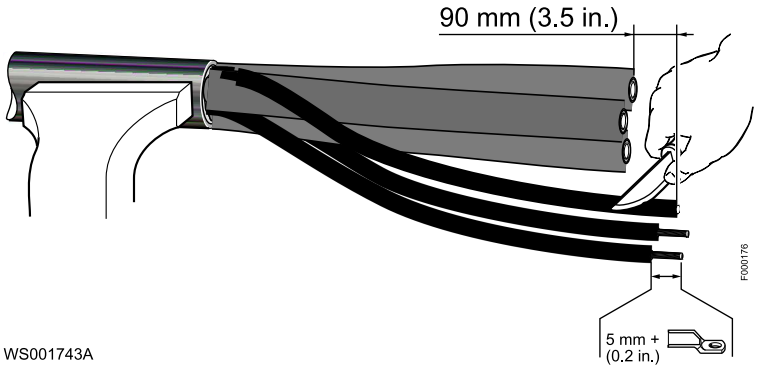


c) Remove the cable casing.

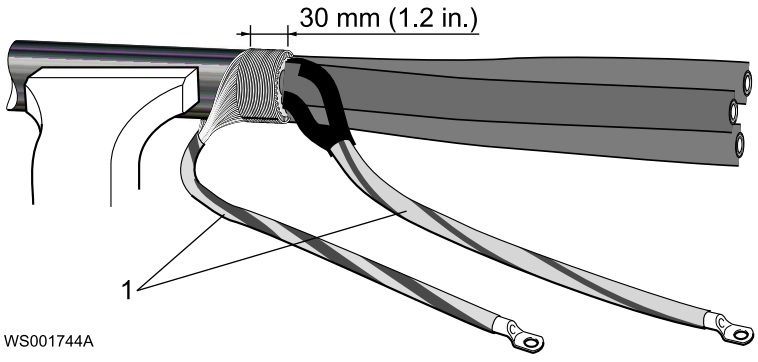


2. Peel off the casing from the leads.

Cable without screen:

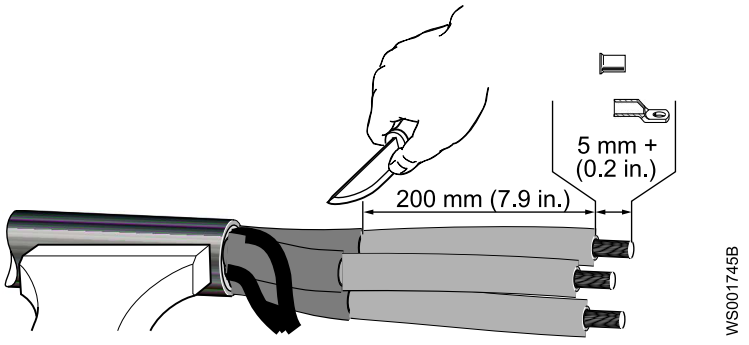


Screened cable:

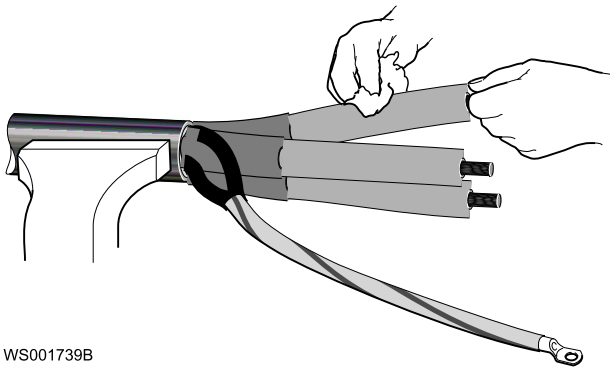


1. Yellow/green insulating hose

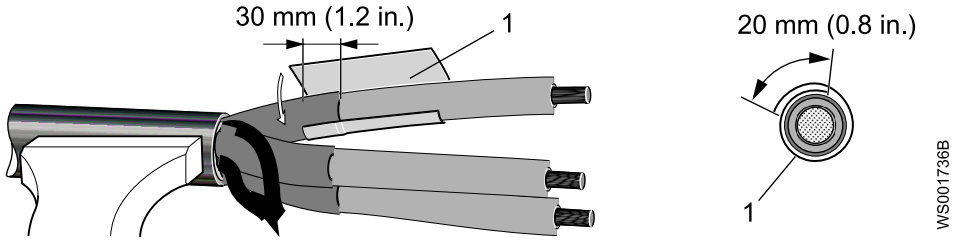
3. Peel off the conductive layer.



4. Clean the power leads with chemically pure petrol.

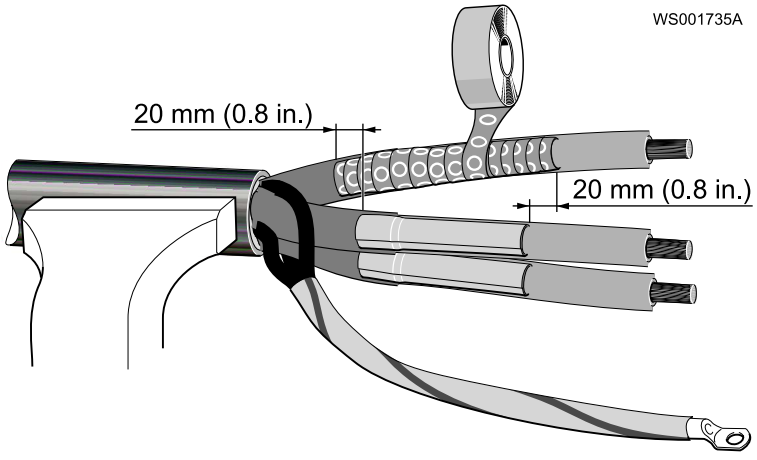


5. Attach the FSD (stress-grading pad) to the leads.

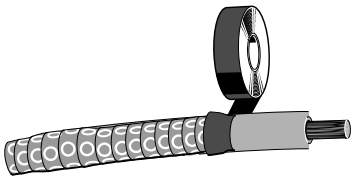


1. FSD, stress-grading pad

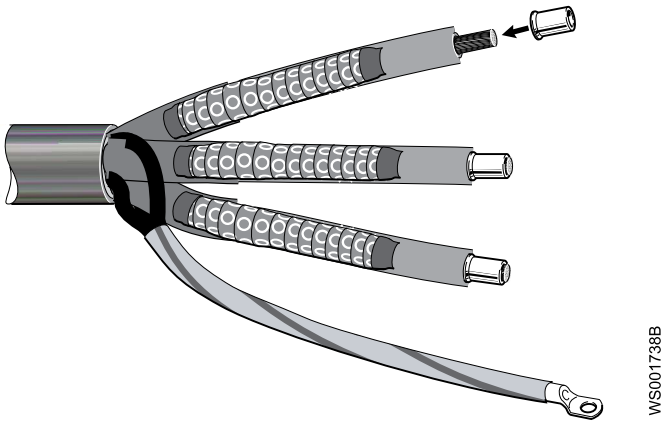
6. Apply four turns of IV (insulating self-bonding) tape with half overlap. Stretch the tape until the markings are circular.



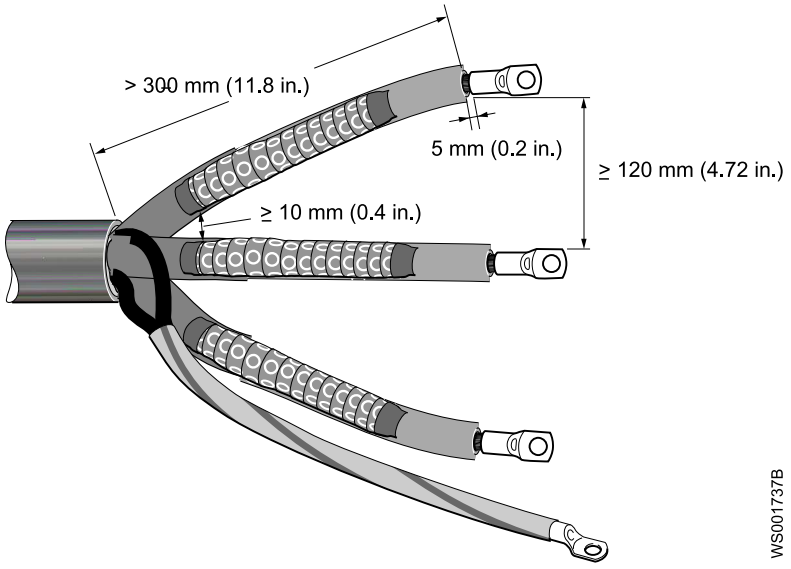
7. Fasten the IV tape ends with electrical tape.



8. Fasten the connection shoes and connection eyes to the leads.



Example of cable end at electrical panel:



Dimensions shown are the recommended distances.

4.6 Cable charts

NOTICE:

Leakage into the electrical parts can cause damaged equipment or a blown fuse. Keep the end of the motor cable dry at all times.

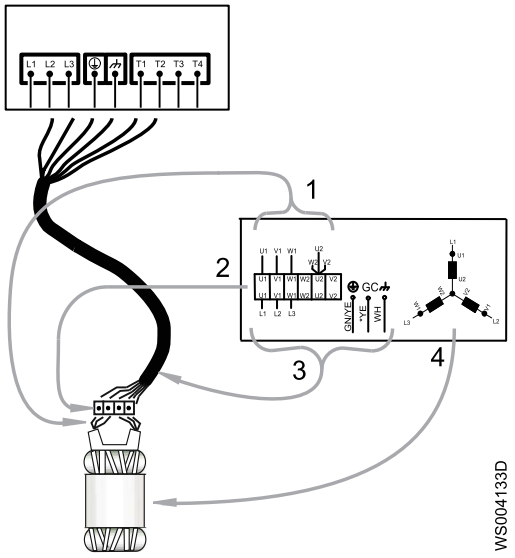
Stator leads connection to terminal board

Terminal board	Stator leads connection to terminal board			
	3 leads Y	6 leads D	6 leads Y	6 leads Y/D
U1	U	U1	U1	U1
V1	V	V1	V1	V1
W1	W	W1	W1	W1
W2	-	W2	W2	W2
U2	-	U2	U2	U2
V2	-	V2	V2	V2

WS007848A

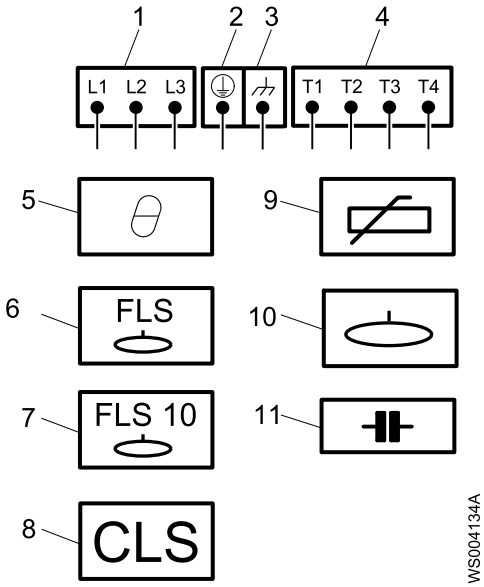
Connection locations

The figures in this section illustrate how to interpret the connection strip symbols.



WS004133D

1. Stator leads
2. Terminal board
3. Power cable leads
4. Stator (internal connection illustrated)



WS004134A

1. Starter equipment and mains leads (L1, L2, L3)
2. ground (earth)
3. Functional ground
4. Control leads (T1, T2, T3, T4)
5. Thermal contact
6. FLS
7. FLS 10
8. CLS
9. Thermistor
10. Level sensor
11. Capacitor

3-phase connection, screened

If a separate control cable is used, then the control cores in the power cable are never used.

The following figure shows screened SUBCAB cable without a separate ground conductor. The ground conductor is made of stranded ground cores. T1 and T2 are twisted together.

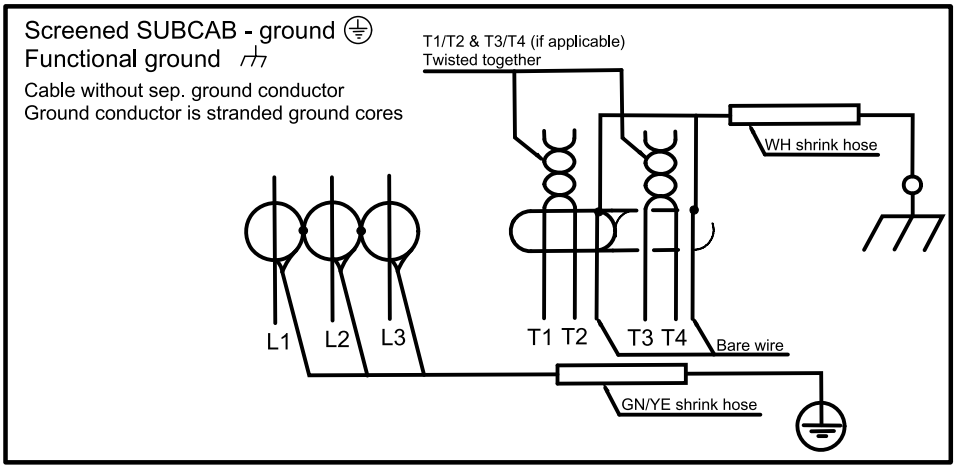


Figure 27: Without separate ground conductor

The following figure shows screened SUBCAB with a functional ground. T1 and T2 are twisted together.

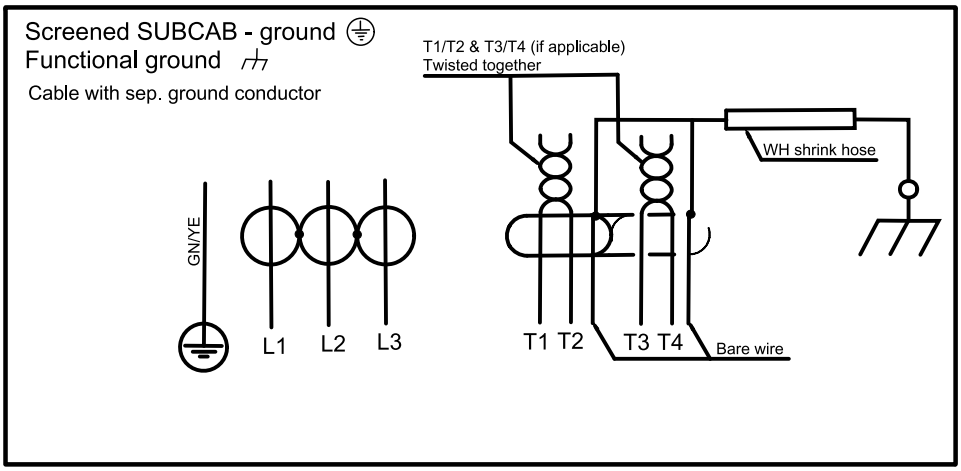


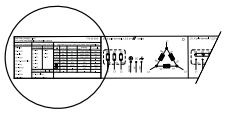
Figure 28: With functional ground

4.6.1 Colors and markings of leads

MOTOR CONNECTION
COLORS AND MARKING OF MAIN LEADS

773 30 00 (REV 4)

COLOR STANDARD	STATOR LEAD COLORS		MOTOR CABLE LEAD COLORS AND MARKING				
	LV Stators	MV Stators	3 ~	SUBCAB	SUBCAB AWG	SUBCAB S6x95+95+S(4x0.5)	MV cables
BK - Black	U1 - RD	U - BK	L1	BN	RD	1 WH , 4 WH	BK
BN - Brown	U2 - GN	V - BK	L2	BK	BK	2 WH , 5 WH	BK
BU - Blue	V1 - BN	W - BK	L3	GY	WH	3 WH , 6 WH	BK
GN - Green	V2 - BU		T1, T2	WH	WH	WH	-
GN/YE - Green/Yellow	W1 - YE		T3, T4	WH	WH	WH	-
GY - Grey	W2 - BK		⏚	GN/YE	GN/YE	GN/YE	GN/YE
OG - Orange			⏚	WH	-	WH	WH
RD - Red	VOLTAGE DENOMINATIONS		GC	-	YE	-	-
WH - White	LV - Low voltage						
YE - Yellow	MV - Medium voltage						



WS004335C

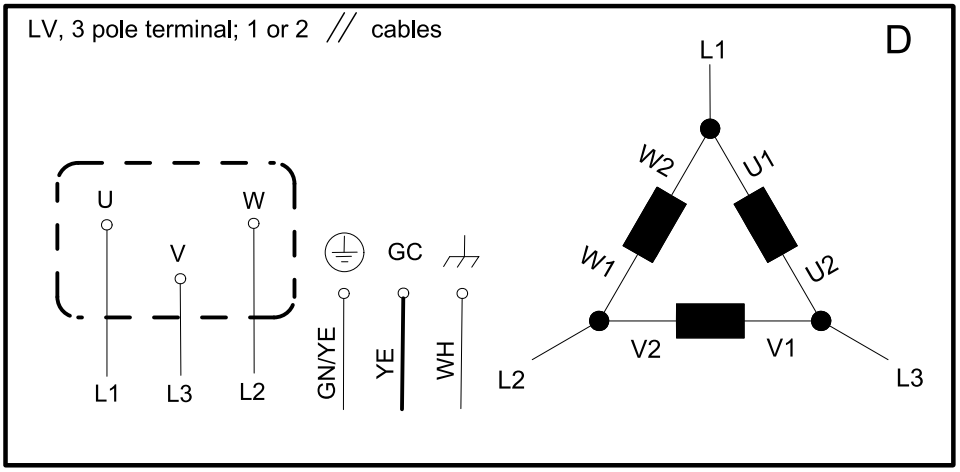
Color code standard

Code	Description
BN	Brown
BK	Black
WH	White
OG	Orange
GN	Green
GNYE	Green-Yellow
RD	Red
GY	Grey
BU	Blue
YE	Yellow

4.6.2 Power wiring diagrams: Drive units up to 1.1 kV

4.6.2.1 D-connection, 3-pole terminal

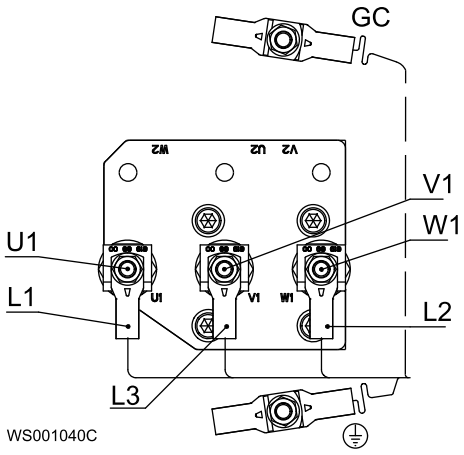
Schematic diagram



Drive units with small connection housing

Drive units:

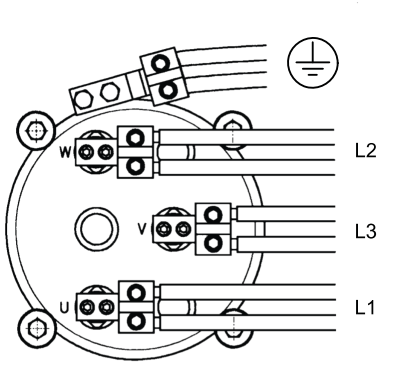
- 605/615, 665/675
- 705/715, 735/745, 765/775 with small connection housing
- 706/716, 736/746, 766/776 with small connection housing



Drive units with large connection housing

Drive units:

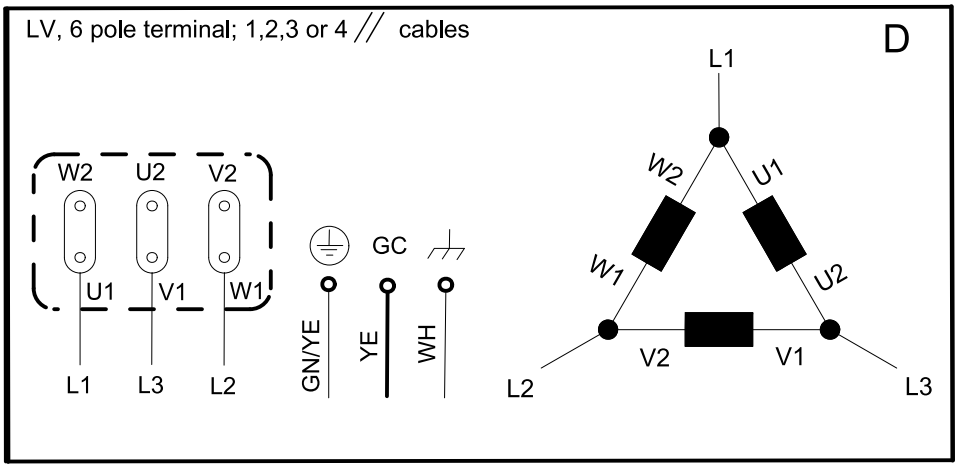
- 705/715, 735/745, 765/775 with large connection housing
- 706/716, 736/746, 766/776 with large connection housing
- 805/815, 835/845, 865/875
- 806/816, 836/846, 866/876
- 905/915, 935/945
- 906/916, 936/946



WS008999B

4.6.2.2 D-connection, 6-pole terminal; 1 cable

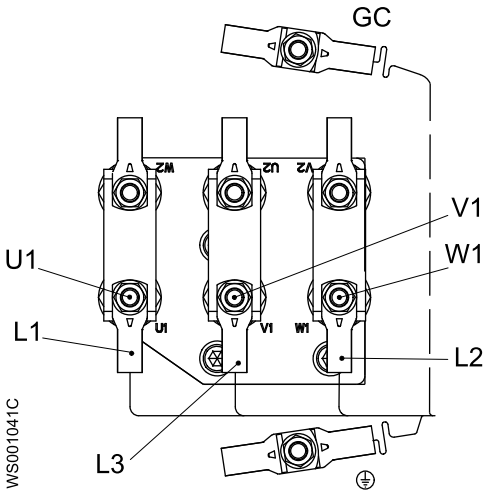
Schematic diagram



WS003911B

Drive units:

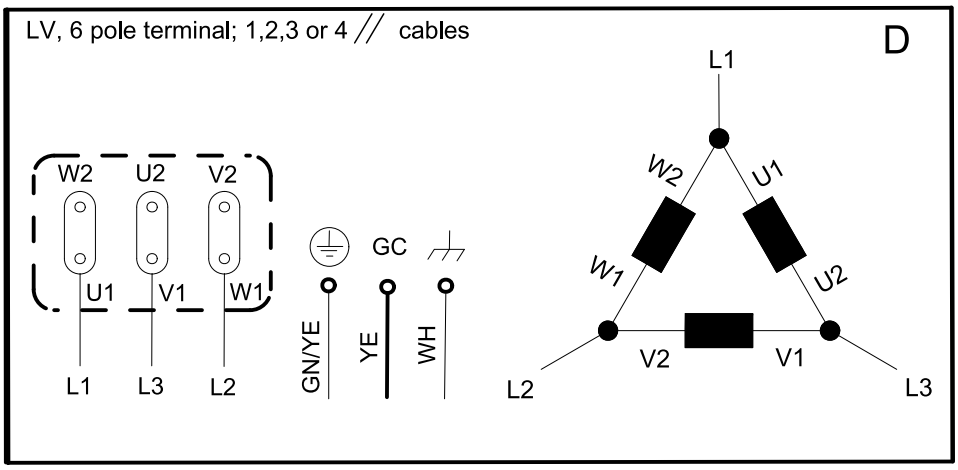
- 605/615, 665/675
- 705/715, 735/745, 765/775 with small connection housing
- 706/716, 736/746, 766/776 with small connection housing



WS001041C

4.6.2.3 D-connection, 6-pole terminal; 2 cables

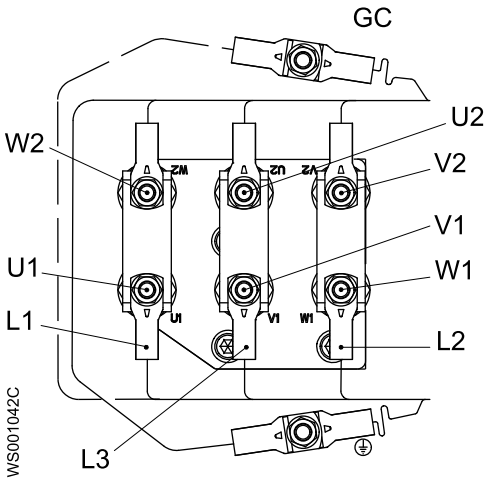
Schematic diagram



Drive units with small connection housing

Drive units:

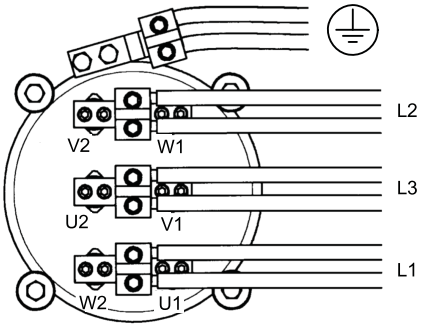
- 605/615, 665/675
- 705/715, 735/745, 765/775 with small connection housing
- 706/716, 736/746, 766/776 with small connection housing



Drive units with large connection housing

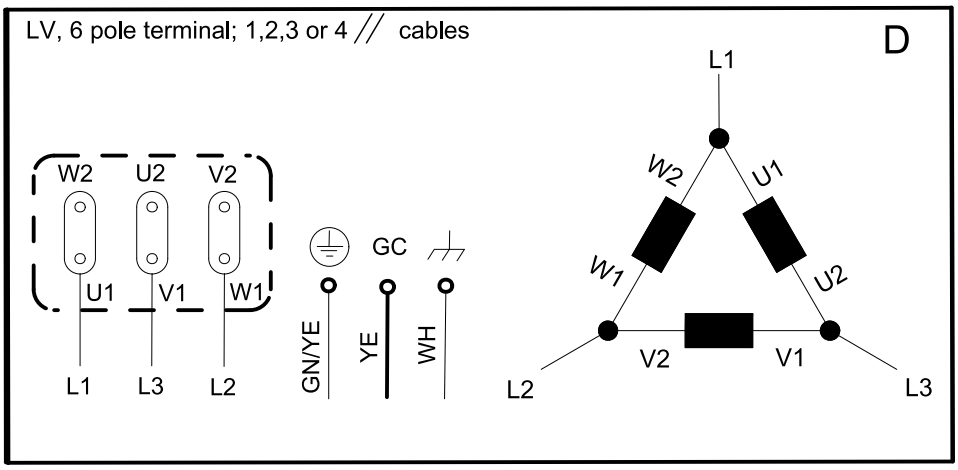
Drive units:

- 705/715, 735/745, 765/775 with large connection housing
- 706/716, 736/746, 766/776 with large connection housing
- 805/815, 835/845, 865/875, 885/895
- 806/816, 836/846, 866/876, 886/896
- 905/915, 935/945
- 906/916, 936/946



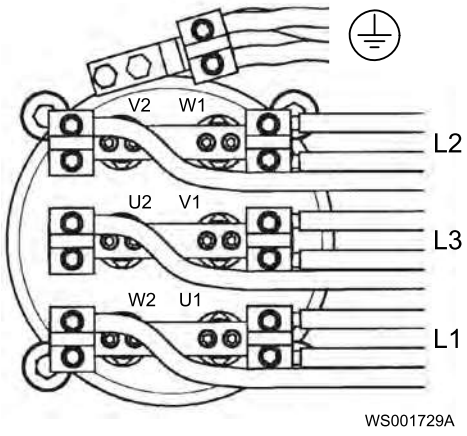
4.6.2.4 D-connection, 6-pole terminal; 3 cables

Schematic diagram



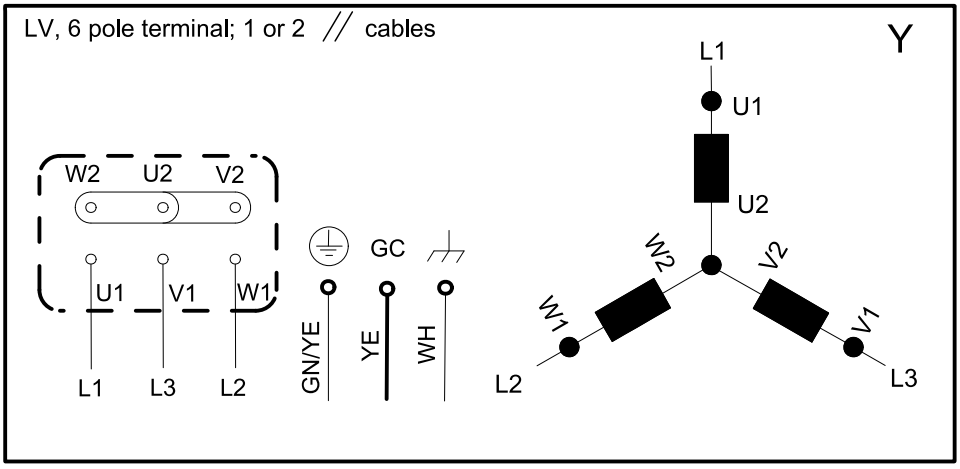
Drive units:

- 705/715, 735/745, 765/775 with large connection housing
- 805/815, 835/845, 865/875, 885/895
- 806/816, 836/846, 866/876, 886/896
- 905/915, 935/945
- 906/916, 936/946



4.6.2.5 Y-connection

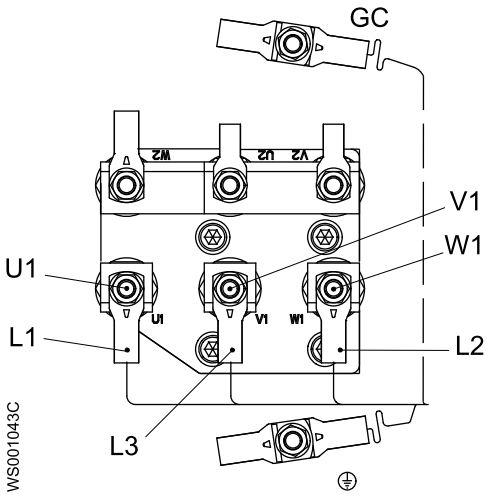
Schematic diagram



Drive units with small connection housing: 1 cable

Drive units:

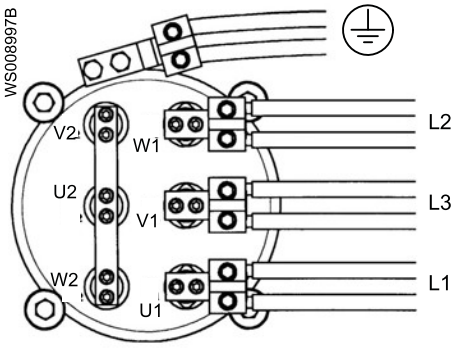
- 605/615, 665/675
- 705/715, 735/745, 765/775 with small connection housing
- 706/716, 736/746, 766/776 with small connection housing



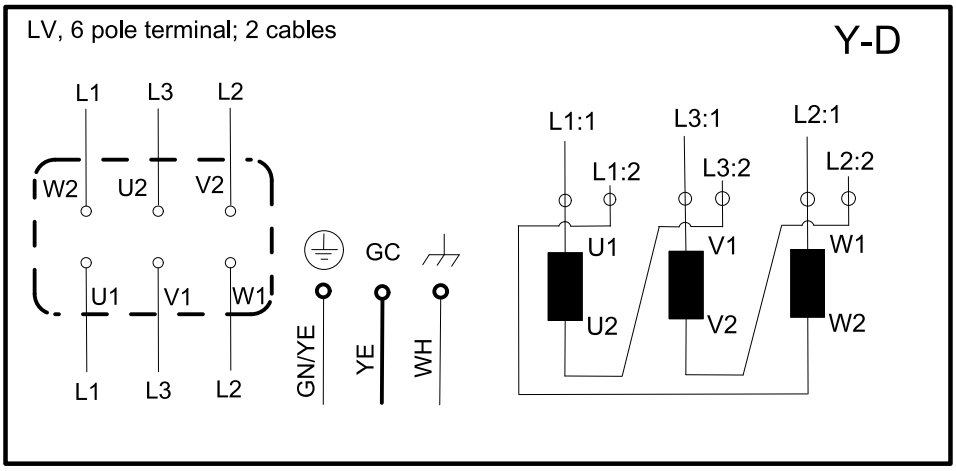
Drive units with large connection housing: 2 cables

Drive units:

- 705/715, 735/745, 765/775 with large connection housing
- 706/716, 736/746, 766/776 with large connection housing
- 805/815, 835/845, 865/875, 885/895
- 806/816, 836/846, 866/876, 886/896
- 905/915, 935/945
- 906/916, 936/946



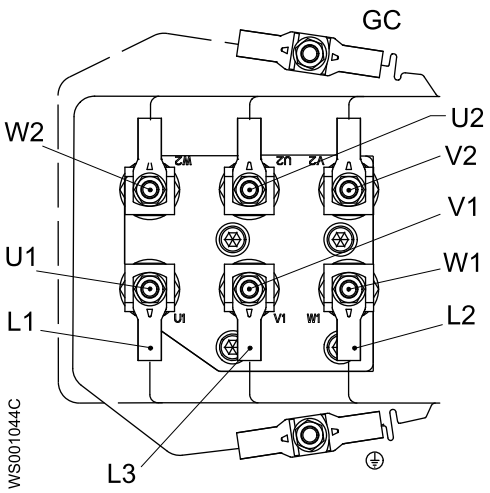
4.6.2.6 Y/D-connection



Drive units with small connection housing

Drive units:

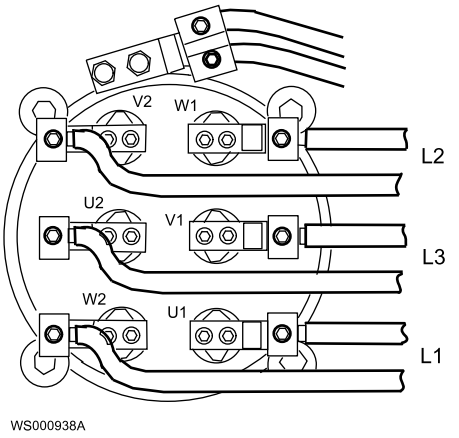
- 605/615, 665/675
- 705/715, 735/745, 765/775 with small connection housing
- 706/716, 736/746, 766/776 with small connection housing



Drive units with large connection housing

Drive units:

- 705/715, 735/745, 765/775 with large connection housing
- 706/716, 736/746, 766/776 with large connection housing
- 805/815, 835/845, 865/875, 885/895
- 806/816, 836/846, 866/876, 886/896
- 905/915, 935/945
- 906/916, 936/946



4.6.3 Power wiring diagram: Drive units 1.2–6.6 kV

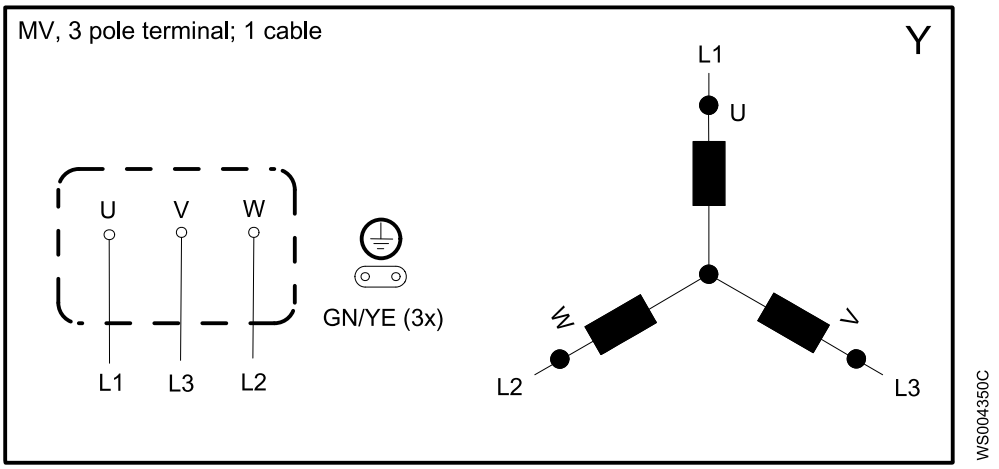
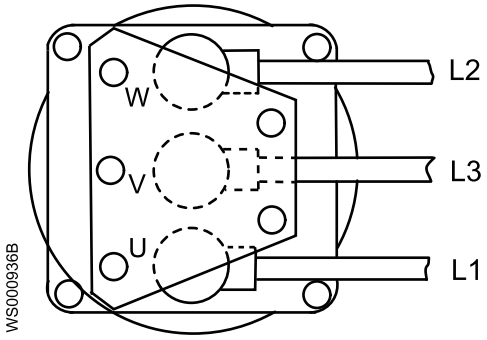


Figure 29: Wiring diagram for medium-voltage (1.2–6.6 kV) drive units

Medium-voltage drive units:

- 862/872, 882/892
- 863/873, 883/893



4.7 Check the impeller rotation

CAUTION: Crush Hazard

The starting jerk can be powerful. Make sure nobody is close to the unit when it is started.

If the propeller rotates in the wrong direction, then the pump lifts up and rotates, which can damage the cables.

1. Start the motor.
2. Stop the motor after a few seconds.
3. Check the propeller rotation.

   The correct direction of propeller rotation is clockwise when you look at the pump from above.

   Direction of propeller rotation. Generic pump shown.

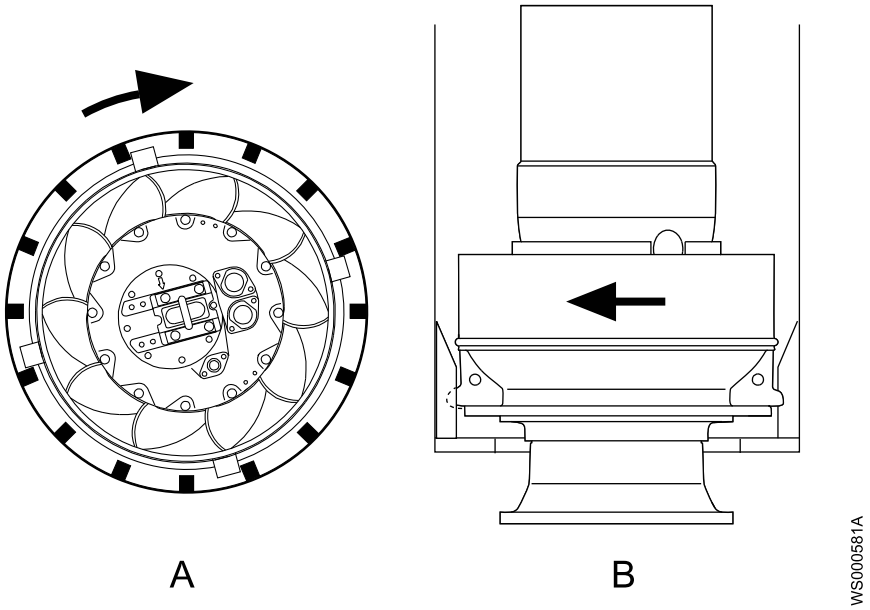


Figure 30: Top view (A) and side view (B)

4. If the impeller/propeller rotates in the wrong direction, then check that the phase leads are correctly connected. See *Power cable phase sequence* on page 58.

   After reconnecting phase leads, do this procedure again.

5 Operation

5.1 Precautions

Before taking the unit into operation, check the following:

- All recommended safety devices are installed.
- The cable and cable entry have not been damaged.
- All debris and waste material has been removed.

NOTICE:

Never operate the pump with the discharge line blocked, or the discharge valve closed.

WARNING: Crush Hazard

Risk of automatic restart.

Distance to wet areas

WARNING: Electrical Hazard

Risk of electrical shock or burn. You must connect an additional ground- (earth-) fault protection device to the grounded (earthed) connectors if persons are likely to come into contact with liquids that are also in contact with the pump or pumped liquid.

CAUTION: Electrical Hazard

Risk of electrical shock or burn. The equipment manufacturer has not evaluated this unit for use in swimming pools. If used in connection with swimming pools then special safety regulations apply.

Noise level

NOTICE:

The sound power level of the product is lower than 70 dB(A). However, in some installations the resulting sound pressure level may exceed 70 dB(A) at certain operating points on the performance curve. Make sure that you understand the noise level requirements in the environment where the product is installed. Failure to do so may result in hearing loss or violation of local laws.

5.2 Estimate zinc anode replacement intervals

The mass and surface area of the zinc anodes are designed to protect the pump surface for 1 year in sea water with an average temperature of 20°C (68°F). Shorter inspection intervals and anode replacement can be required, depending upon the water temperature and the chemical composition as well as the presence of other metals in the vicinity of the pump.

The rate of zinc consumption, and the appropriate inspection intervals, can be estimated by measuring how much zinc is consumed during the first two months following installation.

Anodes are replaced when the anode mass is reduced to a selected fraction of its initial mass. The recommended interval for the selection fraction is 0.25–0.50 (25–50%).

1. Remove, weigh, and reinstall one or more of the exterior zinc anodes before starting up the pump.
2. After two months, remove and weigh the same zinc anode or anodes again.

3. Divide the lapsed time in days (between steps 1 and 2) by the anode weight loss in grams to get the calculated anode consumption rate (days/gram).

   If multiple anodes were weighed, then use the anode which has lost the most weight for this calculation.
4. Calculate future replacement intervals so that they occur when the selected fraction of zinc is remaining.

5.3 Start the pump

CAUTION: Crush Hazard

The starting jerk can be powerful. Make sure nobody is close to the unit when it is started.

1. Check that:
   a) The monitoring equipment works.
   b) The starter equipment is installed according to the instructions from the manufacturer.
   c) All the alarms function.
   d) The lubricant is at the correct level.
2. Remove the fuses or open the circuit breaker, and check that the impeller can be rotated freely.

WARNING: Crush Hazard

Never put your hand into the pump housing.

   Make sure that the locking device has been removed. See *The locking device* on page 35.

   Make sure that the propeller rotates in the correct direction. See *Check the impeller rotation* on page 72.
3. Conduct insulation test phase to ground. To pass, value must exceed 5 megohms. See *Checking insulation and sensors* on page 79.
4. Start the pump.

Check that:

- The machine works without noise or vibration.
- All electrical values are correct.
- All accessories work correctly.

Record any abnormalities.

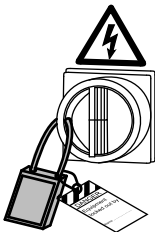
6 Maintenance

6.1 Precautions

Before starting work, make sure that the safety instructions in the chapter *Introduction and Safety* on page 4 have been read and understood.

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.



WARNING: Biological Hazard

Infection risk. Rinse the unit thoroughly with clean water before working on it.

CAUTION: Thermal Hazard

Allow surfaces to cool before starting work, or wear heat-protective clothing.

The following requirements apply:

- Make sure that all safety guards are in place and secure.
- Make sure that equipment is in place so that the unit cannot roll or fall over during the maintenance process.
- Make sure that you have a clear path of retreat.
- Never work alone.
- Check the explosion risk before you weld or use electrical hand tools.
- Before starting work, make sure that the work area is well-ventilated.
- Do not open any vent or drain valves or remove any plugs while the system is pressurized. Make sure that the pump is isolated from the system and that pressure is relieved before you disassemble the pump, remove plugs, or disconnect piping.
- Depressurize and empty the coolant system for T and Z installations, and all installations with external cooling.

Ground continuity verification

A ground (earth) continuity test must always be performed after service.

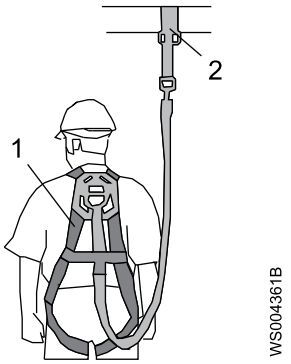
6.1.1 Falling

CAUTION: Fall Hazard

Slips and falls can cause severe injuries. Watch your step.

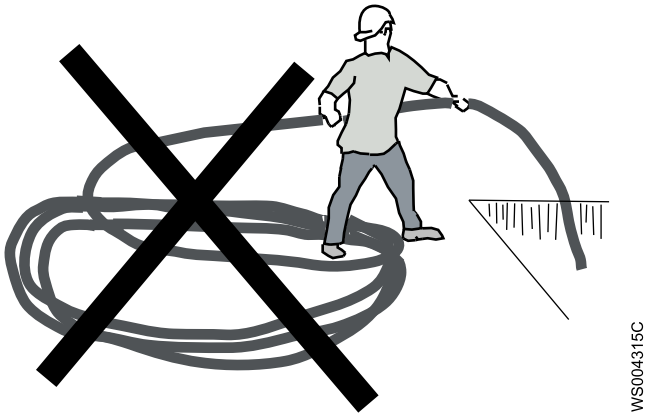
To minimize the risk of falling, observe the following:

- Use appropriate personal protection equipment when working in or near open basins, shafts, or trenches.



1. Fall protection harness
2. Anchoring point

- Make sure that all safety guards are in place and secure, and that there is a suitable barrier around the work area.
- Wear clean slip-resistant shoes.
- Make sure that any ladders or climbing equipment that is used is correctly sized and in good working condition.
- Never stand in coiled cables, ropes or wires, or between them and the open shaft or basin.



6.2 Service

Regular inspection and service of the pump makes sure that operation will be more reliable.

Every time the site is visited, visually examine the accessories and sump for corrosion, wear or damage.

Table 23: Service intervals

Type of service	Purpose	Interval
Initial inspection	To make a check up of the pump condition by an authorized Xylem service representative and, based on the result and findings from these measures, to determine the intervals for periodical inspection and major overhaul for the specific installation.	In the first year of operation.

Type of service	Purpose	Interval
Periodical inspection	To prevent operational interruptions and machine breakdown. Measures to secure performance and efficiency are defined and decided for each individual application. It can include such things as impeller trimming, wear part control and replacement, control of zinc-anodes and control of the stator.	12,000 hours or 3 years, whichever comes first. Applies to normal applications and operating conditions at media (liquid) temperatures < 40°C (104°F).
Major overhaul	To secure a long operating lifetime for the product. It includes the replacement of key components and the measures that are taken during an inspection.	24,000 hours or 6 years, whichever comes first. Applies to normal applications and operating conditions at media (liquid) temperatures < 40°C (104°F).

NOTICE:

Shorter intervals may be required when the operating conditions are extreme, for example with very abrasive or corrosive applications or when the liquid temperatures exceed 40°C (104°F).

6.2.1 Inspection

CAUTION: Compressed Gas Hazard

Air inside may cause parts or liquid to be propelled with force. Be careful when opening.

Regular inspection and service of the pump makes sure that the operation is more reliable.

For seal lubricant information, see *Lubricants used in the drive units* on page 81.

Do the following to service the pump:

Part to service	Action
Pump exterior	Check the entire pump and the cables for external mechanical damage.
Cable	1. If the outer jacket is damaged, replace the cable. 2. Check that the cables do not have any sharp bends and are not pinched. 3. Check that the leads and cable entry screws are correctly connected and tightened to the correct torque.
Lifting handle	Check the lifting handle for corrosion or other damage.
Junction box	1. General: Check that it is clean and dry. If it is wet: a. Check the cable entry. b. Replace the O-rings. Fit new O-rings to all O-ring seal joints which are opened during inspection. 2. Terminal board: Check that the connections are properly secured.
Junction box insulation: Drive units up to 1.1 kV	Check the condition and function. See *Check the insulation, up to 1 kV drives or generators* on page 80.

Part to service	Action
Junction box insulation: Drive units 1.2–6.6 kV	Check the condition and function. See *Check the insulation, 1.2–6.6 kV drives* on page 80.
Stator housing Drive units with oil as the seal lubricant.	1. Check that it is clean and dry. – If there is oil in the stator housing, then drain and clean it. Check the stator housing again after one week of operation. If there is still oil in the stator housing, then change the seals. – If there is water in the stator housing and there was water in the oil, change the seals immediately. – If there is water in the stator housing, but there was no water in the oil, check all other connections. 2. Replace the O-rings.
Oil housing Drive units with oil as the seal lubricant	1. Check the oil quality: – If there is water in the oil, then drain the oil and replace with new oil. After one week of operation, check the oil quality again. – If the oil is free from water, then fill the oil to the correct level, if necessary. 2. Replace the filling plug O-rings.
Hydraulic parts	1. Check the general condition of the impeller or propeller and the wear ring. 2. Replace if necessary. 3. If applicable, check O-ring.
Zinc anodes	Check and change if necessary.
Screw joints	Check all externally accessible screw joints, and tighten if necessary to the correct torque. See *Torque values* on page 91.
Electrical cabinets	Check that it is clean and dry.
Connection to power	Check that the connections are properly secured.
Level regulators	Check the condition and function. See *Check the leakage detectors* on page 80.
Temperature sensors	Check the condition and function. See *Check the temperature sensors* on page 80.

After any service involving the power connections, you must check the rotation before operating the pump. See *Check the impeller rotation* on page 72.

6.2.2 Major overhaul

1. Perform a complete inspection service. See *Inspection* on page 77.
2. Do these additional steps:

Part to service	Action
Motor: insulation check Drive units up to 1.1 kV	Check that the resistance between earth and phase lead is more than 5 MΩ. Use a 500 VDC or 1000 VDC insulation and continuity tester.
Motor: insulation check 1.2–6.6 kV drive units	1. Check that the resistance between earth and phase lead is more than the minimum for the motor voltage. Recommended test voltage: 2500 VDC The resistance value is related to the motor voltage and must have minimum value of 5 MΩ/kV at a temperature of 25°C (77°F). For example, for a 6 kV motor the resistance between earth and phase lead must be more than 30 MΩ.
Cable	Check that the rubber sheathing is undamaged. Change if necessary.
Oil housing	Change the lubricant. For lubricant information, see *Lubricants used in the drive units* on page 81.

Part to service	Action
General dismantling and cleaning	1. Dismantle the pump completely. 2. Clean all the parts. 3. Reassemble after replacing bearings, O-rings, and seals.
Bearings	Replace the bearings with new bearings.
O-rings and other rubber sealing parts	Replace O-rings and other rubber sealing parts.
Seals	Replace with new seals.
Sensors	Check the following: 1. Stator temperature sensors 2. Bearing temperature sensors 3. FLS and CLS sensors See *Check the temperature sensors* on page 80 and *Check the leakage detectors* on page 80.
Impeller or propeller	Check the general impeller or propeller status. Change if necessary. Check general wear ring status. Change if necessary.
Zinc anodes	Check their condition. Replace if necessary.
Screw joints	Check all externally accessible screw joints and tighten if necessary to the correct torque. See torque table and Parts List.
Lifting handle	Check its condition. Replace if necessary.
Painting	Touch up any painting if necessary.
Rotational direction	Check the impeller or propeller rotation direction. See *Check the impeller rotation* on page 72.
Voltage and amperage	Check the running values.
Electrical cabinets or panels	Check that it is clean and dry.
Connection to power	Check the cable connections. Tighten if necessary.
Overload protection and other protections	Check the correct settings.
Level regulators	Check condition and function.

After any service involving the power connections, check the rotation before operating the pump. See *Check the impeller rotation* on page 72.

6.2.3 Checking insulation and sensors

It is important that the checks for motor insulation, temperature sensors and leakages sensors are performed correctly and using appropriate tools. Parts of the unit, for example temperature sensors or the PEM, can be damaged if a megger or other device is used to apply a voltage higher than 2.5 V.

Use the following table to choose the appropriate procedures.

Item	Section
Motor insulation, drive units or generators up to 1 kV	*Check the insulation, up to 1 kV drives or generators* on page 80
Motor insulation, drive units or generators 1.2–6.6 kV	*Check the insulation, 1.2–6.6 kV drives* on page 80
Thermal contacts	*Check the temperature sensors* on page 80
PTC thermistors	
Pt100	
FLS leakage detector	*Check the leakage detectors* on page 80
CLS leakage detector	

6.3 Check the insulation, up to 1 kV drives or generators

1. Check that the resistance between earth and phase lead is more than 5 MΩ.

   Use a 500 VDC or 1000 VDC megger.
2. Keep a record of the results.

6.4 Check the insulation, 1.2–6.6 kV drives

1. Check that the resistance between earth and phase lead is above the minimum for the motor voltage.

Motor rating	Recommended test voltage
1.0 – 2.5 kV AC	1.0 – 2.5 kV DC
2.5 – 6.6 kV AC	2.5 – 5 kV DC

   The resistance value is related to the motor voltage and should have minimum value of 5 MΩ/kV at a temperature of 25°C (77°F).

   For example, for a 6 kV motor the resistance between earth and phase lead should be more than 30 MΩ.
2. Keep a record of the results.

6.5 Check the temperature sensors

If the unit is connected to the MAS monitoring system, then it is recommended that the sensors be checked in the MAS unit. Otherwise, use a multimeter.

The different types of temperature sensors are:

- Thermal switches
- PTC thermistors
- Pt100

NOTICE:

Do not use a megger or other device applying a higher voltage than 2.5 V.

1. Disconnect the sensor wires.
2. Check the status of the sensor and wiring by measuring the resistance according to the values in *Product Description* on page 18.
3. Measure between each sensor lead and ground (earth) to establish that the resistance is infinite (or at least several megohms).

6.6 Check the leakage detectors

If the unit is connected to the MAS monitoring system, then it is recommended that the sensors be checked in the MAS unit. Otherwise, use a multimeter.

1. Check the float switch (FLS) in the stator housing, according to the values in *Product Description* on page 18.
2. Check the float switch (FLS) in the junction box or connection housing.
3. If the drive unit is equipped with a CLS water-in-oil sensor in the oil housing, then check the CLS by following this procedure.
   a) Connect the CLS to a 12 VDC supply.

      The sensor must have the correct polarity to be checked. However, a switched plus and minus does not damage the sensor.
   b) Use the multimeter as an ammeter and connect it in series with the sensor.
   c) If the sensor is accessible, then check: the alarm function by gripping the sensor with the hand.

Skin tissue and blood contain a high content of water.

For interpretation of the CLS measurement results, see *Product Description* on page 18.

6.6.1 FLS

Table 24: Float switch sensor (FLS)

Description	Measured value	Fault values
The float switches are leakage sensors. The float switches are located in the lower part of the stator housing and in the junction box.	Resistance. 2 sensor variants: FLS: • Normal: 1530 ohm • Alarm: 330 ohm FLS 10: • Normal: 1200 ohm • Alarm: 430 ohm	> 10% (approx.) deviation from rated ohm values indicates sensor fault, or fault in the wiring.

6.7 Lubricants used in the drive units

Drive units	Seal lubricant
605, 615, 665, 675	Oil For instructions about changing the oil, see *Change the oil* on page 81.
705, 715, 735, 745, 765, 775	
706, 716, 736, 746, 766, 776	
805, 815, 835, 845, 865, 875, 885, 895 862, 872, 882, 892	
806, 816, 836, 846, 866, 876, 886, 896 863, 873, 883, 893	
905, 915, 935, 945, 965, 975 950, 960, 985, 995, 988, 998	
906, 916, 936, 946, 966, 976 951, 961, 986, 987, 996, 997	

6.8 Change the oil

To check which pumps use oil as the seal lubricant, see *Lubricants used in the drive units* on page 81.

The pump is delivered with a tasteless, odorless, medical white oil of a paraffin type that fulfills FDA 172.878.

Examples of suitable oil types are the following:

- Statoil MedicWay 32™
- BP Enerpar M 004™
- Shell Ondina 927™
- Shell Ondina X430™

The amount of oil is given in the table. Fill up the oil to the bottom thread.

Table 25:

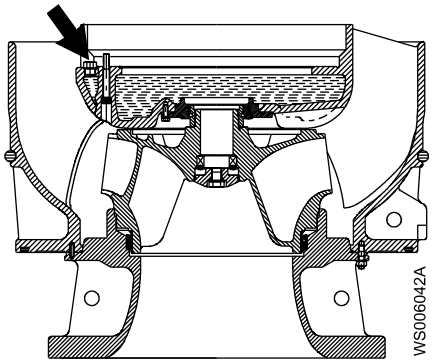
Hydraulic unit	Volume of oil
L3356	19 L (20.1 quarts). If an oil-reduction is necessary, fill up the oil to the bottom thread and then suck out 4 L (4.3 quarts)
L3400	20 L (21.2 quarts)
L3602	25 L (26.4 quarts)

Empty the oil

1. Unscrew the oil plugs.

CAUTION: Compressed Gas Hazard

Air inside the chamber may cause parts or liquid to be propelled with force. Be careful when opening. Allow the chamber to de-pressurize before removal of the plug.



2. Pump out the oil.

   Use the oil drainage pump 83 95 42. Make sure that the plastic tube goes all the way to the bottom of the oil housing.

Fill with oil

1. Fill up with the new oil.
2. Insert and tighten plugs with the new O-rings and plugs.

   Tightening torque: 80 Nm (60 lbf·ft)
3. Check the paint; if damaged, repaint.

6.9 Horizontal lifting

Two sets of lifting equipment must be used to lift the unit for repair work.

If the unit is turned upside-down, so that the hydraulic end is at the top, then use two slings or straps at the hydraulic end. The two slings or straps must be put directly opposite each other, so that the unit can hang between them.

The drive unit must never stand on the shaft unit or the impeller or propeller. Damage to the impeller or propeller, seals, or bearings can result from standing the drive unit on the impeller or propeller or shaft.

Use the following method to lift the unit in the horizontal position.

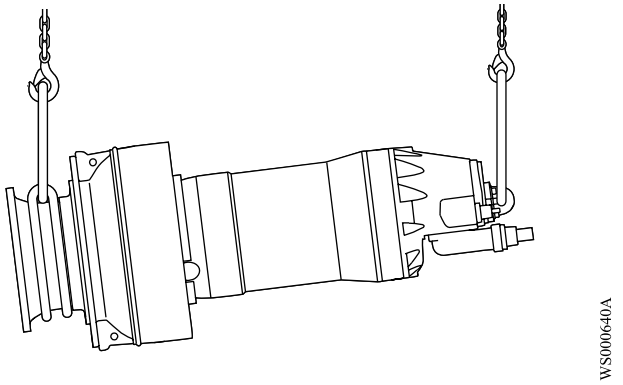


Figure 31: Lift unit for repair work. Generic pump shown.

6.10 Replace the wear parts

When the clearance between the impeller skirt and the pump housing wear ring exceeds 2 mm (0.08 in.) one or more of the following replacements must be made.

6.10.1 Replace the pump housing wear ring

If the wear ring is made of brass this procedure will be easier if the suction cover is first heated, and/or the wear ring is cooled down.

1. Remove the screws that fasten the pump housing to the drive unit.
2. Lift off the drive unit from the pump housing.
3. Lay the drive unit in a horizontal position.

WARNING: Crush Hazard

Make sure that the unit cannot roll or fall over and injure people or damage property.

4. Remove the wear ring by using a crow bar.

5. Drive in the new wear ring.

   To prevent deformation, use a maul and a wooden block.

6.10.2 Replace the impeller wear ring

1. Disconnect and lift off the drive unit with pump housing from the suction cover.
2. Lay the drive unit in a horizontal position.

WARNING: Crush Hazard

Make sure that the unit cannot roll or fall over and injure people or damage property.

3. Knock off the wear ring from the impeller.

If necessary, use a grinder to make grooves in the wear ring.

4. Heat the new wear ring and press it onto the impeller.

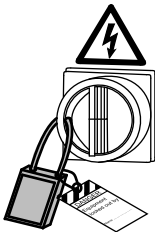
6.11 Replace the impeller

Before you replace the impeller, you must drain the oil in the oil housing. See applicable steps in *Empty the oil* on page 82.

6.11.1 Rotating propeller

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.



6.11.2 Remove the impeller

CAUTION: Cutting Hazard

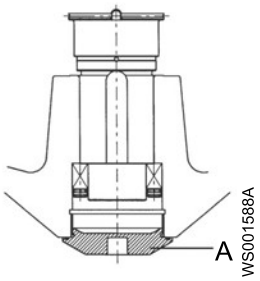
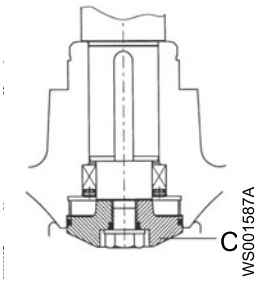
Worn parts can have sharp edges. Wear protective clothing.

1. Do the following.
   a) Disconnect and lift off the drive unit from the pump housing.
   b) Lay the drive unit on its side.

CAUTION: Crush Hazard

Make sure that the unit cannot roll or fall over and injure people or damage property.

2. Depending on which pump model you have, do one of the following:

Pump	Action
L3356	Remove the impeller-sealing washer (A) using the Allen key hole in the washer. (The washer is threaded into the impeller hub.) Use a 19 mm Allen key. 
L3400 or L3602	Remove the impeller screw by inserting the puller screw 576 84 00 in the thread of the impeller-sealing washer (C).  

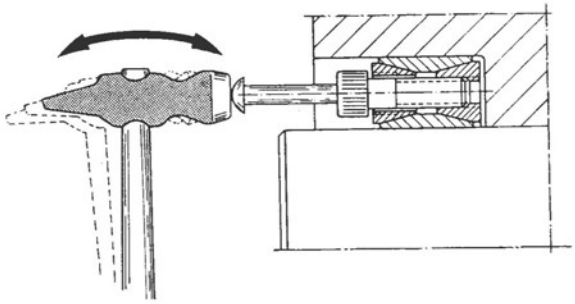
The locking assembly is now accessible for removal.

6.11.3 Remove the locking assembly

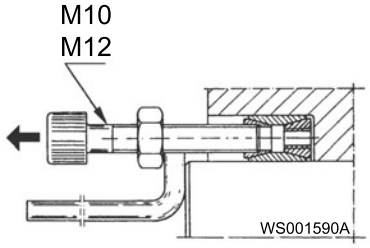
1. Remove the locking assembly:
   a) Loosen the screws on the locking assembly evenly and in sequence.
   See *Sequence for tightening or loosening locking assembly bolts* on page 89.

b) If the locking assembly is still locked, then do as follows:

1. Loosen the inner ring by tapping it lightly, as shown in the illustration.



2. If tapping did not loosen the ring, then replace the three "light-colored" screws with three M10 draw-bolts (for 84 59 12 and 84 59 13) or M12 draw-bolts (for 84 59 14 and 84 59 17).



c) Remove the locking assembly.

2. Pull off the impeller:

a) Fit the tools that are required for impeller removal according to the tool list for the appropriate pump. See *Tools* on page 92.

b) Pull off the impeller.

Use the hydraulic unit with the partially threaded screw in the Basic kits for removal.

6.11.4 Install the impeller

When installing a stainless steel impeller onto a stainless steel shaft, the shaft end should be greased with National Chemsearch THREAD-EZE. Make sure that no grease is on the contact surfaces of the locking assembly.

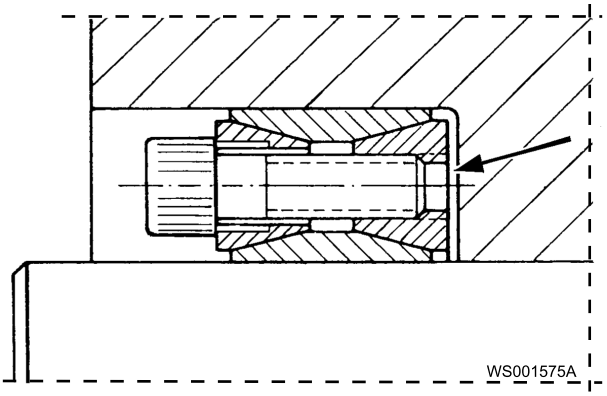
1. Make sure that the end of the shaft is clean and free of burrs.

   Polish off any flaws with fine emery cloth.
2. Grease the end of the shaft and the impeller hub.
3. Place the impeller on the shaft and fit the hydraulic tool with the M16 screw.
4. Use the appropriate washer to press the impeller in place.
5. Remove the hydraulic tool.
6. Go on to *Install the locking assembly* on page 87.

6.11.5 Install the locking assembly

1. Fit the locking assembly in place:
   a) Apply a thin layer of grease at the surface indicated by the arrow in the illustration below.

      Do not use oil containing molybdenum disulphide (MoS_2).



b) Fit the locking assembly (well-oiled) in the impeller hub without tightening any screws.

2. Fit the impeller:

a) Place the washer over the locking assembly.

See *Tools* on page 92 for the washer for the respective pump.

For the correct position, use an Allen key through one of the slots in the washer and into one of the "light-colored" screws in the locking assembly.

b) Fit the impeller screw, or the screw unit (with hydraulic tool if applicable), through the center hole in the washer and into the shaft end.

See *Tools* on page 92 for the screw/screw unit for the respective pump.

c) Tighten the center screw so that the washer keeps the locking assembly and the impeller in place.

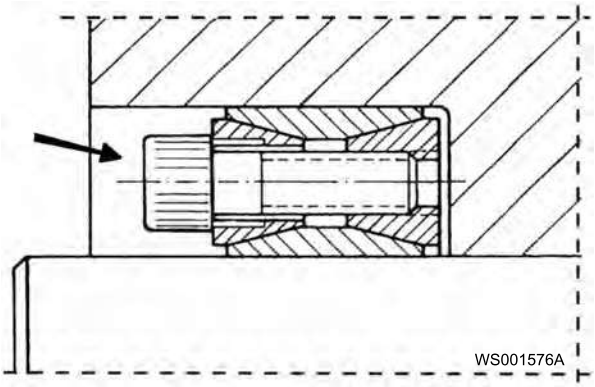
d) When the impeller is firmly seated, slightly tighten the three "light-colored" screws in the locking assembly through the slots in the washer.

This keeps the impeller in place against the shaft shoulder.

e) Remove the center screw and the washer.

3. Tighten the locking assembly screws evenly in three stages, following the sequence and tightening torques that are given in *Sequence for tightening or loosening locking assembly bolts* on page 89.
4. Fill the space with grease, allowing space for the sealing washer.

   The space to be filled with grease is indicated by the arrow in the illustration below.



5. Fit the impeller sealing washer and tighten the impeller screw.

After installing the impeller you must do the following:

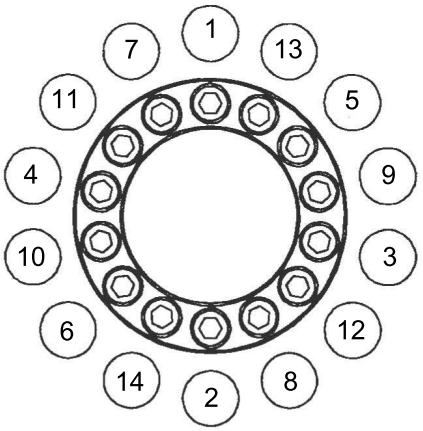
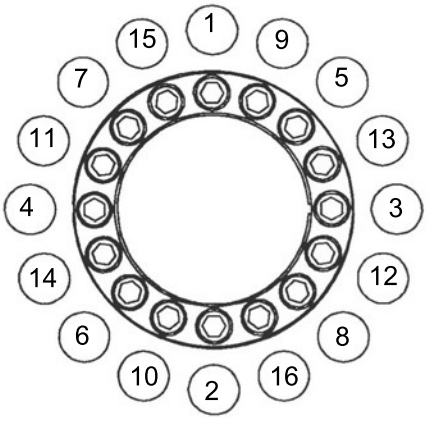
1. Check that the impeller can be rotated by hand.
2. Check the zinc anodes (if applicable) to make sure that they are large enough and intact. Replace after approximately 75% consumption.
3. Fit the drive unit with pump housing to the suction cover. Do not forget the O-ring between pump housing and suction cover.

More extensive repairs require special tools and should be carried out by a service technician authorized by Xylem.

6.11.6 Sequence for tightening or loosening locking assembly bolts

Bolt sequence

The following illustrations show the sequence used for tightening or loosening the impeller locking assembly bolts.

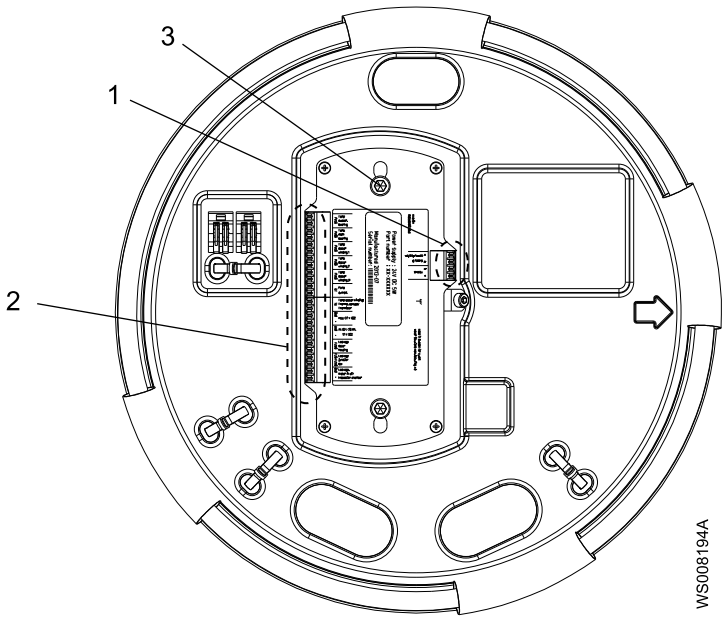
Locking assembly	Sequence for tightening or loosening bolts
84 59 12 84 59 13 84 59 14	
84 59 17	

Tightening torques

The table below gives the torque which should be used in each stage of the bolt-tightening process.

Locking assembly	Torque for tightening bolts
84 59 12 84 59 13	• Stage 1: 12 Nm (8.8 ft-lb) • Stage 2: 24 Nm (18 ft-lb) • Stage 3: 35 Nm (26 ft-lb)
84 59 14	• Stage 1: 24 Nm (18 ft-lb) • Stage 2: 48 Nm (35 ft-lb) • Stage 3: 70 Nm (52 ft-lb)
84 59 17	• Stage 1: 24 Nm (18 ft-lb) • Stage 2: 48 Nm (35 ft-lb) • Stage 3: 70 Nm (52 ft-lb)

6.12 Pumps with MAS 801: Replace the PEM



1. PEM communication terminals
2. PEM control terminals
3. Screws securing PEM

1. Disconnect the communication terminals.
2. Disconnect the control terminals on the PEM.
   For specially-approved pumps, do not disconnect T3 and T4 from the separate plinth.
3. Disconnect the functional ground.
4. Remove the two screws securing the PEM.
5. Lift out the PEM.
6. Fit the new PEM into place. Secure with two screws.
7. Connect the functional ground.
8. Connect the control terminals.
   For specially-approved pumps, do not use connections 51 and 63 on the PEM. For EX-pumps, T3 and T4 must be connected to the separate plinth.
9. Connect the communication terminals.
10. To download information to the PEM, see the System Installation and Operation (SIO) Manual for the MAS 801 monitoring equipment.

6.13 Torque values

All screws and nuts must be lubricated to achieve correct tightening torque. Screws that are screwed into stainless steel must have the threads coated with suitable lubricants to prevent seizing.

If there is a question regarding the tightening torques, then contact a sales or authorized service representative.

Screws and nuts

Table 26: Stainless steel, A2 and A4, torque Nm (ft-lbs)

Property class	M4	M5	M6	M8	M10	M12	M16	M20	M24	M30
50	1.0 (0.74)	2.0 (1.5)	3.0 (2.2)	8.0 (5.9)	15 (11)	27 (20)	65 (48)	127 (93.7)	220 (162)	434 (320)
70, 80	2.7 (2)	5.4 (4)	9.0 (6.6)	22 (16)	44 (32)	76 (56)	187 (138)	364 (268)	629 (464)	1240 (915)
100	4.1 (3)	8.1 (6)	14 (10)	34 (25)	66 (49)	115 (84.8)	248 (183)	481 (355)	–	–

Table 27: Steel, torque Nm (ft-lbs)

Property class	M4	M5	M6	M8	M10	M12	M16	M20	M24	M30
8.8	2.9 (2.1)	5.7 (4.2)	9.8 (7.2)	24 (18)	47 (35)	81(60)	194 (143)	385 (285)	665 (490)	1310 (966.2)
10.9	4.0 (2.9)	8.1 (6)	14 (10)	33 (24)	65 (48)	114 (84)	277 (204)	541 (399)	935 (689)	1840 (1357)
12.9	4.9 (3.6)	9.7 (7.2)	17 (13)	40 (30)	79 (58)	136 (100)	333 (245)	649 (480)	1120 (825.1)	2210 (1630)

Hexagon screws with countersunk heads

For hexagon socket head screws with countersunk head, maximum torque for all property classes must be 80% of the values for property class 8.8 above.

6.14 Tools

Tools

Beside ordinary tools, the following tools are required to perform the necessary maintenance of the pump.

Part number	Denomination	Range of use	
83 95 42	Oil drainage pumps	Drainage pumps for emptying oil housing	
84 13 68	Hydraulic unit, 200 kN	Bearing removal	584 83 00

L3356

Part number	Denomination	Range of use
432 43 00	Washer. Included in Basic Kit II.	
436 19 00	Basic Kit II	
436 74 00	Impeller tool	
582 65 00	Stand unit	Rotor removal
588 92 00	Mounting unit	Washer mounting

L3400

Part number	Denomination	Range of use
332 91 00	Tool for removing stop spring	
399 41 00	Mounting tool set	Seal mounting, for shaft Ø 75 mm and 90 mm
576 83 01	Washer	For shaft Ø 75 mm
576 83 02	Washer	For shaft Ø 90 mm
576 84 00	Puller screw	
584 81 00	Washer	
587 72 00	Impeller tool	For shaft Ø 75 mm and shaft Ø 90 mm
587 94 00	Basic Kit V	

L3602

Part number	Denomination	Range of use
332 91 00	Tool for removing stop spring	

Part number	Denomination	Range of use
399 41 00	Mounting tool set	Seal mounting, for shaft Ø 75 mm and 90 mm
576 83 01	Washer	For shaft Ø 75 mm
576 83 02	Washer	For shaft Ø 90 mm
576 83 03	Washer	For shaft Ø 110 mm
576 84 00	Puller screw	
584 81 00	Washer	
587 73 00	Impeller tool	For shaft Ø 110 mm
587 94 00	Basic Kit V	

7 Troubleshooting

Introduction

DANGER: Electrical Hazard

Troubleshooting a live control panel exposes personnel to hazardous voltages. Electrical troubleshooting must be done by a qualified electrician.

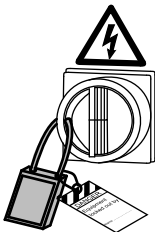
Follow these guidelines when troubleshooting:

- Disconnect and lock out the power supply except when conducting checks that require voltage.
- Make sure that no one is near the unit when the power supply is reconnected.
- When troubleshooting electrical equipment, use the following:
  - Universal instrument multimeter
  - Test lamp (continuity tester)
  - Wiring diagram

7.1 The pump does not start

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.



NOTICE:

Do NOT override the motor protection repeatedly if it has tripped. Doing so may result in equipment damage.

Cause	Remedy
An alarm signal has been triggered on the control panel.	Check that: • The impeller rotates freely. • The sensor indicators do not indicate an alarm. • The overload protection is not tripped. If the problem still persists: Contact a sales or authorized service representative.
The pump does not start automatically, but can be started manually.	Check that: • The start level regulator is functioning. Clean or replace if necessary. • All connections are intact. • The relay and contactor coils are intact. • The control switch (Man/Auto) makes contact in both positions. Check the control circuit and functions.

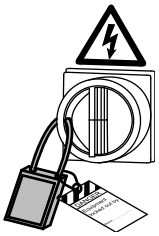
Cause	Remedy
The installation is not receiving voltage.	Check that: • The main power switch is on. • There is control voltage to the start equipment. • The fuses are intact. • There is voltage in all phases of the supply line. • All fuses have power and that they are securely fastened to the fuse holders. • The overload protection is not tripped. • The motor cable is not damaged.
The impeller is stuck.	Clean: • The impeller • The sump in order to prevent the impeller from clogging again.

Always state the serial number of the product, see *Product Description* on page 18.

7.2 The pump does not stop when a level sensor is used

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.



Cause	Remedy
The pump is unable to empty the sump to the stop level.	Check that: • There are no leaks from the piping and/or discharge connection. • The impeller is not clogged. • The non-return valve(s) are functioning properly. • The pump has adequate capacity. For information: Contact a sales or authorized service representative.
There is a malfunction in the level-sensing equipment.	• Clean the level regulators. • Check the functioning of the level regulators. • Check the contactor and the control circuit. • Replace all defective items.
The stop level is set too low.	Raise the stop level.

Always state the serial number of the product, see *Product Description* on page 18.

7.3 The pump starts-stops-starts in rapid sequence

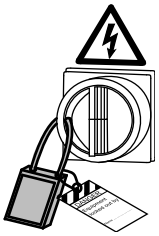
Cause	Remedy
The pump starts due to back-flow which fills the sump to the start level again.	Check that: • The distance between the start and stop levels is sufficient. • The non-return valve(s) work(s) properly. • The length of the discharge pipe between the pump and the first non-return valve is sufficiently short.
The self-holding function of the contactor malfunctions.	Check: • The contactor connections. • The voltage in the control circuit in relation to the rated voltages on the coil. • The functioning of the stop-level regulator. • Whether the voltage drop in the line at the starting surge causes the contactor's self-holding malfunction.

Always state the serial number of the product, see *Product Description* on page 18.

7.4 The pump runs but the motor protection trips

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.



NOTICE:

Do NOT override the motor protection repeatedly if it has tripped. Doing so may result in equipment damage.

Cause	Remedy
The motor protection is set too low.	Set the motor protection according to the data plate and if applicable the cable chart.
The impeller is difficult to rotate by hand.	• Clean the impeller. • Clean out the sump. • Check that the impeller is properly trimmed.
The drive unit is not receiving full voltage on all three phases.	• Check the fuses. Replace fuses that have tripped. • If the fuses are intact, then notify a certified electrician.
The phase currents vary, or they are too high.	Contact a sales or authorized service representative.
The insulation between the phases and ground in the stator is defective.	• Drive units up to 1 kV: See *Check the insulation, up to 1 kV drives or generators* on page 80. • Drive units 1.2–6.6 kV: See *Check the insulation, 1.2–6.6 kV drives* on page 80.

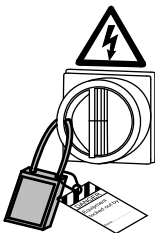
Cause	Remedy
The density of the pumped fluid is too high.	Make sure that the maximum density is 1100 kg/m3 (9.2 lb/US gal) • Change the impeller, or • Change to a more suitable pump • Contact a sales or authorized service representative.
There is a malfunction in the overload protection.	Replace the overload protection.

Always state the serial number of the product, see *Product Description* on page 18.

7.5 The pump delivers too little or no water

DANGER: Crush Hazard

Moving parts can entangle or crush. Always disconnect and lock out power before servicing to prevent unexpected startup. Failure to do so could result in death or serious injury.



NOTICE:

Do NOT override the motor protection repeatedly if it has tripped. Doing so may result in equipment damage.

Cause	Remedy
The impeller rotates in the wrong direction.	If it is a 3-phase pump, then transpose two phase leads.
One or more of the valves are set in the wrong positions.	• Reset the valves that are set in the wrong position. • Replace the valves, if necessary. • Check that all valves are correctly installed according to media flow. • Check that all valves open correctly.
The impeller is difficult to rotate by hand.	• Clean the impeller. • Clean out the sump. • Check that the impeller is properly trimmed.
The pipes are obstructed.	Clean out the pipes to ensure a free flow.
The pipes and joints leak.	Find the leaks and seal them.
There are signs of wear on the impeller, pump, and casing.	Replace the worn parts.
The liquid level is too low.	• Check that the level sensor is set correctly. • Depending on the installation type, add a means for priming the pump, such as a foot valve.

Always state the serial number of the product, see *Product Description* on page 18.

8 Technical Reference

8.1 Application limits

Table 28: Process data

Parameter	Value
Liquid temperature	Max. +40°C (+105°F)
Depth of immersion	Max. 20 m (65 ft)
pH of pumped liquid	pH 5.5–14
Liquid density	Max. 1100 kg/m^3 (9.17 lb per gal.)

8.2 Drive units overview

The following table shows the range of drive units for large submersible pumps. Not all drive units can be used for a particular pump. For drive unit–hydraulic unit compatibility, see the compatibility charts or the Product Data for the drive unit.

Drive units	Not Explosion-proof	Explosion-proof	HE Motor	Voltage Range		Cooling System				Connection House	
				LV, up to 1 kV	MV, 1.2–6.6 kV	External	Integrated	Direct	Internal Closed-loop	Small	Large
605, 665	X			X		X	X	X		X	
615, 675		X		X		X	X	X		X	
705, 735, 765	X			X		X	X	X		X	X
706, 736, 766	X		X	X				X	X	X	X
715, 745, 775		X		X		X	X	X		X	X
716, 746, 776		X	X	X				X	X	X	X
805, 835, 865	X			X		X	X	X			X
885	X			X				X			X
806, 836, 866	X		X	X				X	X		X
886	X		X	X				X			X
815, 845, 875		X		X		X	X	X			X
895		X		X				X			X
816, 846, 876		X	X	X				X	X		X
896		X	X	X				X			X
862, 882	X				X	X	X	X			X
863, 883	X				X			X	X		X
872, 892		X			X	X	X	X			X
873, 893		X			X			X	X		X
905, 935, 965	X			X		X	X	X			X
915, 945, 975		X		X		X	X	X			X
906, 936, 966	X		X	X				X	X		X
916, 946, 976		X	X	X				X	X		X

Drive units	Not Explosion-proof	Explosion-proof	HE Motor	Voltage Range		Cooling System				Connection House	
				LV, up to 1 kV	MV, 1.2–6.6 kV	External	Integrated	Direct	Internal Closed-loop	Small	Large
950, 985, 988	X				X	X	X	X			X
960, 995, 998		X			X	X	X	X			X
951, 986, 987	X		X		X			X	X		X
961, 996, 997		X	X		X			X	X		X

8.3 Pt100 resistance

This table shows the relationship between temperature (°C) and resistance (ohms).

T, °C	R, ohms	T, °C	R, ohms	T, °C	R, ohms	T, °C	R, ohms	T, °C	R, ohms
0	100.00	33	112.83	66	125.54	99	138.12	132	150.57
1	100.39	34	113.22	67	125.92	100	138.50	133	150.95
2	100.78	35	113.61	68	126.31	101	138.88	134	151.33
3	101.17	36	113.99	69	126.69	102	139.26	135	151.70
4	101.56	37	114.38	70	127.07	103	139.64	136	152.08
5	101.95	38	114.77	71	127.45	104	140.02	137	152.45
6	102.34	39	115.15	72	127.84	105	140.39	138	152.83
7	102.73	40	115.54	73	128.22	106	140.77	139	153.20
8	103.12	41	115.93	74	128.60	107	141.15	140	153.58
9	103.51	42	116.31	75	128.98	108	141.53	141	153.95
10	103.90	43	116.70	76	129.37	109	141.91	142	154.32
11	104.29	44	117.08	77	129.75	110	142.29	143	154.70
12	104.68	45	117.47	78	130.13	111	142.66	144	155.07
13	105.07	46	117.85	79	130.51	112	143.04	145	155.45
14	105.46	47	118.24	80	130.89	113	143.42	146	155.82
15	105.85	48	118.62	81	131.27	114	143.80	147	156.19
16	106.24	49	119.01	82	131.66	115	144.17	148	156.57
17	106.63	50	119.40	83	132.04	116	144.55	149	156.94
18	107.02	51	119.78	84	132.42	117	144.93	150	157.31
19	107.40	52	120.16	85	132.80	118	145.31	151	157.69
20	107.79	53	120.55	86	133.18	119	145.68	152	158.06
21	108.18	54	120.93	87	133.56	120	146.06	153	158.43
22	108.57	55	121.32	88	133.94	121	146.44	154	158.81
23	108.96	56	121.70	89	134.32	122	146.81	155	159.18
24	109.35	57	122.09	90	134.70	123	147.19	156	159.55
25	109.73	58	122.47	91	135.08	124	147.57	157	159.93
26	110.12	59	122.86	92	135.46	125	147.94	158	160.30
27	110.51	60	123.24	93	135.84	126	148.32	159	160.67
28	110.90	61	123.62	94	136.22	127	148.70	160	161.04
29	111.28	62	124.01	95	136.60	128	149.07		

T, °C	R, ohms		T, °C	R, ohms		T, °C	R, ohms		T, °C	R, ohms		T, °C	R, ohms
30	111.67		63	124.39		96	136.98		129	149.45			
31	111.94		64	124.77		97	137.36		130	149.82			
32	112.45		65	125.16		98	137.74		131	150.20			

8.4 Cable bending radius, weight and diameter

Control cables

Table 29: SUBCAB™ control cables

This table shows the minimum bending radius, weight, and outer diameter for SUBCAB control cables.

Cable	Minimum bending radius in mm	Weight in kg/m	Outer diameter, minimum-maximum in mm
12x1.5 mm^2	190	0.53	Ø 18.2–21.2
24x1.5 mm^2	250	0.90	Ø 24.9–28.9
S12x1.5 mm^2	300	0.78	Ø 29.9–31.0
S24x1.5 mm^2	350	1.59	Ø 33.0–37.0

Power cables with power cores and control element

Table 30: Screened SUBCAB

Cable	Minimum bending radius in mm	Weight in kg/m	Outer diameter, minimum-maximum in mm
S3x16 + 3x16/3 + S(4x0.5)	240	1.1	Ø 24–26
S3x25 + 3x16/3 + S(4x0.5)	290	1.4	Ø 29–31
S3x35 + 3x16/3 + S(4x0.5)	320	2.0	Ø 32–34
S3x50 + 3x25/3 + S(4x0.5)	380	3.0	Ø 38–40
S3x70 + 3x35/3 +2 S(2x0.5)	420	3.5	Ø 42–44
S3x95 + 3x50/3 + 2S(2x0.5)	440	4.6	Ø 44–47
S3x120 + 3x70/3 + 2S(2x0.5)	500	5.5	Ø 50–52
S6x95 + 95 + S(4x0.5)	570	7.6	Ø 57–60

Table 31: SUBCAB

Cable	Minimum bending radius in mm	Weight in kg/m	Outer diameter, minimum-maximum in mm
4 G 16 + S(2x0.5)	260	1.13	Ø 26–28
4 G 25 + S(2x0.5)	320	1.7	Ø 32–34
4 G 35 + S(2x0.5)	350	2.24	Ø 35–37
3x50 + 2G35/2 + S(2x0.5)	350	2.6	Ø 35–37
3x70 + 2G35/2 + S(2x0.5)	380	3.3	Ø 38–41
3x95 + 2G50/2 + S(2x0.5)	470	4.5	Ø 47–50
3x120 + 2G70/2 + S(2x0.5)	540	5.7	Ø 54–56

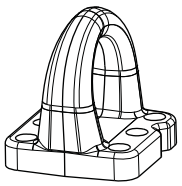
Medium voltage power cables, 1.2–15 kV

Table 32: (N)TSCGEWOEUS 1.2–15 kV

This table shows the minimum bending radius, weight, and outer diameter for (N)TSCGEWOEUS 1.2–15 kV cables.

Cable	Minimum bending radius in mm	Weight in kg/m	Outer diameter, minimum-maximum in mm
3x25+3x25/3	410	2.51	Ø 41–44
3x50+3x25/3	460	3.47	Ø 46–49

8.5 Lifting eye bracket 494 01 01



494 01 01

WS011502A

WS002323B

Xylem |'zīləm|

1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

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xylem
Let's Solve Water

Xylem Water Solutions Global Services AB
361 80 Emmaboda
Sweden
Tel: +46-471-24 70 00
Fax: +46-471-24 74 01
http://tpi.xyleminc.com
www.xylemwatersolutions.com/contacts/

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The original instruction is in English. All non-English instructions are translations of the original instruction.

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CALCULATIONS

WSP USA

7650 Corporate Center Drive
Miami, FL 33126
(305) 514-3100

Date:	**April 5, 2021**
Project Name:	**Monroe County Sea Level Rise Pilot - Big Pine Key, Florida**
Project Number:	**193618A**
Prepared By:	**WR/SS**

PUMP STATION & INJECTION WELL CALCULATIONS

1. Data Collection:

Total drainage area:	A=	49.63	Ac.	Hydrologic location:	Zone 11	
Pavement Area:	A_i=	17.97	Ac.	Design Frequency:	F= 5	
Pervious Area:	A_p=	31.66	Ac.	Rainfall amount:	6	inches[1]
Seasonal High Water Table:	SHWT=	1.5	ft-NAVD[2]	Runoff coefficient:		
Mean High Water Table:	MHW=	-0.322	ft-NAVD	Impervious:	Ci= 0.95	
Mean Highest High Water Table:	MHHW=	-0.081	ft-NAVD	Pervious:	Cp= 0.35	
Mean Highest High Water Table:	*$MHHW_{40}$ =*	*0.36*	*ft-NAVD at year 2040*			
Minimum roadway grade:	G=	1	ft-NAVD			

Well design data:

Well capacity:	q_w=	1000	gpm/ft of head

2. Determine the peak discharge rate into the well system:

Weighted runoff coefficient: $C = \frac{CiAi + CpAp}{A} = 0.567247632$

Time of concentration: t_c= 37 minutes

Rainfall intensity: i= 3.95 in/hr (per FDOT IDF curves for tc= 37 min. , for Zone 11)

1: From SFWMD rainfall map for 1-Day;5-year return period
2: Not used since project is controlled by tidal conditions.

$Q = CiA = 111.20$ cfs

=	**49,911**	**GPM**
=	71,872,196	GPD
=	831.85	GPS

3. Determine the net hydraulic head required for a pressurized well system:

Number of pressurized wells: n_p= 12 wells

Safety factor: SF= 1.5

Pressurized net head: $H_p = \frac{SF*Q}{0.00223*qw*np} + \Delta H$ = 7.73 ft

(ΔH = 1.5 ft; head required to discharge thru tidal water)

Required head elevation: Head = $MHHW_{40} + H_p$ = 8.09 ft NAVD

CHECK: 8. ft NAVD > 8 ft NAVD

4. Determine the 90-second retention volume for each pressurized well:

Required detention volume: $V_{90s} = \frac{90*Q}{Np}$ = 834.0 ft^3 per well

Note: 90-second detention will be provided at proposed swales. Treatment units will also be used.
Total for all wells: 10008.21 ft^3

5. Calculate total pressurized net head:

Required pump discharge: Q_p= SF*Q = 166.80 cfs

Required head elevation for well discharge: Head = 8.09 ft NAVD
(from item 3 above)

The pump station will have to deliver a flow of 166.80 cfs with a maximum head of 8.09 ft NGVD plus the calculated static head (see below).

6. Calculate static head:

a. Force main pipe diameter estimate:
Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10 ft/sec	
Q =	Peak Flow	831.85 GPS	49911.2 gpm
D =	**Pipe Diameter**	**48.00 in**	
D =	Pipe Diameter	4.00 ft	

A = Pipe Cross-Sectional Area 12.57 ft^2

$D^2 = 4Q/(\pi (V))$ = 14.160 ft^2

Approximate Pipe Dia. (D) = 3.76 ft or 45.16 inches OK

b. Equivalent length of pipe for 48 -inch force main:

Pump Station - Force Main

	Quantity	Unit	Friction Loss*	Equivalent Length (ft)
Pump Discharge =	2	EA.	9.30	18.60
Manifold from 2 to 1 FM (T-fitting) =	1	EA.	60.00	60.00
FM Length[3] =	1150	LF	1.00	1150.00
Well Discharge (T-fitting)=	12	EA.	10.00	120.00
			Total Equivalent Length=	**1,349**

c. Wet well design:

Assume:

Wet Well Volume (V) = (Q * T)/4

	number of pumps	4	pumps
T =	Time for one pump cycle	5	minutes
V =	Wet Well Volume	X	gallons
Q =	Pump Rate (peak flow per pump)	12,477.81	GPM
S =	Peak Daily Flow	49,911.25	GPM

$$V = \frac{12{,}477.81 \times 5}{4}$$

V = 15,597 gallons

2,085 ft^3

Wet Well Dimensions 18 ft x 12 ft

Area of Wet Well (A) = 216 ft^2

Depth between LEAD PUMP ON and PUMP OFF level (H) = V / A

H = 10 ft

3: Assumes 100-ft spacing between wells; based on PCCP.

d. Liquid level regulators: Force Main El -5.4

Assume:			
Rim Elevation =	3.20	ft NAVD	
Invert Elevation =	-6.20	ft NAVD	22.40
High Water Alarm Elevation=	-6.20	ft NAVD	
LAG Pump on Elevation =	-7.20	ft NAVD	
LEAD Pump on Elevation =	-8.20	ft NAVD	
Pumps off Elevation =	-18.20	ft NAVD	
Low Water Alarm Elevation=	-18.70	ft NAVD	
Bottom of wet well elevation=	-19.20	ft NAVD	
TOTAL WELL DEPTH:	22.40	FT	

e. Calculate static head:

Static Head = Invert elevation of FM - Pumps off Elevation

Static Head = 12.80 ft for Pumps Station

7. Total head:

Pump station must be designed to account for the total static head plus the total pressurized net head (calculated in item 5 above):

8.09 + 12.80 = **20.89 FT of head**

8. Total dynamic head loss:

Equivalent pipe length			1349	ft
Force main pipe diameter			48	in
Total Head			20.89	ft
Tie-In Pressure			0.00	ft
C (PCCP)			120	
Lift Station Flow (GPM)	Static Head + Tie-In Pressure (ft)	Velocity Head $V^2/2g$ (ft)	48" Storm Force Main losses (ft) max	Total Dynamic Head (ft)
27000	20.89	0.36	2.05	22.95
30000	20.89	0.44	2.50	23.39
35000	20.89	0.60	3.32	24.21
40000	20.89	0.78	4.25	25.14
49911	20.89	1.22	6.40	**27.29**
50000	20.89	1.22	6.42	27.31
55000	20.89	1.48	7.66	28.55

Notes:

1. The following formula was used to calculate the Total Dynamic Head (TDH):

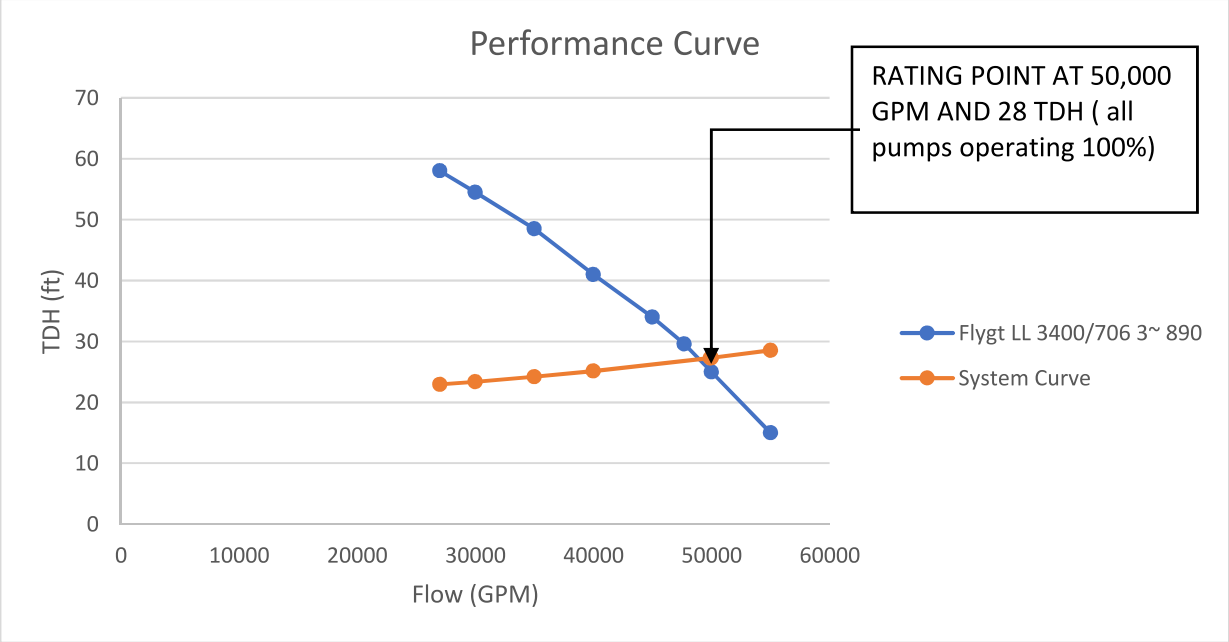
Hazen & Williams formula: $hf = \frac{10.44 * (L) * (Q)^{1.85}}{(C)^{1.85} * (D)^{4.87}}$

Where:
- hf = head loss (ft.)
- Q= flow (GPM)
- L= equivalent length of pipe
- C= Hazen Williams Coefficient
- D= pipe diameter (in)

2. The following formula was used to calculate the Velocity:

Steady Flow: $V = \frac{Q}{A} = \frac{.4085 * (Q)}{D^2}$

Where:
- V= velocity (fps)
- Q= discharge, flow (GPM)
- A= cross sectional area (ft^2)
- D= pipe diameter (in)



9. Calculate Time of Concentration for Basin:

Tc= (tsh + tsc + tch) * (60 min/ 1 hr)

tsh= sheet flow travel time (hr)

[0.007*(nol*Lsh)^0.8] / [(P2^0.5)*(Ssh^0.4)]

where:
nol= overland flow roughness coefficient
Lsh= sheet flow length (ft)
P2= 3yr, 24-hr rainfall depth (in)

sheet flow lengths:

						0.01
L=	80	ft in roadway	n=	0.011	S=	0.009
L=	20	ft in grass	n=	0.41	S=	**0.0099**
Lsh=	**100**		**nol=**	**0.0908**	**Ssh=**	

P2= 5 inches per SFWMD rainfall map

tsh= 0.116017 hrs

tsc= shallow concentrated flow time (hr)

Lsc / [3600*K*(Ssc^0.5)]

where:
Lsc= shallow concentrated flow length (ft)
K= 16.13 for
Ssc= shalow concentrated flow slope (ft/ft)

						0.01
L=	16	ft in roadway	n=	0.01	S=	0.009
L=	278	ft in grass	n=	0.41	S=	**0.0093**
Lsh=	**294**		**nol=**	**0.388231293**	**Ssh=**	

K= 20.32
K= 16.13
K= 16.35803 inches

tsc= 0.051658 hrs

tch= channel flow time (hr) (thru ditch)

Lch / [3600*(1.49/n)*R^(2/3)*Sch^(1/2)]

where:
Lch= channel flow length (ft)
n= Manning's
Sch= channel flow slope (ft/ft)

0.01

L=	90	ft in road /driveway	n=	0.01	S=	0.009
L=	191.6	ft in grass	n=	0.035	S=	0.003
L=	85	ft in grass	n=	0.035	S=	**0.0073**
Lsh=	**366.6**	**ft**	**nol=**	**0.020747409**	**Ssh=**	

R= **0.249136** ft hydraulic radius
6-ft on each side, 6" depth

tch_1= 0.041868 hrs

tch= channel flow time (hr) (thru pipe)

Lch / [3600*(1.49/n)*R^(2/3)*Sch^(1/2)]

where:
Lch= channel flow length (ft)
n= Manning's
Sch= channel flow slope (ft/ft)

L=	2728	pipe	n=	0.016	S=	0.001 **0.0010**
Lsh=	**2728**		**nol=**	**0.016**	**Ssh=**	

R= **0.5** ft hydraulic radius
full 24" dia. Pipe

tch_2= 0.408472 hrs

Tc= tsh + tsc + tch_1 + tch_2 = 0.618014878 hrs = 37.1 min

Force Main Calcs per FM section:

Before injection well #1:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	831.85	GPS
D =	**Pipe Diameter**	**48.00**	**in**
D =	Pipe Diameter	4.00	ft
A =	Pipe Cross-Sectional Ar	12.57	ft^2

$D^2 = 4Q/(\pi (V))$ = 14.160 ft^2

45.16 inches OK

Approximate Pipe Dia. (D) = 3.76 ft or

Before injection well #2:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	762.53	GPS
D =	**Pipe Diameter**	**48.00**	**in**
D =	Pipe Diameter	4.00	ft
A =	Pipe Cross-Sectional Ar	12.57	ft^2

$D^2 = 4Q/(\pi (V))$ = 12.980 ft^2

43.23 inches OK

Approximate Pipe Dia. (D) = 3.60 ft or

Before injection well #3:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	693.21	GPS
D =	**Pipe Diameter**	**48.00**	**in**
D =	Pipe Diameter	4.00	ft
A =	Pipe Cross-Sectional Ar	12.57	ft^2

$D^2 = 4Q/(\pi (V))$ = 11.800 ft^2

41.22 inches OK

Approximate Pipe Dia. (D) = 3.44 ft or

Before injection well #4:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	623.89	GPS
D =	**Pipe Diameter**	**48.00**	**in**
D =	Pipe Diameter	4.00	ft
A =	Pipe Cross-Sectional A	12.57	ft^2

$D^2 = 4Q/(\pi (V))$ = 10.620 ft^2

Approximate Pipe Dia. (D) = 3.26 ft 39.11 inches OK

Before injection well #5:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	554.57	GPS
D =	**Pipe Diameter**	**48.00**	**in**
D =	Pipe Diameter	4.00	ft
A =	Pipe Cross-Sectional A	12.57	ft^2

$D^2 = 4Q/(\pi (V))$ = 9.440 ft^2

Approximate Pipe Dia. (D) = 3.07 ft 36.87 inches OK

Before injection well #6:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	485.25	GPS
D =	**Pipe Diameter**	**36.00**	**in**
D =	Pipe Diameter	3.00	ft
A =	Pipe Cross-Sectional A	7.07	ft^2

$D^2 = 4Q/(\pi (V))$ = 8.260 ft^2

Approximate Pipe Dia. (D) = 2.87 ft 34.49 inches OK

Before injection well #7:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	415.93	GPS
D =	**Pipe Diameter**	**36.00**	**in**
D =	Pipe Diameter	3.00	ft
A =	Pipe Cross-Sectional A	7.07	ft^2

$D^2 = 4Q/(\pi (V))$ = 7.080 ft^2

Approximate Pipe Dia. (D) = 2.66 ft 31.93 inches OK

Before injection well #8:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	346.61	GPS
D =	**Pipe Diameter**	**36.00**	**in**
D =	Pipe Diameter	3.00	ft
A =	Pipe Cross-Sectional A	7.07	ft^2

$D^2 = 4Q/(\pi (V))$ = 5.900 ft^2

Approximate Pipe Dia. (D) = 2.43 ft 29.15 inches OK

Before injection well #9:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	277.28	GPS
D =	**Pipe Diameter**	**36.00**	**in**
D =	Pipe Diameter	3.00	ft
A =	Pipe Cross-Sectional A	7.07	ft^2

$D^2 = 4Q/(\pi (V))$ = 4.720 ft^2

Approximate Pipe Dia. (D) = 2.17 ft 26.07 inches OK

Before injection well #10:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	207.96	GPS
D =	**Pipe Diameter**	**24.00**	**in**
D =	Pipe Diameter	2.00	ft
A =	Pipe Cross-Sectional A	3.14	ft^2

$D^2 = 4Q/(\pi (V)) =$ 3.540 ft^2

Approximate Pipe Dia. (D) = 1.88 ft 22.58 inches OK

Before injection well #11:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	138.64	GPS
D =	**Pipe Diameter**	**24.00**	**in**
D =	Pipe Diameter	2.00	ft
A =	Pipe Cross-Sectional A	3.14	ft^2

$D^2 = 4Q/(\pi (V)) =$ 2.360 ft^2

Approximate Pipe Dia. (D) = 1.54 ft 18.43 inches OK

Before injection well #12:

a. Force main pipe diameter estimate:

Velocity (V) = Q/A = $4Q/(\pi D^2)$

V =	Pipe Velocity	10	ft/sec
Q =	Peak Flow	69.32	GPS
D =	**Pipe Diameter**	**24.00**	**in**
D =	Pipe Diameter	2.00	ft
A =	Pipe Cross-Sectional A	3.14	ft^2

$D^2 = 4Q/(\pi (V)) =$ 1.180 ft^2

Approximate Pipe Dia. (D) = 1.09 ft 13.04 inches OK

RATING CURVE

Head Loss Calculation for Modification Of Pump Curve

Equation-1 Head Loss (Hazen-Williams Formula) $H_{f=}$ $0.002083*L(100/C)^{1.85}(Q^{1.75}/ d^{4.8655})$

Equation-2 Head Loss by Fitting and Valves $H_{f=}$ $K(V^2/2g)$

Gravity		32.2	ft/sec^2
Resistence Coeficient		120	
Pipe Length (L)		20	ft
Diameter		48	In

DUTY PUMP
ITT
PRODUCT:
CURVE No. PL-7050

FRICTION AND MINOR LOSSES CALCULATION						
Flow Rate (Q)	Flow Rate (Q)	Velocity (V)	$H_{f\ Long)}$	Velocity head	H_f	Ht
(gpm)	(cfs)	(fps)	(ft)	(ft)	Fitting	
		48	**48**		All	
10000	**22.28**	1.77	0.01	0.049	0.124	**0.131**
15000	**33.42**	2.66	0.02	0.110	0.278	**0.294**
20000	**44.56**	3.55	0.03	0.195	0.494	**0.521**
25000	**55.70**	4.43	0.04	0.305	0.772	**0.812**
30000	**66.84**	5.32	0.05	0.439	1.112	**1.166**

Operational Table Flygt LL3400/706 3~890 (2 OF 4 PUMPS)

Fitting	K	Count	Total Loss
90 Elbow	0.45	1	0.45
45 Elbow	0.21	0	0
22.5 Elbow		0	0
11.25 Elbow		0	0
check valve	1.3	1	1.3
plug valve	0.23	0	0
24"x16" 45 Wye	0.78	0	0
Reducer (24-32)	0.21	0	0
disch.elbow 28"x24"	0.83	0	0
Cross (branch flow)	0.78	1	0.78
Cross (line flow)	0.26	0	0
Reducer (16-24)	0.28	0	0
		Total	2.53

RATING CURVE					
Flow Rate (Q) (cfs)	H (ft)	Ht	Result Head	Icpr Head Value	Flow Rate
22.28	**62.00**	0.131	61.9	-61.9	22.28
33.42	**56.00**	0.294	55.7	-55.7	33.42
44.56	**41.50**	0.521	41.0	-41.0	44.56
55.70	**24.50**	0.812	23.7	-23.7	55.70
66.84	**6.50**	1.166	5.3	-5.3	66.84

DIP PIPING AND FITTINGS

PART 1 - GENERAL

1.01 SCOPE:

A. This section describes materials, testing, and installation of ductile-iron pipe and fittings .The work included in this section consists of furnishing all material, equipment, craft labor and performing all operations necessary for the supply, installation, and commissioning of all piping, fittings and accessories within the limits of work, as shown on the drawings and specified herein.

B. Where references are made to other standards or codes, unless specific date references are indicated the latest edition of said standard or code shall govern.

1.02 RELATED SECTIONS:

A. FDOT Section 430 Pipe Culverts

1.03 NOT USED

1.04 PIPING LAYOUT AND DESIGN CRITERIA:

A. Field verify dimensions prior to preparation of layout and shop drawings. Obtain the following information from the drawings and specifications:

1. Elevation of the pipe centerline and of the completed ground.
2. Alignment of the pipeline.
3. Field test hydraulic gradient elevation (HGL).
4. Nominal internal diameter, ID.
5. Design internal pressure class or HGL
6. Joint types.

B. Obtain shop drawing approval prior to fabrication of piping. All items not specifically mentioned in the Specifications or noted on the approved Plans, but which are reasonably necessary to for a complete, functional, and satisfactory installation shall be included.

1.05 SUBMITTALS

A. Submit shop drawings in accordance with the General Provisions.

B. Provide an affidavit of compliance with standards referenced in this specification, e.g., AWWA C151, AWWA C153, etc.

C. Submit copy of report of pressure tests for qualifying the designs of all sizes and types of pipe and fittings that are being used in the project. The pressure test shall demonstrate that the minimum safety factor described in relevant standard is met.

D. Submit piping layout profile drawings showing location and dimensions of pipe and fittings; submit after equipment and valve submittals have been reviewed and marked **"Resubmittal not required."** Include laying lengths of valves, meters, in-line pumps, and other equipment

determining piping dimensions. Label or number each fitting or piece of pipe. Piping having identical design pressure class, laying lengths, and bell-and-spigot dimensions that is to be placed in long straight reaches of alignment may have the same identifying label or number. E. Provide the following information:

1. Mortar lining thickness.

2. Wall thickness.

3. Material test data for this project.

4. Show deflections at push-on and mechanical joints.

5. Submit joint and fitting details and manufacturer's data sheets.

F. Fully detailed drawings of all fittings proposed shall be supplied by the manufacturer with his bid. The tabulated nominal weight of each size and type of fitting shall also be supplied by the manufacturer for all items proposed. This weight shall be that of the bare casting prior to application of any lining or coating.

G. Submit calculations and test data proving that the proposed restrained joint arrangement for restrained joint pipe can transmit the required forces with a minimum safety factor of 1.5.

H. Submit copy of manufacturer's quality control check of pipe material and production. Include hydrostatic test records and acceptance test records. For each acceptance test, submit a stress-strain diagram showing yield strength, yield point, tensile strength, elongation, and reduction in area. Provide specimen test section dimensions and speed and method used to determine speed of testing, method used for rounding of test results, and reasons for replacement specimens, if any. Submit ring-bending test of pipe of the same diameter and pressure class as the pipe required for this project to prove ring-bending stress at 48 ksi results in a factor of safety of 2.0.

I. For Ductile Iron Pipe and fittings, submit certificate that cement for mortar lining complies with ASTM C150, designating type.

J. Submit test report on physical properties of rubber compound used in the gaskets.

K. Submit test reports and certifications for ceramic epoxy lining as specified herein. Submit applicators qualifications. Submit manufacturer's written recommendations for application and repair of coating.

L. Submit drawing or manufacturer's data sheet showing flange facing, including design of facing serrations.

M. Submit weld procedure specification, procedure qualification record, and welder's qualifications prior to any welding to ductile-iron pipe or fittings.

1.06 DELIVERY, STORAGE, AND HANDLING

A. During shipping, delivery and installation of pipe and accessories, handle in a manner that is incompliance with the manufacturer's recommendations, and employ procedures that ensure delivery of an undamaged operable product

B. Exercise particular care not to damage coatings by limiting exposure or physical contact with other materials, objects, or the environment.

1.07 INSPECTION

The Owner's Representative will inspect materials, production, and testing of pipes, fittings, and special pieces at manufacturer's plant.

1.08 QUALITY ASSURANCE

All pipe, fittings and other materials supplied under this contract shall be subject to inspection while still on the delivery truck. It is the sole responsibility of the vendor and supplier to make prior contact with the Storekeeper or the Construction Management section and provide a minimum of 48-hours prior notice of delivery. When so notified, the Department will make arrangements for inspection of the material upon arrival or within a reasonable time thereafter. Material shall not be unloaded without inspections taking place either prior to or, if necessary for examination, during the unloading procedure. The Department will not be responsible for any delays or additional costs created by noncompliance with the requirement for prior notification or the requirement for thorough inspection.

Materials shall be delivered in complete compliance with the AWWA Standards as modified herein, without damage, and shall match or exceed the quality of any samples supplied. The Department absolutely reserves the right to require samples of any material supplied and to perform whatever tests considered by the Engineer, whose decision shall be final, to be in the Department's best interest on said samples. Where such tests are of a destructive nature, the sample, if it passes the test will be paid for (at cost as shown by invoice) by the Department. Samples failing will be immediately replaced with suitable material at the supplier's/contractor's expense. Samples required prior to order as a condition for purchase or as a materials submittal for approval will be at the supplier's/contractor's expense but, if approved and not used for destructive tests, may be used in the work with permission from the Engineer.

Materials found to be defective, not in strict compliance with the quality standards of samples supplied or these specifications shall be immediately returned to the vendor at his expense. If defects are discovered at a later time, the vendor shall be required to remove said items and shall bare all costs for so doing together with any replacement costs. Rejection of items may subject the vendor to liquidated and/or actual damages as specified elsewhere herein.

Foundries supplying materials shall maintain their metallurgical records for a minimum period of two years after fabrication and firms not doing so may be found in default.

Flaws which provide cause for rejection include;

1. Incorrect metallurgy or metallurgy which cannot be verified to the complete satisfaction of the Engineer;

2. Foundry identification/location, size, pressure and material identification information lost, removed, non-existent, or not visible when assembled;

3. Not in complete compliance with all applicable AWWA Standards as modified herein and/or these specifications;

4. Not in compliance with NSF;

5. Not in compliance with approved shop drawings;

6. Out of roundness in excess of AWWA requirements;

7. Dimensional differences in excess of AWWA requirements;

8. Rough exterior coating;

9. Chipped, cracked, scratched or otherwise damaged interior or exterior coatings or linings;

10. Interior or exterior coatings which are too thin;

11. Coatings too thick to allow proper assembly; coatings too thick to allow proper grip by restraining gaskets or other restraining elements;

12. Pin holes or honey combing of pipe;

13. Weld spatter or excess metal in gasket grooves or the whole of the bell area;

14. Bell areas which are distorted or otherwise improperly cast;

15. Spigots which are out of round, not of proper dimension, or not beveled to an extent that will allow easy assembly of the pipe joint;

16. Gaskets which are defective or of the wrong material;

17. Lack of joint materials;

18. Improper or defective joint materials;

19. Bolting of the wrong material or size;

20. Electro galvanizing or other exterior plating when hot-dip galvanizing is required;

21. Incorrect, flawed or damaged interior coating or lining;

22. Lack or non-submittal of all required certifications;

23. Non-timely submission of certifications; incorrect/incomplete certifications or certifications lacking the signature, date and seal of a professional engineer when so required;

24. Flanges which are too thin, not a right angles to the pipe centerline, or otherwise distorted;

25. The above listed items together with all other flaws or defects which in the opinion of the Engineer, whose decision shall be final, adversely affect the assembly and/or function of the piping system as intended.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS: DUCTILE IRON

A. GENERAL

As used herein, "ANSI" denotes the American National Standards Institute, "AWWA" denotes the American Water Works Association, and "ASTM" denotes the American Society for Testing and Materials.

All pipe and fittings to be furnished hereunder shall conform to the referenced ANSI and/or AWWA Standard as modified herein, as appearing in the following sections.

All markings required on pipe and fittings, shall be permanent and clearly legible and located such that they will not be hidden or destroyed when assembled into the intended system. Plainly mark each length of straight pipe and each fitting at the bell end to identify the design pressure class, the wall thickness, and the date of manufacture, and the proper location of the pipe item by reference to the layout schedule. Mark the spigot end of restrained joint pipe to show clearly the required depth of insertion into the bell.

B. DUCTILE IRON PIPE

All pipes shall be ductile iron pipe conforming to ANSI/AWWA Standard C151/A21.51-09, "Ductile-Iron Pipe, Centrifugally Cast, for Water". All pipe and fittings for water applications shall be in full compliance with ANSI/NSF 61, "Drinking Water System Components-Health Effects". Manufacturers shall maintain their NSF certification for the duration of the Contract and any extensions thereof.

The pipe thickness and outside diameter of pipe for sanitary sewer and water usage shall conform to Tables 1 and 2 (for push-on and mechanical joint pipe, respectively) of ANSI/AWWA Standard C151/A21.51-09 for the following sizes. The pressure class specified is the minimum permitted:

Size	Pressure Class
4-inch through 12-inch	350
14-inch through 20-inch	250
24-inch	200
30-inch through 54-inch	150

For restrained joint pipe, the thickness of the pipe barrel remaining after grooves are cut, if required in the design of restrained end joints, shall not be less than the nominal wall thickness of equal sized non-restrained joint pipe as shown above.

Minimum wall thickness for pipe having threaded flanges shall be Special Class 53 or Pressure Class 350.

Minimum pipe wall thickness required for corporation stops and tapped outlets shall be in accordance with Table A.1 of ANSI/AWWA C151/A21.51-09 for three full threads for design pressures up to 250 psi and four full threads for design pressures over 250 to 350 psi.

For flanged ductile-iron pipe with integrally cast flanges or threaded flanges, the nominal wall thickness of the pipe barrel shall be as specified in Section 3.3, "Joints and Accessories" under "Flanged Joints", herein below.

Minimum wall thicknesses for pipe having grooved-end joints shall be as shown in the following table:

DI Pipe and Fitting Sizes (inches)	**Grooved End Joint Wall Thickness***
16 and smaller	Special Class 53
18	Special Class 54
20	Special Class 55
24 to 36	Special Class 56
42 and larger	Special Class 53 or Pressure Class 350
*Special Class and Pressure Class per AWWA C151-09.	

Each piece of pipe shall be marked as required in Subsection 4.7 of AWWA C151-09. Letters and numerals on pipe sizes 12-inch and smaller shall be not less than 3/8-inch.

The Water and Sewer Department absolutely reserves the right to require the use of "thickness" class pipe or higher pressure class pipe in applications where in the opinion of the Engineer (i.e. the Chief, Engineering Division, M-D WASD or his representative) such use is in the best interest of the Department. The Engineer's decision in this regard shall be final.

A sufficient quantity of non-toxic vegetable soap lubricant shall be supplied with each shipment of pipe. The soap lubricant shall be suitable for use in subaqueous trench conditions.

Single gasket push-on pipe shall be shipped in standard 18-foot or 20-foot lengths, but not both. Restrained single-gasket push-on joint pipe shall be shipped in standard 18 or 20-foot lengths as specified above or fabricated lengths as noted in each order. At least two lengths of each size of single gasket push-on pipe furnished under each order shall be tested with circumferential gauges to ensure that the pipe may be cut at any point along its length and have an outside diameter which will be within the manufacturer's standard design dimensions and tolerances for plain pipe. These lengths shall be identified with an easily distinguished, painted marking, longitudinally along the full length of the pipe.

C. GASKETS

Water Mains shall use SBR gaskets for typical applications and field conditions. Gaskets constructed of EPDM, Nitrile are used in areas where geotechnical information indicates the presence of moderate contamination is possible. All water mains shall use gaskets material with NSF 61 approval.

Sewer Mains shall use Neoprene or EPDM gaskets for typical applications and field conditions.

Areas with chemical or hydrocarbon contamination shall use the gasket material as recommended by the Ductile Iron Pipe Research Association (dipra.org) or the gasket manufacturer.

D. FITTINGS

Fittings Conforming to ANSI/AWWA C110/A21.11-12 (Water & Sewer Use)

Restrained push-on joint fittings shall be cast ductile iron for use with ductile-iron pipe as specified above. Standard mechanical joint, push-on joint and flanged joint fittings shall also be ductile iron for use with ductile-iron pipe as specified above. Cast ductile-iron fittings in the 3-inch through 24-inch size range shall be pressure rated at 350 psi, minimum; (except flange-joint fittings shall be rated at 250 psi, minimum); and in the 30-inch through 54-inchinch size range shall be pressure rated at 250 psi, minimum. All fittings with mechanical joints, flange joints and push-on joints shall conform to ANSI/AWWA Standard C110/A21.1012, "Ductile-Iron and Gray-Iron Fittings ". In addition, fittings with mechanical joints and pushon joints shall conform to ANSI/AWWA Standard C111/A21.11-12, "Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings".

The weight of fittings shall be as given in ANSI/AWWA C110/A21.11-12 for ductile-iron fittings. The weight of mechanical joint fittings shall be as established in Tables 4 through 13. The weight of flanged joint fittings shall as established in Tables 14 through 21.

Fittings Conforming to ANSI/AWWA C153/A21.53-11 (Water & Sewer Use)

All fittings shall be cast ductile-iron for use with ductile-iron pipe as specified above. Fittings in the 3-inch through 24-inch size range shall be pressure rated at 350 psi, minimum; 30-inch through 48-inch size range shall be pressure rated at 250 psi, minimum; and in the 54-inch through 64-inch size range shall be pressure rated at 150 psi, minimum (except for those fittings such as plugs, caps, and sleeves which are normally rated at a higher pressure). No flanged fittings or mixtures of flanged with other end type fittings will be allowed in the range of 3-inch through 48-inch. All fittings with mechanical joints, flange joints and push-on joints shall conform to ANSI/AWWA Standard C153/A21.53-11, "Ductile-Iron Compact Fittings ". In addition, fittings with mechanical joints and push-on joints shall conform to ANSI/AWWA Standard C111/A21.11-12, “Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings" except as otherwise allowed in C153. Mechanical joint glands shall be ductile-iron only.

The weight of a fitting supplied under the contract shall not be less than ninety-five (95) percent of the tabulated nominal weight supplied by the manufacturer’s catalog literature for that fitting. Further, the weight of fittings supplied shall not be more than five (5) percent above the same tabulated nominal weight.

E. JOINTS AND ACCESSORIES

Joints in below-ground piping shall be flexible push-on or Mechanical joints, except where flanged joints are required to connect to valves, meters, and other equipment. Provide unrestrained buried joints except where restrained joints are specifically shown in the drawings. Joints in aboveground or submerged piping or piping located in vaults and structures shall be grooved end or flanged.

Restrained joints for piping 6 inches and larger shall be American Cast Iron Pipe "Lok-Ring" or "Flex-Ring," U.S. Pipe "TR-Flex," or equal. Weldments for restrained joints shall be tested by the liquid penetrant method per ASTM E165. Restrained joints for field closures shall be “Megalug” by EBAA Iron.

Push-On Type Joints (Single Gasket and Single Gasket with Gasket Restraint)

Push-on joints shall conform to ANSI/AWWA Standard C111/A21.11-12.

The required number of gaskets for each push-on joint pipe plus one extra for every 50 joints or fraction thereof, shall be furnished with each order. The gaskets shall be shipped in suitable protective containers. All single gasket pipe shall be as manufactured by United States Pipe and Foundry Company (Tyton), by the American Cast Iron Pipe Company (Amarillo Fastite), by McWane, Inc. (Mix of Tyton and Fastite), Tyler/Union (Tyton) or approved equal.

Push-on joints together with both their regular and gasket-restraint gaskets shall be of the design, dimensions and tolerances of either those provided by American Cast Iron Pipe Company (Amarillo Fastite/Fast-Grip) or those provided by United States Pipe and Foundry Company (Tyton/Field Lok). No other designs will be acceptable.

The pressure rating shall be stamped on the restrained gasket. The restrained gasket and joint restraining system shall conform to ANSI/AWWA Standard C111/A21.11-12 rated at the following:

Size	Pressure Rating (Min.)
4-inch through 12-inch	350
14-inch through 20-inch	250
24-inch	200
30-inch and above	150

The restrained gasket shall be manufactured a color other than black to allow for visual inspection of the pipeline. The restrained gasket color shall be consistent throughout the system and shall be inherent within the rubber, not painted.

Mechanical Joints

Mechanical joints for fittings shall conform to ANSI/AWWA Standard C111/A21.11-12. Bolt holes for mechanical joints shall be equally spaced, and shall straddle the vertical centerline. Tee head bolts and hexagonal nuts for all mechanical joints in fittings shall be of high strength low-alloy steel with composition, dimensions and threading as specified in ANSI/AWWA

Standard C111/A21.11-12. Glands shall be of ductile-iron construction for ductile iron fittings, and cast gray iron or ductile iron for cast gray-iron fittings.

The proper number of gaskets, glands, bolts and nuts, all conforming to ANSI/AWWA Standard C111/A21.11-12, plus one extra gasket for every 10 joints or fraction thereof, shall be furnished with each order. The gaskets and joint accessories shall be shipped in suitable protective containers. Follower glands held in place with set screws will not be acceptable. Segmented glands will not be acceptable.

Mechanical Joint Megalug-Type Restraining Systems

In any mechanical joint or push on joint underground piping system restrained glands may be utilized for underground pipeline. The ASTM A536 ductile iron casting of the restrained gland shall be bonded powder coated. The wedge and wedge assembly shall have a bonded liquid polymer coating applied for corrosion protection. The gland shall utilize torque limiting twist off wedge actuation screws.

Foreign and domestic manufactured restrained glands are allowed for pipelines 24-inches and below unless otherwise required by the Department due to Federal or State funded projects which require domestic manufacture. In sizes 30, 36, 42 and 48-inch the prior written permission of the Engineer is required to use non-domestic manufactured restraining glands. The country of origin shall be clearly identified on the restraining gland and shop drawing.

The Department absolutely reserves the right to require other forms of restraint where in the opinion of the Engineer the use of this form of restraint is not in the best interest of the Department and his decision shall be final. Use of this type of restraint is restricted to underground mechanical joint or push-on joint applications and in general may not be used above grade or as a substitute for flanged joints.

The Megalug restraint systems manufactured by EBAA Iron Sales, Eastland Texas, will be considered the standard of quality for comparison purposes and if the Department has any doubts as to the durability, quality or ability to restrain of a proffered substitute, the entity offering the substitute shall bear the entire burden of proving this equality to the complete satisfaction of the Engineer. Other manufacturers producing this type of restraint system shall submit data with their shop drawings showing that their restraint system has been in the marketplace for a minimum of three years in this country.

Each thrust-resistant mechanical joint or push on joint made up with this type of restraint and the pipe and fitting of which it is a part, shall be designed to withstand an axial thrust from an internal pipeline pressure of at least 150 psi at bulkhead conditions without reduction because of its position in the pipeline nor for support from external thrust blocks.

This type of joint restraint shall not be used above grade except as previously specified nor shall it be used as a carrier pipe within a casing. This type of restraint shall not be used with tape wrapped pipe or with too great a coating thickness on the exterior of the pipe.

Restrained Push-on Joints (Single Gasket Non-Gasket Restrained)

Restrained joints in pipe and fittings shall be of the single gasket push-on type, and shall conform to all applicable provisions of ANSI/AWWA Standard C111/A21.11 and the following requirements:

Thickness of the pipe barrel remaining at grooves cut, if required in the design of restrained end joints, shall not be less than the nominal wall thickness of equal sized non-restrained pipe as specified in Section 3.1 above.

Restrained joints using field welding, set screws, or gaskets with expanding metal inserts are not acceptable.

The restraining components, when not cast integrally with the pipe and fittings, shall be ductile iron or a high strength non-corrosive alloy steel.

Tee head bolts and hexagonal nuts for all restrained joints in pipe and fittings shall be of high strength low-alloy steel with composition, dimensions and threading as specified in ANSI/AWWA Standard C111/A21.11, except that the length of the bolts shall meet the requirements for the restrained joint design.

The proper number of gaskets, bolts, nuts and all necessary joint material, plus one extra gasket for every 10 joints or fraction thereof, shall be furnished with each order. The gaskets and joint accessories shall be shipped in suitable protection containers.

Each thrust-resistant joint and the pipe and fitting of which it is a part, shall be designed to withstand the axial thrust from an internal pipeline pressure of at least 150 psi at bulkhead conditions without reduction because of its position in the pipeline nor for support from external thrust blocks.

Restrained push-on joint pipe and fittings shall be capable of being deflected after assembly. During deflection, all components in the restrained system shall be in contact to provide an equal force on all contact areas.

When restrained spigot ends are ordered for items of Group A, the corresponding bell ends of the pipe to be restrained (also within Group A), shall be furnished with the required matching restraining features at no additional cost other than the price bid per foot of pipe.

Flanged Joints

Connecting pieces with one end flanged and the other end either plain-end or mechanical joint, shall conform to ANSI/AWWA Standard C110/A21.10. Joint material for both the flanged end and the mechanical joint accessories for connecting pieces with a mechanical joint end shall be furnished as specified.

Other types of flanged fittings, and flanged pipe, shall conform to the following requirements unless otherwise stated in the order:

Flanged fittings shall conform to ANSI/AWWA Standard C110/A21.10, as specified hereinabove.

Flanged ductile-iron pipe with integrally cast flanges shall be manufactured in accordance with ANSI/AWWA Standard C151/A21.51, and with provisions contained hereinabove for

centrifugally cast ductile iron pipe, and shall be furnished with ANSI Standard Class 125 flanges, plain faced and drilled, conforming to ANSI Standard B16.1, "Cast Iron Pipe Flanges and Flanged Fittings", latest revision. Hollow back flanges are not acceptable.

Flanged ductile-iron pipe with threaded flanges shall be manufactured in accordance with ANSI/AWWA Standard C115/A21.15, "Flanged Ductile-Iron Pipe With Ductile-Iron or Grey-Iron Threaded Flanges", and shall be rated for a working pressure of 250 psi, minimum. The nominal thickness of flanged ductile-iron pipe, 6-inch and larger, shall not be less than those shown in Table 1 of ANSI/AWWA Standard C115/A21.15. The nominal thickness of 4-inch flanged ductile-iron pipe shall be Class 54 (min.) conforming to Tables 3 and 4 of ANSI/ Standard C151/A21.51. Flanges shall be solid-back.

The pipe shall be furnished with ANSI Standard Class 125 flanges, plain faced and drilled, conforming to ANSI Standard B16.1, latest revision. Hollow back flanges and grey-iron flanges shall not be acceptable for use as threaded flanges. Threaded flanges shall be individually fitted and machine tightened on the threaded pipe by the manufacturer, and shall not be interchangeable in the field.

Flanges shall be back-faced parallel to the face of flange. Prior to assembly of the flange onto the pipe, apply a thread compound to the threads to provide a leak-free connection. There shall be zero leakage through the threads at a hydrostatic test pressure of 250 psi without the use of the gasket. Pipe lengths shall be as ordered. Removal of flanges, cutting and rethreading the pipe, and re-installing the flanges will not be permitted in any case. Where a raised face flange connects to a flat-faced flange, remove the raised face of the flange.

All flanges on ductile-iron pipe and fittings shall be of ductile iron, class 70-50-5 in accordance with ANSI/AWWA C110/A21.10. All joint materials for flanged pipe and fittings, shall be supplied with all pipe or fittings ordered. Bolts and nuts shall comply with all requirements of Appendix Section A.1 of ANSI/AWWA Standard C115/A21.15-11 except that both shall be stainless steel. Bolts shall be of sufficient length to fully engage all threads in the nut. Unless ring gaskets are specified, gaskets shall be full-faced, and gaskets shall be of 1/8-inch thickness. Gaskets shall fully conform to the requirements of ANSI/AWWA Standard C115/A21.15-11 Appendix Section A.2 except that gaskets shall be SBR for water and neoprene for sewer usages.

Grooved-end Fittings and Couplings

Grooved-end fittings shall conform to ANSI/AWWA C110/A21.10-12 with grooved ends conforming to ANSI/AWWA C606-11, radius cut rigid joints. Fitting material shall conform to ASTM A48, Class 30; ASTM A126, Class B; or ASTM A536, Grade 65-42-10. Wall thickness of ductile-iron (ASTM A536) fittings shall conform to AWWA C110 or C153; wall thickness of cast-iron fittings shall conform to AWWA C110. Fittings and couplings shall be furnished by the same manufacturer.

Grooved-end pipe couplings shall be ductile iron, ASTM A536 (Grade 65-45-12). Gaskets shall be Buna-N and shall conform to ASTM D2000. Bolts in exposed service shall conform to ASTM A183, 110,000-psi tensile strength. Bolts in buried or submerged service shall be ASTM A193, Grade B8, and Class 2.

Couplings for pipe 24 inches and smaller shall conform to AWWA C606 for flexible radius ductile-iron pipe, except where rigid radius couplings are required to connect to fittings.

Couplings for pipe sizes 30 and 36 inches shall be in accordance with the coupling manufacturer's published literature for tolerances and dimensions for flexible and rigid radius cut joints. Couplings shall be Victaulic Style 31, Gustin-Bacon No. 500, or equal.

Couplings for pipe larger than 36 inches shall conform to AWWA C606 for shouldered end pipe. Couplings shall be Victaulic Style 44 or equal.

Grooved-end adapter flanges for piping 24 inches and smaller having an operating pressure of 150 psi and less shall be Victaulic Style 341 or 342 or equal. Flange dimensions shall conform to ASME B16.1, Class 125.

Grooved-end transition couplings for connecting ductile-iron pipe 12 inches and smaller to steel pipe shall be Victaulic Style 307 or equal.

Outlets and Nozzles

Provide outlets three quarters of an inch and smaller by direct tapping Ductile Iron Pipe in accordance with AWWA C600-10, Section 4.8. Provide outlets larger than three quarters of an inch up to 2 inches by tapping the pipe and attaching a service clamp. or use a threaded welded-on boss. Use stainless steel clamps for exposed piping. For outlets larger than 2 inches, use a tee with a flanged outlet. For outlets larger than 2 inches in buried piping, use a tee with a restrained joint outlet.

Ductile-Iron Pipe Weldments

All welding to ductile-iron pipe, such as for bosses, joint restraint, and joint bond cables, shall be done at the place of manufacture of the pipe. Perform welding by skilled welders experienced in the method and materials to be used. Welders shall be qualified under the standard qualification procedures of the ASME Boiler and Pressure Vessel Code, Section IX, Welding Qualifications.

Welds shall be of uniform composition, neat, smooth, full strength, and ductile. Completely grind out porosity and cracks, trapped welding flux, and other defects in the welds in such a manner that will permit proper and complete repair by welding.

Material for fittings with welded-on bosses shall have a Charpy notch impact value of minimum 10 ft-lbs under the conditions defined in ANSI/AWWA C151/A21.51-09. Test completed welds by the liquid penetrant method per ASTM E165.

Completed welds shall be inspected at the place of manufacture by the liquid penetrant method. Conform to the requirements specified in ASTM E165, Method A, Type I or Type II. The materials used shall be water washable and nonflammable.

E. LININGS AND COATINGS

Saltwater Intrusion and Corrosive Soils Requirements

In saltwater intrusion areas where the installation is subject to groundwater level variation (East of I-95 or saltwater intrusion line), the Department shall require the use of V-Bio

Enhanced Polyethylene Encasement and ductile iron pipe with a zinc basecoat under the asphaltic topcoat. All ductile iron pipe and fittings shall be wrapped with the V-Bio Polyethylene Enhanced Encasement and have the zinc protective coating factory applied.

For corrosive soils encountered outside of saltwater intrusion areas during construction V-Bio Polyethylene Encasement shall be installed to protect the ductile iron main, fittings and valves.

Zinc Basecoat: The exterior of ductile iron pipe shall be coated with a layer of arc-sprayed zinc per ISO 8179. The mass of the zinc applied shall be 200 g/m^2 of pipe surface area. A finishing layer topcoat shall be applied to the zinc. The mean dry film thickness of the finishing layer shall not be less than 3 mils with a local minimum not less than 2 mils. The coating system shall conform in every respect to ISO 8179-1 "Ductile iron pipes - External zinc-based coating - Part 1: Metallic zinc with finishing layer. Ductile iron fittings shall also have a zinc protective coating sprayed on at the factory at a minimum of 3 mils.

The V-Bio Polyethylene Enhanced Encasement shall be accordance with AWWA C600 and ANSI/AWWA C105/A21.5, “Polyethylene Encasement of Ductile-Iron Pipe Systems”. Color shall be blue for potable water, purple for recycled water, and green for sanitary sewage service. Polyethylene encasement for use with ductile iron pipe systems shall consist of three layers of co-extruded linear low density polyethylene (LLDPE), fused into a single thickness of not less than 8 mils. The inside layer of the polyethylene wrap to be in contact with the pipe exterior shall be infused with a corrosion inhibitor and antimicrobial biocide to to control galvanic corrosion. Product: V-Bio or approved equal.

Polyethylene encasement for ductile-iron pipe shall be supplied as a flat tube meeting the dimensions of Table 1 in AWWA C105 and shall be supplied by the ductile-iron pipe manufacturer.

Plastic adhesive tape shall consist of polyolefin backing and adhesive which bonds to common pipeline coatings including polyethylene. Products: Canusa Wrapid Tape; Tapecoat H35; Polyken 934; AA Thread Seal Tape, Inc.; or approved equal.

Install the polyethylene to completely encase the pipe and fittings to provide a watertight corrosion barrier. Continuously secure overlaps and ends of sheet and tube with polyethylene tape. Make circumferential seams with two or more complete wraps, with no exposed edges. Tape longitudinal seams and longitudinal overlaps, extending tape beyond and beneath circumferential seams. Wrap bell-spigot interfaces, restrained joint components, and other irregular surfaces with wax tape or moldable sealant prior to placing polyethylene encasement. Minimize voids beneath polyethylene.

Place circumferential or spiral wraps of polyethylene tape at 2-foot intervals along the barrel of the pipe to minimize the space between the pipe and the polyethylene. Overlap adjoining polyethylene tube coatings a minimum of 1 foot and wrap prior to placing concrete anchors, collars, supports, or thrust blocks. Hand-wrap the polyethylene sheet, apply two complete wraps with no exposed edges to provide a watertight corrosion barrier, and secure in place with 2-inch-wide plastic adhesive tape. Repair polyethylene material that is damaged during installation. Use polyethylene sheet, place over damaged or torn area, and secure in place with 2-inch-wide plastic adhesive tape.

Repair polyethylene encasement at all service connections in accordance with AWWA C60010, Section 4.8.

Asphaltic Coating

All Ductile Iron pipe and fittings shall be outside-coated with an asphaltic material applied by means of the airless spray method. The exterior coating shall comply with ANSI/AWWA C151/A21.51 for this type of coating, shall be smooth without pinholes, thin, bare or overly thick areas. Smoothness shall be such that when hand rubbed, no “sand paper” feeling will be experienced and such that the spigot area will readily slide through the gasket without pulling, tearing, rolling or otherwise disturbing the sealing capabilities of the gasket. Spigot ends shall be beveled prior to coating to an extent that will permit ready insertion of the spigot through the gasket area.

Cement-Mortar Lining

Ductile Iron Pipe and fittings unless otherwise specified shall be double-thickness cementlined and seal-coated in accordance with ANSI/AWWA Standard C104/A21.4-14, "CementMortar Lining for Ductile-Iron Pipe and Fittings ".

Ceramic Epoxy Lining

Ductile Iron Pipe and fittings where so specified shall be lined with ceramic epoxy

Ceramic epoxy shall contain pigmentation to resist ultraviolet exposure under the same conditions.

All ductile iron pipe and fittings for which ceramic epoxy lining is to be applied shall be delivered to the application facility without asphalt, cement lining or other lining on the interior surface or the first 6 inches on the spigot end of the pipe exterior.
Ceramic epoxy material shall be a high-build multi-component Amine cured Novalac epoxy, Protecto 401, by Vulcan Painters, Inc. of Bessemer, AL 35021 or Department-approved equal. Permox CTF is also an acceptable sanitary sewer lining.

Ceramic epoxy material shall meet the following criteria and shall be accompanied by certification of the following test results:

A. A permeability rating of 0.00 when tested according to Method A of ASTM E96-00 "Test Method for Water Vapor Transmission of Materials", Procedure A with a test duration of 30 days.

B. The following test must be run on coupons from factory lined ductile iron pipe:

    1. ASTM B117 Salt Spray (scribed panel) - Results to equal no more than 0.5mm undercutting after one year.

    2. ASTM G95 Cathodic Disbondment 1.5 volts @ 77 degrees F. Results to equal no more than 0.5mm undercutting after 30 days.

    3. Immersion Testing rating using ASTM D714-87 (1994).

a. 20% Sulfuric Acid - No effect after one year.
b. 25% Sodium Hydroxide - No effect after one year.
c. 160° F. Distilled Water - No effect after one year.
d. 120° F. Tap Water (scribed panel) - 0.0 undercutting after one year with no effect.

C. A statement from the manufacturer attesting to the fact that at least 20% of the volume of the lining contains ceramic quartz pigment.

D. A statement concerning recoat ability and repair to the lining.

Ceramic Epoxy Application

a. The lining shall be applied by a competent firm with a successful history of applying linings to the interior of ductile iron pipe and fittings.

b. Surface Preparation
Prior to abrasive blasting, the entire area which will receive the protective compound shall be inspected for oil, grease, etc. Any areas where oil, grease or any substance is present which can be removed by solvent shall be solvent cleaned using the guidelines outlined in SSPC-1 Solvent Cleaning. After the surface has been made free of grease, oil or other substances, all areas to receive the protective compounds shall be abrasive blasted using compressed air nozzles with sand or grit abrasive media. The entire surface to be lined shall be struck with the blast media so that all rust, loose oxides, etc., are removed from the surface. Only slight stains and tightly adhering annealing oxide may be left on the surface. Any area where rust reappears before coating must be re-blasted to remove all rust.

c. Lining Application
After the surface preparation and within 8 hours of surface preparation, apply to the interior of pipe and fittings a minimum forty (40) mils dry film thickness of the protective lining. No lining shall take place when the substrate or ambient temperature is below 40 degrees Fahrenheit. The surface also shall be dry and dust free. If flange ends are included in the Project, the linings shall not be used on the face of the flange; however, full face gaskets must be used to protect the ends of the pipe. The 40-mil system shall not be applied in the gasket grooves.

d. Coating of Gasket and Spigot Ends
Coat the gasket area and exterior of the spigot end for 6 inches back from the end of the spigot with six (6) mils minimum, ten (10) mils maximum of Protecto Joint Compound. This coating shall be applied by brush to ensure complete coverage. Care shall be taken that the coating is smooth without excess buildup in the gasket groove or on the spigot end. All material for the gasket groove and spigot end shall be applied after the application of the lining as specified in the preceding paragraph.

e. Number of Coats
The number of coats of lining material applied shall be as recommended by the lining manufacturer. However, in no case shall this material be applied above the dry thickness per coat recommended by the lining manufacturer in printed literature. The time between coats shall never exceed that time recommended by the lining material manufacturer. No material shall be used for lining which is not indefinitely recoated able with itself without roughening the surface.

f. Touch-Up and Repair

Protecto Joint Compound shall be used for touch-up or repair. Procedures shall be in accordance with manufacturer's recommendations.

F. INSPECTION AND CERTIFICATION

a. Inspection

1. All ceramic epoxy lined ductile iron pipe and fitting linings shall be checked for thickness using a magnetic film thickness gauge. The thickness testing shall be done using the method outlined in SSPC-PC-2 Film Thickness Rating. Re-line any pipe whose lining is below the specified minimum thickness.

2. The interior lining of all pipe and fittings shall be tested for pinholes with a nondestructive 2,500 volt test. Re-line any pipe not passing the test.

3. Each pipe joint and fitting shall be marked with the date of application of the lining system and with its numerical sequence of application on the date.

Procedures for Sealing Cut Ends and Repairing Field Damaged Areas

1. Remove burrs caused by field cutting of ends or handling damage and smooth out the edge of the lining if rough.

2. Remove all traces of oil, grease, asphalt, dust, dirt, etc.

3. Areas of loose or damaged lining associated with field cutting the pipe shall be repaired, if approved by the Engineer, as recommended by the pipe manufacturer. The damaged area shall be stripped back by chiseling or scraping about 1 to 2 inches into the well-adhered lining before patching.

   The exposed metal and the 1 to 2-inch lining overlap shall be roughened with a coarse grade of emery cloth (#40 grit), rasp or small chisel. Avoid wire brushing or similar buffing which would make the surface too smooth for good adhesion.

4. With the area to be sealed or repaired absolutely, clean and suitably roughened, apply a coat of Protecto Joint Compound by brush in accordance with the manufacturer's recommendations.

PART 3 - EXECUTION

3.01 General:

A. Furnish and maintain all barricades and flashing warning lights necessary to warn of the construction throughout the Project.

B. Pipe and fittings shall at all times be handled with great care to avoid damage. Exercise particular care not to injure pipe coatings. In loading and unloading, they shall be lifted with cranes or hoists

or slid or rolled on skidways in such manner as to avoid shock. Under no circumstances shall this material be dropped or allowed to roll or slide against obstructions.

C All work shall be performed by skilled workmen experienced in pipeline construction.

D. All pipe and fittings shall be adequately supported by clamps, brackets, straps, concrete supports, rollers or other devices as shown and/or specified. Supports or hangers shall be spaced so that maximum deflection between supports or hangers shall not exceed 0.050 inch for pipe filled with liquid, but shall not be further than 6 feet apart, whichever is closer, unless otherwise shown. All pipe supports shall be secured to structures by approved inserts or expansion shields and bolts.

E. All pipe shall be thoroughly cleaned internally before being installed. All pipes, except oxygen service, air and gas, shall be flushed with water and swabbed to assure removal of all foreign matter before installation. Air and gas piping shall be tapped with a hammer to loosen scale or other foreign matter that might be within the pipe, and then thoroughly blown with a high pressure air hose. Furnish and maintain suitable air compressor.

F. Whenever possible, the pipe shall be installed with minimum 48-inches of cover. Deviations shall not be installed without written approval by the Owner.

G. Joints may only be opened to adjust alignment by half of the AWWA or manufacturer's recommended opening (which is smaller).

H. Pipe Sleeves and Wall Casings: Pipe sleeves and wall casings shall be provided at the locations called for on the Drawings and specified herein. These units shall be as detailed and of the material as noted on the Drawings and specified herein. They shall be accurately set in the concrete or masonry to the elevations shown. All wall sleeves and castings required in the walls shall be in place when the walls are poured. Ends of all wall casings and wall sleeves shall be of a type consistent with the piping to be connected to them.

I. Tie Rods: Unless otherwise indicated on the Drawings, the size and number of tie rods for a joint or installation shall be as recommended by the manufacturer's design chart for a working pressure of 150 psi. Tie rods shall be installed as recommended by the manufacturer.

3.02 EXCAVATION FOR PIPING

A. Make all excavation necessary for the construction of the pipelines, connections, valves and appurtenances, to the lines and grades shown on the Plans.

B. Excavate the trench at least 6 inches below pipe laying grade as shown on the Plans. Install sheeting and shoring for the protection of workers in trenches, and where it is necessary for pipe installation and property protection or required by the Trench Safety Act. The cost of dewatering any excavation shall be at the Contractor's expense. The disposal of water removed from an excavation shall be in a manner which will not create a hazard, or be detrimental to the public health or to public or private property.

C. Obtain all necessary permits approving the location and proposed method of disposal before discharging water from any excavation into any portion of the public right-of-way or into any existing drainage structure or facility. Furnish and maintain all construction signs required.

3.03 INSTALLATION OF PIPE, FITTINGS AND VALVES

A. General:

1. The design Drawings are in some cases diagrammatic. They may not show every bend, off-set, elbow or other fitting which may be required in the piping for installation in the space allotted. . Install gravity lines at uniform grade to low point after field verification of low point invert.

2. The centerline of the pipe shall not vary by more than 2 inches from the location shown on the Plans and the top of the pipe shall not vary by more than 2 inches from the established grade, except at points where this tolerance must be changed to clear obstructions, or make connections.

3. Limit onsite pipe storage to a maximum of one week. Use unloading and installation procedures that avoid cracking of the lining. If necessary, use plastic sheet bulkheads to close pipe ends and keep cement-mortar lining moist. Deliver the pipe alongside the pipe laying access road over which the pipe trailer-tractors can travel under their own power. Place the pipe in the order in which it is to be installed and secure it from rolling. Sandbags may be used to support the pipe in the ditch but no pipe shall be laid on blocks, except by the written permission of the Engineer of Record. Do not move pipe by inserting any devices or pieces of equipment into the pipe barrel. Field repair linings damaged by unloading or installation procedures. Flanged joints, mechanical joints and push-on joints in cast iron pipe and fittings may be made under water.

B. Installation of Ductile Iron Pipe

1. Install Ductile Iron Pipe in accordance with ANSI/AWWA C600-10 “Installation of Ductileiron Mains and Their Appurtenances”, and the following. For potable water pipelines, comply with NSF/ANSI 61 “Drinking Water System Components – Health Effects. All bends, tees, and plugs, unless otherwise specified, shall be backed with concrete to undisturbed ground. Provision shall be made to prevent concrete from adhering to plugs or bolts by wrapping in polyethylene sheet complying with ANSI/AWWA C105/A21.5-05.

2. Bolts, nuts and rubber gaskets for use in flanged and mechanical joints shall be stored under cover. During laying operations, do not place tools, clothing, or other materials in the pipe Gaskets shall not be exposed to heat, light or any petroleum products, shall be kept clean and shall not be handled with greasy or dirty hands. When pipe laying is not in progress, close the ends of the installed pipe by a child- and vermin-proof plug.

3. Assemble Flanged joints in accordance with the written recommendations of the pipe manufacturer. Before making up flanged joints in cast iron pipe and fittings, the back of each flange under the bolt heads, and the face of each flange shall have all lumps, blisters and excess bituminous coating removed and shall be wire brushed and wiped clean and dry. Cut the bore of the gaskets such that the gaskets do not protrude into the pipe when the flange bolts are tightened.

4. Before laying the ductile iron pipe, all lumps, blisters and excess asphaltic coating shall be removed from the bell and spigot ends of each pipe and the outside of the spigot and the inside of the bell wire brushed and wiped clean and dry. The entire gasket groove area

shall be free of bumps or any foreign matter which might displace the gasket. The cleaned spigot and gasket shall not be allowed to touch the trench walls or trench bottom at any time. Vegetable soap lubricant shall be applied in accordance with the pipe manufacturer's recommendations, to aid in making the joint. Exercise caution to prevent damage to the gasket or the adherence of grease or particles of sand or dirt. Deflections shall be made only after the joint has been assembled.

5. Cutting of ductile iron pipe for inserting valves, fittings, etc., shall be done with a mechanical pipe saw in a neat and workmanlike manner without damage to the pipe, the lining, or the coating.

6. Unless otherwise directed, ductile iron pipe shall be laid with the bell ends facing in the direction of laying; and for lines on an appreciable slope, the bells shall, at the discretion of the Engineer, face upgrade. Small angular changes (less than 2.5 degrees) in horizontal alignment defined in the drawings by a point of inflection (PI) with no accompanying curve data shall be approximated as a curve by deflecting an equal amount of equal length pipe segments to create a curve equally distributed on both sides of the given PI. Accomplish a larger (greater than or equal to 2.5 degrees) change in horizontal alignment where a curve is not called for in the drawings through the use of an elbow placed at the station of the PI shown in the drawings. Small angular changes (less than 2.5 degrees) in vertical alignment may be accomplished by the use of pulled joints. For larger vertical deflections, place an elbow at the station and elevation of the vertical PI shown in the drawings.

7. Push-on and mechanical joints in ductile iron pipe and fittings shall be made in accordance with the manufacturer's written recommendations except as otherwise specified herein. Joints between push-on and mechanical joint pipe and/or fittings shall be made in accordance with AWWA Standard Specifications, "Installation of Ductile Iron Water Mains and Appurtenances," C600-10, except that deflection at joints shall not exceed one-half of the manufacturer's recommended allowable deflection, or one-half of the allowable deflection specified in AWWA C600-10, whichever is the lesser amount.

8. Flanged joints shall be used only where indicated on the Plans. Before making up flanged joints in the pipeline, the back of each flange under the bolt heads and the face of each flange shall have all lumps, blisters and excess bituminous coating removed and shall be wire brushed and wiped clean and dry. Flange faces shall be kept clean and dry when making up the joint, and the workmen shall exercise caution to prevent damage to the gasket or the adherence of grease or particles of sand or dirt. Bolts and nuts shall be tightened by opposites in order to keep flange faces square with each other, and to insure that bolt stresses are evenly distributed.

9. Bolts and nuts in flanged and mechanical joints shall be tightened in accordance with the written recommendations of the pipe manufacturer for a leak-free joint. Exercise caution to prevent overstress. Torque wrenches shall be used until, in the opinion of the Engineer, the workmen have become accustomed to the proper amount of pressure to apply on standard wrenches.

END OF SECTION

VALVES, GENERAL

PART 1 - GENERAL

1.01 SCOPE

A. The Contractor shall provide all tools, supplies, materials, equipment, and labor necessary for furnishing, installing, adjusting, and testing of all valves and appurtenant work, complete and operable. For buried valves, the Contractor shall furnish and install valve boxes to grade, with covers, extensions, and position indicators.

B. The provisions of this Section shall apply to all valves and valve operators called out in the various Sections of these Specifications except where otherwise specified. Valves and operators in particular locations may require a combination of units, sensors, limit switches, and controls specified in other sections of these Specifications.

C. All valves specified herein shall be furnished with an affidavit from the manufacturer(s) certifying that the valves furnished comply with the applicable provisions of the AWWA specifications, as modified herein. That they were factory tested in accordance with the AWWA Standard Leakage and Hydrostatic Tests as modified herein, with a certified test report furnished to the Department for each valve.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Piping, General

1.03 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

A. Codes: All codes, as referenced herein, are specified in Section entitled "Reference Standards." As used herein, "ANSI" denotes the American National Standards Institute; "AWWA", the American Water Works Association; and "ASTM", the American Society for Testing and Materials.

B. Commercial Standards:

ANSI B16.1 Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.

ANSI B16.5	Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys.
ANSI/ASME B1.20.1	General Purpose Pipe Threads (Inch).
ANSI/ASME B31.1	Power Piping.

ASTM A 36	Specification for Structural Steel.
ASTM A 48	Specification for Gray Iron Castings.
ASTM A 126	Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
ASTM A 536	Specification for Ductile Iron Castings.
ASTM B 61	Specification for Steam or Valve Bronze Castings.
ASTM B 62	Specification for Composition Bronze or Ounce Metal Castings.
ASTM B 148	Specification for Aluminum-Bronze Castings.
ASTM B 584	Specification for Copper Alloy Sand Castings for General Applications.
ANSI/AWWA C500	Gate Valves for Water and Sewerage Systems.
AWWA C550	Protective Interior Coatings for Valves and Hydrants.

1.04 MANUFACTURER

All valves shall be the product of domestic manufacturing firms which have been engaged in the production of valves for not less than five (5) years.

1.05 QUALITY ASSURANCE

A. Valve Testing: The Contractor is advised that he is required to furnish all labor, materials and equipment necessary to pressure test each valve furnished by himself or the Department, bi-directionally, prior to installation, to the satisfaction of the Engineer of Record. If the valves are available, the tests shall be performed prior to the start of construction. Otherwise, the tests shall be performed as soon as the valves are available to afford the maximum time for any corrective work required. The Contractor shall include all costs for this requirement under the appropriate Proposal Item(s), no other compensation will be provided.

B. Bronze Parts: Unless otherwise specified, all interior bronze parts of valves shall conform to the requirements of ASTM B 62.

C. Provide valves that have the manufacturer's name and valve rating cast in body.

1.06 SUBMITTALS

A. Shop Drawing: Shop drawings of all valves and operators including associated wiring diagrams and electrical data.

B. Approved Drawings: The Engineer of Record's drawings, which constitute an integral part of this Contract, indicate the general layout of the complete system. Field verification of scale dimensions on plans is directed since actual locations, distances and levels will be governed by actual field conditions. The Contractor shall also review architectural, structural, and mechanical plans and shall adjust his work to conform to all conditions indicated thereon. Discrepancies shown on different plans, or between plans and actual field conditions, or between plans and specifications, shall promptly be brought to the attention of the Engineer of Record, for a decision. All items not specifically mentioned in the specifications or noted on the drawings, but which can be reasonably assumed as necessary to make a complete working installation shall be included.

PART 2 - PRODUCTS

2.01 VALVES

A. General: The Contractor shall furnish all valves, gates, valve operating units, stem extensions, operators and other accessories as shown or specified. All valves and gates shall be new and of current manufacture. All non-buried valves, 6-inch and larger, shall have operators with position indicators. Where buried, these valves shall be provided with valve boxes, covers and valve extensions. Valves mounted higher than 6-feet above working level shall be provided with chain operators. All valves shall have a minimum design pressure rating of 150 psi unless otherwise specified elsewhere herein.

B. Cast iron parts of valves shall meet the requirements of ASTM A126, "Standard Specifications for Gray Iron Castings for Valves, Flanges and Pipe Fittings, Class 'B'." Flanged ends shall be flat-faced and have bolt circle and bolt patterns conforming to ANSI B16.1 Class 125.

C. All castings shall be clean and sound, without defects of any kind and no plugging, welding or repairing of defects will be permitted. All bolt heads and nuts shall be hexagonal conforming to ANSI B18.2. Gaskets shall be full-face and made of synthetic elastomers in conformance with ANSI B16.21 suitable for the service characteristics, especially chemical compatibility and temperature. Non-ferrous alloys of various types shall be used for parts of valves as specified. Where no definite specification is given, the material shall be the recognized acceptable standard for that particular application.

D. All buried valves shall be provided with cast-iron valve boxes unless otherwise indicated. The boxes shall conform with Department Standards and be installed perpendicularly, centered around and covering the upper portions of the valve operator. The top of each valve box shall be placed flush with finish grade unless otherwise indicated on the Drawings. Valve boxes shall be as specified elsewhere in this Section.

E. All buried valves and other valves located below a concrete operating deck or level, specified or noted to be key operated, shall have an operator to finish grade or deck level, non-rising stem, a 2-inch square AWWA nut with skirt, and cover or box and cover, as may be required.

F. Valve Flanges: The flanges of valves shall be in accordance with Section 15060, "Piping and Fittings."

G. Gate Valve Stems: Gate valve stems shall be of bronze in accordance with AWWA C515, containing not more than 5 percent of zinc nor more than 2 percent of aluminum.

H. Protective Coating: Except where otherwise specified, ferrous surfaces, exclusive of stainless steel surfaces, in the fluid passages of all valves 4-inch and larger shall receive an epoxy coating in accordance with AWWA C550. Flange faces of valves shall not be epoxy coated. The valve manufacturer, shall certify in writing that such coating has been applied and tested in the manufacturing plant prior to shipment, in accordance with these Specifications. Exterior coating shall be asphalt varnish conforming to Federal Specification TT-C-494A.

I. Valve Labeling: A label shall be provided on all shut-off valves exclusive of hose bibs and chlorine cylinder valves. The label shall be of 1/16-inch brass or stainless steel, minimum 2 inches by 4 inches in size, and shall be permanently attached to the valve or on the wall adjacent to the valve or as indicated by the Department.

2.02 VALVE OPERATORS

A. General

1. All butterfly valves, plug valves over 8-inch size and gate valves installed horizontally shall be furnished with geared operators, provided by the manufacturer. All valves of a particular size and pressure rating by a given manufacturer shall be supplied with the same operator. No variation will be permitted during the contract. All valve operators, regardless of type, shall be installed, adjusted, and tested by the valve manufacturer at the manufacturing plant. Operator orientation shall be verified with the Department prior to fabrication. If this requirement is not met, changes to orientation shall be made at no cost the Department.

2. All operators shall turn counter-clockwise to open. Operators shall have the open direction clearly and permanently marked. Field adjustment and testing of the operators and valves to ensure proper installation and operation shall be the responsibility of the Contractor.

B. Manual Operators

1. All manual operators shall be equipped with AWWA square nuts, handwheels or chain drives as appropriate. Some small (6-inch or less) valves may be lever operated if so specified elsewhere herein. Where buried, the valves shall have extensions with square nuts or floor stands as indicated on the Drawings. Valves mounted higher than

6 feet above floor or operating level shall have chain operators with chain terminating 4 feet above operating level.

2. Operation of valves and gates shall be designed so that the effort required to operate the handwheel, lever or chain shall not exceed 40 pounds applied at the extremity of the wheel or lever. The handwheels on valves 14 inches and smaller shall not be less than 8 inches in diameter, and on valves larger than 14 inches the handwheel shall not be less than 12 inches in diameter.

3. Chainwheel operator shall be fabricated of malleable iron with pocketed type chainwheels with chain guards and guides. Chainwheel operators shall be marked with an arrow and the word "open" indicating direction to open. The operators shall have galvanized smooth welded link type chain. Chain that is crimped or has links with exposed ends is not acceptable.

2.03 TORQUE LIMITING DEVICE

Each butterfly valve shall be provided with a torque limiting device designed to protect the actuator and valve parts. The device shall consist of an overtorque protection mechanism enclosed in a hermetically sealed cast iron housing. The mechanism shall be permanently lubricated and factory set to trip between 200 and 220 ft. lbs. of applied torque. The housing shall have integrally cast, 2-inch AWWA operating nut and matching socket to operate and to fit over the actuator or extension shaft nuts, respectively. The socket shall be provided with a set screw to fit the device. The direction of rotation shall be permanently shown with word and arrow next to the operating nut. The entire device shall be coated inside and out with a 2-part epoxy. The torque limiting device shall be as manufactured by Annspach Controls Company of St. Louis, Missouri, or approved equal.

2.04 FLOOR STANDS

Floor stands shall be cast iron, non-rising stem type with lockable hand wheel operator, valve position indicator and stainless steel or bronze extension stem. Hand wheel shall be lockable in the full open and full closed positions. The floor stand shall be furnished with an armored padlock and six keys. Lock shall be as manufactured by Master, Schlage or equal. Floor stand shall be standard pattern type as manufactured by Clow Corporation, or equal.

2.05 VALVE BOXES

Cast iron valve boxes shall be provided for all valves installed underground. All valves boxes shall be No. 2 or 3 (for water) and No. 52 or 53 (for sewer) in accordance with Department Standards.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: All work shall be performed by skilled workmen experienced in similar installations. All valves shall be adequately supported by clamps, brackets, straps, concrete supports or other devices as shown or specified. All supports shall be secured to structures by approved inserts or expansion shields and bolts.

B. All valves shall be thoroughly cleaned internally before being installed. Installation of valves shall be done in accordance with construction methods specified in "Pipes and Fittings" Section of these Specifications.

C. Install valves as recommended by manufacturer.

D. Install valves so that they are easily accessible for operation, visual inspection and preventive maintenance.

E. Location of valves and chain operators: Install valves so as to be accessible for operation and free from interferences when operated. Position so that leakage will not contact any electrical equipment that may be located below.

F. The installation of all underground valves shall include a valve box and riser in accordance with the Details shown on the Plans or in the Standard Details for the various sizes and types of valves to be installed. Riser pipes and valve boxes shall be carefully centered and set flush with the finished grade if in paving, or with the top of the ground if out of paved areas. All valve boxes shall be held in position with concrete as shown on the Plans or in the Standard Details.

G. Upon completion of the Project, but prior to final acceptance, the Contractor in the presence of the Engineer, shall fully open each valve installed by him, except at connections to existing Department mains. For valves 16-inch and larger, the Contractor, shall count the number of turns required to operate each valve from a completely closed to a fully opened position, and shall paint the number on the bottom of the valve box lid or manhole cover. Valves at connections to existing Department mains shall only be operated by Department forces.

END OF SECTION

SECTION 125
EXCAVATION FOR STRUCTURES AND PIPE

125-1 Description.

Excavate for box culverts, pipes, retaining walls, headwalls for pipes and drains, catch basins, drop inlets, manholes, and similar structures. Construct and remove cofferdams, sheeting, bracing, etc.; pump or otherwise dewater foundations; remove and dispose of any existing structures or portions of structures not covered by other items in the Contract, including foundations, abutments, piers, wings, and all other materials, obstructions, etc., found necessary to clear the site for the proposed work; backfill, dispose of surplus material, and perform final cleaning, as may be necessary for the proper execution of the work. This Section does not include excavation for bases or pavements, curbs, curb and gutter, valley gutter, ditch pavement, or rubble gutter.

125-1.1 Trench Excavation Safety System and Shoring, Special (Trench Excavation): When performing trench excavation in excess of 5 feet in depth, comply with the Occupational Safety and Health Administration's (OSHA) trench safety standards, 29 CFR, 1926, Subpart P, and all subsequent revisions or updates adopted by the Department of Labor and Employment Security. Ensure that trench boxes are wide enough to accommodate compaction and density testing.

Submission of bid and subsequent execution of the Contract will serve as certification that all trench excavation in excess of 5 feet in depth will be in compliance with Section 553.62, Florida Statutes.

Consider all available geotechnical information when designing the trench excavation safety system.

Consider these and any more stringent trench safety standards as minimum Contract requirements.

125-2 Classification.

Consider all materials excavated as unclassified and as excavation regardless of the material encountered.

125-3 Cofferdams.

125-3.1 Construction:

125-3.1.1 Methods: Construct all foundations by open excavation, and shore, brace, or protect the foundation openings with cofferdams. Provide cofferdams or cribs for foundation construction below the bottom of the footings. Provide sufficient clearance in the cofferdam interiors to permit construction of forms and inspection of their exteriors, and for pumping equipment.

125-3.1.2 Protection of Concrete: Construct cofferdams to protect green concrete against damage from a sudden rising of the water and to prevent damage by erosion. Do not leave timber or bracing in cofferdams or cribs that extend into the substructure masonry except where permitted in writing by the Engineer.

125-3.1.3 Placing in the Dry: For placing footings in the dry, the Engineer may require cofferdam sheeting to be driven to an elevation 6 feet below the elevation of the bottom of the footings and require sufficient pumping equipment to dewater and maintain the cofferdam in a comparatively dry condition.

125-3.1.4 Working Drawings: For substructure work, submit drawings showing the proposed method of cofferdam construction and other details left to choice or not fully shown in the Plans. Obtain the Engineer's approval of the type and clearance of cofferdams, insofar as such details affect the character of the finished work. For other details of design that do not affect the character of the finished work, assume responsibility for the successful construction of the work. Retain a Professional Engineer, registered in the State of Florida, to prepare the above construction drawing, and keep a signed and sealed copy on hand at the site at all times.

125-3.2 Removal: Unless otherwise provided, remove cofferdams or cribs, with all sheeting and bracing, after completion of the substructure without disturbing or marring the finished masonry.

125-4 Excavation.

125-4.1 Requirements for all Excavation: Perform all excavation to foundation materials, satisfactory to the Engineer, regardless of the elevation shown in the Plans. Remove rock, boulders or other hard lumpy or unyielding material to a depth of 12 inches below the bottom of pipes and box culverts elevations. Remove muck or other soft material to the depth indicated in the Plans or as directed by the Engineer.

125-4.2 Earth Excavation:

125-4.2.1 Foundation Material other than the Rock: When masonry is to rest on an excavated surface other than rock, take special care to avoid disturbing the bottom of the excavation, and do not remove the final foundation material to grade until just before placing the masonry. In case the foundation material is soft or mucky, the Engineer may require excavation to a greater depth and to backfill to grade with approved material.

125-4.2.2 Foundation Piles: Where foundation piles are used, complete the excavation of each pit before driving the piles. After the driving is completed, remove all loose and displaced material, leaving a smooth, solid, and level bed to receive the masonry.

125-4.2.3 Removal of Obstructions: Remove boulders, logs, or any unforeseen obstacles encountered in excavating. Compensation will be in accordance with the requirements of 4-3.

125-4.3 Rock Excavation: Clean all rock and other hard foundation material, remove all loose material, and cut all rock to a firm surface. Either level, step vertically and horizontally, or serrate the rock, as may be directed by the Engineer. Clean out all seams, and fill them with concrete or mortar.

125-4.4 Pipe Trench Excavation: Excavate trenches for pipes to the elevation of the bottom of the pipe and to a width sufficient to provide adequate working room. Remove soil not meeting the classification specified as suitable backfill material in 125-8.3.2.2, to a depth of 4 inches below the bottom of the pipe elevation. Where the soils permit, ensure that the trench sides are vertical up to at least the mid-point of the pipe.

For pipe lines placed above the natural ground line, place and compact the embankment, prior to excavation of the trench, to an elevation at least 2 feet above the top of the pipe and to a width equal to four pipe diameters, and then excavate the trench to the required grade.

For pipe trenches utilizing trench boxes, ensure that the trench box used is of sufficient width to permit thorough tamping of bedding material under and around the pipes as specified in 125-8.1.6.

Do not disturb the installed pipe and its embedment when moving trench boxes. Move the trench box carefully to avoid excavated wall displacement or damage. As the trench

box is moved, fill any voids left by the trench box and continuously place and compact the backfill material adjacent to and all along the side of the trench box walls to fill any voids created by the trench box.

125-5 Preservation of Channel.

125-5.1 General: Unless shown in the Plans, do not excavate outside of caissons, cribs, cofferdams, or sheet piling, and do not disturb the natural stream bed adjacent to the structure. If excavating or dredging at the site of the structure before sinking caissons, cribs, or cofferdams, complete the foundation and backfill all such excavations to the original ground surface or other required elevation, with material satisfactory to the Engineer.

125-5.2 Removal of Excavated Materials: Do not allow materials that are deposited adjacent to the stream area to infiltrate the water areas. Leave the stream in its original condition.

125-6 Disposal of Surplus.

Use suitable excavated materials for backfilling over or around the structure. Dispose of unsuitable materials. Meet the disposal requirements pertaining to water pollution contained in Section 104 and in 7-1.1.

125-7 Pumping.

Pump from the interior of any foundation enclosure in such manner as to preclude the possibility of any portion of the concrete materials being carried away. Do not pump while placing concrete, or for a period of at least 24 hours thereafter, unless using a suitable pump separated from the concrete work by a watertight wall.

125-8 Backfilling.

125-8.1 General Requirements for Structures and Pipe:

125-8.1.1 General: Backfill in the dry whenever normal dewatering equipment and methods can accomplish the needed dewatering. A LOT is defined as one lift of backfill material placement, not to exceed 500 feet in length or a single run of pipe connecting two successive structures, whichever is less. Backfill for structures and pipe compacted in one operation will be considered as one LOT within the cover zone. Backfill around structures compacted separately from the pipe will be considered as separate LOTs. Backfill on each side of the pipe for the first lift will be considered a separate LOT. Backfill on opposite sides of the pipe for the remaining lifts will be considered separate LOTs, unless the same compactive effort is applied. Same compactive effort is defined as the same type of equipment (make and model) making the same number of passes on both sides of the pipe. For multiple phase backfill, a LOT shall not extend beyond the limits of the phase.

When placing backfill within trench box each lift of backfill is considered a LOT. Placement of backfill within trench box limits will be considered a complete operation before trench box is moved for next backfill operation. When the trench box is moved for next backfill operation this will start new LOTs for each lift. Follow the density testing frequency in 125-9.3.1.

125-8.1.2 Equipment and Methods: Provide normal dewatering equipment including, but not limited to, surface pumps, sump pumps, wellpoints and header pipe and trenching/digging machinery. Provide normal dewatering methods including, but not limited to, constructing shallow surface drainage trenches/ditches, using sand blankets, perforated pipe drains, sumps and siphons.

125-8.1.3 Backfill Materials: Backfill to the original ground surface or subgrade surface of openings made for structures, with a sufficient allowance for settlement. The Engineer may require that the material used for this backfill be obtained from a source entirely apart from the structure. Use only material accepted by the Engineer.

Do not allow heavy construction equipment to cross over culvert or storm sewer pipes until placing and compacting backfill material to the finished earthwork grade or to an elevation at least 4 feet above the crown of the pipe.

125-8.1.4 Use of A-7 Material: In the backfilling of trenches, A-7 material may be used from a point 12 inches above the top of the pipe up to the elevation shown in the Design Standards as the elevation for undercutting of A-7 material.

125-8.1.5 Time of Placing Backfill: Do not place backfill against any masonry or concrete abutment, wingwall, or culvert until the Engineer has given permission to do so, and in no case until the masonry or concrete has been in place seven days or until the specified 28 day compressive strength occurs.

125-8.1.6 Placement and Compaction: Place the material in horizontal layers not exceeding 6 inches compacted thickness, in depth above water level, behind abutments, wingwalls and end bents or end rest piers, under the haunches of the pipes and around box culverts and all structures including pipe culverts. When the backfill material is deposited in water, compact as specified in 125-8.2.5 and 125-8.3.4.

The Contractor may elect to place material in thicker lifts of no more than 12 inches compacted thickness above the Soil Envelope if he can demonstrate with a successful test section that density can be achieved. Notify the Engineer prior to beginning construction of a test section. Construct a test section of the length of one LOT. Perform five quality control (QC) tests at random locations within the test section. All five tests must meet the density required by 125-9.2 and be verified by the Department. Identify the test section with the compaction effort and soil classification in the Logbook. In case of a change in compaction effort or soil classification, construct a new test section. When a QC test fails the requirements of 125-9.2 or when the QC tests cannot be verified, construct a new test section. The Contractor may elect to place material in 6 inches compacted thickness at any time.

125-8.2 Additional Requirements for Structures Other than Pipe:

125-8.2.1 Density: Where the backfill material is deposited in water, obtain a 12 inch layer of comparatively dry material, thoroughly compacted by tamping, before verifying the layer and density requirements. Meet the requirements of 125-9.2.

125-8.2.2 Box Culverts: For box culverts over which pavement is to be constructed, compact around the structure to an elevation not less than 12 inches above the top of the structure, using rapid-striking mechanical tampers.

125-8.2.3 Other Limited Areas: Compact in other limited areas using mechanical tampers or approved hand tampers, until the cover over the structure is at least 12 inches thick. When hand tampers are used, deposit the materials in layers not more than 4 inches thick using hand tampers suitable for this purpose with a face area of not more than 100 square inches. Take special precautions to prevent any wedging action against the masonry, and step or terrace the slope bounding the excavation for abutments and wingwalls if required by the Engineer.

125-8.2.4 Culverts and Piers: Backfill around culverts and piers on both sides simultaneously to approximately the same elevation.

125-8.2.5 Compaction Under Wet Conditions: Where wet conditions do not permit the use of mechanical tampers, compact using hand tampers. Use only A-3 material for the hand tamped portions of the backfill. When the backfill has reached an elevation and condition such as to make the use of the mechanical tampers practical, perform mechanical tamping in such manner and to such extent as to transfer the compaction force into the sections previously tamped by hand.

125-8.3 Additional Requirements for Pipe 15 Inches Inside Diameter or Greater:

125-8.3.1 General: Trenches for pipe may have up to four zones that must be backfilled.

Lowest Zone: The lowest zone is backfilled for deep undercuts up to within 4 inches of the bottom of the pipe.

Bedding Zone: The zone above the lowest zone is the bedding zone. Usually it will be the backfill which is the 4 inches of soil below the bottom of the pipe. When rock or other hard material has been removed to place the pipe, the bedding zone will be the 12 inches of soil below the bottom of the pipe.

Cover Zone: The next zone is backfill that is placed after the pipe has been laid and will be called the cover zone. This zone extends to 12 inches above the top of the pipe. The cover zone and the bedding zone are considered the Soil Envelope for the pipe.

Top Zone: The top zone extends from 12 inches above the top of the pipe to the base or final grade.

125-8.3.2 Material:

125-8.3.2.1 Lowest Zone: Backfill areas undercut below the bedding zone of a pipe with coarse sand, or other suitable granular material, obtained from the grading operations on the project, or a commercial material if no suitable material is available.

125-8.3.2.2 Soil Envelope: In both the bedding zone and the cover zone of the pipe, backfill with materials classified as A-1, A-2, or A-3. Material classified as A-4 may be used if the pipe is concrete pipe.

125-8.3.2.3 Top Zone: Backfill the area of the trench above the soil envelope of the pipe with materials allowed on Design Standards, Index No. 505.

125-8.3.3 Compaction:

125-8.3.3.1 Lowest Zone: Compact the soil in the lowest zone to approximately match the density of the soil in which the trench was cut.

125-8.3.3.2 Bedding Zone: If the trench was not undercut below the bottom of the pipe, loosen the soil in the bottom of the trench immediately below the approximate middle third of the outside diameter of the pipe.

If the trench was undercut, place the bedding material and leave it in a loose condition below the middle third of the outside diameter of the pipe. Compact the outer portions to meet the density requirements of the acceptance criteria. Place the material in lifts no greater than 6 inches (compacted thickness).

125-8.3.3.3 Cover Zone: Before placing the cover zone material, lay pipe according to Section 430. Excavate for pipe bells before laying pipe. Place the material in 6 inch layers (compacted thickness), evenly deposited on both sides of the pipe, and compact with mechanical tampers suitable for this purpose. Hand tamp material below the pipe haunch that cannot be reached by mechanical tampers. Meet the requirements of in 125-9.2.

125-8.3.3.4 Top Zone: Place the material in layers not to exceed 12 inches in compacted thickness. Meet the requirements of the density acceptance criteria.

125-8.3.4 Backfill Under Wet Conditions: Where wet conditions are such that dewatering by normal pumping methods would not be effective, the procedure outlined below may be used when specifically authorized by the Engineer in writing. The Department will pay for any select material which is not available from the grading as Unforeseeable Work. The Department will not pay for select material that might be used by the Contractor for his own convenience instead of dewatering.

The Department will permit the use of granular material below the elevation at which mechanical tampers would be effective, but only material classified as A-3. Place and compact the material using timbers or hand tampers until the backfill reaches an elevation such that its moisture content will permit the use of mechanical tampers. When the backfill has reached such elevation, use normally acceptable backfill material. Compact the material using mechanical tampers in such manner and to such extent as to transfer the compacting force into the material previously tamped by hand.

The Department will permit the use of coarse aggregate below the elevation at which mechanical tampers would be effective. Use coarse aggregate as specified in Section 901 for Aggregate Size Number 89, 8, 78, 7, 68, 6, or 57. Place the coarse aggregate such that it will be stable and firm. Fully wrap the aggregate with a layer of Type D-4 filter fabric, as specified in Section 985. Do not place coarse aggregate within 4 feet of the ends of the trench or ditch. Use normally accepted backfill material at the ends.

125-9 Acceptance Program.

125-9.1 General Requirements: Meet the requirements of 120-10, except replace the requirements of 120-10.1.6 with 125-9.1.1, 120-10.2 with 125-9.2, 120-10.3 with 125-9.3, and 120-10.4 with 125-10.

125-9.1.1 Reduced Testing Frequency: When no resolution testing is required for six consecutive LOTs, or if required, the QC test data was upheld, reduce the QC density testing to one test every two LOTs or one every four LOTs for trench box operations. Identify the substantiating tests in the Density Log Book and notify the Engineer in writing prior to starting reduced frequency of testing. Generate random numbers for selecting test locations for the LOTs under consideration. When QC test frequency is reduced to one every two LOTs, obtain the Engineer's approval to place more than one LOT over an untested LOT. Assure similar compaction efforts for the untested sections. If the Verification test fails, and QC test data is not upheld by Resolution testing the QC testing will revert to the original frequency.

125-9.2 Acceptance Criteria:

125-9.2.1 Density: Obtain a minimum QC density in any LOT of 100% of the Standard Proctor maximum density as determined by AASHTO T99, Method C, or the requirements of 125-8.3.3.1 when applicable. When the cover height below the bottom of base under asphalt pavement, below concrete pavement, or below unpaved ground, exceeds 15 inches, compact the pipe backfill in the cover zone to a density of at least 95% of the Standard Proctor maximum density as determined by AASHTO T99, Method C.

For density requirements around drainage structures, obtain a minimum QC density in any LOT of 100% of the Standard Proctor maximum density as determined by AASHTO T99 for a distance of one pipe diameter but not less than 3 feet from the outside face of the structure.

125-9.2.2 Exceptions to Structures and Pipe Density Requirements: Compact the backfill to a firmness approximately equal to that of the soil next to the pipe trench in locations outside the plane described by a two (horizontal) to one (vertical) slope downward

from the roadway shoulder line or the gutter line as applicable. Apply 125-9.2.1 when compacting side-drain pipe backfill under driveways serving a property that is not a single residential lot.

125-9.3 Additional Requirements:

125-9.3.1 Frequency: Conduct QC Standard Proctor maximum density sampling and testing at a minimum frequency of one test per soil type. The verification test will be at a minimum of one test per soil type:

Test Name	Quality Control	Verification
Standard Proctor Maximum Density	One per soil type	One per soil type
Density	One per LOT	One per four consecutive LOTs and for wet conditions, the first lift not affected by water
Soil Classification	One per Standard Proctor Maximum density	One per Standard Proctor Maximum density

125-10 Verification Comparison Criteria and Resolution Procedures.

125-10.1 Standard Proctor Maximum Density Determination: The Engineer will verify the QC results if the results compare within 4.5 PCF of the verification test result. Otherwise, the Engineer will take one additional sample of material from the soil type in question. The State Materials Office or an AASHTO accredited laboratory designated by the State Materials Office will perform resolution testing. The material will be sampled and tested in accordance with AASHTO T99, Method C.

The Engineer will compare the resolution test result with the QC test results. If the resolution test result is within 4.5 PCF of the corresponding QC test results, the Engineer will use the QC test results for material acceptance purposes for each LOT with that soil type. If the resolution test result is not within 4.5 PCF of the Contractor's QC test, the verification test result will be used for material acceptance purposes.

125-10.2 Density Testing: When a verification or independent verification density test fails the acceptance criteria, retest the site within a 5 feet radius and the following actions will be taken:

1. If the QC retest meets the acceptance criteria and compares favorably with the verification or independent verification test, the Engineer will accept those LOTs.
2. If the QC retest does not meet the acceptance criteria and compares favorably with the verification or independent verification test, rework and retest the LOT. The Engineer will re-verify those LOTs.
3. If the QC retest and the verification or independent verification test do not compare favorably, complete a new equipment-comparison analysis as defined in 120-10.1.2. Once acceptable comparison is achieved, retest the LOTs. The Engineer will perform new verification testing. Acceptance testing will not begin on a new LOT until the Contractor has a gauge that meets the comparison requirements.

125-10.3 Soil Classification: Meet the requirements of 120-10.4.3.

125-11 Site Restoration.

Wherever the existing site is disturbed solely for the purpose of constructing or removing box culverts, pipes, inlets, manholes, etc., completely replace and restore the site to the Engineer's satisfaction, without additional compensation.

125-12 Cleaning Up.

Upon completion of the work, leave the structure and all adjacent areas in a neat and presentable condition, clear up all temporary structures, rubbish and surplus materials and leave the space under the structure unobstructed and in such shape that drift will not collect nor scour or be induced. Pile all material from existing structures that have been removed neatly on the bank, unless otherwise directed by the Engineer. Pull false work piling unless the Engineer permits it to be cut or broken off in which case it will be cut or broken off at least 2 feet below the ground line or stream bed.

125-13 Method of Measurement.

When direct payment for excavation for structures is provided in the proposal, and such payment is on a unit basis, such excavation will be measured in its original position by the cross-section method to determine the amount of material. The cubic yard volume of excavation used as a basis of payment will then be that material actually removed below the original ground line or stream bed, but not including that shown in the Plans to be paid for either as regular excavation, subsoil excavation, lateral ditch excavation or channel excavation, or which is included in the item for grading, and except that no payment will be made for material removed in excavating for footings or foundations outside of an area which is bounded by vertical planes 12 inches outside of the limits of the footing and parallel thereto. For pipe trenches the width used to be in the calculation shall be the diameter of the pipe, plus 24 inches.

125-14 Basis of Payment.

125-14.1 When No Direct Payment Provided: When direct payment for excavation for structures is not provided for in the proposal, all work specified in this Section, other than as specified in 125-14.3 through 125-14.7, shall be included in the Contract price for the concrete or for other items covering the applicable structure.

125-14.2 Direct Payment: When direct payment for work under this Section is provided, the Contract price per cubic yard (measured as provided in 125-13), as shown in the proposal, shall be full compensation for all the work specified in this Section, except such work as is specifically stipulated to be paid for separately, in 125-14.3 through 125-14.7.

125-14.3 Excavation Below Plan Grade: When excavation of material below plan grade is called for in the Plans or authorized by the Engineer, and payment for Excavation for Structures is on a cubic yard basis, the material excavated below plan grade will be included in the measurement for this item.

Payment for the material used for the backfill will be made as specified in 125-14.7.

125-14.4 Strengthening Foundations: The work of strengthening the foundations (as provided in 125-4.2) shall be paid for as provided in 4-4, unless such work is covered by a bid item.

125-14.5 Backfilling for Additional Support: The work of providing additional support by backfilling with sand or other satisfactory material, where called for by the Engineer (as specified in 125-8), shall be paid for as provided in 4-4.

125-14.6 Removal and Replacement of Existing Pavement: For pavement, curb, etc., which is removed only in order to construct pipe culverts or storm sewers, as specified in 125-11, all costs of such removal and replacement shall be included in the costs of the pipe or other structure for which it is removed, unless otherwise provided for in the contract.

125-14.7 Removal and Replacement of Material Unsuitable for Backfill: When it cannot reasonably be anticipated from information contained in the Plans, that material excavated for the structure will be unsuitable for use as backfill, and such material proves to be unsuitable for this use, the work of disposing of such material away from the site will be paid for as Unforeseeable Work, and the work of bringing in substitute material for the backfill will be paid for as specified for the particular case shown below:

1. No additional payment will be made for backfill materials obtained from surplus material available from the normal excavation or grading operations.

2. When the necessary material is not available from the normal excavation or grading operations, and the Contract includes an item for borrow excavation, backfill material authorized to be obtained from designated borrow areas will be included in the volume of borrow excavation to be paid for.

3. When the necessary material is not available from the normal excavation or grading operations and no separate item for borrow excavation is included in the Contract, any backfill material obtained by increasing the volume of excavation within the roadway right of way will be measured and paid for as regular excavation subject to the provisions of 9-3.2.2.

4. When authorization is given for obtaining the material from outside the right of way and from other than designated borrow areas, such excavation will be paid for as unforeseeable work.

5. Where pipe bedding is provided, as specified in 125-8, by the use of select granular material, the quantity of such select material obtained either as commercial material or from material from the grading operations other than in the immediate vicinity of the pipe to be bedded, as authorized by the Engineer, will be paid for at the Contract price per cubic yard for select bedding material. No payment for this material will be made for material available from the excavation for the pipe culvert or from other material available from the grading operations at a location not sufficiently remote as to require loading on trucks.

125-14.8 Pay Items: Payment for the work under this Section, when provided for directly, shall be made under:

Item No. 125- 1- Excavation for Structures - per cubic yard.
Item No. 125- 3- Select Bedding Material - per cubic yard.

GENERAL NOTES:

1. Use a 1-piece cover, unless the 2-piece cover is called for in the Plans, except at inlets and manholes with sump bottoms. Use the 2-piece cover when the sump depth exceeds 2', unless otherwise noted.
2. Include "Adjustable" on the cover for Type 1 manhole adjustable frames.
3. For square or rectangular precast drainage structures, use either deformed or smooth WWR meeting the requirements of Specification 931. WWR must be continuous around the box and lapped in accordance with Option 1 or 3 as shown in the Wall Reinforcing Splice Details.
4. Lap splice horizontal steel in the walls of rectangular structures in accordance with Option 1, 2 or 3 as shown in the Wall Reinforcing Splice Details.
5. Welding of splices and laps is permitted. Use AASHTO M259 requirements and restrictions on welds.
6. Rebar straight end embedment of peripheral reinforcement may be used in lieu of ACI standard hooks for top and bottom slabs, except when hooks are specifically called for in the Plans.
7. Precast opening for pipe must be the pipe OD plus 6" (± 2" tolerance). Use mortar to seal the pipe into the opening of such a mix that shrinkage will not cause leakage into or out of the structure. Dry-pack mortar may be used to seal openings less than 2½" wide.

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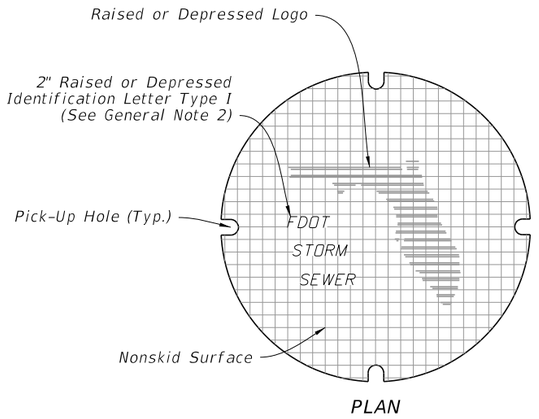
Sheet	Description
1	General Notes, Contents, Manhole Top Overview, and Manhole Covers
2	Manhole Frames and Manhole Tops
3	Inlet Locking Grates, Subgrade and Base Temporary Drains, and Pipe to Structure Filter Fabric Wrap
4	Drainage Structure Invert, Sump Bottom, Wall Reinforcing Splice Details, and Typical Slab to Wall Details
5	Precast Option and Equivalent Reinforcement substitution
6	Construction Joints and Minimum Box Riser Segment Dimensions
7	Skewed Pipe in Rectangular Structures
8	Miscellaneous Pipe Connection Details



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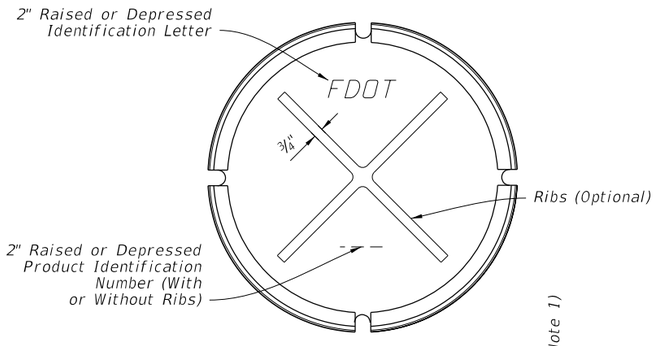

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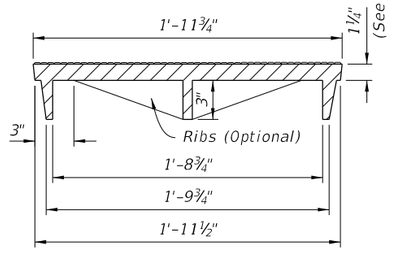
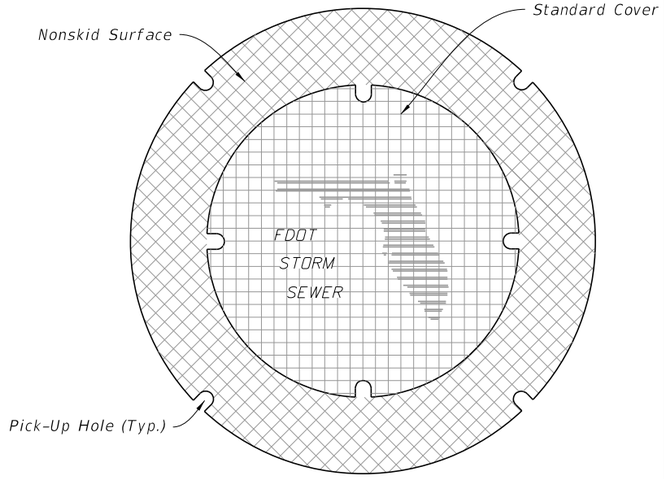


ELEVATION

1-PIECE COVER



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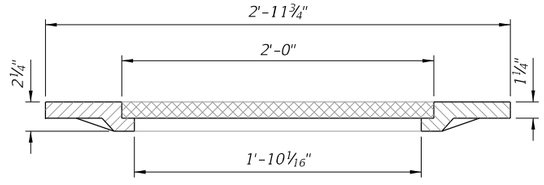
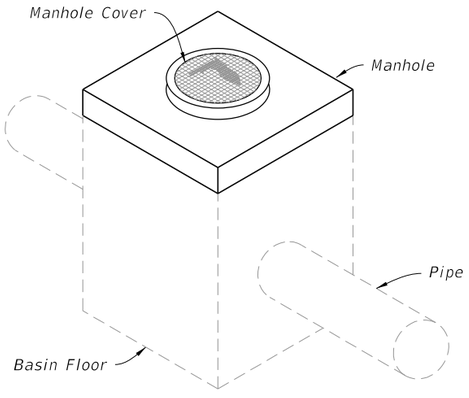


ELEVATION

2-PIECE COVER



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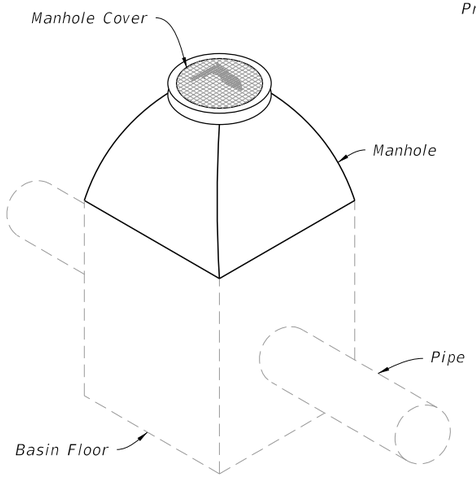


TYPE 8

MANHOLE TOPS

MANHOLE COVERS

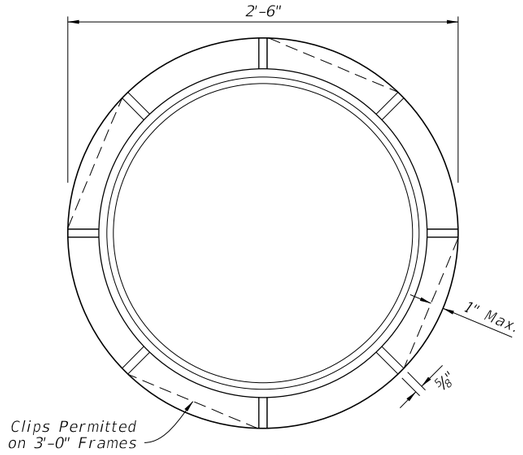
10/12/2020 6:42:25 AM

LAST REVISION	REVISION	DESCRIPTION:				
11/01/20			FY 2021-22 STANDARD PLANS	SUPPLEMENTARY DETAILS FOR DRAINAGE STRUCTURES	INDEX 425-001	SHEET 1 of 8

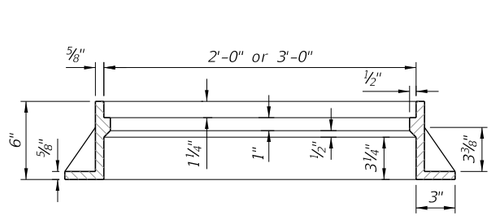
TABLE 1
WEIGHT OF CASTINGS (lb)

Frame Type	2'-0" OPENING		3'-0" OPENING			
	Frame	Cover (Std.)	Frame	2-Piece Cover		
				Inside	Outside	Total
I	155	190	220	190	220	410
II	145	190	255	190	220	410
III	90	190	180	190	220	410

NOTE:
Frame Type I in Table 1, includes Adjustable frames.

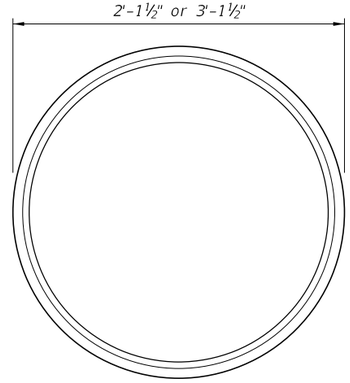


PLAN

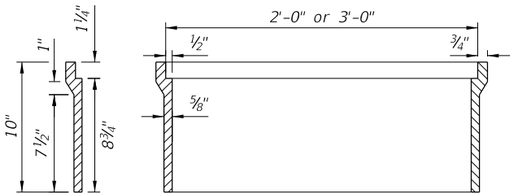


ELEVATION

TYPE I
(For Manholes)



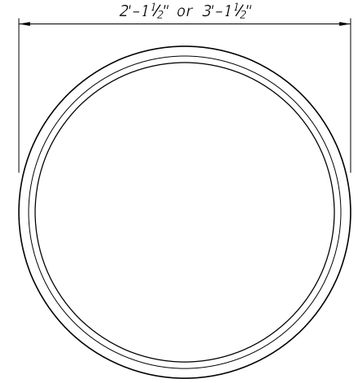
PLAN



WALL SECTION

ELEVATION

TYPE II
(For Curb Inlets Types 1, 2, 3, & 4)



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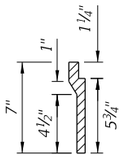
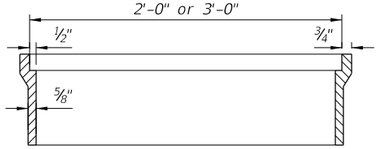


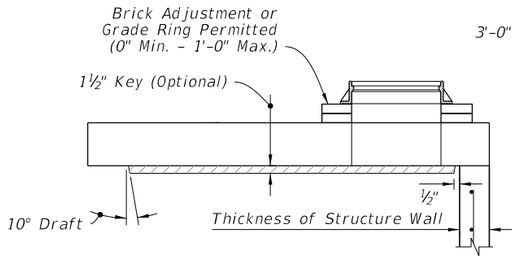
WALL SECTION



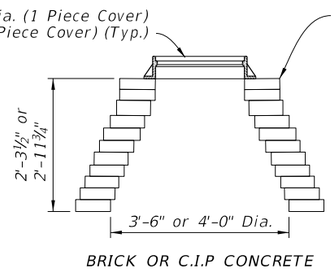
ELEVATION

TYPE III
(For Curb Inlets Types 7 & 8)

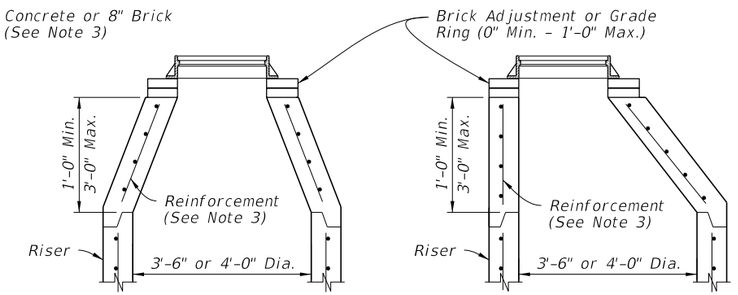
MANHOLE FRAMES



TYPE 7



BRICK OR C.I.P CONCRETE
(Brick Shown)



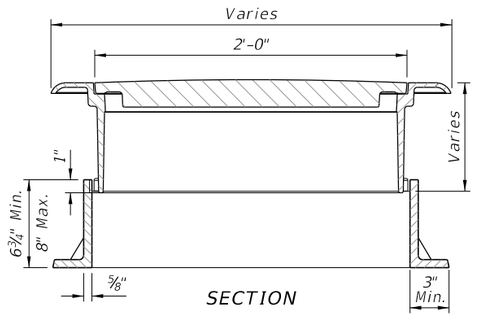
PRECAST CONCENTRIC CONE

PRECAST ECCENTRIC CONE

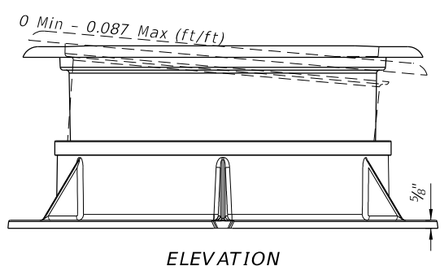
TYPE 8

NOTES:

1. Use Class II concrete for Manhole top Type 7 slabs.
2. Manhole top Type 7 slabs may be of cast-in-place or precast construction. The optional key is for precast tops and in lieu of dowels. Omit frame and slab openings when top is used over a junction box.
3. Manhole top Type 8 may be of cast-in-place, precast concrete construction, or brick construction. For concrete construction, use the same concrete and steel reinforcement as the supporting wall unit. An eccentric cone may be used.
4. Use construction joint options, as shown on Sheet 6 to secure manhole tops to structures.
5. Frames may be adjusted to a maximum 12" height with brick or precast ASTM C478 grade rings.
6. Manhole top Type 8 may be substituted for a Type 7, if the minimum dimensions are not reduced.
7. Manhole top Type 7 may be substituted for Type 8, if the minimum thickness (h) above pipe opening cannot be maintained with Type 8.



SECTION



ELEVATION

TYPE I ADJUSTABLE FRAME

MANHOLE TOPS

MANHOLE FRAMES AND MANHOLE TOPS

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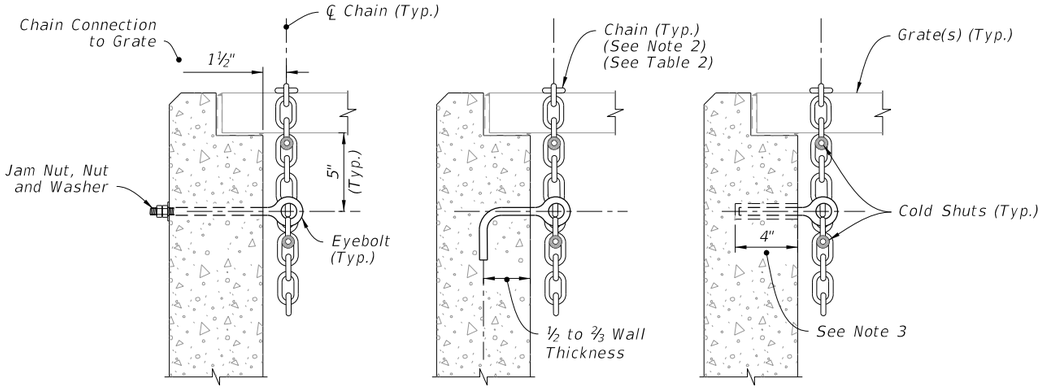


THRU-BOLT J-TYPE ADHESIVE BONDED ANCHOR

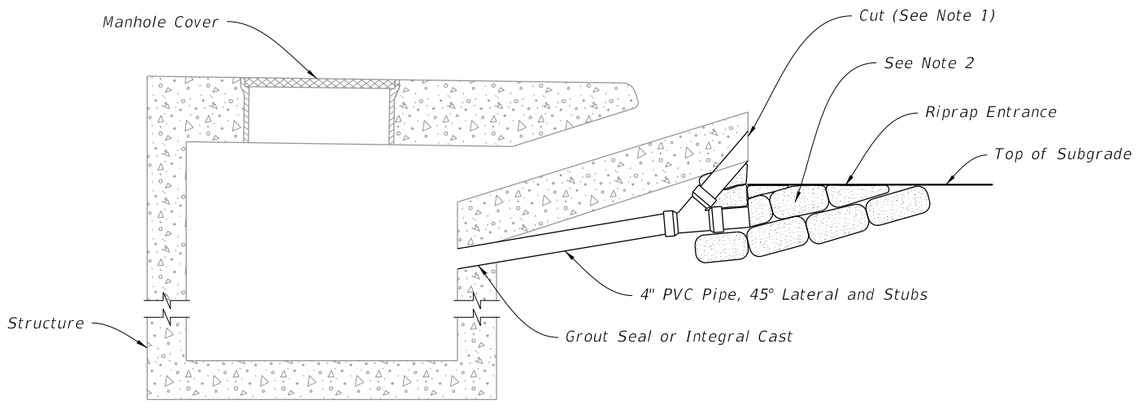
NOTES:

1. Install either a ½" Ø x 1" Diameter Threaded Straight (Thru-Bolt), a J-Type, or an adhesive Bonded Anchor Eyebolt.
2. Install a 5/16" Chain and 3/16" Cold Shuts. When chaining two grates together provide adequate loop for easy handling.
3. Install adhesive bonded anchor option with a minimum of 4" embedment, and in accordance with Specification 416.

TABLE 2
EYEBOLT AND CHAIN REQUIREMENTS

Index Number	Inlet Type	Eye-Bolts	Length of Chain	Handling & Remarks
425-030	1	1	4'-0"	Slide & Spin
	2	2	2 @ 4'-0"	Slide & Spin
425-031	N/A	1	3'-8"	Slide or Slide & Spin
425-032	N/A	1	4'-0"	Slide & Spin
425-040	S	1	4'-0"	Slide & Spin
425-041	V	1	4'-0"	Slide & Spin
425-050	A	1	3'-0"	Slide
425-051	B	1	5'-0"	Slide & Spin
425-052	C	1	2'-6"	Slide & Spin
	D	1	2'-6"	Slide & Spin
	E	2	2 @ 2'-6"	Slide & Spin
	H	2	2 @ 2'-6"	Flip Ctr. Grate and Slide & Spin Single Free Grate
			1 or 2 @ 1'-6"	Center Grate(s) Chained to One End Grate
425-053	F	1	3'-6"	Flip or Slide & Spin
	G	1	6'-0"	Slide
			2'-0"	Lifting Loop
425-054	J	1	4'-0"	Slide & Spin

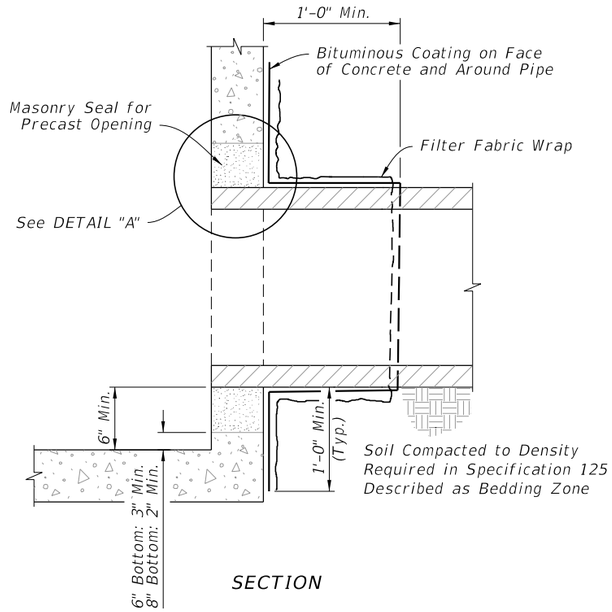
LOCKING GRATES TO INLETS



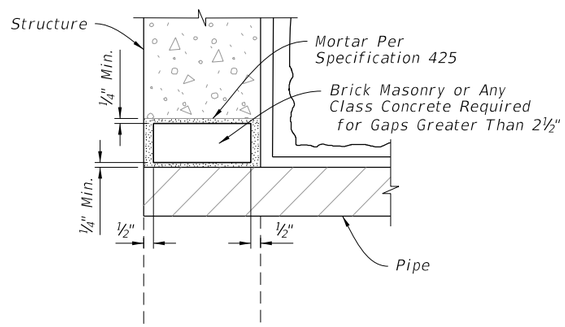
NOTES:

1. Bevel cut upper stub to match forming for apron face. Capping or plugging of upper stub is not required. Remove friable base material at stub opening to permit covering of opening with structural course material.
2. Remove riprap, cement PVC cap on lower stub, and place compacted fill in entrance prior to placing base material.

SUBGRADE AND BASE TEMPORARY DRAINS



SECTION



DETAIL "A"

PIPE TO STRUCTURE FILTER FABRIC WRAP

LOCKING GRATES, SUBGRADE AND BASE TEMPORARY DRAINS, AND PIPE TO STRUCTURE FILTER FABRIC WRAP

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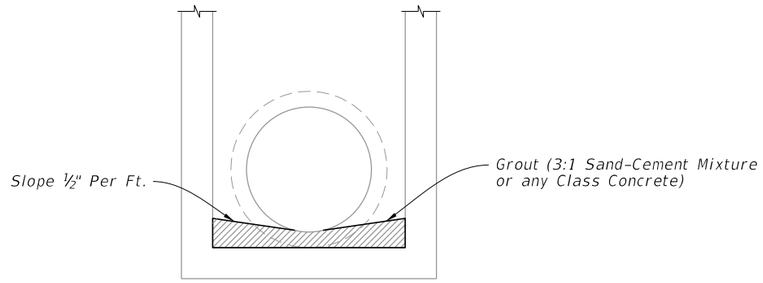
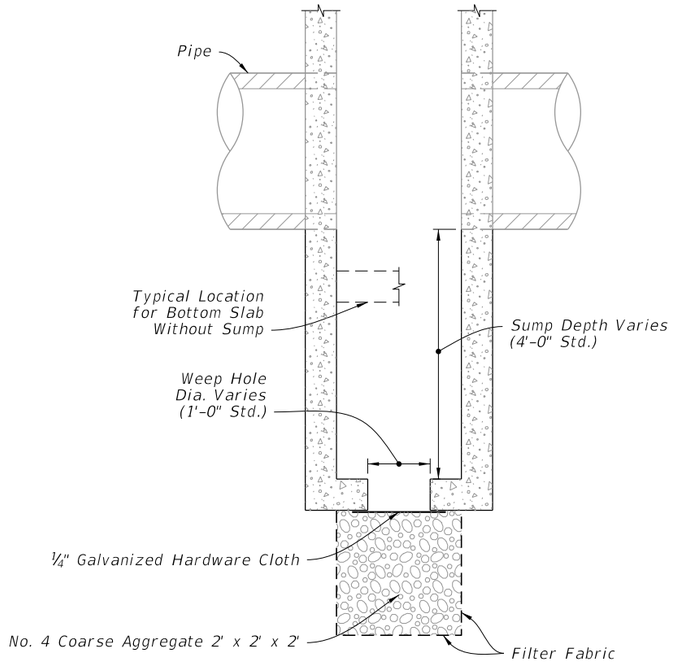


NOTE: For all structures unless excluded by special detail.

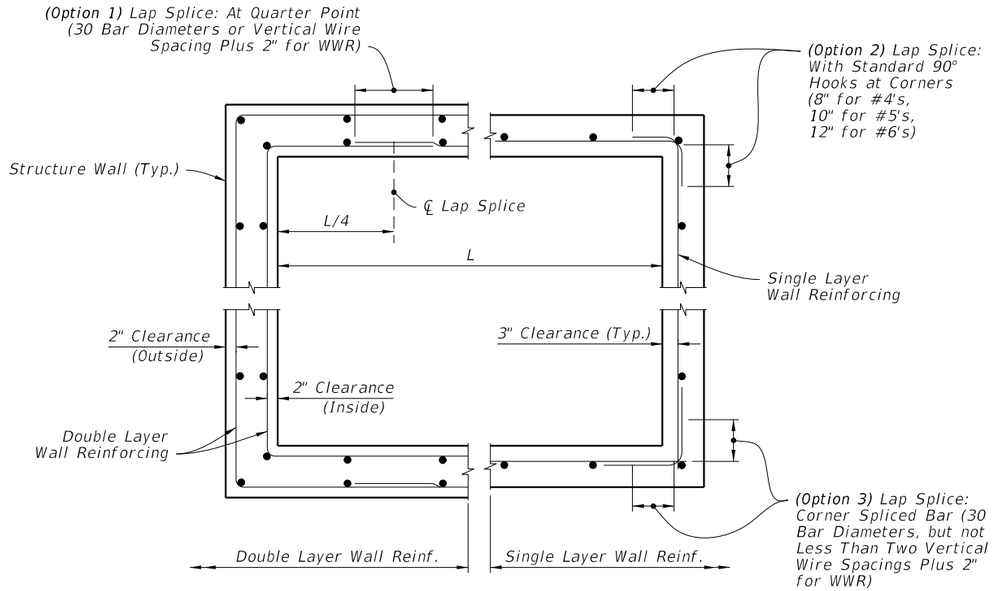
DRAINAGE STRUCTURE INVERT



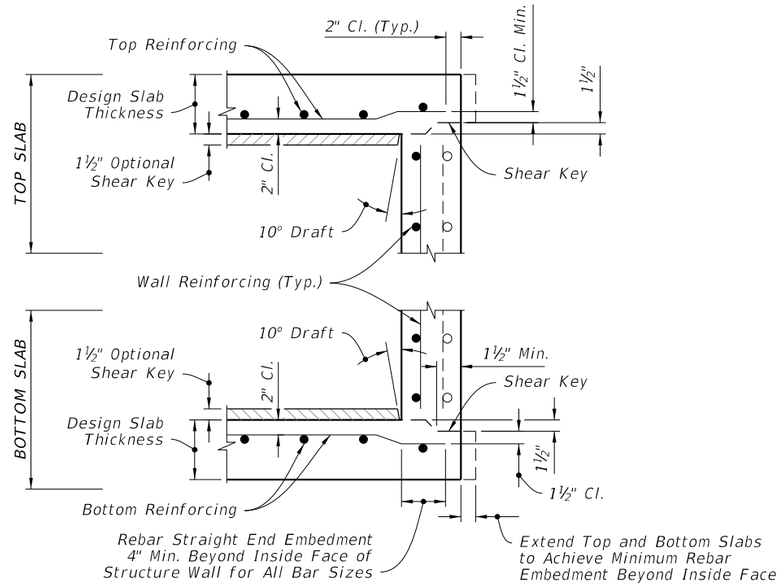
NOTES:

1. Construct sumps in inlets and manholes connecting to French Drains unless excluded in the Plans.
2. Construct sumps only where called for in the Plans at all other locations.
3. Construct weep holes in sump bottom only where called for in the Plans.

SUMP BOTTOM



WALL REINFORCING SPLICE DETAILS



NOTES:

1. See Sheet 6 for optional construction joints.
2. Bend bars as required to maintain cover.

TYPICAL SLAB TO WALL DETAILS
(PRECAST STRUCTURE SHOWN)

DRAINAGE STRUCTURE INVERT, SUMP BOTTOM, WALL REINFORCING SPLICE DETAILS, AND TYPICAL SLAB TO WALL DETAILS

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EXAMPLE TABLE OF EQUIVALENT STEEL AREA

SCHEDULE	GRADE 60 REINFORCING BAR		EQUIVALENT GRADE 40 REINFORCING BAR		EQUIVALENT 65 KSI SMOOTH WELDED WIRE REINFORCEMENT		EQUIVALENT 70 KSI DEFORMED WELDED WIRE REINFORCEMENT	
	Bar Size & Spacing	Steel Area (in^2/ft)	Bar Size & Spacing	Steel Area (in^2/ft)	Style Designation	Steel Area (in^2/ft)	Style Designation	Steel Area (in^2/ft)
A	#3 @ 6½" Ctrs. #4 @ 12" Ctrs.	0.20	#3 @ 4½" Ctrs. #4 @ 8" Ctrs. #5 @ 12" Ctrs.	0.30	3"x3"–W4.6xW4.6 4"x4"–W6.2xW6.2 6"x6"–W9.2xW9.2	0.1846	3"x3"–D4.3xD4.3 4"x4"–D5.7xD5.7 6"x6"–D8.6xD8.6	0.1714
B	#3 @ 5½" Ctrs. #4 @ 10" Ctrs.	0.24	#3 @ 3½" Ctrs. #4 @ 6½" Ctrs. #5 @ 10" Ctrs.	0.36	3"x3"–W5.5xW5.5 4"x4"–W7.4xW7.4 6"x6"–W11.1xW11.1	0.2215	3"x3"–D5.1xD5.1 4"x4"–D6.9xD6.9 6"x6"–D10.3xD10.3	0.2057
Special 1	#3 @ 5" Ctrs.. #4 @ 9" Ctrs.	0.267	#3 @ 3" Ctrs. #4 @ 6" Ctrs. #5 @ 9" Ctrs.	0.40	3"x3"–W6.2xW6.2 4"x4"–W8.2xW8.2 6"x6"–W12.3xW12.3	0.2465	3"x3"–D5.7xD5.7 4"x4"–D7.6xD7.6 6"x6"–D11.4xD11.4	0.2289
C	#3 @ 3½" Ctrs. #4 @ 6½" Ctrs. #5 @ 10" Ctrs.	0.37	#4 @ 4" Ctrs. #5 @ 6½" Ctrs. #6 @ 9½" Ctrs.	0.555	3"x3"–W8.5xW8.5 4"x4"–W11.4xW11.4 6"x6"–W17.1xW17.1	0.3415	3"x3"–D7.9xD7.9 4"x4"–D10.6xD10.6 6"x6"–D15.9xD15.9	0.3171
D	#4 @ 4½" Ctrs. #5 @ 7" Ctrs. #6 @ 10" Ctrs.	0.53	#4 @ 3" Ctrs. #5 @ 4½" Ctrs. #6 @ 6½" Ctrs.	0.795	3"x3"–W12.2xW12.2 4"x4"–W16.3xW16.3 6"x6"–W24.5xW24.5	0.4892	3"x3"–D11.4xD11.4 4"x4"–D15.1xD15.1 6"x6"–D22.7xD22.7	0.4543
E	#4 @ 3" Ctrs. #5 @ 5" Ctrs. #6 @ 7" Ctrs.	0.73	#5 @ 3½" Ctrs. #6 @ 4½" Ctrs. #7 @ 6½" Ctrs.	1.095	3"x3"–W16.8xW16.8 4"x4"–W22.5xW22.5 6"x6"–W33.7xW33.7	0.6738	3"x3"–D15.6xD15.6 4"x4"–D20.9xD20.9 6"x6"–D31.3xD31.3	0.6257
F	#5 @ 3½" Ctrs. #6 @ 5" Ctrs. #7 @ 7" Ctrs.	1.06	#6 @ 3" Ctrs. #7 @ 4½" Ctrs. #8 @ 6" Ctrs.	1.59	3"x3"–W24.5xW24.5 4"x4"–W32.6xW32.6 6"x6"–W48.9xW48.9	0.9785	3"x3"–D22.7xD22.7 4"x4"–D30.3xD30.3 6"x6"–D45.4xD45.4	0.9086
Special 2	#5 @ 3" Ctrs. #6 @ 4" Ctrs. #7 @ 5½" Ctrs.	1.24	#7 @ 4" Ctrs. #8 @ 5" Ctrs.	1.86	3"x3"–W28.6xW28.6 4"x4"–W38.2xW38.2 6"x6"–W57.2xW57.2	1.1446	3"x3"–D26.6xD26.6 4"x4"–D35.4xD35.4 6"x6"–D53.1xD53.1	1.0629
G	#6 @ 3½" Ctrs. #7 @ 5" Ctrs.	1.46	#7 @ 3" Ctrs. #8 @ 4" Ctrs.	2.19	3"x3"–W33.7xW33.7 4"x4"–W44.9xW44.9	1.3477	3"x3"–D31.3xD31.3 4"x4"–D41.7xD41.7	1.2514

NOTES:

1. See inlet indexes for optional precast inlet construction details up to depths of 15'.

2. Interior dimensions of an Alt. "B" Bottom may be adjusted to reflect these inlet interior dimensions when precast units are used in conjunction with Alt. "B" Structure Bottoms, Index 425-010.

3. Use concrete meeting the requirements of ASTM C478 or Class IV for precast structures with 6" wall or slab thickness.

4. Reinforcement may be deformed bar reinforcement or welded wire reinforcement. Bar reinforcement other than 60 ksi may be used, however only two grades are recognized: Grade 40 and Grade 60. Smooth welded wire reinforcement will be recognized as having a design strength of 65 ksi and deformed welded wire reinforcement will be recognized as having a design strength of 70 ksi. The area of reinforcement required may be adjusted in accordance with the Equivalent Steel Area Table provided. Use the following equations to determine the steel area and spacing for bars not otherwise specified:

   Grade 40 Steel Area = As40= 60/40 x As60

   Smooth Welded Wire Reinforcement Steel Area = As65= 60/65 x As60

   Deformed Welded Wire Reinforcement Steel Area = As70= 60/70 x As60

   When a reduced area of reinforcement is provided, any maximum bar spacing shown must also be reduced as determined by the following equations, unless otherwise shown:

   Max. Grade 40 Bar Spacing = Grade 60 Bar Spacing

   Max. Smooth Welded Wire Spacing = Grade 60 Bar Spacing x 0.86

   Max. Deformed Welded Wire Spacing = Grade 60 Bar Spacing x 0.74

   When an increased area of reinforcing is provided, the maximum bar spacing may be increased by the squared ration of increased steel area, but not to exceed 12":

   $$\text{Max. Bar Spacing Provided} \leq = \text{Max. Bar Spacing Required} \times \left(\frac{\text{Steel Area Provided}}{\text{Min. Steel Area Required}} \right)^2$$

   Use wire no smaller than than W3.1 or D4.0, or larger and with spacing 8" or less. Use bar reinforcement displaying the minimum yield designation grade mark, or either the number 60 or one (1) grade mark line to be acceptable at the higher value. Use maximum bar spacing no greater than two (2) times the slab thickness with a maximum spacing of 12" or three (3) times the wall thickness, with a maximum spacing of 18" for vertical bars and 12" for horizontal bars. Wires smaller than W3.1 or D4.0 may be used in the walls of ASTM C 478 round structure bottoms and round risers.

5. Fiber-reinforced concrete may be substituted for conventional steel reinforcement in accordance with the Structures Design Guidelines. Submit shop drawings corresponding to an approved fiber-reinforced concrete mix design for approval to the State Drainage Engineer.

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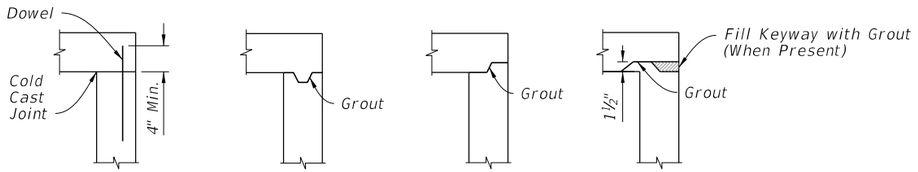
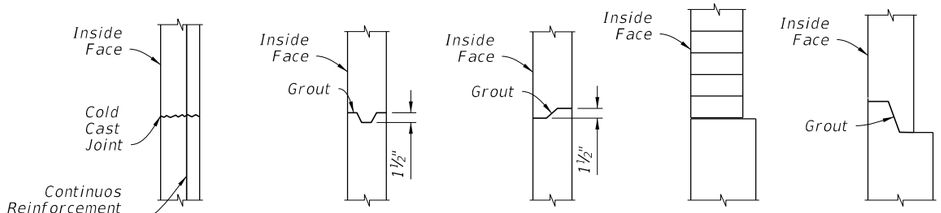
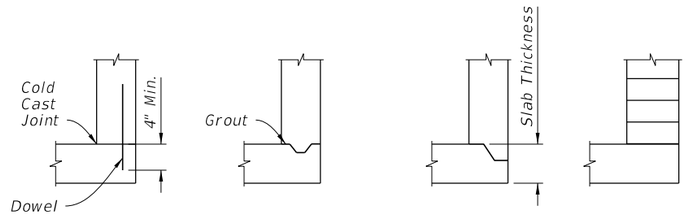
PRECAST OPTION AND EQUIVALENT REINFORCEMENT SUBSTITUTION



TOP SLABS TO WALL JOINTS



WALL JOINTS



BOTTOM SLAB TO WALL JOINTS

NOTES:

1. One or more types of joints may be used in a single structure, except brick wall structure. Brick wall construction is permitted on circular units only.

2. All grouted joints are to have a maximum thickness of 1".

3. Keyways are to be a minimum of 1½" deep.

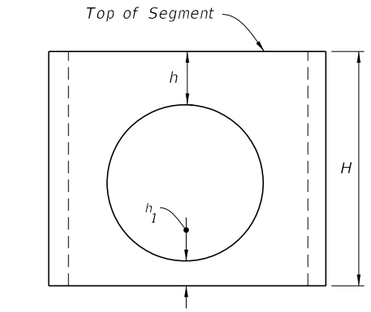
4. Joint dowels are to be #4 bars, 12" long with a minimum of 6 bars per joint approximately evenly spaced for circular structures or at maximum 12" spacing for rectangular structures. Bars may be either Adhesive Bonded Dowels in accordance with Specification 416, or placed approximately 6" into fresh concrete leaving the remainder to extend into the secondary cast. Welded wire reinforcement may be substituted for the dowel bar in accordance with the equivalent steel area table on Sheet 5.

5. Minimum cover on dowel reinforcing bars is 2" to outside face of structure.

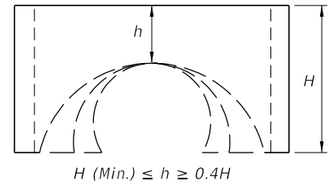
6. Seal joints between wall segments and between wall segments and top or bottom slabs with preformed plastic gasket material inaccordance with Specification 430 or non-shrink grout in accordance with Specification 934.

7. Insert products approved by the Engineer may be used in lieu of dowel embedment.

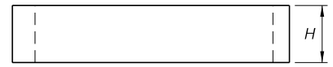
CONSTRUCTION JOINT OPTIONS



When	Then (Reqd.)
$6" \le h_1 < 0.75H$ (Min.)	$h \ge 0.4H$
$h_1 \ge 0.75H$ (Min.)	$h \ge H$ (Min.)



H (Min.) ≤ h ≥ 0.4H



H ≥ H Min.

NOTES:

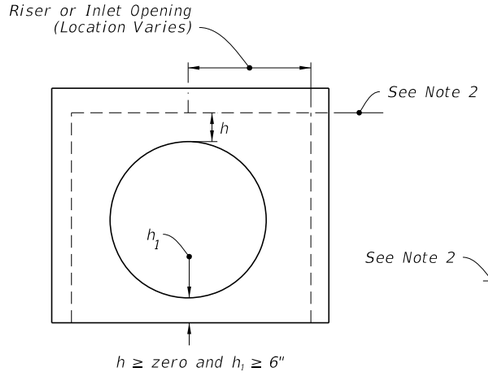
1. Segments may be inverted. Opening for pipe is the pipe OD plus 6" (± 2" tolerance).

2. If h can not be attained, then a top or bottom slab must be attached to the segment as shown below.

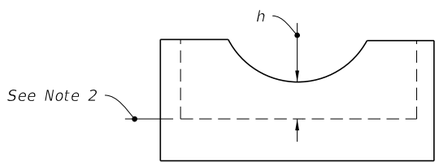
TABLE 3
Minimum Value for H

H (min.)	Box or Riser Diameter
1'-0"	3'-6" & 4'-0"
1'-6"	5'-0" & 6'-0"
2'-0"	>6'-0"

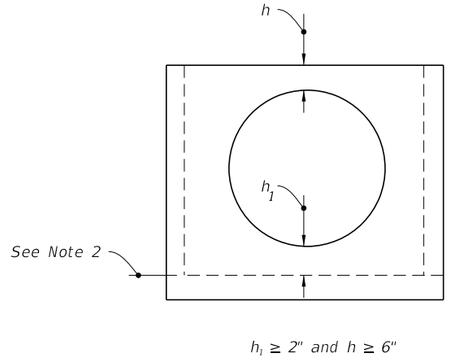
RISER SEGMENTS OTHER THAN DOWEL



h ≥ zero and $h_1 \ge 6"$



Top or Bottom Segment:
h ≥ 2"



$h_1 \ge 2"$ and $h \ge 6"$

NOTES:

1. h may be less than 6" when approved by the Engineer, but not for inlet segments at finish grade elevation.

2. Dowel construction joint or monolithic cast only.

SEGMENTS FOR SLAB TO WALL DOWEL CONSTRUCTION JOINTS OR MONOLITHIC CAST

MINIMUM BOX AND RISER SEGMENT DIMENSIONS

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CONSTRUCTION JOINT OPTIONS AND MINIMUM BOX AND RISER SEGMENT DIMENSIONS

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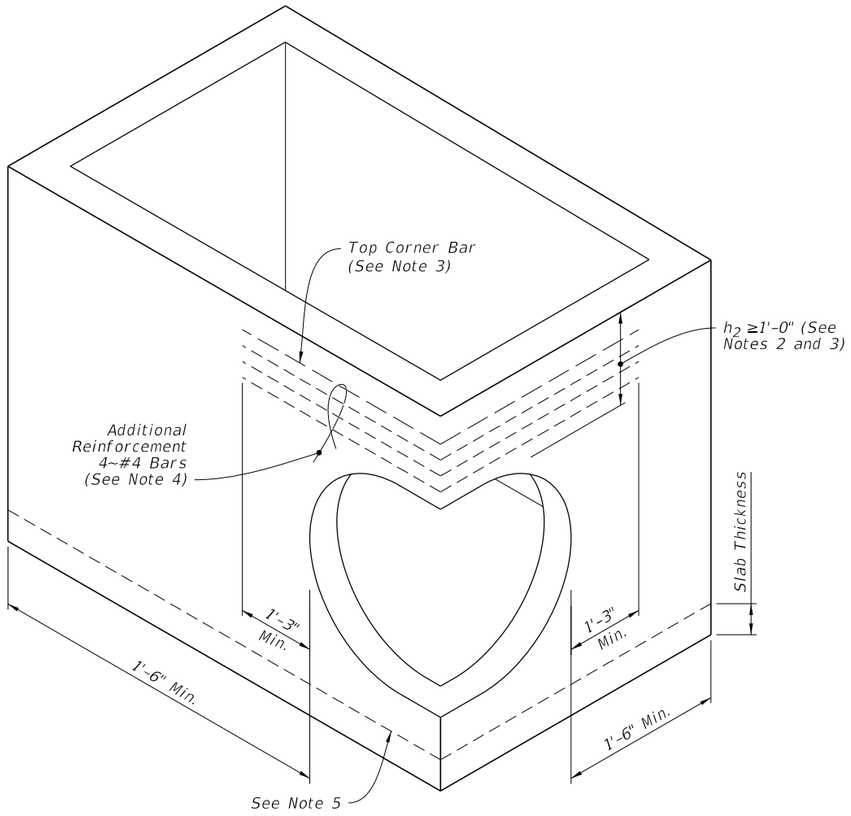

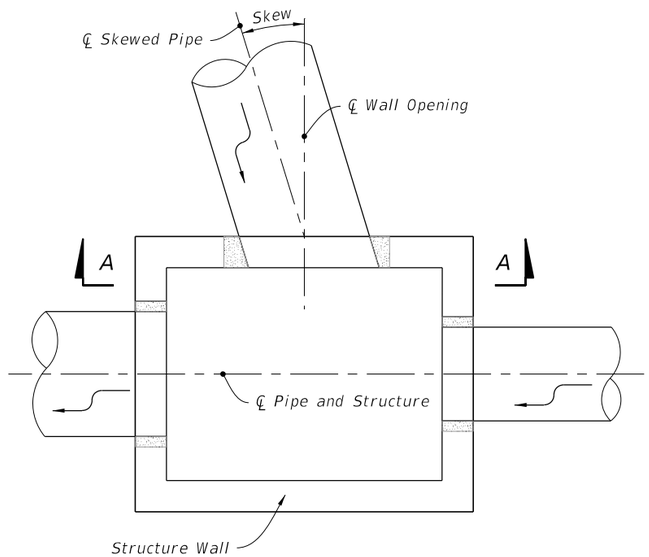

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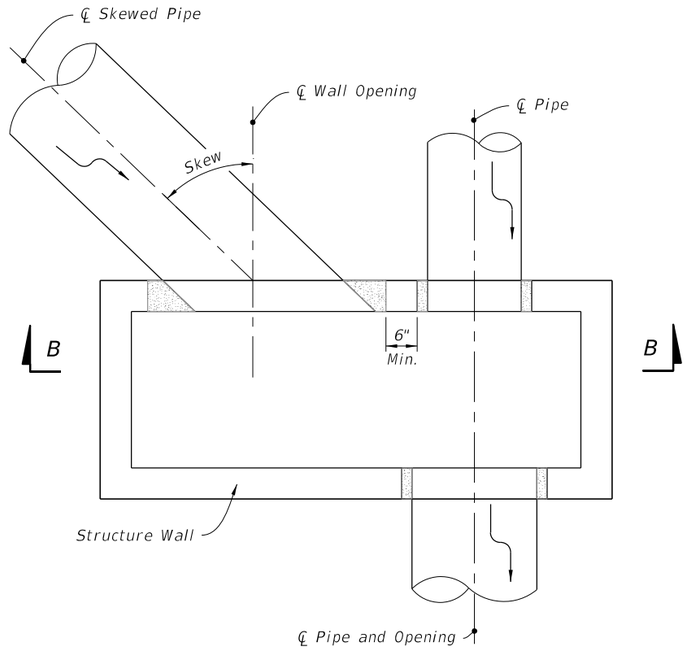

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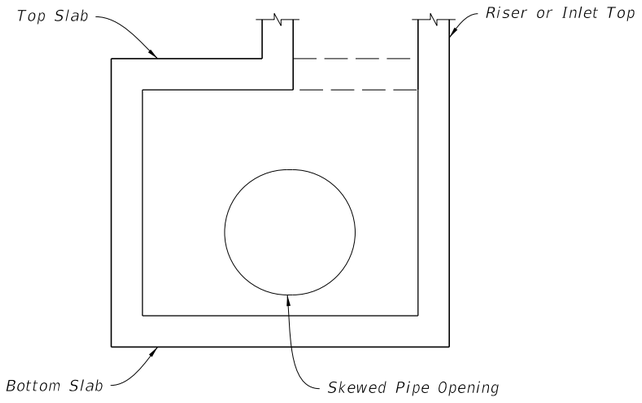
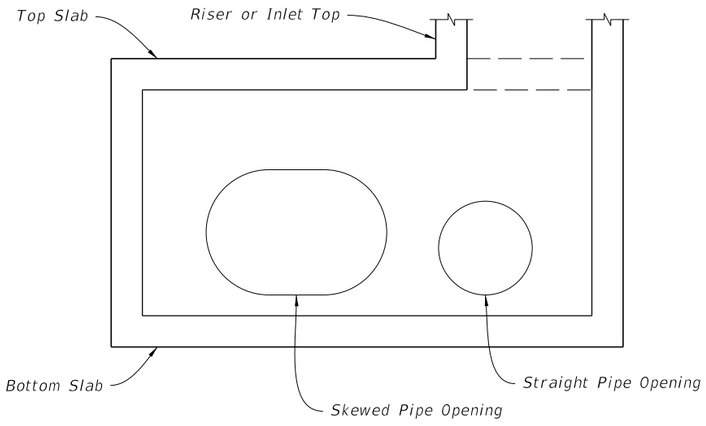


SECTION A-A

SKEWS ≤ 45°
(Not Centered)



SECTION B-B

SKEWS > 45°
(Not Centered)

NOTES:

1. Submit Shop Drawings of corner openings for approval by the Engineer.
2. h_2 may be less than 1'–0" when a minimum 1'–0" deep segment, 8" slab or curb inlet is provided above the corner opening.
3. For inlet segments at finish grade elevation, substitute a #8 Bar for the top corner bar when $1'-0" \leq h_2 < 2'-0"$.
4. Install bars continuously around corner and evenly spaced. Tie additional reinforcement to the outside of vertical wall reinforcement.
5. Dowel construction joint or monolithically cast wall and slabs.

PIPE OPENING AT CORNER

SKEWED PIPE IN RECTANGULAR STRUCTURES
(See Table 4 on Sheet 8)

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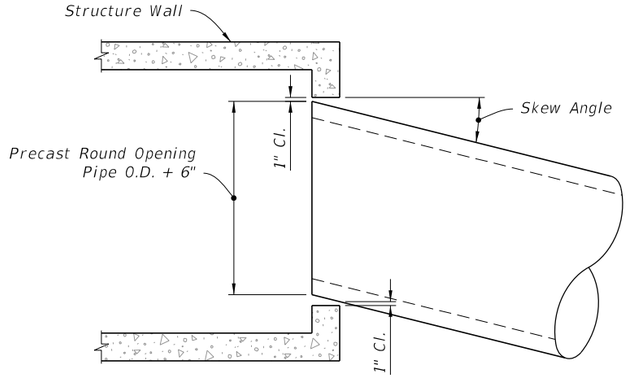
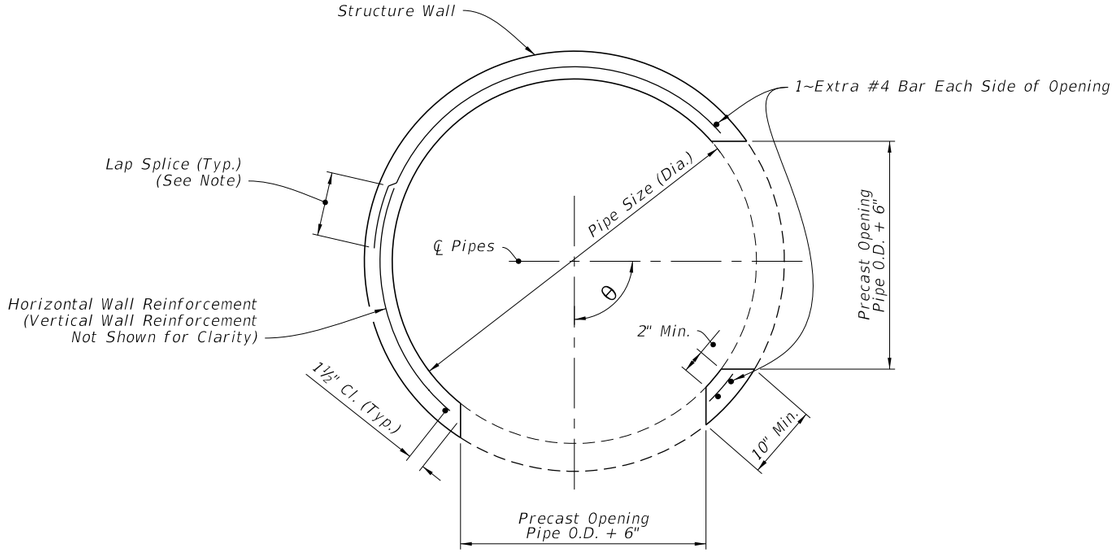


PLAN VIEW

TABLE 4 - MAXIMUM PIPE SKEW FOR PRECAST ROUND OPENINGS												
	WALL THICKNESS	PIPE SIZE										
		18"	24"	30"	36"	42"	48"	54"	60"	66"	72"	78"	84"
MAXIMUM SKEW ANGLE	8"	19°	17°	16°	16°	15°	14°	14°	13°	13°	13°	12°	12°
	6"	21°	20°	18°	17°	17°	16°	15°	15°	14°	14°	13°	13°

NOTE:
These values are based on 2" clearance for precast structures. Larger skews are possible for Cast-In-Place Structures or elliptical pipe openings when approved by the Engineer.

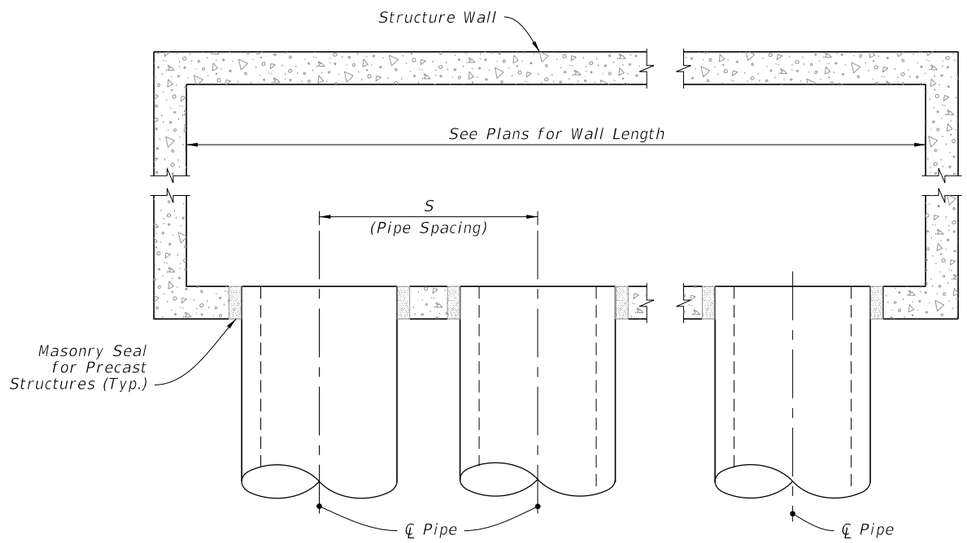
MAXIMUM PIPE SKEW FOR PRECAST ROUND OPENINGS



PLAN VIEW

NOTE:
Lap splice: 20 bar diameter for deformed wire or bar, but not less than vertical wire spacing plus 2" for WWR or 40 bar diameters for smooth wire.

MULTIPLE PIPE CONNECTIONS - PRECAST ROUND STRUCTURES



PLAN VIEW

TABLE 5 - MINIMUM SIZES FOR MULTIPLE PARALLEL PIPE CONNECTIONS	
PIPE SIZE	PIPE SPACING (S)
18"	2'-10"
24"	3'-5"
30"	4'-3"
36"	5'-1"
42"	6'-0"
48"	6'-9"
54"	7'-8"
60"	8'-6"
66"	9'-0"
72"	10'-0"
78"	10'-9"
84"	11'-8"

MULTIPLE PARALLEL PIPE CONNECTIONS - RECTANGULAR STRUCTURES

10/15/2020 9:32:10 AM

MISCELLANEOUS PIPE CONNECTION DETAILS

GENERAL NOTES:

1. Work this Index with Specification 425 and Index 425-001.

2. Type P standard structure bottoms are 4'-0"diameter and smaller (Alt. A) and 3'-6" square (Alt. B) . Larger standard structure bottoms are designated Type J. Risers are permitted for all structures.

3. Walls of circular structures (Alt. A) constructed in place may be of brick or reinforced concrete. Construct precast and rectangular structures (Alt. B) with reinforced concrete only.

4. Wall thickness and reinforcement are for either reinforced cast-in-place or precast concrete units except that precast circular units may be furnished with walls in accordance with ASTM C478 (See Table 1).

5. Top and bottom slab thickness and reinforcement are for precast and cast-in-place construction. Use Class II concrete, except when Class IV concrete is shown in the Plans.

6. Alt. A or Alt. B structure bottoms may be used in conjunction with curb inlet tops Types 1, 2, 3, 4, 5, 6, 9, and 10, and any manhole or junction box. Alt. B structure bottoms may be used in conjunction with curb inlet Types 7 & 8, or any ditch bottom inlet.

7. Rectangular structures may be rotated as directed by the Engineer in order to facilitate connections between the structure walls and pipes.

8. Use straight embedment reinforcement in top and bottom slabs ,except when ACI hooks are specifically required.

9. Construct corner fillets as shown for rectangular structures used with circular risers and inlet throats, and when used on skew with rectangular risers, inlets, and inlet throats. Construct fillets in the top slab of the Alt. A structure bottoms when used with the Type B risers. Reinforce each fillet with two #5 bars.

10. Units larger than specified standards may be substituted at the contractor's option when these units will not cause or increase the severity of utility conflicts. Furnish such larger units at no additional cost to the Department. Larger Alt. A units cannot replace Alt. B units without approval of the Engineer. This Note applies to this Index only.

REINFORCEMENT NOTES:

1. Locate wall reinforcement in rectangular structures as shown in the WALL REINFORCEMENT SPLICE DETAILS in Index 425-001.

2. Provide a minimum 2"clear cover for all reinforcement unless otherwise noted and except for 3'6"diameter ASTM C478 units.

3. Additional bars used to restrain hole formers for precast structures with grouted pipe connections may be left flush with the hole surface.

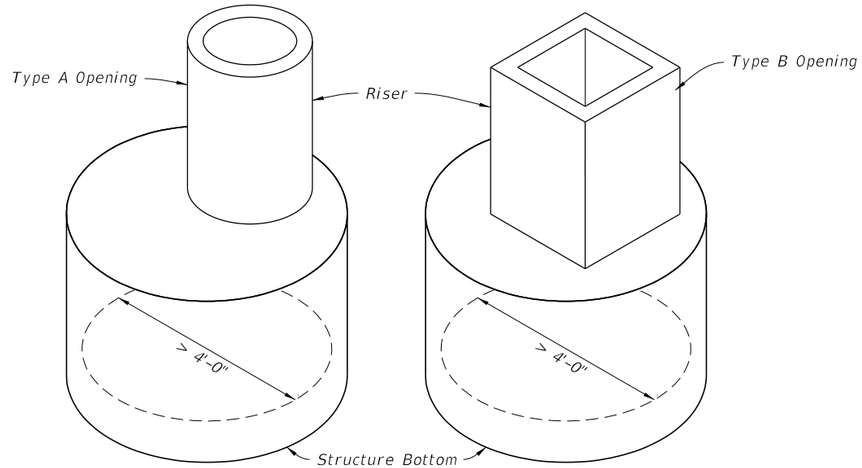
4. Cut or bend reinforcement at pipe openings to maintain cover.

5. Remove exposed ends of reinforcing at precast pipe openings and grouted joints to 1" below the concrete surface and seal with a Type F Epoxy meeting the requirements of Specification 926.

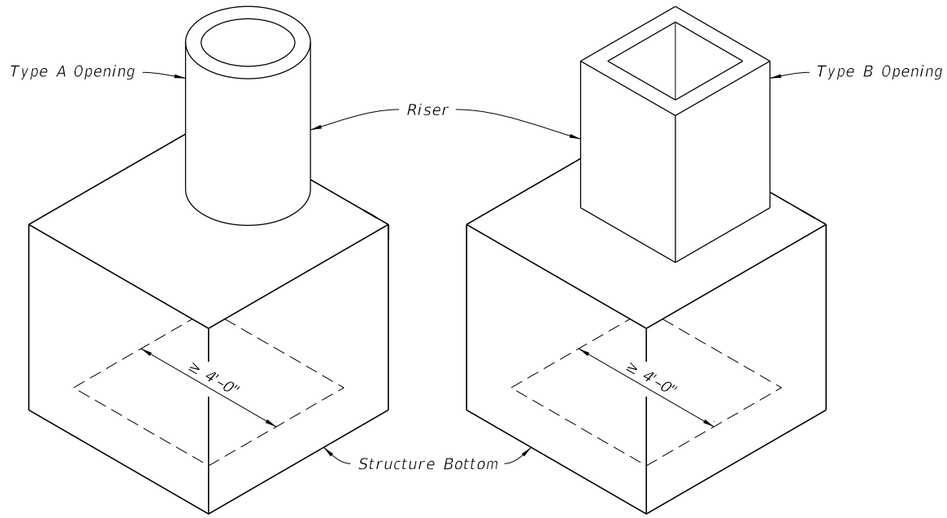
6. Equivalent area smooth or deformed welded wire reinforcement may be substituted in accordance with Index 425-001.

TABLE OF CONTENTS:

Sheet	Description
1	General Notes and Contents
2	Dimensional and Reinforcing Details
3	Tables 1, 2, 3, and 4
4	Tables 5 and 6

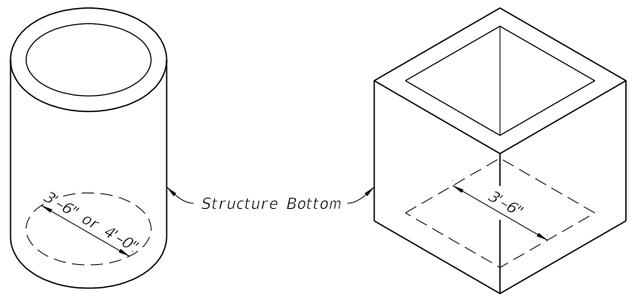


ALTERNATE A



ALTERNATE B

TYPE J



ALTERNATE A ALTERNATE B

TYPE P

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LAST REVISION	REVISION	DESCRIPTION:	FDOT FY 2021-22 STANDARD PLANS	STRUCTURE BOTTOMS TYPE J AND P	INDEX	SHEET
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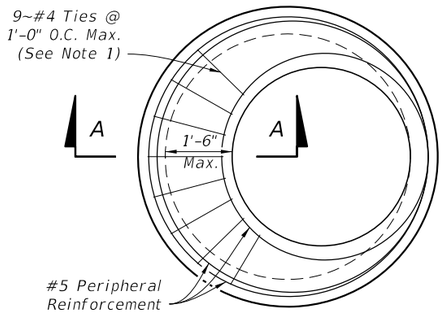

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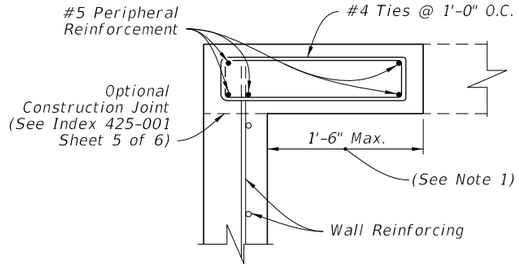
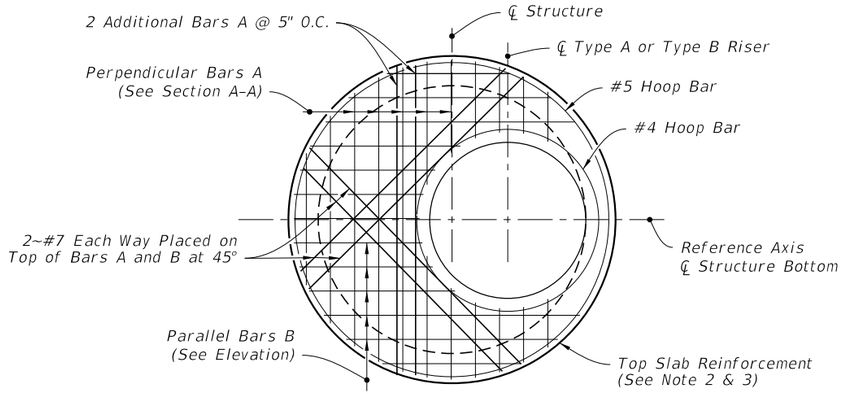


SECTION A-A

SPECIAL TOP SLAB



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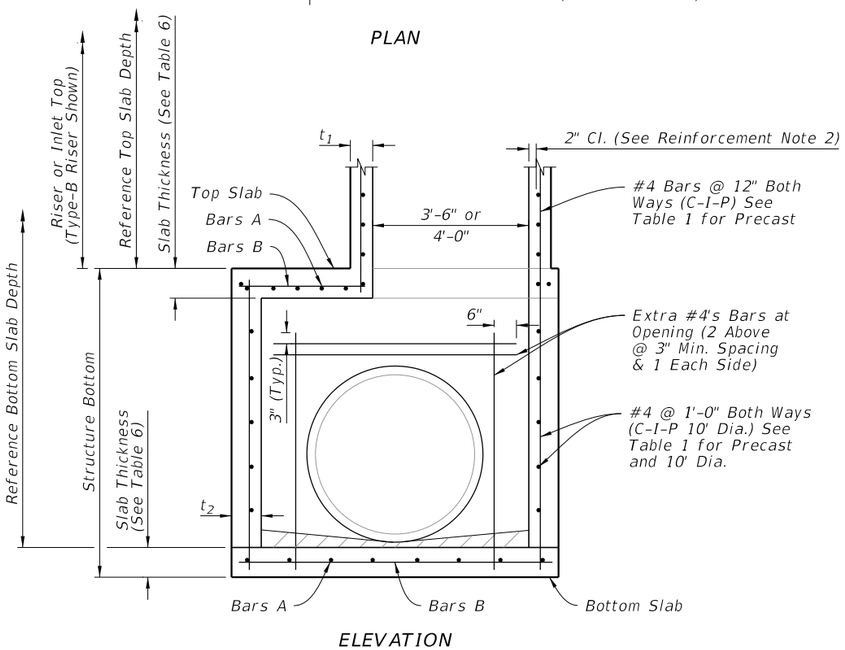
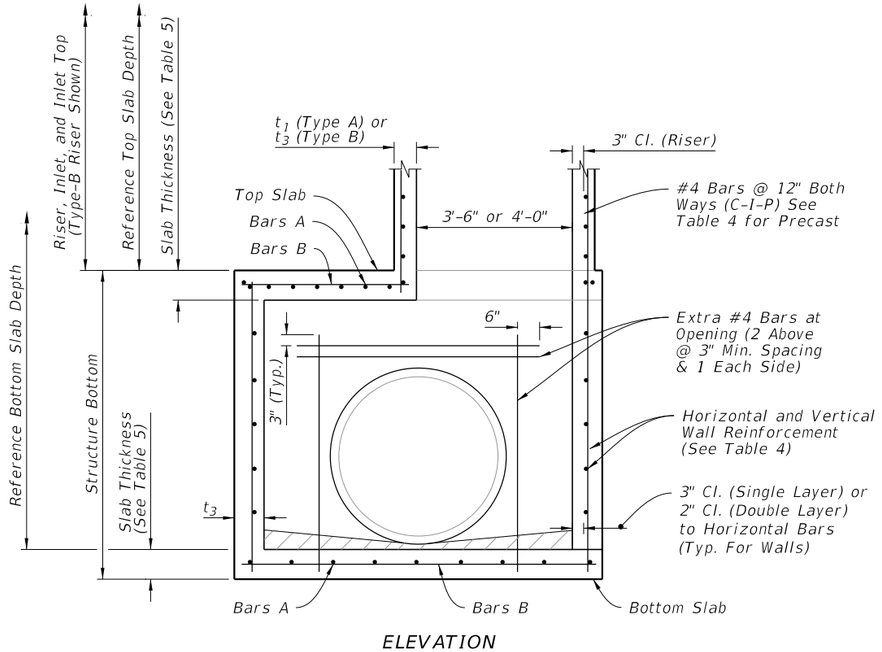


ELEVATION

TYPE J BOTTOM - ALTERNATE A

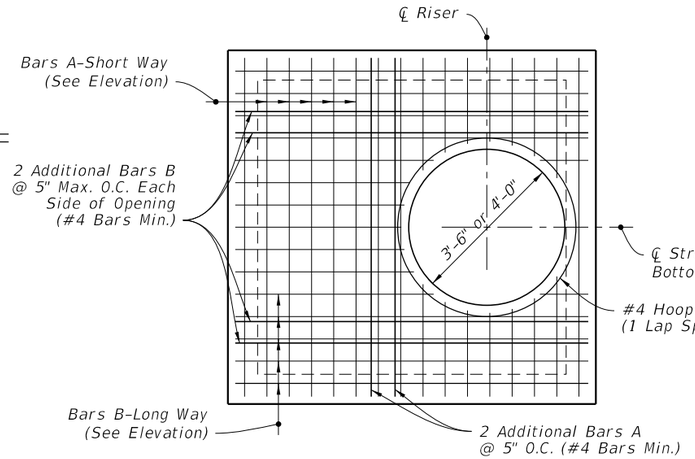


ELEVATION

TYPE J BOTTOM - ALTERNATE B

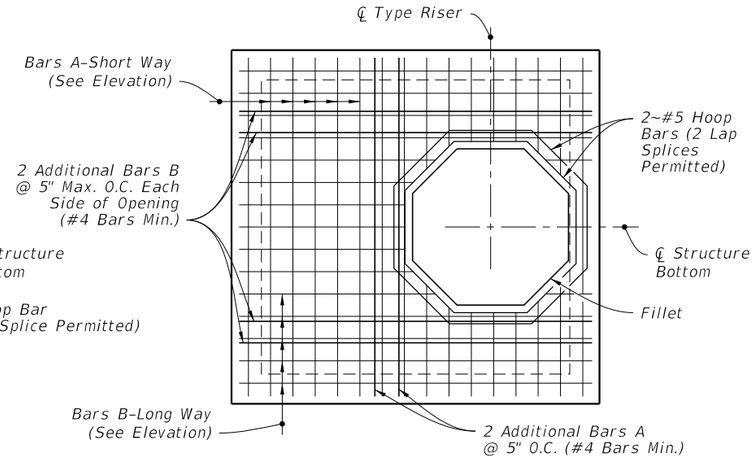
ALTERNATE A NOTES:

1. Rotate #4 Bars as required to maintain cover.
2. Construct the top or riser of the structure according the top slab to the "Special Top Slab" details, when the inside diameter of a round structure is not more than 1'-6" larger than the opening in the riser or top slab.
3. Alternate A slab reinforcing not applicable for Type A, B, C, D & E Ditch Bottom Inlets or Type S & V Gutter Inlets. See Indexes 425-040, 425-041, 425-050, 425-051, and 425-052.



TYPE A - ROUND RISER OPENING

PLAN



TYPE B - SQUARE RISER OPENING

PLAN

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DIMENSIONAL AND REINFORCING DETAILS

TABLE 1 - ALTERNATE A - STRUCTURES

TYPE	STRUCTURE/RISER DIAMETER (ft)	CAST-IN-PLACE ITEMS CLASS II CONCRETE			PRECAST ITEMS				
					CLASS II CONCRETE			ASTM C478	
		t_1 RISER (in.)	t_2 BOTTOM (in.)	A_S (in.²/ft.)	t_1 RISER (in.)	t_2 BOTTOM (in.)	A_S (in.²/ft.)	t_1 or t_2 (in.)	A_2*** (in.²/ft.)
P	3'-6"	6	8	0.20	6	8	0.20	4**	0.105
P	4'-0"	6	8	0.20	6	8	0.20	5**	0.120
J	5'-0"	–	8	0.20	–	8	0.20	6**	0.150
J	6'-0"	–	8	0.20	–	8	0.20	6	0.180
J	7'-0"	–	8	0.20	–	8	0.20	7	0.210
J	8'-0"	–	8	0.20	–	8	0.20	8	0.240
J	10'-0"	–	10	0.40##	–	10	0.40##	10	0.300
J	12'-0"	–	10	0.40##	–	12	0.40##	12	0.360

t_1 and t_2 – Wall Thickness.

A_S – Vertical and horizontal areas of reinforcement.

##Provide 0.20 eq. in.²/ft. at each face, 12" max. bar spacing.

**Modified minimum wall thickness.

***Min. total circumferential reinforcement for continuous steel hoops:

A2 = 0.40 sq. in. for riser section height equal or less than 2'-0" (2 hoop min.)

A_2 = 0.60 sq. in. for riser section height more than 2'-0" up to 4'-0" (3 hoop min.)

Areas of reinforcing for precast items are based on Grade 60 reinforcing.

No reduction in the area of reinforcement is allowed for welded wire fabric in Table 1.

Area of vertical reinforcing may be reduced in accordance with ASTM C478.

TABLE 2 - ALTERNATE B SQUARE AND RECTANGULAR STRUCTURES

TYPE	WALL LENGTH (FT)	MAX. DEPTH (FT)	WALL THICKNESS (t_3)	
			C-I-P (in.)	PRECAST (in.)
P	≤ 3'-6"	40	6 Riser 8 Bottom	6
J	4'-0"	40	8	6
J	5'-0"	22	–	6
J	6'-0"	15	–	6
J	5'-0" to 9'-0"	40	8	8
J	10'-0"	26	8	8
J	10'-0" to 12'-0"	40	10	9
J	16'-0"	35	–	9
J	16'-0"	40	10	10
J	20'-0"	25	–	9
J	20'-0"	30	10	10

See Table 4 for Reinforcing Schedule.

TABLE 3 - REINFORCING SCHEDULE

SCHEDULE	GRADE 60 BARS OR 65 KSI & 70 KSI WELDED WIRE REINFORCING			
	GRADE 60 AREA (in.² /ft)	MAXIMUM SPACING		
		GR 60 BARS (in.)	WWR EQUIV. AREA	
			65 KSI (in.)	70 KSI (in.)
A12	0.20	12	8	8
A6	0.20	6	5	4½
B10	0.24	10	8	7½
B5.5	0.24	5½	5	4
C6.5	0.37	6½	6	5
C3.5	0.37	3½	3	2½
D7	0.53	7	6	5
D4.5	0.53	4½	4	3½
E5	0.73	5	4	4
E3	0.73	3	3	3
F5	1.06	5	4	4
F3.5	1.06	3½	3	3
G5	1.45	5	4	4
G.3.5	1.45	3½	3	3
H4	1.75	4	3	3

TABLE 4 - WALL DESIGNS - RECTANGULAR STRUCTURES

VERTICAL REINFORCING			HORIZONTAL REINFORCING			WALL THICKNESS
WALL DEPTH	SCHEDULE		WALL DEPTH	SCHEDULE		
SIZE: 3'-6" & RISER						
≥1.17' – 40'	A12		≥1.17' < 10'	B10		6"/8"
			10' < 18'	B5.5		6"/8"
			18' < 29'	C6.5		6"/8"
			29' – 40'	C3.5		6"/8"
SIZE: 4'-0"						
≥1.17' – 40'	A12		≥1.17' < 6'	B10		6"/8"
			6' < 10'	B5.5		6"/8"
			10' < 20'	C6.5		6"/8"
			20' < 28'	C3.5		6"/8"
			28' – 40'	D4.5		6"/8"
SIZE: 5'-0"						
≥1.17' – 40'	A12		≥1.17' < 5'	B5.5		6"/8"
			5' < 9'	C6.5		6"/8"
			9' < 15'	C3.5		6"/8"
			15' < 22'	D4.5		6"/8"
			22' – 40'	E3		8"
SIZE: 6'-0"						
≥1.17' < 26'	A12		≥1.17' < 9'	C3.5		6"/8"
			9' < 15'	D4.5		6"/8"
			15' < 26'	E3		8"
	Inside	Outside		Inside	Outside	
26' – 40'	A12	A12	26' – 40'	D7	D7	8"
SIZE: 7'-0"						
	Inside	Outside		Inside	Outside	
≥1.17' < 25'	A12	A12	≥1.17' < 7'	B10	B10	8"
26' – 40'	B10	B10	7' < 10'	B5.5	B5.5	8"
			10' < 20'	C6.5	C6.5	8"
			20' < 30'	D7	D7	8"
			30' – 40'	E5	E5	8"
SIZE: 8'-0"						
	Inside	Outside		Inside	Outside	
≥1.17' < 20'	A12	A12	≥1.17' < 6'	B5.5	B5.5	8"
20' – 40'	C6.5	C6.5	6' < 13'	C6.5	C6.5	8"
			13' < 22'	D7	D7	8"
			22' < 31'	E5	E5	8"
			31' – 40'	F5	F5	8"
SIZE: 9'-0"						
	Inside	Outside		Inside	Outside	
≥1.17' < 12'	A12	A12	≥1.17' < 8'	C6.5	C6.5	8"
12' < 28'	C6.5	C6.5	8' < 15'	D7	D7	8"
28' – 40'	D7	D7	15' < 23'	E5	E5	8"
			23' – 40'	F5	F5	8"
SIZE: 10'-0"						
	Inside	Outside		Inside	Outside	
≥1.17' < 10'	B10	B10	≥1.17' < 10'	D7	D7	8"
10' < 21'	C6.5	C6.5	10' < 17'	E5	E5	8"
21' < 26'	D7	D7	17' < 26'	F5	F5	8"
26' – 40'	C6.5	C6.5	26' – 40'	F5	F5	10"

VERTICAL REINFORCING			HORIZONTAL REINFORCING			WALL THICKNESS
WALL DEPTH	SCHEDULE		WALL DEPTH	SCHEDULE		
SIZE: 10'-0" (Precast Only)						
	Inside	Outside		Inside	Outside	
26' – 40'	D7	D7	26' – 40'	F5	F5	9"
SIZE: 12'-0"						
	Inside	Outside		Inside	Outside	
≥1.17' < 14'	B10	B10	≥1.17' < 10'	C6.5	C6.5	10"
14' < 25'	C6.5	C6.5	10' < 17'	D7	D7	10"
25' – 40'	D7	D7	17' < 24'	E5	E5	10"
			24' – 40'	F5	F5	10"
SIZE: 12'-0" (Precast Only)						
	Inside	Outside		Inside	Outside	
≥1.17' < 12'	B10	B10	≥1.17' < 10'	D7	D7	9"
12' < 24'	C6.5	C6.5	10' < 17'	D4.5	D4.5	9"
24' – 40'	D7	D7	17' < 23'	E5	E5	9"
			23' < 32'	F5	F5	9"
			32' – 40'	G5	G5	9"
SIZE: 16'-0"						
	Inside	Outside		Inside	Outside	
≥1.17' < 11'	C6.5	C6.5	≥1.17' < 13'	D7	D7	10"
11' < 20'	D7	D7	13' < 20'	E5	E5	10"
20' < 28'	E5	E5	20' < 28'	F5	F5	10"
28' – 40'	F5	F5	28' – 40'	G5	G5	10"
SIZE: 16'-0" (Precast Only)						
	Inside	Outside		Inside	Outside	
≥1.17' < 10'	C6.5	C6.5	≥1.17' < 9'	D7	D7	9"
10' < 18'	D7	D7	9' < 13'	D4.5	D4.5	9"
18' < 25'	E5	E5	13' < 19'	E5	E5	9"
25' – 35'	F5	F5	19' < 27'	F5	F5	9"
			27' – 35'	G5	G5	9"
SIZE: 20'-0"						
	Inside	Outside		Inside	Outside	
≥1.17' < 10'	C6.5	C6.5	≥1.17' < 8'	D7	D7	10"
10' < 17'	D7	D7	8' < 12'	E5	E5	10"
17' – 30'	E5	E5	12' < 20'	F5	F5	10"
			20' – 30'	G5	G5	10"
SIZE: 20'-0" (Precast Only)						
	Inside	Outside		Inside	Outside	
≥1.17' < 8'	C6.5	C6.5	≥1.17' < 8'	D4.5	D4.5	9"
8' < 13'	D7	D7	8' < 12'	E5	E5	9"
13' – 25'	E5	E5	12' < 19'	F5	F5	9"
			19' – 25'	G5	G5	9"

TABLE 4 NOTES:

1. Wall depth is measured to the top of the bottom slab for boxes and to the top of the intermediate slab for risers.
2. Wall height is the distance between top of lower slab to bottom of upper slab. Maximum wall height is 12' for wall lengths exceeding 5', or 10' for wall lengths exceeding 12'.
3. Wall lengths exceeding 6'-0" require two layers of reinforcing (See Table 4) with 2" of cover from the horizontal bars to the inside and outside faces for each layer.
4. Wall lengths exceeding the dimensions or depths shown in Table 4, or 12'-0" diameter require a special design.
5. Wall thickness and reinforcing for rectangular structures is based on the longer wall length.

TABLES 1, 2, 3, AND 4

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LAST REVISION	REVISION	DESCRIPTION:			INDEX	SHEET
11/01/20			FY 2021-22 STANDARD PLANS	STRUCTURE BOTTOMS TYPE J AND P	425-010	3 of 4

TABLE 5 - SLAB DESIGNS - SQUARE AND RECTANGULAR STRUCTURES

(ALL SLABS 8" THICK EXCEPT AS NOTED - REINFORCING PARALLEL TO SHORT WAY AND LONG WAY)

SHORT-WAY		LONG-WAY	
SLAB DEPTH	SCHEDULE (Bars A)	SLAB DEPTH	SCHEDULE (Bars B)
SIZE: 3'-6" x UNLIMITED			
≥0.5' < 8'	B10	≥0.5' < 24'	B10
8' < 13'	B5.5	24'–40'	B5.5
13' < 31'	C6.5		
31'–40'	D7		
SIZE: 4' x UNLIMITED			
≥0.5' < 7'	B5.5	≥0.5' < 15'	B10
7' < 19'	C6.5	15' < 29'	B5.5
19' < 31'	D7	29'–40'	C6.5
31'–40'	E5		
SIZE: 5' x 5'			
≥0.5' < 3'	C6.5	≥0.5' < 3'	C6.5
3' < 7'	B5.5	3' < 13'	C6.5
7' < 22'	C6.5	13' < 22'	D7
22' < 29'	D7	22' < 29'	D4.5
29'–40'	E5	29'–40'	E5
SIZE: 5' x 6'			
≥0.5' < 12'	C6.5	≥0.5' < 3'	C6.5
12' < 26'	D7	3' < 9'	B5.5
26'–40'	E5	9' < 23'	C3.5
		23' < 35'	D4.5
		35'–40'	E5
SIZE: 5' x 7'			
≥0.5' < 10'	C6.5	≥0.5' < 10'	B5.5
10' < 20'	D7	10' < 31'	C3.5
20' < 34'	E5	31'–40'	D4.5
34'–40'	F5		
SIZE: 5' x 8'			
≥0.5' < 7'	C6.5	≥0.5' < 8'	B10
7' < 13'	D7	8' < 17'	B5.5
13' < 24'	E5	17' < 25'	C6.5
24'–40'	F5	25'–40'	C3.5
SIZE: 5' x 9'			
≥0.5' < 8'	C6.5	≥0.5' < 14'	B10
8' < 14'	D7	14' < 24'	B5.5
14' < 25'	E5	24' < 34'	C6.5
25'–40'	F5	34'–40'	C3.5
SIZE: 5' x UNLIMITED			
≥0.5' < 8'	C6.5	≥0.5' < 14'	B10
8' < 14'	D7	14' < 24'	B5.5
14' < 25'	E5	24' < 34'	C6.5
25'–40'	F5	34'–40'	C3.5

SHORT-WAY		LONG-WAY	
SLAB DEPTH	SCHEDULE (Bars A)	SLAB DEPTH	SCHEDULE (Bars B)
SIZE: 6' x 6'			
≥0.5' < 13'	C6.5	≥0.5' < 10'	C3.5
13' < 23'	D7	10' < 18'	D4.5
23'–40'	E5	18' < 27'	E5
		27' < 33'	E3
		33'–40'	F5
SIZE: 6' x 7'			
≥0.5' < 8'	C6.5	≥0.5' < 8'	C6.5
8' < 16'	D7	8' < 12'	C3.5
16' < 28'	E5	12' < 21'	D4.5
28'–40'	F5	21' < 28'	E5
		28' < 35'	E3
		35'–40'	F5
SIZE: 6' x 8'			
≥0.5' < 6'	C6.5	≥0.5' < 6'	B5.5
6' < 13'	D7	6' < 11'	C6.5
13' < 22'	E5	11' < 17'	C3.5
22' < 35'	F5	17' < 22'	D4.5
35'–40'	G5	22' < 32'	E5
		32'–40'	E3
SIZE: 6' x 9'			
≥0.5' < 8'	D7	≥0.5' < 8'	B5.5
8' < 14'	E5	8' < 14'	C6.5
14' < 24'	F5	14' < 21'	C3.5
24'–34'	G5	21' < 25'	D4.5
		25'–34'	E5
SIZE: 6' x UNLIMITED			
≥0.5' < 8'	D7	≥0.5' < 8'	B5.5
8' < 14'	E5	8' < 14'	C6.5
14' < 24'	F5	14' < 21'	C3.5
24'–34'	G5	21' < 25'	D4.5
		25'–34'	E5
SIZE: 7' x 7'			
≥0.5' < 8'	C6.5	≥0.5' < 4'	C6.5
8' < 15'	D7	4' < 7'	C3.5
15' < 26'	E5	7' < 11'	D4.5
26'–40'	F5	11' < 22'	E3
		22' < 32'	F3.5
		32'–40'	G3.5
SIZE: 7' x 8'			
≥0.5' < 5'	C6.5	≥0.5' < 5'	C6.5
5' < 11'	D7	5' < 8'	C3.5
11' < 19'	E5	8' < 13'	D4.5
19' < 30'	F5	13' < 22'	E3
30'–40'	G5	22' < 30'	F3.5
		30'–40'	G3.5
SIZE: 7' x 9'			
≥0.5' < 9'	D7	≥0.5' < 7'	C6.5
9' < 15'	E5	7' < 10'	C3.5
15' < 25'	F5	10' < 14'	D4.5
25' – 34'	G5	14' < 21'	E5
		21' < 29'	F5
		29'–34'	F3.5

SHORT-WAY		LONG-WAY	
SLAB DEPTH	SCHEDULE (Bars A)	SLAB DEPTH	SCHEDULE (Bars B)
SIZE: 8' x 8'			
≥0.5' < 10'	D7	≥0.5' < 9'	D4.5
10' < 19'	E5	9' < 13'	E5
19'–30'	F5	13' < 18'	F5
		18' < 23'	F3.5
		23'–30'	G3.5
SIZE: 8' x 9'			
≥0.5' < 8'	D7	≥0.5' < 7'	D7
8' < 14'	E5	7' < 9'	D4.5
14' < 23'	F5	9' < 15'	E3
23'–31'	G3.5	15' < 20'	F5
		20' < 23'	F3.5
		23'–31'	G3.5
SIZE: 9' x 9'			
≥0.5' < 8'	D7	≥0.5' < 7'	D4
8' < 14'	E5	7' < 10'	E5
14' < 22'	F5	10' < 17'	F3.5
		17' < 22'	G3.5
SIZE: 9'x9'x10" SLAB THICKNESS			
22' < 36'	F5	22' < 31'	F3.5
36'–40'	G5	31'–40'	G3.5
SIZE: 10'x10'x10" SLAB THICKNESS			
≥0.5' < 7'	C6.5	0.5' < 6'	C6.5
7' < 10'	D7	6' < 9'	D4.5
10' < 18'	E5	9' < 15'	E5
18' < 27'	F5	15' < 22'	F5
27'–32'	G5	22'–32'	G3.5
SIZE: 12'x12'x12" SLAB THICKNESS			
≥0.5' < 10'	D7	≥0.5' < 8'	D7
10' < 16'	E5	8' < 14'	E5
16' < 25'	F5	14' < 22'	F5
25'–35'	G5	22' < 30'	G5
		30'–35'	H4

SLAB AND WALL DESIGN TABLE NOTES

1. Size is the inside dimension(s) of a structure.
2. Slab reinforcement is appropriate for top, intermediate, and bottom slabs.
3. Bottom Slabs for precast 3'–6" x 3'–6" rectangular structures at 15' depth or less, may be 6" thick.
4. Slab depth is measured from finished grade to top of slab.
5. Reinforcing schedules with larger areas of steel may be substituted for schedules with smaller bar or wire spacing, except that Schedule B10 may not be substituted for Schedule A6. See Index 425-001 for allowable bar spacing adjustments when larger areas of reinforcing are substituted.

TABLE 6 - SLAB DESIGNS ROUND STRUCTURES

SLAB DEPTH	SLAB THICKNESS	REINF. (2-WAY) SCHEDULE
SIZE: 3'-6" DIAMETER		
2'–15'	6" Precast	C6.5
0.5' < 30'	8"	A6
30'–40'	8"	B5.5
SIZE: 4'-0" DIAMETER		
≥0.5' < 19'	8"	A6
19' < 30'	8"	B5.5
30'–40'	8"	C6.5
SIZE: 5'-0" DIAMETER		
≥0.5' < 15'	8"	B5.5
15' < 26'	8"	C6.5
26' < 35'	8"	D7
35'–40'	8"	D4.5
SIZE: 6'-0" DIAMETER		
≥0.5' < 9'	8"	B5.5
9' < 15'	8"	C6.5
15' < 22'	8"	C3.5
22' < 30'	8"	D4.5
30'–40'	8"	E5
SIZE: 7'-0" DIAMETER		
≥0.5' < 8'	8"	C3.5
8' < 16'	8"	D4.5
16' < 23'	8"	E5
23' < 27'	8"	E3
27'–40'	8"	F3.5
SIZE: 8'-0" DIAMETER		
≥0.5' < 10'	8"	D4.5
10' < 16'	8"	E5
16' < 19'	8"	E3
19' < 29'	8"	F3.5
29'–40'	10"	F5
SIZE: 10'-0" DIAMETER		
≥0.5' < 12'	10"	D4.5
12' < 20'	10"	E5
20' < 28'	10"	F5
28'–40'	10"	G3.5
SIZE: 12'-0" DIAMETER		
≥0.5' < 8'	10"	D4.5
8' < 13'	10"	E5
13' < 18'	10"	F5
18' < 26'	10"	G3.5
26'–40'	12"	G3.5

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TABLES 5 AND 6

GENERAL NOTES:

1. Work with Index 425-001 and Index 425-010.

2. Use Class II Concrete.

3. Maximum opening for pipe shall be the pipe OD plus 6". Mortar used to seal the pipe into the opening will be of such mix that shrinkage will not cause leakage into or out of the structure.

4. If a conflict with a potable water supply line is discovered during construction, submit the following to Florida Department of Environmental Protection (FDEP) District Administrator For Drinking Water prior to constructing conflict structure:

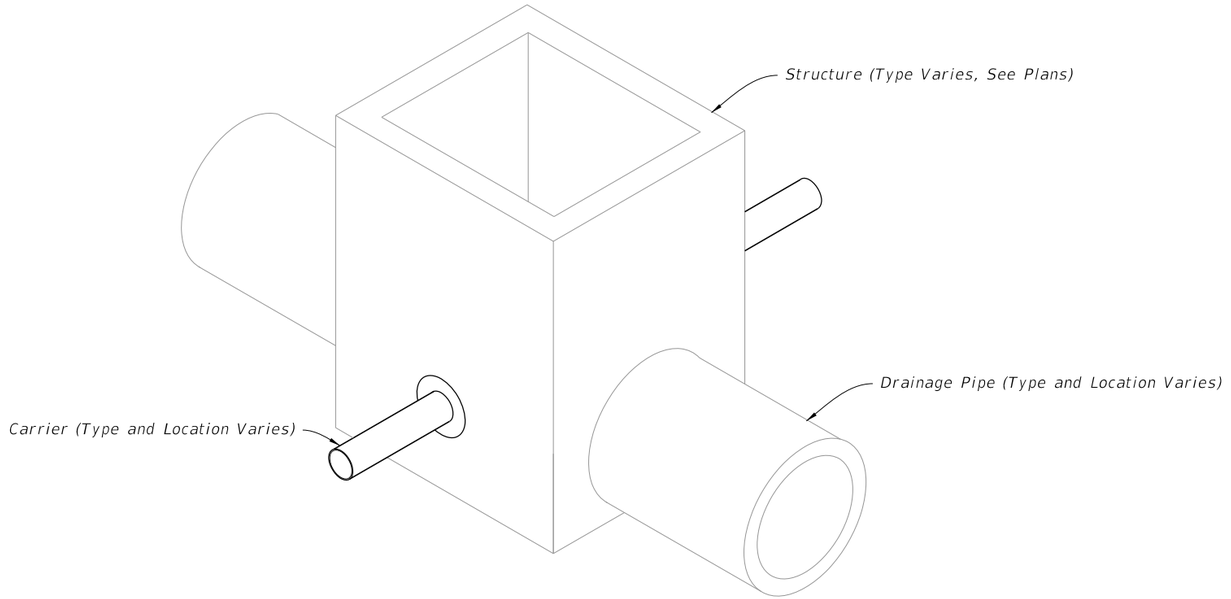
   a. Plans Revision(s)
   b. Justification describing inordinate cost and practical avoidance
   c. Upon request, Utility Agency Owner (UAO) supporting documentation for cost of relocation or adjustment

   Potable water supply lines passing through a drainage structure must be in compliance with Chapter 62-555.314(3) F.A.C. This Index and rule citation provide accepted methods for addressing conflicts when they cannot be reasonably avoided.

   Website for District FDEP Drinking Water Contacts:
   https://floridadep.gov/water/source-drinking-water/content/organization-drinking-water-program

TABLE OF CONTENTS:

Sheet	Description
1	General Notes and Contents
2	Utility Conflict Condition I and II Details



UTILITY CONFLICT

(Condition I Shown, Condition II Similar)

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LAST REVISION	REVISION	DESCRIPTION:	FDOT	FY 2021-22 STANDARD PLANS	UTILITY CONFLICT THRU DRAINAGE STRUCTURES	INDEX	SHEET
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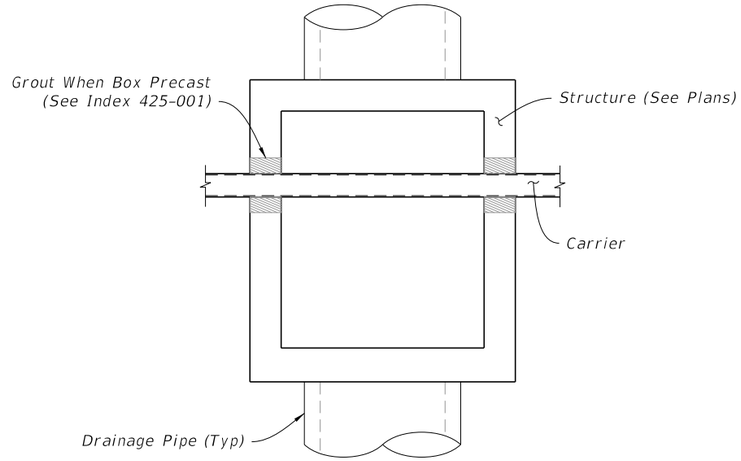

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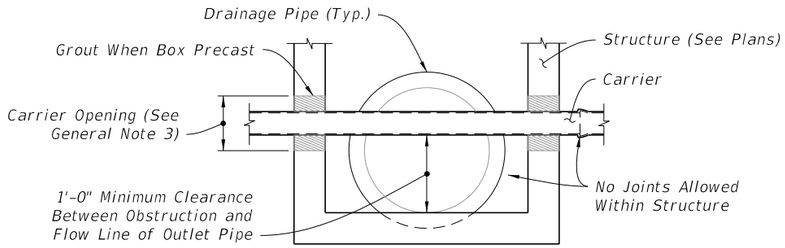

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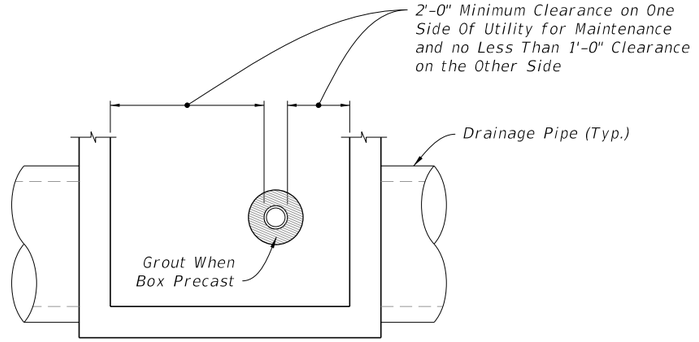
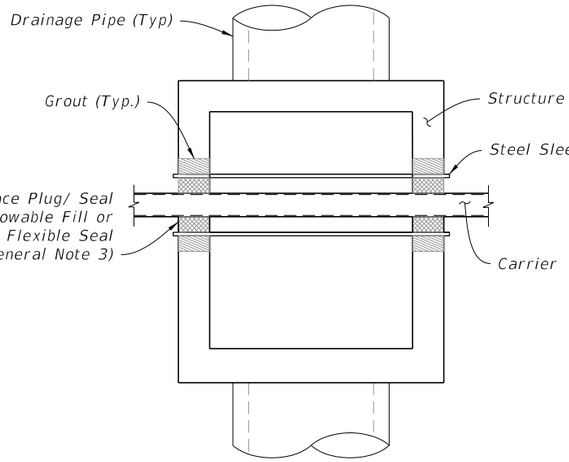


SIDE ELEVATION

UTILITY CONFLICT CONDITION I
(Nonpressure or Nonfluid Carrier Installations)



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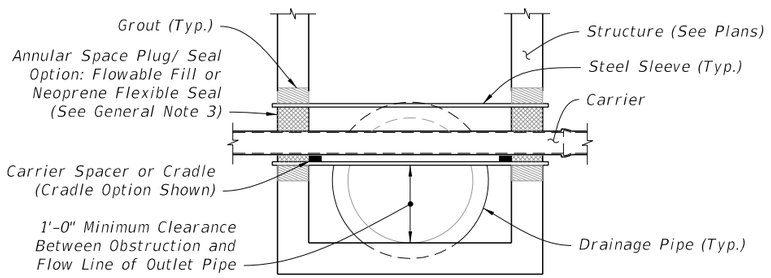

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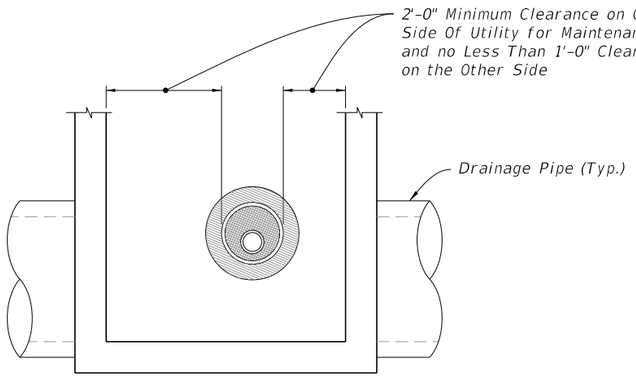

SIDE ELEVATION

UTILITY CONFLICT CONDITION II
(Pressure or Fluid Carrier Installations)

UTILITY CONFLICT CONDITION I AND II DETAILS

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LAST REVISION	REVISION	DESCRIPTION:			INDEX	SHEET
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SECTION 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The work includes also all supervision, labor, materials, equipment, facilities and installation required for the complete electrical systems as indicated on the drawing and called for in these specifications, or as may be reasonably implied by either. When drawings, notes and/or specifications are in conflict, the most stringent requirements shall apply.

B. The provisions of this Section apply to all electrical items specified in the various Sections of Division 16 of these Specifications, except where otherwise specified or shown in Contract Documents.

C. Provide complete and operating electrical systems consisting of the following:

1. Power, control, instrumentation, including Automatic Transfer Switch, Distribution Panelboard, Stepdown Transformer, VFDs, Pump Control Panel, feeders, sub-feeders, grounding, branch circuits, control wiring, and receptacles and all other equipment shown on drawings or called for in the specifications.

2. Electrical connections to equipment furnished by other trades.

3. Power and control wiring of all motors and electrically operated equipment, including startup and testing.

4. Conduits, sleeves, pull, junction and terminal boxes, etc. required for all exposed and underground systems.

5. Miscellaneous items obviously required for a complete and operating system (nuts and bolts, masonry anchors, conduit and equipment supports, drilling, welding, scaffolding, crane service, etc.) but not specifically called for on the drawings or specifications.

D. Visit the project site before submitting a bid. Verify all dimensions shown on the Contract drawings and determine the characteristics of the site which will affect performance of the work, but which are not shown on the drawings or described within these Specifications.

1.02 CODES AND STANDARDS

A. Reference within these Specifications to standards and codes implies that any item, product, or material so identified must comply with the minimum requirements as stated therein. Only the latest approved editions are applicable.

B. The Specifications and latest approved Editions of codes and standards listed below form a part of these specifications:

1. National Electrical Code (NEC).

2. National Electrical Contractor's Association (NECA).

3. National Fire Protection Association (NFPA).
4. Underwriters' Laboratories (UL).
5. National Electrical Manufacturers Association (NEMA).
6. American National Standards Institute (ANSI).
7. Federal Specifications (Fed. Spec.).
8. Insulated Power Cable Engineers Association (IPCEA).
9. South Florida Building Code (SFBC).
10. American Concrete Institute (ACI).
11. Institute of Electrical and Electronic Engineers (IEEE).
12. American Society for Testing and Materials (ASTM).
13. American Society of Mechanical Engineers (ASME).

C. Furnish equipment listed and bearing the label of Underwriters' Laboratories Inc. (UL) or of an independent testing laboratory acceptable to the Engineer, WASD's Best Practices/Standards, and the local Code enforcement agency having jurisdiction.

D. Install equipment and materials in compliance with applicable provisions of the OSHA Safety and Health Standards (29CFR1910 and 29CFR1926, as applicable), State Building Standards and applicable local codes and regulations.

1.03 DRAWINGS

A. The drawings indicate the extent and general arrangements of equipment and wiring systems. If any departures from the drawings are deemed necessary by the Contractor, details of such departures and reasons therefore shall be submitted to Monroe County for approval within thirty days after award of the Contract. No such departures shall be made without the prior written approval of the County. All items not specifically mentioned in the Specifications or noted on the Drawings but obviously necessary to make a complete working installation shall be included.

B. Mechanical equipment shown on the Electrical Drawings is included solely as a convenience to the Contractor and is not to be regarded as necessarily final or complete nor superseding in any way the work outlined in the mechanical Specifications and Drawings. Where electrical plans differ from the mechanical plans in regard to horsepower, voltage, phases, load rating or equipment location, the information shown on the Mechanical Drawings prevails and the required power shall be provided.

C. Wiring as shown on drawings are for a typical installation and based on the requirement for similar jobs but might not show all conductors required for this particular Contract. Coordinate with the manufacturers of proposed equipment the power and control wiring requirement and bid the job accordingly.

1.04 SHOP DRAWINGS

A. Within 30 days after the date of the award of the Contract, and before any material or equipment is purchased, submit to the Engineer for approval, a complete list in quintuplicate of electrical materials, fixtures and equipment to be incorporated in the work. Include catalog number, diagrams, Drawings, material, finish, dimensions, fabrication details, installation and maintenance instructions books, interconnecting wiring diagrams, compliance with standards, UL approval and any other descriptive data as may be required by the Engineer. No material shall be delivered or installed previous Shop Drawings approval.

B. Provide detailed operational information of control systems, particularly those related to wiring, ladder and logical diagrams as well as a detailed sequence of operations of every component such as relays, lamps, timer, counter, etc. that makes up the proposed system.

C. Prepare a detailed system interconnection diagram, including the coordination of drawings and equipment from the various suppliers. This submittal shall be considered a Shop Drawing and shall include block and step by step process diagrams if needed for clarification or requested by the Engineer.

D. When submitting alternated items, provide a complete price breakdown for both, the original item and the proposed alternate item. This breakdown shall be in identical form for both items in NECA form or similar. Specify the net change in Contract price for each item and for the total price. Provide also complete information on every proposed alternate item for comparison and technical evaluation. Alternate proposals will not be considered prior to Bid opening.

E. Approval of material will be based on the manufacturer's compliance with the specifications, published ratings, or on test results where specified.

F. Any deviation from the specifications or drawings shall be listed separately and submitted with Shop Drawings. Failure to list all deviations shall be grounds for requiring removal of such items and installation of items in accord with the specifications at no extra cost to the County.

G. Where installation procedures or part of the installation procedures are required to be in accordance with manufacturers' instructions, submit printed copies of those instructions. Do not proceed with the installation until the instructions are processed and authorized. Failure to submit the installation instructions shall be cause for rejection of the equipment or material.

H. Decision on acceptance or rejection of any and/or all proposed alternate items shall be made by the Engineer only and such decision is final and binding.

1.05 QUALITY ASSURANCE

A. Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for two years prior to bid opening.

B. Equipment, materials, installation and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70.

C. Equipment shall have a nameplate bearing the manufacturer's name, address, model number and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.06 COORDINATION WITH OTHER UTILITIES AND TRADES

A. The Drawings are generally diagrammatic, coordinate the electrical work with the work of other trades and furnish all necessary offsets in raceways, fittings, etc. so that mechanical, architectural and structural interferences or conflict with conduits, piping, equipment, etc. are prevented.

B. Where failure to coordinate the work with other trades results that equipment have to be removed and relocated, the Engineer shall determine which one has to be moved regardless of which equipment was installed first. Work required for relocation shall exactly match original finish. All relocation work must be done at no cost to the Department.

C. Coordinated installation of underground ducts and conduits with other utilities on the site. Details of routing, burial depth, size of bends and termination at each end of service shall be verified on the job site.

1.07 CUTTING AND PATCHING N/A

1.08 STORAGE

A. Store equipment and material furnished by the Contractor in a safe and orderly manner. Materials shall not be stored directly on the ground or floor and shall be kept clean, dry and free from damage or deteriorating elements. Damaged or rusted materials shall not be installed until replaced of refinished by the manufacturer. Manufacturer's recommendations for storage of equipment shall be strictly adhered to, including energizing of motor and equipment space heaters.

1.09 OPERATIONAL MANUALS AND AS BUILT DRAWINGS

A. Upon completion of the work, prepare and deliver to the Engineer the following:

1. Operation and maintenance manuals for each power, control and special system installed. Manuals shall consist of detailed Drawings or catalog sheets for each component, control diagrams and sequence of operation, replacement parts lists, maintenance instructions and possible breakdowns and repairs, description of system operation. Include also complete parts list and name, address and phone number of the supplier and nearest manufacturer's representative of the equipment.

B. As-Built Drawings with exact location of underground equipment like conduits, grounding, etc. Point to point wiring diagram indicating terminal and wire numbers, color coding and routing.

1. In addition, frame under glass single line "As Built" Drawings and mount them on the inside the Control Panel door in conjunction with the require Control Schematic of Motor Control Panel.

1.10 TRAINING

A. Provide equipment manufacturer instructors for a minimum of forty (40) HRS to train designated County personnel in the operation and maintenance of the different systems of the Contract.

PART 2 PRODUCTS

2.01 MATERIALS

A. Furnish equipment, materials and components new, standard current products and latest design of manufacturers regularly engaged in the production of such equipment.

B. All materials shall bear the label of Underwriter's Laboratory (UL) for the intended use in all cases where this labeling is available or shall be materials reviewed by the code enforcing authorities and Engineer. All components shall be mechanically and electrically compatible with rating of apparatus in which installed.

C. Equipment of a similar nature shall be identical. Example: All proposed electrical equipment such as VFDs, panelboards and transformer shall be of the same manufacturer and of the same style. Equipment such as Standby Generator, Automatic Transfer Switch and Motor Control Panels could be from a specialized manufacturer; however, the gear manufacturer shall be responsible for all equipment.

D. Coordinate shipping lengths of Automatic Transfer Switch, Standby Generator, Panelboard, VFDs Tranformar, etc. Those equipment shall be able to be removed and replaced in the future if necessary, with the access and openings provided in the structure.

E. Furnish panelboards, terminal cabinets and other equipment requiring wire and cable terminations, with wiring gutter sized as required by NEC Tables 312.6(A) and 312.6(B).

F. For the control system provide all required relays, timers, control switches, push buttons, indicating lights, wire, conduit and fittings.

G. When reference is made to one manufacturer's name and catalog number, it does not necessarily mean that the equipment is an "off the shelf" item. Variances may be required for finish, material or other modifications. The Contractor shall assure that all such required modifications are made.

H. Provide single phase protection devices for circuit breaker combination starters with current limiting fuses to ensure that the circuit breaker trips if any fuse blows.

2.02 ACCESSORIES

A. Use hardware and accessory fittings that are:

1. Corrosion protected and suitable for the atmosphere in which they are installed.

2. Designed, intended and appropriated for the use, and at the same time, complement the items with which they are used.

3. U.S. standard sizes.

2.03 SPARE PARTS

A. Submit a list of manufacturers recommended spare parts for all major equipment including descriptions of each part, part number and cost.

B. For Future Decorative Enclosure Luminaire furnish LED luminaires with boards. Supply at least ten percent, but not less than two spare parts for each type of luminaire specified.

C. Furnish fusible equipment with fuses, and ten percent (three minimum) of spare fuses of each type.

D. Furnish control equipment with spare parts, ten percent (three minimum) of relays, fuses, pilot lights, etc. and one spare of each different fully assembled electronic board.

E. Turn over to an authorized person spare parts provided with any equipment. Obtain signed and dated receipt for them.

PART 3 EXECUTION

3.01 INSTALLATION

A. All materials shall be installed at the locations shown on the Drawings and in accordance with the specific manufacturer's recommended installation methods.

B. External control circuits or interlock circuits between motors and other equipment such as pressure or temperature switches, thermostats, etc., shown or not in the Electrical Drawings, must be wired in compliance with the provisions of Division 16, Electrical.

C. All equipment shall be set level, at the correct heights, properly aligned and bolted together where delivered in sections. Install surface mounted equipment, including panelboards, automatic transfer switches, safety switches, individually mounted enclosed circuit breakers, motor starters, etc., on a metal framing support system (continuous slot metal channel system).

D. Install conduit and equipment in such a manner as to avoid obstructions, preserve head room and keep openings and passageways clear.

E. Secure all materials and equipment firmly in place. All screws, bolts, nuts, clamps, fittings or other fastening devices shall be made up tight. Do not weld electrical materials for attachment and/or support.

F. Effectively ground all equipment in accordance with the NEC and as specified hereinafter. Use thermowell process for taps to grounding grid and ground rods and appropriate two holes bolted tongue type connectors for above ground connections.

G. Provide concrete pad with steel reinforcing and necessary bolts, anchors, inserts and conduit sleeves for floor mounted self supported equipment such as transformers, control panels, etc and extend the pad in front of equipment to facilitate removal of breakers and starters that have to be rolled out. Concrete Pad shall be coordinated with the Structural Plans.

H. Where dimensions are given, the equipment is to be placed accordingly. Where equipment is not located by dimension, it shall be located in the area shown, exercising coordination with other trades and providing appropriate maintenance space around the equipment and working clearance that meet or exceed code requirements as per NEC Tables 110-26(A) and 110-34(A).

3.02 IDENTIFICATION

A. Clearly and permanently label electrical equipment such as panelboards, transformers, control panel, etc., with securely fastened nameplates made of 1/16 inch thick black laminated plastic with 1/4 inch high white letters indicating electrical characteristics and identification.

B. Include in the nameplate whatever information applies, such as: Voltage, current rating, number of phases, the panel and circuit number from which the equipment is fed, and the item it controls.

C. Identify panelboards circuits with a door mounted, plastic protected, typewritten directory.

D. Use color coding, flame and abrasion resistant vinyl plastic tape equal to Scotch No. 35 to identify conductor phases. Colors as indicated in Section 16120, Conductors - 600 Volts and Under.

E. Identify control conductors with permanent, non-conductive tags at panels, terminal boxes and control stations to indicate their control function and feeders at every accessible point.

F. Feeder conduits shall be identified at wireways, panels, pull boxes, cabinets and similar locations to assist in future circuit tracing. Use adhesive markers, Dymo Labels or other approved methods.

G. Identify every conduit stub up with stamped nonferrous tags attached with stainless steel wire.

H. For identification of conduits and conductors, use the ID number as shown in the Wiring and Conduit Schedule.

3.03 EQUIPMENT CONNECTIONS

A. Make all connections and install and connect starters, contactors, and controls, including wiring requirements as determined in accordance with control wiring diagrams furnished for the equipment.

B. Examine other discipline drawings and make connections to equipment furnished by other Contractors even if not shown in the Electrical Drawings.

C. Changes required by the Contractor furnished equipment shall be the Contractor’s responsibility.

3.04 TESTING

A. General:

1. Notify the Engineer 30 days prior to commencement of all tests so they can be witnessed and submit the following:

a. Schedule for performing inspections and tests.

b. List of the testing equipment to be used.

c. Sample copy of equipment and material test forms.

2. Test equipment to have accuracy and been calibrated in accordance with the International Electrical Testing Association.

3. Correct at no cost to the County, any defects or variances from standard or specified conditions found during these tests.

4. Tighten with calibrated torque wrench and to manufactures' recommendations, all accessible bolted connections, including the wiring connections.

5. Prior to the final test, perform continuity, insulation, and resistance tests to assure there are no shorts or unintentional ground in the entire electrical system.

6. Energize, start-up and test operate all the systems and equipment in the presence of the Engineer.

7. Energize the main service and all feeders and branch circuits from the normal power source. Take and record readings of phase to phase and phase to ground voltage, and each phase current at the service entrance, panelboards, transformers (primary and secondary) and at each three phase motors. Coordinate all work with the main switchgear de-energization and re-energization with the electrical utility company.

8. Check motors and starters to verify correct operation and inspect panelboards prior cover installation to verify correct conductor sizing and color coding

9. Test electrical equipment such as ats, transformers, control panel, etc. following manufacturers' start-up test procedures and other requirements set up in this and other sections under Division 16.

10. Make insulation resistance test on each 480 volt and 240 volt feeder conductor before and after installation.

11. Test insulation of motors 200 HP or less in accordance with IEEE 43 and test voltages of NETA ATS, Table 10.2 for 1-minute duration with resistances tabulated at 30 and 60 seconds. Insulation values to be equal or greater than ohmic values established by the manufacturer. For larger motors, follow manufacturers' insulation test instructions.

12. Test all lighting fixtures and receptacles and verify they are properly installed.

B. Personnel and Equipment:

1. Provide instruments and equipment required to test the different systems.

2. Use safety devices such as rubber gloves and blankets, protective screens and barriers, danger signs, etc., to adequately protect and warn all personnel in the vicinity of the tests.

3. Provide qualified personnel, temporary power, lighting, wiring and all materials required to conduct the testing.

4. When specified or required, provide equipment manufacturer's representative to assist in testing their equipment.

5. In the event that equipment fails to pass the tests, provide the services of the equipment manufacturer's representative to assist the Contractor in repairing or troubleshooting their equipment.

C. Quality Assurance:

1. Corporately and financially independent organization functioning as an unbiased testing authority with no professional or business association with the manufacturers, suppliers and installers of the tested equipment.

2. Engineers and technicians certified by the International Electrical Testing Association.

3. Registered Professional Engineer in the State of Florida to provide comprehensive project report outlining services performed, test results, recommendations, actions taken and comments.

D. Test Reports:

1. Maintain a written record of all tests showing dates, personnel making test, equipment or materials tested, tests performed, and results. Have reports signed by the Department Engineer that witnessed the test.

2. Furnish tabulated and certified test reports.

3.05 TOOLS

A. Use only tools designed for the particular operation. Keep tools in good condition and do not use worn or broken tools.

B. Turn over to an authorized person, special tools provided with any equipment. Obtain signed and dated receipt for them.

3.06 FLOOR ISOLATING MATS N/A

3.07 CLEAN-UP AND PAINTING

A. After completion of the installation, clean inside and outside equipment enclosures removing foreign material, grease, dust, rust and chipped plaster and concrete until left in brand new condition.

B. Clean lighting fixtures, lenses and reflectors.

C. Remove corrosion found on metal surfaces and repair to prevent future corrosion.

D. Touch-up painting where finished surfaces have received minor scratches during installation. When damage cannot be corrected with minor touch-up, equipment shall be refinished at the factory at no cost to the Department.

3.08 FINAL INSPECTION

A. On completion of the final inspection, deliver to the Department the Certificate of Final Inspection from the local authority having jurisdiction.

END OF SECTION

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 WORK INCLUDED

A. This Section Includes the Following Electrical Materials and Methods:

1. Wire, connectors, and splices for branch circuits and feeders.
2. Supporting devices for electrical components.
3. Concrete equipment bases.
4. Electrical identification.
5. Touchup painting.
6. Meter sockets.

1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.03 SUBMITTALS

A. General: Submit each item in this article according to the Conditions of the Contract and Division 01 Specification Sections.

B. Product data for each type of product specified.

C. Shop Drawings detailing fabrication and installation of supports and anchorage for electrical items.

1.04 QUALITY ASSURANCE

A. Comply with NFPA 70 for components and installation.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The terms "listed and labeled": As defined in the National Electrical Code, Article 100.

1.05 SEQUENCING AND SCHEDULING

A. Coordinate electrical equipment installation with other building components.

B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for electrical installations.

C. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

D. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the work. Coordinate installing large equipment requiring positioning prior to closing in the building.

E. Coordinate connecting electrical service to components furnished under other Sections.

F. Coordinate connecting electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

G. Coordinate installing electrical identification after completion of finishing where identification is applied to field-finished surfaces.

PART 2 PRODUCTS

2.01 WIRE

A. Description: Single conductor, copper. Solid conductor for No. 10 AWG and smaller; stranded conductor for larger than No. 10 AWG.

B. Connectors and Splices: Units of size, ampacity rating, material, type, and class suitable for service indicated. Select to comply with project's installation requirements.

2.02 SUPPORTING DEVICES

A. Channel and angle support systems, hangers, anchors, sleeves, brackets, fabricated items, and fasteners are designed to provide secure support from the building structure for electrical components.

1. Material: Steel, except as otherwise indicated, protected from corrosion with zinc coating or with treatment of equivalent corrosion resistance using approved alternative finish or inherent material characteristics.

2. Metal items for use outdoors or in damp locations: Hot-dip galvanized steel, except as otherwise indicated.

B. Steel channel supports have 9/16 IN DIA holes at a maximum of 8 IN OC, in at least 1 surface.

1. Fittings and accessories mate and match with channels and are from the same manufacturer.

C. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded c-clamps with retainers, and spring steel clamps or "click"- type hangers.

D. Sheet-Metal Sleeves: 0.0276 IN or heavier galvanized sheet steel, round tube, closed with welded longitudinal joint.

E. Pipe sleeves: ASTM A53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

F. Cable Supports for Vertical Conduit: Factory fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable iron casting with hot-dip galvanized finish.

G. Expansion Anchors: Carbon-steel wedge or sleeve type.

H. Toggle Bolts: All-steel springhead type.

I. Powder-driven Threaded Studs: Heat-treated steel.

2.03 CONCRETE EQUIPMENT BASES

A. Forms and Reinforcing Materials: See FDOT Specifications Section 400.

B. Concrete: 3000 psi, 28-day compressive strength as specified in FDOT Specifications Section 400.

2.04 ELECTRICAL IDENTIFICATION

A. Manufacturer's Standard Products: Where more than one type is listed for a specified application, selection is Installer's option, but provides a single type for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.

2.05 TOUCHUP PAINT

A. For Equipment: Provided by equipment manufacturer and selected to match equipment finish.

B. For Non-Equipment Surfaces: Matching type and color of undamaged, existing adjacent finish.

C. For Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 EXECUTION

3.01 EQUIPMENT INSTALLATION REQUIREMENTS

A. Install components and equipment to provide the maximum possible headroom where mounting heights or other location criteria are not indicated.

B. Install items level, plumb, and parallel and perpendicular to other building systems and components, except where otherwise indicated.

C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.

D. Give right of way to raceways and piping systems installed at a required slope.

3.02 WIRING METHODS

A. Feeders: Type THHN/THWN, copper conductor, in raceway, except as otherwise indicated.

B. Underground Feeders: Type UF, copper conductor, 90C insulation, in raceway, except as otherwise indicated.

C. Branch Circuits: Type THHN/THWN, in raceway.

D. Class 2 And Class 3 Control Circuits: Type THHN/THWN, in raceway.

3.03 ELECTRICAL SUPPORTING METHODS

A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.

B. Dry Locations: Steel materials.

C. Support Clamps for PVC Raceways: Click-type clamp system.

D. Conform to manufacturer's recommendations for selecting supports.

E. Strength of Supports: Adequate to carry all present and future loads, times a safety factor of at least 4; 200 LB minimum design load.

3.04 INSTALLATION

A. Install wires in raceway according to manufacturer's written instructions and NECA's "Standard of Installation."

B. Conductor Splices: Keep to the minimum and comply with the following:

1. Install splices and taps that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.

2. Use splice and tap connectors that are compatible with conductor material.

C. Wiring at Outlets: Install with at least 6 inches of slack conductor at each outlet.

D. Connect outlets and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torqueing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

E. Install devices to securely and permanently fasten and support electrical components.

F. Raceway Supports: Comply with NFPA 70 and the following requirements:

1. Conform to manufacturer's recommendations for selecting and installing supports.

2. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

3. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.

4. Spare Capacity: Size supports for multiple conduits so capacity can be increased by a 25 percent minimum in the future.

5. Support individual horizontal raceways with separate, malleable iron pipe hangers or clamps.

G. Miscellaneous Supports: Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices except where components are mounted directly to structural features of adequate strength.

H. Sleeves: Install for cable and raceway penetrations of concrete slabs except where core-drilled holes are used. Install sleeves during erection of concrete pad.

I. Fastening: Unless otherwise indicated, securely fasten electrical items and their supporting hardware to the building structure. Perform fastening according to the following:

1. Fasten by means of wood screws or screw-type nails on wood; toggle bolts on hollow masonry units; concrete inserts or expansion bolts on concrete or solid masonry; and by machine screws, welded threaded studs, or spring-tension clamps on steel.

2. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or any other items.

3. In partitions of light steel construction use sheet-metal screws.

4. Drill holes in concrete beams so holes more than 1-1/2 IN deep do not cut main reinforcing bars.

   a. Do not drill concrete beams and columns unless approved in writing by the Engineer.

5. Drill holes in concrete so holes more than 3/4 IN deep do not cut main reinforcing bars.

   a. Do not drill concrete beams and columns unless approved in writing by the Engineer.

6. Fill and seal holes drilled in concrete and not used.

7. Select fasteners so the load applied to any fastener does not exceed 25 percent of the proof-test load.

8. Cutting, welding, or other weakening of building structure to facilitate equipment installation are not permitted.

J. Install concrete pads and bases according to requirements of FDOT Specifications Section 400.

K. Install utility-metering equipment according to utility company's written requirements. Provide grounding and empty conduits as required by company.

L. Install Identification Devices Where Required.

1. Install labels where indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

2. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated on the Contract Documents or required by codes and standards. Use consistent designations throughout the project.

3. Self-adhesive Identification Products: Clean surfaces of dust, loose material, and oily films before applying.

4. Identify raceways and cables of certain systems with color banding as follows:

   a. Bands: Colored adhesive marking tape. Make each color band 2 IN wide, completely encircling conduit, and place adjacent bands of 2-color markings in contact, side by side.

   b. Locate bands at changes in direction, at penetrations of walls and floors, at 50 FT maximum intervals in straight runs, and at 25 FT in congested areas.

5. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

3.05 CUTTING AND PATCHING N/A

3.06 TOUCHUP PAINTING

A. Thoroughly clean damaged areas and provide primer, intermediate, and finish coats to suit the degree of damage at each location.

B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.

END OF SECTION

SECTION 16060

GROUNDING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing and installation of a complete neutral and grounding system.

1.02 RELATED SECTIONS

A. 16010 Basic Electrical Requirements.

B. 16131 Raceways.

C. All other sections related to equipment such as panels, motor disconnects and controllers, transformers, etc.

1.03 PERFORMANCE

A. Ground and bond the complete electrical system according to the NEC, SFBC and as specified herein, and conforming to ANSI C33.8, IEEE-81 and IEEE-142.

B. Install grounding and bonding system as shown on Drawings. and/or a complete robust equipotential. System that assures and enhances the power quality of the pump station

1.04 SUBMITTALS

A. Submit for review and approval:

1. Properly identified manufacturers' literature, and shop drawings giving materials, finishes, accessories and installation directions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Conductors:

1. Provide copper stranded, soft or annealed, green insulated conductors sized as shown on Drawings or specified herein. If not indicated, size conductors by the requirements of the National Electrical Code. Minimum size to be No. 12 AWG. Use tinned bare copper cable when buried in earth.

B. Bonding Jumpers:

1. Use bonding jumpers across metal parts that must be bonded together and are separated by a non-conducting media.

C. Ground Rods:

1. Ground rods to be copper clad steel not less than 3/4 inches in diameter and 10 feet long.

D. Connections:

1. Make inaccessible or underground connections with the exothermic welding process using equipment manufactured by Burndy or Erico Products.

2. Make accessible connections with multiple bolt silicon bronze connectors specifically designed and approved for the purpose. Connectors to be as manufactured by Burndy or O.Z. Gedney Electric.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install grounding system as shown on Drawings and never use a neutral conductor as grounding or bonding means.

B. Make connections to equipment, bus or conduit with approved type of solderless connector. Surfaces shall be unpainted and thoroughly cleaned before connection is made to insure a good metal to metal contact.

C. Drive ground rods full length into the earth. Main ground electrode system resistance to ground to be no greater than 3 ohms. Use as many rods as needed to attain this level.

D. Ground switchgear and panelboard frames, fittings, fixtures and devices, cable sheaths and screens, neutral of transformers, boxes and raceways, motor frames, street lights, non-current carrying parts of appliances and devices, control equipment and panels, and all other parts and equipment as required by the NEC.

E. Do not use metallic conduit (flexible or rigid) as the only bonding medium.

F. Provide every branch circuit for power and lighting and each 120-volt receptacle circuits, with a green grounding conductor of the same size and type as the power conductors installed in the same raceway.

G. Unless otherwise shown on drawings, ground equipment as follows:

1. Equipment rated 50 amperes or under with one No. 8 AWG in feeder circuit conductor raceway.

2. Equipment rated 50 to 125 amperes with one No. 6 AWG in feeder circuit conductor raceway.

3. Equipment rated over 125 amperes shall be grounded with one No. 6 AWG in feeder circuit conductor raceway and one No. 1/0 in 3/4 inch conduit to building grounding loop.

H. Make locknut connections to cabinets, pullboxes junction boxes, etc., sufficiently tight to assure a continuous metal-to-metal bond.

I. Bond all metallic conduits stubbing under switchgears, switchboards, motor control centers and similar locations, with bonding bushings.

J. The neutral conductor of circuits requiring neutral must be pulled with the phase conductors in the same raceway.

3.02 TESTING

A. Fall-Of-Potential Test:

1. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.

2. Main ground electrode system resistance to ground to be no greater than 3 ohms.

B. Two-Point Direct Method Test:

1. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames and system neutral and derived neutral points.

2. Equipment ground resistance not to exceed main ground system resistance by 0.25 ohms.

C. Test several points of the system including: the neutral of every voltage level used in the system, enclosure of switchgears, motor control centers and panelboards and metal enclosure of outlet or fixture at remote location designated by the Engineer. Initial resistance to ground shall not be over 2.5 ohms for water pipe grounds and 15 ohms for made grounds.

END OF SECTION

SECTION 16070

EQUIPMENT AND RACEWAY SUPPORT SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnishing and installation of supporting systems for all equipment and conduits shown on drawings and or specified in other sections of these Specifications.

1.02 RELATED SECTIONS

A. Related Specification Sections include but are not necessarily limited to:

1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
2. Division 1 - General Requirements.
3. Section 16010 - Basic Electrical Requirements.
4. Section 16110 - Raceways.
5. All other sections related to equipment such as panels, motor disconnects and controllers, transformers, etc.

1.03 REFERENCES

A. ASTM International (ASTM):

1. A123, Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
2. A153, Zinc Coating (Hot Dip) on Iron and Steel Hardware.
3. A575, Steel Bars, Carbon, Merchant Quality M Grades.
4. A576, Steel Bars, Carbon, Hot-Wrought, Special Quality.

1.04 PERFORMANCE

A. Install surface mounted equipment on a metal framing support system.

B. Provide metal frames, hangers, supports and braces, for the proper installation of conduits, cable trays, panelboards, starting and control equipment as well as all other electrical equipment installed under this Contract.

C. Support in an approved manner and independently of the conduits, cabinets, outlet and pullboxes.

1.05 SUBMITTALS

A. Submit for Review and Approval:

1. Properly identified manufacturer's literature, and Shop Drawings giving materials, finishes, accessories and installation directions.
2. Concrete insert installation Shop Drawings.

PART 2 PRODUCTS

2.01 MATERIALS

A. Panel, Conduit and Equipment Supports:

1. Where exposed to the weather, high humidity or the corrosive ambience use stainless steel nuts, bolts, washers, shims etc.

2. Construct all supports with sufficient rigidity to hold all mounted equipment and accessories permanent and neat alignment.

B. Metal Framing (Continuous Slot Metal Channel System):

1. Configuration: Single channel or two single channels welded together, with continuous 7/8 IN slot and to accept spring-held steel nuts.

2. Dimensions: For single channel, 1-5/8 by 1-5/8 IN. For double channel, 1-5/8 by 3-1/4 IN, both 12 gage. Fittings to be 1-5/8 IN wide by 1/4 IN thick minimum.

3. Finishing of channels, pipe clamps and fittings to be hot dip galvanized after fabrication conforming to ASTM A123 or ASTM A153, as applicable. Minimum weight of coating, 2.0 OZ/SF. Nuts, bolts and screw to be electro galvanized.

C. Threaded Hanger Rods: N/A

D. Trapeze-Type Multiple Conduit Hangers: N/A

E. Continuous and Spot Concrete Inserts:

1. Finishing: Hot-dip galvanized after fabrication ASTM A123 or ASTM A153 as applicable. Minimum coating weight, 2 OZ/SF.

2. Install concrete inserts filling the channel interior with expanded polystyrene or covered by other approved means to prevent seepage of concrete into the channel during concrete pouring.

3. Continuous Insert:

a. Single channel, 1-5/8 by 1-5/8 IN, 12 gage with continuous 7/8 IN slot to accept spring held steel nuts and with concrete anchors.

b. Loading: 2000 LBS/FT. Minimum safety factor 3.

4. Spot Insert:

a. Deep drawn metal cup 1-5/8 IN high by 3-3/4 IN maximum width, 12 gage with knockout openings to accept either square or rectangular nuts.

b. Loading: 800 LBS with a minimum safety factor of 3.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install items rigid, secure, plumb, level and in true alignment with related and adjoining work. Do not weld electrical materials for attachment or support.

B. Provide templates, layout Drawings, and supervision at the job site to ensure correct placing of anchorage items in concrete. Check embedded items for correctness of location and detail before concrete is placed.

C. Space conduit supports at intervals, as required by the NEC for the type of conduit being installed, but never exceeding 8 FT OC and 3 FT from bends, junction boxes, outlets, etc.

D. Control erection tolerances so as not to impair the strength, safety, serviceability, or appearance of the installations. Determine exact location of conduits. Route conduit parallel to building grid lines.

1. Fastening methods:

a. To Steel Work: Machine screws, welded threaded studs, or spring-tension clamps. Do not weld raceways or pipe straps to steel structures.

b. To Light Steel Construction Partitions: Sheet Metal screws. Bar hangers may be attached with saddle ties of 16 gage double strand zinc-coated steel wire.

c. Threaded C-clamps shall not be used.

d. Drilled holes not used must be filled.

3.02 TESTING

A. Test overhead inserts selected by the Engineer, by suspension of 800 LBS of weight from the insert. If there is evidence of failure, replace the inserts in a manner satisfactory to the Engineer.

END OF SECTION

SECTION 16110

RACEWAYS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install complete raceway system as indicated on drawings or required.

1.02 STANDARDS

A. Size of raceways shall be not less than NEC requirements but in no case shall be less than indicated on the Drawings. Drawings are diagrammatic and routing of conduits shall be made by the Contractor to avoid interferences with other work. The Contractor shall install larger size raceways than shown where required for pulling of wire.

B. Materials shall bear UL labels.

1.03 RELATED WORK

A. Related Specification Sections include but are not necessarily limited to:

1. FDOT Specification Section 400 – Concrete Structures.
2. Section 16010 - Basic Electrical Requirement.
3. Section 16060 - Grounding.
4. Section 16070 - Equipment and Raceway Support Systems”

1.04 SUBMITTALS

A. Submit for review, properly identified manufacturer's literature and Shop Drawings giving materials, finishes, dimensions, weights and standards of compliance.

1.05 QUALITY ASSURANCE

A. Materials manufactured within scope of Underwriters Laboratories shall conform to UL Standard and have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MATERIALS

A. Rigid Conduit:

1. Steel: Hot dipped zinc coated, galvanized, threaded rigid steel conduit conforming to ANSI C80.1, Fed. Spec. WW-C-581 and UL Standard 6. Conduit to be as manufactured by Triangle, Republic Steel Corp., Robroy or approved equal.

2. Aluminum: Shall contain less than 0.1 percent copper and shall conform to Federal Specification WW-C-540C. It shall be as manufactured by Kaiser Aluminum and Chemical Corp. or approved equal. Alcoa thread lubricant shall be used on all aluminum threads.

3. Plastic: Rigid, Schedule 40 & 80, 90 DegC., UL rated PVC plastic conforming to UL 651, Fed. Spec. W-C-1094 and NEMA TC-2. Fittings to conform with UL 514 and NEMA TC-3. Plastic conduit and fittings to be as manufactured by Carlon, Sedco, Robroy or approved equal.

4. Couplings, Elbows and Nipples for Rigid Steel Conduit shall be galvanized steel, threaded.

B. Flexible Metal Conduit:

1. Standard: Flexible zinc coated conforming to UL 1.

2. Liquid-Tight: Flexible zinc coated conduit with liquid-tight flexible plastic sheath, conforming to UL 360 Standard. Conduit to be as manufactured by Triangle, Robroy, Anaconda, or approved equal.

3. Fittings for Flexible Conduit: Fed. Spec. W-R-406B and UL 514, as manufactured by Midwest, Robroy or approved equal.

C. Fittings for Rigid Conduit and device Boxes:

1. Conduit fittings and device boxes embedded in concrete shall be galvanized cast "Feraloy" FD Series, by Crouse Hinds, or approved equal.

2. Device boxes, condulets, clamps and other fittings in aluminum conduit runs shall be copperfree cast aluminum. Condulets shall be oversized and device boxes shall be FD Series cast aluminum with die cast aluminum covers, by Crouse-hinds, or approved equal.

D. Straps and Fastenings for Conduit: Straps and fasteners shall be furnished in materials compatible with conduits being supported. Dissimilar metal will not be permitted. Provide cast aluminum EFCOR 233AL straps and clamp backs to attach conduit to concrete surfaces where channels and clamp are not used.

E. Wireways:

1. Aluminum, flangeless of the size indicated with hinged cover, of 12 gage aluminum without knockouts, type HW, as manufactured by General Metals, Inc., or approved equal.

2. Exterior locations shall have accepted weathertight gasketed covers and joints and UL listed raintight.

3. Conform to UL 870.

F. Conduit Expansion and Deflection Fittings: N/A

G. Pull Wires: 16 gage galvanized steel wire or 200 LBS tensile strength plastic rope.

H. Fire Stopping Material/Sealing Compound: N/A

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide metal conduits, tubing, wireways, and electrical ducts where indicated in accordance with NEC, subject to following provisions.

B. The plans are generally indicative of the work to be installed, but do not show all bends, fittings, boxes, and specialties which may be required or the exact location of all conduits.

C. Carefully investigate the structural and finish conditions of the project and arrange the work accordingly, furnishing everything required to meet such conditions.

D. Arrange all runs of conduit to clear beams, pipes, and other obstructions. Any changes from locations shown on the plans must be approved by the Engineer.

E. Run exposed conduit and wireways parallel or perpendicular to structural members or vertical planes intersections of the building structure and horizontal raceway close to ceiling and above piping. When running parallel to heated piping, keep a minimum of 12 IN clearance.

F. All conduit at ends shall be square cut and reamed to remove burrs. Running threads will NOT be permitted. Cold galvanize field made threads. Approved couplings shall be used. All conduit joints shall be made up wrench tight, using strap wrenches, and shall be made waterproof in such a manner as not to interrupt the electrical bonds. An approved thread lubricant shall be used on all aluminum threads.

G. Changes in direction of raceway runs shall be made with symmetrical bends or cast metal fittings. Field made bends and offsets shall be made with a hickey or conduit bending machine specifically for size and type of conduit used. Minimum radius 6 times diameter for rigid metal conduit. Crushed or deformed raceways shall not be used. Use factory formed fittings for surface raceways.

H. Conduit shall be sized as shown on the Drawings. Minimum size of conduit shall be ¾ IN, except as follows:

1. Flexible conduit to a light fixture to be 3/8 IN (Maximum length 6 FT).

2. Where shown otherwise on the Drawings.

I. Take care to prevent lodgement of plaster, dirt, or trash in raceways, boxes, fittings and equipment during course of construction. Clogged raceways to be entirely freed of obstructions or to be replaced.

J. Install conduits in such a manner that wires may be removed and replaced later, and to insure against collection of condensation or rainwater.

K. Except where boxes, panels and other equipment have threaded openings, make conduit connections as follows:

1. Double locknuts, one inside and one outside.

2. Provide malleable, iron or steel bushing with Bakelite liner molded and bonded into the bushing.

3. Place bushing on end of conduit in addition to locknuts.

4. As soon as installed, all open conduit ends, including those terminating in boxes, shall be plugged or capped and so maintained during construction to prevent the entrance of moisture and dirt. All conduit shall be carefully cleaned and dried inside before the installation of the wire. Conduit for future use shall have a pull wire installed, unless otherwise shown on the Contract Drawings, and shall be capped or plugged at both ends to prevent entry of dirt or moisture.

5. Conduits and ducts entering an underground structure shall be temporarily sealed, and tested for leakage with a head of water equal to five feet above grade. Leakage in excess of 1 IN fall of water-level in five minutes is not acceptable, and the conduit or duct shall be repaired and/or replaced.

L. Exposed Conduits: Install parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Install horizontal raceways close to ceiling or ceiling beams, and above water piping and other piping wherever possible.

M. Location and Use of Each Type of Conduit:

1. Galvanized threaded rigid steel conduit shall be used:

   a. For underground work beyond buildings where concrete encased plastic conduits have not been specified.

   b. Wherever specifically called for on plan.

   c. Where feeder raceway elbows, from duct banks, stub up under equipment.

2. Rigid aluminum conduit shall be used for above ground exposed installations.

3. Plastic conduit shall be used:

   a. Where poured in slabs or underground below slab on grade, or poured concrete walls.

   b. Where specifically called for on Plans, for underground work beyond buildings.

   c. Trenches for direct buried PVC conduit shall be free of rocks and other material that may damage the conduit.

4. Flexible metal conduit shall be used for connections to rotating or vibrating equipment such as motor, transformers and devices on piping and ductwork. Flexible conduit may be used for short connections to control devices, recessed fixtures and similar items. Connection between structure and first point of attachment to vibrating equipment shall be flexible. Provide not less than 24 IN except for recessed lighting fixtures.

5. Liquid-tight flexible metal conduit shall be used for connections to rotating or vibrating equipment in wet and damp locations and exterior locations. Install liquid-tight flexible metal conduit so that liquids run off surface and drain away from fittings provide not less than 24 IN.

6. PVC coated rigid steel conduit shall be used in all areas subject to corrosive liquids or gases.

N. Installing Galvanized, or Rigid Steel Conduit Below Slabs on Grade or in Ground.

1. Coat underfloor and underground metal conduits including fittings with two coats of Carboline Bitumastic No. 300, or approved equal.

O. Raceways Fastenings and Supports:

1. Supports:

a. Secure, support and fasten in place raceways at intervals of not more than eight feet, within 3 FT of any bend and every outlet or junction box. This shall apply on vertical runs as well as horizontal runs.

b. Support individual horizontal conduits not larger than 1-1/2 IN in diameter by means of two-hole pipe straps or individual pipe hangers.

c. Support individual horizontal conduits larger than 1-1/2 IN in diameters by individual pipe hangers.

d. Space conduits, installed against concrete surfaces not less than 1/4 IN away from the surfaces by clamp backs or other approved means.

e. In dry locations, spring steel fasteners, clips, or clamps specifically designed for supporting exposed single conduits may be used in lieu of pipe straps or pipe hangers.

f. Hanger rod used in connection with spring steel fasteners, clips, and clamps shall be either not less than 1/4 IN in diameter galvanized steel rods or, if concealed above a suspended ceiling, galvanized perforated steel strapping.

g. Support parallel conduits at the same elevations on trapeze-type multiple conduit hangers or channel inserts. Secure each conduit to the pipe hanger or channel insert member, by a U-bolt, one-hole strap, or other specifically designed and approved fastener suitable for use with the pipe hangers or channel inserts.

h. Installation of supporting devices shall be done in a neat and workmanlike manner and care shall be taken that at no time shall any portion of the building structure be overloaded. Should the building structure sustain damage through carelessness or through failure of the Contractor to properly support and install the electrical equipment, the Contractor shall bear all costs involved in repairing or replacing such installation.

2. Fastenings:

a. To Steel Work: Machine screws, welded threaded studs, or spring-tension clamps. Raceways or pipe straps shall not be welded to steel structures.

b. To Light Steel Construction Partitions: Sheet Metal screws. Bar hangers may be attached with saddle ties of 16 gage double strand zinc-coated steel wire.

c. Threaded C-clamps shall not be used.

3. Surface Wireways and Auxiliary Gutters: Use fastenings appropriate for surface.

P. Sleeves:

1. Install where conduit passes through concrete floors, walls, ceilings or as indicated.

2. Provide 1/2 IN minimum clearance around conduit. Extend sleeve through full thickness of concrete.

3. Secure sleeves to concrete forms to prevent displacement during placing of concrete.

4. Filling of Openings: Wherever slots, sleeves, or other openings are provided in floors or walls for the passage of raceways, fill such opening, to prevent fire spread, passage of water or spread of products of combustion, as follows:

   a. Install the specified sealing compound.

   b. Where conduits passing through openings are exposed in finished rooms, use filling material that matches, and is flush with the adjoining finished floor, ceiling or wall.

5. Wall sleeves for conduit shall be 0.Z. positive watertight through wall entrance fittings, FSK Series.

Q. Raceway Seals:

1. Seal with the specified sealing compound raceways through which moisture may contact energized live parts.

2. Underground Raceways Entering a Building: Seal the end entering the building with the specified sealing compound to prevent the entrance of moisture or gasses.

R. Install sealing compound in accordance with the manufacturer's written instructions and as follows:

1. Opening or Empty Conduit: Install non-flammable material, to stop flow of sealant, leaving not less than two-inch length of conduit to be filled with the sealant.

2. Conduit with Wires: Separate wires so that sealant can penetrate between wires, and between wires and conduit.

END OF SECTION

SECTION 16120

INSTRUMENTATION AND CONDUCTORS 600 VOLTS AND UNDER

PART 1 GENERAL

1.01 STANDARDS

A. Materials shall bear UL labels.

1.02 SUBMITTALS

A. Submit for review, properly identified manufacturer's literature and shop drawings giving wire size, insulation type, rated voltage and temperature and NEC designation.

PART 2 PRODUCTS

2.01 MATERIALS

A. Conductors:

1. Conductors shall be rated at 600 volts and shall be manufactured in strict accordance with applicable requirements of IPCEA, NEMA, IEEE, UL and ANSI standards by a manufacturer with minimum five (5) years' experience in this type of cable.

2. Conductors shall be composed of 98% annealed copper. Furnish conductor sizes for circuits as shown on drawings. Minimum size shall be AWG 12 except as specified for control wiring. All conductors #10 and smaller may be single strand, No. 8 through No. 2. shall be 7 strand, No. 1 through 4/0 shall be 19 strand and, 250 MCM through 500 MCM shall be 37 strand.

3. All conductors shall be 600 volt Class B, heat and moisture resistant, thermoplastic type THHN/THHW rated with a 90ºC dry/75ºC wet rating. Provide a polyvinyl chloride insulation resistant to oil, gasoline and weather. Insulation shall meet UL Standard 83.

4. All conductors shall be plainly marked on outer braid at least every two feet with name of manufacturer, size and grade of insulation.

5. Conductors shall be as manufactured by General Cable, Phelps Dodge, Okonite or approved equal.

B. Color Code all service, feeder and branch circuit wire as follows:

1. 120/208 Volt 3-phase System:

a. White - Neutral.

b. Black - Phase A.

c. Blue - Phase B.

d. Red - Phase C.

2. 277/480 Volt 3-phase System:

a. Gray - Neutral.

b. Yellow - Phase A.

c. Brown - Phase B.

d. Orange - Phase C.

3. Bonding conductor - green.

4. Solid colored insulation shall be used on all conductors #8 AWG and smaller and, colored coding tape or painted with two coats of correct color paint at all terminals and connection points for #6 AWG and larger.

2.02 CONTROL WIRING

A. Wiring for monitoring system and control shall be single conductor #14 AWG minimum, solid or stranded with THW or THWN insulation.

B. Wiring for analog or pulse systems shall be 3-conductor shielded cable with #14 AWG stranded copper conductors with individual thermoplastic color-coded insulation. Overall shield shall be either copper or aluminum tape providing 100% shielding coverage and provided with a stranded copper ground drain wire and an overall vinyl jacket. Cable shall be Belden, Dekoron or approved equal.

C. Multiconductor cable shall be copper conductors, flame retarded ethylene-propylene insulated for 600 V with a 90ºC rating. The single conductors of the multiple conductor cable shall be color coded with integral color for proper identification. Color coding shall be equal to ICEA S-68-514, Table K-2. Cable shall meet the requirements of IEEE-383. A heat, moisture flame and chemical resistant, mechanically rugged ethylene-propylene insulating compound, 30 mils thick, shall be provided for #14 AWG. Conductors shall be tin or alloy coated stranded copper as per ASTM B-8 and B-33 or B-189. Overall cable jacket shall be chlorosulfonated polythylene compound over cable tape and fillers and shall exceed the requirements of ICEA S-68-516.

D. Fireproofing tape shall be Irvington No. 7700, or approved equal, applied in accordance to the manufacturer’s instructions.

E. Connectors, Terminals and Splices:

1. Provide connectors, terminals and splices for all power and lighting circuits using 600-volt wire and cable as follows:

a. Provide connectors, terminals, and splices, for all wire, cable, and equipment and bus connections that are designed and approved for the specific type and size of conductors being connected.

b. Connectors and terminals shall be designed and UL approved for use with the associated conductor material, and shall provide a uniform compression over the entire contact surface. Solderless terminal lugs shall be used on all stranded conductors.

c. Pressure-crimp type connectors, terminals and splices shall be applied with a mechanical or hydraulic tool with proper size crimpling dies for making each connection. The tool shall be of the type that will not release until the correct pressure has been applied.

d. Splices and taps in wire No. 10 AWG, and smaller, shall be made with approved, wire-nut-type, patent spring connectors. Use 3M Scotchlocks or equal.

e. Provide Burndy, type YAV box, or equal, pressurecrimp ring-tongue terminals for termination of No. 8 stranded cable.

f. Provide Burndy type YSV box butt splices, or equal, for splicing No. 8 AWG stranded cable.

g. For termination and splicing of cable of AWG No. 6 or larger, provide long-barrel, type YA pressurecrimp lugs and type YS tubular pressure-crimp splices by Burndy or equal. Use long-barrel pressure-crimp lugs wherever space conditions permit. Use long-barrel pressure crimp splices exclusively for splicing. Where space is inadequate for use of long-barrel lugs, provide Burndy Type YA-L, pressure-crimp, short barrel lugs, or equal. Use 2 hole lugs on cable of 250 MCM and larger.

h. For tap off AWG No. 8 cable and larger, provide Burndy type KS split-bolt copper connectors (bugs), with Burndy type SC one-piece plastic split bolt covers, or equal. Other types of connectors for tapping may be used subject to prior approval by the Engineer.

i. Use proper size bronze bolts, nuts, washers, and lock washers of Burndy Durium alloy, or equal, for bolting cable terminations to equipment terminals and bus bars.

j. Termination of solid wires of AWG No. 10 and smaller at terminal blocks shall be made by forming the wires in a ring to fit under a screwhead, thus regarding no terminal lug.

2. Provide terminals and splices and make connections in control, alarm and instrumentation system as follows:

a. For solid wiring provide type TP, vinyl-insulated, ring-tongue terminals by Burndy, or equal, for all terminations.

b. In locations where splicing of solid wire is indicated or permitted by specifications, use type SP vinyl-insulated, butt splices by Burndy, or equal.

c. Wire terminals shall be installed with pressure tools equal to those manufactured by American Pamcor, one of which is No. 59072, which obliges the Electrician to apply the correct pressure required to produce a tight connection before the tool is released. Use a pressure tool designed for the specific size of connector and wire being terminated.

d. Taps in solid wire may be made with 3M, Scotchlock wire nut, or equal, except that the conductor being tapped shall not be cut, and shall be twisted together with the tap conductor before wire nut application.

PART 3 EXECUTION

3.01 INSTALLATION

A. Conductors shall not be pulled into conduit until all mechanical work is complete.

B. Pulling lubricants shall be of the type accepted for the cable insulation and as recommendation by the cable manufacturer.

C. Conductors in panelboards, junction boxes, pull boxes, etc., to be formed, grouped and taped to present a neat and orderly appearance.

D. Leading end of each conductor pulled shall be carefully examined for damage to jacket. If damaged, cable shall be extended and further checked for damage with good cable only to remain.

E. At each outlet, allow not less than 6 inches slack for connection to load.

F. Wire and Cable Supports:

1. Provide support for all conductors within vertical raceways at intervals as required by, and using one or more of the support methods conforming to the requirements of NEC, and as follows:

a. For insulating wedge supports, and where indicated, provide OZ Company, or equal, type R, plug-type, canvas-bakelite cable supports of proper duct or conduit size, and number of holes.

b. Cable ties, where required, shall be Panduit Corporation Pany-Ty, or equal, nylon cable ties.

2. Provide Kellems Grip supports for wire and cable where indicated.

3. Support wire and cable within all enclosures and at each connection so that any strain on the wire or cable shall not be transmitted to the connection as follows:

a. With nylon cable ties.

b. With insulated cable clamps sized per O.D. of cable or wire bundle and bolted to equipment enclosure.

c. With Kellems grips where indicated.

G. Taping: Tape all connections in 600-volt wire and cable as follows:

1. In dry locations, tape all connections, splices, taps and exposed barrels of terminal lugs with half-lapped layers of 3M Scotch 33, vinyl plastic tape, or equal, applied to a thickness equal to the conductor insulation.

2. In damp or wet locations, tape connections per paragraph 1 above, and in addition, apply at least two half-lapped layers of 3M Scotch 88 vinyl plastic tape over the first layers of tape, and waterproof the taped connection with a final overall application of an electrical varnish or sealer.

3. Insulated splices and wire-nut connections, in dry locations, and where not subject to vibration, need not be taped.

3.02 WIRE AND CABLE MARKING

A. Identify each phase of all three phase feeder conductors with 3M Scotch 35, or equal, vinyl plastic marking tape. Use color groups, with three distinct colors in each group, for phase identification of feeders of different system voltage as per 2.1 above.

B. All feeders and branch circuit conductors, and all control, and instrumentation wires shall be identified at all terminations, junction boxes, pull boxes, handholes and manholes as follows:

1. Each feeder conductor in a pull box or panel shall be identified by tag. Tags shall be 1-inch in diameter and have stamped numbers and letters ¼-inch high.

2. Insulation of conductors shall be color coded as hereinbefore specified to indicate phases and neutral respectively. The same color shall be used throughout the job to indicate the same phase and voltages.

3. All other conductors shall be identified at all access points by means of a self adhesive pressure sensitive numbered wire markers. A typed cable index shall be attached to inside cover or cabinets where more than six circuits pass through or terminate.

3.03 INSTALLATION OF 600-VOLT WIRE AND CABLE

A. Install wire and cable in conduits, ducts, wireways, cable trays and other enclosures as indicated.

B. Except as otherwise indicated or specified, all wire and cable shall be installed in continuous runs between terminal points without splicing.

C. Make splices and taps only in junction boxes, from terminals in terminal boxes, in manholes, in handholes and other accessible enclosures.

D. Do not splice wire and cable in ducts or conduits.

E. Except as otherwise indicated, or specified, do not splice or tap control, alarm or instrumentation wiring in underground manholes and handholes.

F. When pulling wire or cable, do not subject the wire or cable to a tension greater than 50% of the yield strength of the conductor. Pulling lugs shall be attached to the conductor with a sleeve or grip over the cable sheath to prevent slipping the insulation.

G. Use a UL approved lubricant to decrease friction when pulling cable in ducts and conduits.

H. Do not subject cable to a bending radius less than 8 times the cable O.D. during or after installation.

I. In wet locations, make splices first as for dry locations, then encapsulate them in an epoxy resin sealing and potting compound. Encapsulation of compression sleeve splices shall be with preformed molds.

J. Pulling of wires and cable into conduits shall be done in a manner which will in no way injure the insulation.

K. All wires in conduit shall be continuous between pull points without splices. No joints or splices in the conductors shall be permitted except at outlet or accessible junction boxes.

L. Sufficient lengths of wire shall be left at pull boxes for connecting to equipment and apparatus without straining.

M. All wires passing through pull boxes shall have enough slack in each box so they may be pulled out of the box a distance of no less than 6" across the entire length of the box.

N. Pull together all cables or conductors to be installed in a single conduit.

O. Wire Sizes: Drawings indicate wire and conduit sizes for typical equipment. If sizes shown on the drawings are not appropriate for the equipment chosen by the Contractor, wires and conduit shall be sized for the proper current-carrying capacity (including voltage drop and motor inrush allowances) in accordance with the NEC, at no extra cost to the Department. On 120/240 volts systems, "Homeruns" of over 50 feet in total length from panel to first outlet shall be #10 AWG minimum size and on 277/480 volts, the distance shall be 100 feet total length for #12 AWG minimum size.

3.04 TERMINATIONS

A. Terminate solid conductors on screw terminals or mechanical connectors furnished on devices and equipment.

B. Terminate stranded conductors on mechanical connectors furnished on equipment. Where no connectors are included, provide suitable mechanical connectors.

C. Termination of stranded conductors on screw terminals will not be permitted. Provide suitable size compression or mechanical type connector with spade tongue.

3.05 TESTING

A. Test for insulation resistance after all wiring is completed and connected ready for the attachment of fixtures and equipment, and again when fixtures and equipment are connected ready for use. Perform test with a 500V DC megger (conductor to conductor and conductor ground) capable of measuring accurately the resistance involved. Take readings after the voltage has been applied continuously for one minute. The insulation resistance between conductors and also between each conductor and ground shall be measured. For wiring completed and connected ready for the attachment of fixtures and equipment, the values of insulation resistance shall be those recommended in the National Electrical Code. For wiring completed and with all fixtures and equipment connected ready for use, one-half such values shall apply.

END OF SECTION

SECTION 16130

OUTLET, PULL AND JUNCTION BOXES

PART 1 GENERAL

1.01 STANDARDS

A. Materials to bear UL labels.

1.02 STANDARDS

A. Submit for review, properly identified manufacturer's literature, and shop drawings giving materials, finishes, accessories and installation directions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Outlet Boxes:

1. Outlet boxes for all other devices shall be of suitable type and size in accordance with recommendations of manufacturer of equipment.

2. Outlet boxes shall be as manufactured by National, Steel City, Appleton or equal.

B. Pull and Junction Boxes:

1. Outdoor pull and junction boxes shall be gasketed with screw cover mounting on outward-turned flanges of boxes.

2. Spliced control wires in boxes shall be interconnected thru terminal blocks and every conductor shall be provided with spade type lug.

3. Junction and pull boxes shall be as manufactured by General Metals, Inc. or approved equal.

C. Concrete Pull Boxes:

1. Provide precast concrete pull boxes as indicated on the Plans. Pull boxes shall be installed on firmly compacted ground level and plumb at the elevations indicated on the Plans. Pull boxes shall be equipped with pulling-in irons opposite and below each ductway entrance. Pull boxes shall have cable supports so that each cable is supported at a minimum of 3 foot intervals within the manhole or pull box. Cable supports shall be fastened with 316 stainless steel bolts and shall be fabricated of fiberglass or 316 stainless steel.

2. Make provision for drainage and if grounding needed.

3. Covers shall be provided for pull boxes with identification as follows:

a. "Electric" where voltages within are 600 volts and less.

b. "Signal" for instrumentation, telephone and control.

4. Locations of pull boxes are approximate. CONTRACTOR shall coordinate exact location with existing and new piping and shall adjust accordingly.

PART 3 EXECUTION

3.01 INSTALLATION

A. Outlet, Pull and Junction Boxes:

1. Maximum number of conductors in a box shall comply with NEC - Table 370 6(a).

2. Boxes and "U" channel supports shall be fastened as follows:

   a. To steel work with machine screws or welded studs.

3. All outlet, pull and junction boxes shall be of adequate size to accommodate installation of conductors without excessive bending of conductors which would damage insulation.

4. Outlet, pull and junction boxes shall be surface or flush mounted as required.

5. Pull and junction boxes shall be provided at such location as required to reduce length of cable pull or reduce number of elbows between outlets.

6. Wet Locations: Install cast-iron alloy hub-type outlet boxes and conduit bodies with gaskets.

END OF SECTION

SECTION 16140

SWITCHES AND RECEPTACLES

PART 1 GENERAL

1.01 SUBMITTALS

A. Submit for review, properly identified manufacturer's literature giving material, finishes, accessories and installation directions where required.

1.02 STANDARDS

A. Materials shall bear UL labels.

B. All wiring devices shall be installed in strict accordance with manufacturer recommendations.

C. All wiring devices furnished under this Section shall conform to NEMA.

PART 2 PRODUCTS

2.01 MATERIALS

A. All receptacles cover plates shall be weather proof.

B. Duplex Receptacles with ground fault interrupter shall be an integral unit suitable for mounting in a standard outlet box and conform to UL 943.

1. Ground fault interrupter, shall be hospital grade and consist of a differential current transformer, solid state sensing circuitry and a circuit interrupter switch. It shall be rated for operation on a 60 Hz, 120 volt, 20 ampere branch circuit. Device shall have nominal sensitivity to ground leakage current of five milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes on the load side of the device. Device shall have a minimum nominal tripping time of 1/30th of a second.

2. Receptacle shall be rated at 20 amps, 125 volts for indoor use and shall be the standard 2-pole, 3-wire grounding type.

PART 3 EXECUTION

3.01 INSTALLATION

A. Mounting Heights:

1. Duplex receptacles as is indicated on the plans to centerline unless otherwise indicated.

2. Wiring devices location shall be checked prior to rough-in of outlet boxes and conduit with Architectural Drawings for door swings and furniture details. Duplex receptacles in finished areas shall be mounted vertically.

B. Receptacles and other devices shall be ganged and provided with a single multi-gang cover plate.

C. Receptacles in outdoor locations shall be installed in exposed cast-metal outlet boxes with gasketed weatherproof cast-metal cover plates with a while-in-use cover over each receptacle.

D. Isolated ground receptacles shall be identified by an orange dot, clearly embedded on face of receptacle.

END OF SECTION

SECTION 16220

MOTORS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the quality criteria, design, materials and installation procedures required for electrical motors furnished under this Contract.

1.02 STANDARDS

A. All electric motors shall conform to the latest standards of IEEE, ANSI, and NEMA except as other wise specified herein.

1.03 SUBMITTALS

A. Furnish and submit Shop Drawings, Operation and Maintenance Manuals, etc. as outlined in Section 01340 and Section 01730. Coordination of Shop Drawings shall conform to the requirements of Division 1 and coordination of the work shall be made with the driven equipment suppliers or pump suppliers. In addition, the submission shall include the following technical information:

1. Motor efficiency.
2. Motor torque speed curves from zero to full load speed for motors over 10 HP.
3. Certifications:
    a. When utilized with a variable frequency drive, certify that motor and driven equipment are compatible.

1.04 CONDITIONS OF SERVICE

A. All electrical motors shall be designed to operate under the following conditions, except for specific variations stated herein:

1. Altitude at sea level.
2. Ambient temperature 0° to 50 DegC maximum.
3. Voltage variation plus or minus 10 percent.
4. Continuous duty.
5. Frequency Variation plus or minus 5 percent.
6. Combined voltage and frequency variation plus or minus 10 percent frequency; variation not to exceed plus or minus 5 percent.
7. Across-the-line starting except where otherwise specified or shown on the Drawings.
8. Power factor correction by means of capacitors installed in the motors.

9. When motors are furnished with driven equipment, the driven equipment supplier shall be responsible for assembling the motor and driven equipment as a complete unit, correctly aligned and coupled with the coupling or sheave specified on the driven equipment data sheet, and designing for vibration, special, or unbalanced forces resulting from equipment operation.

10. Variable speed equipment applications: The driven equipment manufacturer shall have single source responsibility for coordination of the equipment and VFD system and ensure their compatibility.

11. Motors used with adjustable frequency drives shall comply with NEMA MG-1, Part 31, and shall be clearly identified as “Inverter Duty.”

PART 2 PRODUCTS

2.01 EQUIPMENTS

A. General: Motors shall be squirrel cage induction motors, designed in accordance with the latest ANSI, NEMA, and IEEE standards. The driven equipment manufacturer shall be responsible for supplying the motor and shall factory mount the motor to insure proper coordination. Electric motors shall be manufactured by General Electric, U.S. Motor, Siemens-Allis, or equal.

B. Inverter duty:

1. At a minimum, applied to motors connected to a VFD.

2. Windings insulated for 1600 peak volts and voltage rise times of 0.1 microseconds.

3. Nameplate identification of meeting NEMA MG 1 Part 31 requirements.

4. Have the following minimum turndown ratio without the use of a blower to provide continuous supply of cooling air over the motor.

a. Variable torque: 10:1.

b. Constant torque: 6:1.

5. Insulated drive end bearing on all motors.

6. Motors 100 HP and larger the non-drive end shall have an insulted bearing carrier.

7. Shaft grounding ring on all motors:

a. Factory installed, maintenance free, circumferential, bearing protection ring with conductive microfiber shaft contacting material.

b. Electro Static Technology AEGIS SGR Bearing Protection Ring or approved equal.

C. Design of motors:

1. Horsepower: The driven equipment manufacturer shall be responsible for sizing the motors in accordance with the driven equipment so that nameplate rated horsepowers are not exceeded; and motors are not required to operate within their service factors at any point within the driven equipment's operation. For variable speed application, the motor shall be designed for operation at the rated maximum speed and at reduced speeds down to standstill without overloading and overheating. The Engineer reserves the right to reject driven equipment which requires motors larger than the minimum as specified under other sections of these Specifications or to require the Contractor to bear additional costs if larger electrical equipment is required.

2. Motor Efficiency: Unless a higher efficiency is specifically required for a motor, the efficiency shall not be less than:

   a. 84 percent for motors 1 to 5 hp.

   b. 88 percent for motors 7 1/2 to 10 hp.

   c. 90 percent for motors 15 to 25 hp.

   d. 91 percent for motors 30 to 50 hp.

   e. 93 percent for motors 60 to 75 hp.

   f. 94 percent for motors 100 and larger.

   g. Meet NEMA MG 1 (NEMA Premium) efficiencies.

   h. If motor type, horsepower or speed is not included in the NEMA requirements for NEMA Premium, provide manufacturers "premium energy efficient" design.

3. Temperature Rise: Motors shall conform to standards for NEMA class F Insulation System, unless otherwise specified.

4. Voltage and Current: All fractional horsepower motors shall be 115/230 volts, 60 hertz, single phase, except as otherwise specified. Motors of larger H.P. shall be 230/460 volts, 60 hertz, 3 phase, except as otherwise specified. Motors 350 horsepower and larger shall be as specified.

5. Power Factor: Motors shall have capacitors installed to correct the power factor to 95 percent lagging.

6. Service Factor:

   a. 100 hp or less: 1.15.

   b. Greater than 100 hp: 1.0 unless noted otherwise.

   c. Inverter duty: 1.0.

7. Speed: As tabulated in respective Sections of these Specifications.

8. Torque: At least 20 percent greater than the maximum full load torque requirements of the driven equipment throughout the full operating range of the driven equipment form start to full load.

D. Materials and Construction:

1. Enclosure: Enclosure shall be constructed of cast iron or fabricated steel of such design as to contain and adequately protect and support all motor components in proper position. Fans may form part of the rotor and shall be of non-sparking metal on totally enclosed motors. Plastic fans are not acceptable.

2. Unless otherwise specified, enclosures for motors less than 30 horsepower shall be General Electric Type K Custom for severe duty; Westinghouse, Mill & Chemical Specification or approved equal, for motors 30 horsepower and larger, up to and including 100 horsepower enclosures shall be Weather Proof 1.

3. Insulation: All motors shall have Class F inorganic, non-hygroscopic insulation, unless otherwise noted.

4. Tropicalization: All motors shall be "tropicalized". After removing all moisture and air pockets both, stator and rotor windings shall receive a tropicalization process as follows:

   a. Stator winding shall receive two dips of 100 percent unmodified epoxy.

   b. Stator windings end coils and rotor windings shall receive two coats of asphalt modified epoxy.

   c. Stator, rotor, exciter and line leads shall be coated with fungicidal varnish.

5. Stator: The stator shall be assembled from high grade electrical sheet steel laminations adequately secured together.

   a. Windings shall be copper and the insulation shall consist of Class F materials such as polyester film, synthetic varnish or glass cloth. Windings shall be random or form wound, adequately insulated and securely braced to resist failure due to electrical stresses and vibrations. Any junction in motor insulation, such as at coil connections or between slot and end winding sections, shall have protection equivalent to that of the slot sections of coils.

   b. For 100 and larger horsepower motors, three (3) phase leads shall be connected by the motor manufacturer to the surge protection equipment described further in these specifications in a separate junction box mounted on the side of the motor. The box shall be located in accordance with conduit terminations indicated on the Drawings.

6. Rotor: The shaft shall be made of high grade machine steel or steel forging of size and design adequate to withstand the load stresses. The rotor of motor 100 HP and larger shall be made of carbon steel meeting SEA standards for 4140 steel. The rotor shall be fabricated of high grade electrical sheet steel laminations adequately fastened together and to the shaft. The squirrel cage winding may be cast aluminum of bar type construction with brazed end rings.

7. Bearings: Bearings shall be ball or roller bearing, forced grease lubricated. The bearings shall have a B-10 life of 40,000 HRS for motors less than 30 horsepower; and General Electrical Type K Custom, severe duty, or Westinghouse Mill & Chemical, Specification B-10 (Standard) for motors 30 horsepower and larger.

    a. For motors 30 HP and larger, bearings shall be supplied with bearing temperature detectors connected to 4 1/2 IN dial type indicators mounted on the base plate. The indicators shall be provided with two snap action normally closed contacts with adjustable actuators, one for high temperature indication and one for tripping the motor starter at a higher but safe bearing temperature. All contacts shall be wired through rigid conduit to a separate terminal box mounted on the motors.

    b. For vertical motors, thrust bearings shall be ball or roller bearing as required for the design thrust load. Guide bearings shall be radial type ball bearing.

8. Space Heaters: On all motors 75 horsepower and larger; 120 volt, single phase, space heaters shall be provided to maintain a motor temperature of approximately 10 DegC above ambient. Rodent screens shall be provided when motors are furnished with space heaters. All leads shall be brought out to a separate terminal box.

9. Surge Protection: Suitable surge protection capacitors shall be furnished and mounted directly at the motor terminals and encased in a separate junction box at the motor.

10. Leads and Terminals: All leads shall be suitably marked and identified.

11. Grounding Means: Each motor shall have adequate means for attaching a copper grounding conductor of the size as indicated to the motor frame near the base. It shall be a clamp type terminal connector located on the same side as the stator lead junction box.

12. Direction of Rotation: Motors shall be designed for operation in a direction as required for driven equipment. The phase sequence, at the specification rotation, shall be marked permanently and plainly inside the stator lead junction box.

13. Noise: All motors shall have a sound level not to exceed 90 dBa for 8 HR duration as determined in accordance with OSHA Standard Title 29, Section 1910.95.

14. Drain Plugs: All motors shall have drain plugs to allow proper drainage of moisture form inside.

15. Temperature Detectors: The stator of motors 100 hp and larger shall be provided with six resistance temperature detectors, two per phase to operate with alarm and shutdown relays that have to be provided in the motor controller.

16. Motor Vibration Protection: Metrix, 3-wire, 24VCD, 4-20mA or equal.

17. Nameplates: Each motor shall have a nameplate, including the following minimum amount of information:

a. Manufacturer's type designation.

b. Frame Number.

c. Output horsepower rating.

d. Duty.

e. Rated load speed.

f. Temperature rise in degrees centigrade at rated load rotor and stator.

g. Stator voltage rating.

h. Rotor open circuit voltage.

i. Stator full load amperes.

j. Rotor full load amperes.

k. Service factor (marked for operation at 50 DegC ambient).

l. Frequency.

m. Number of phases.

n. Inrush or locked rotor kVa.

o. Code letter designation.

PART 3 EXECUTION

3.01 TESTING

A. Shop Test and Test Reports:

1. Motors smaller than 50 horsepower shall be given a standard short commercial test conforming to IEEE, ANSI, and NEMA standard requirements to determine that they are free from electrical or mechanical defects and to provide assurance that they meet design conditions. These tests shall include:

a. Running light load current.

b. Locked rotor current.

c. Secondary voltage at collector rings (induction motors.

d. High potential.

e. Bearing inspection.

f. Winding resistance.

2. Five certified copies of the above test results shall be furnished for each motor 50 horsepower and greater up to and including 100 horsepower.

3. Motors larger than 100 horsepower shall be given a complete initial test consisting of full load heat run; percent slip; running light current; locked rotor current; breakdown torque; winding resistance; high potential; efficiencies at 100, 75, and 50 percent of full load. Efficiency test will be witnessed by the Engineer.

B. Field Tests: The motors and driven equipment shall be tested after installation as described in the pertinent Sections of these Specifications.

3.02 INSTALLATION

A. All motors shall be factory mounted by the driven equipment manufacturer in accordance with the motor manufacturers Drawings and instructions. Field installation of the unit, including final alignment shall be the responsibility of the Contractor.

B. Installation shall include furnishing necessary oil and grease for initial operation and making final adjustments to place the equipment in operable condition.

C. All control and alarm wires as required on these Specifications shall be provided even if not shown on plan Drawings.

3.03 PAINTING

A. Motors shall be shipped to the site with manufacturer's prime coat that is compatible with the finish coats specified in Section 09900 - Painting. After installation and before being placed in final operation, the Contractor shall have the motors painted in accordance with the requirements of the Section 09900.

3.04 TOOLS, SUPPLIES, AND SPARE PARTS

A. For each motor furnish the following:

1. One complete set of all bearings for motors 10 hp and larger.

2. All spare parts shall be plainly tagged and marked for identification and reordering.

3. Furnish all special tools necessary to disassemble, service, repair and adjust the equipment and one year's supply of all recommended lubricants.

END OF SECTION

SECTION 16265

VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 SCOPE

A. This section covers minimum specifications for a Variable Frequency Drive (VFD) system when required for control in a pumping station facility.

B. The Contractor shall furnish the VFD system in a cabinet so that only external field installed wires are required for a fully operational system.

C. This specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.

1.02 UNIT RESPONSIBILITY

A. All drives at new installations shall be provided by one manufacturer who shall assume responsibility for proper operation of the system and every component within it.

1.03 QUALITY ASSURANCE

A. The Contractor shall submit documentation verifying that the drive manufacturer has at least ten (10) years of experience in manufacturing and integrating VFD systems of similar size, type and scope.

B. All equipment, materials and components used in the system shall be new, the standard current products of manufacturers regularly engaged in the production of such equipment, the manufacturer's latest design and UL labels when applicable.

C. The Variable Frequency Drive shall be built to meet the latest standards of ANSI, IEEE, NEMA and the National Electric Code.

D. The manufacturer shall be both ISO-901 and ISO- 14001 certified.

E. All products shall be CE marked, UL labeled, and meet the requirements of UL- 508C.

F. To ensure quality and minimize infantile failures on the jobsite, all VFD"s shall be completely tested by the manufacturer. The VFD shall operate a dynamometer at full load and speed under elevated temperature conditions.

G. All optional features shall be functionally tested at the factory for proper operation.

H. Factory test documentation shall be available upon request.

1.04 SUBMITTALS

A. Submit for review six copies of properly identified manufacturer’s literature and shop drawings of VFD and major components. Submittal shall include manufacturer’s performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD‟s FLA rating, certification agency file numbers, catalog information and catalog cut-sheets for all major components.

B. Approval for fabrication and installation will be made only after submittal and review of all shop drawings and manufacturer's literature. The information required for approval shall include as a minimum, the following:

1. Computer generated 3-line electrical diagram of power and control.

2. Submit a computer-generated Harmonic Distortion Analysis for the jobsite location.

3. Description of control operation, system operation and analog signal processing.

4. System block, schematic and interconnection diagrams.

5. Detailed drawing of the enclosure (size, construction, mounting, etc.).

6. Stamped and sealed report and calculation by a Florida Registered Engineer that all anchorages, shielding plates, skeleton frames and foundation slab for the enclosure comply with the wind loads of the "Florida Building Code" and the "Designed Loads for Buildings and Other Structures" (ASCE 7-93 Section 6). All wind pressures, including calculated uplift shall be modified by the corresponding use and shape factors, including those required for the Coastal Building Zone, if applicable.

1.05 DESIGN DATA

A. The system shall be capable of operating pumps in a variable speed mode keeping sewage level, despite system demands, within a settable range and without causing a sewage overspill.

B. Each pump shall be started via VFD and operate in variable speed mode in normal operation and soft-start and operate in full speed mode in by-pass mode.

C. The available power shall be 230 or 460 VAC, 3 phase, 60 Hz.

D. The Operation Control Scheme for the pumping station, as regard VFD's, shall be as follows:

1. The (automatically or manually selected) lead pump shall start when the wet well level reaches the point that calls the lead pump to come on. Pumps shall always start at a minimum speed and accelerate to the speed require to maintain the level within a settable proportional band.

2. The lag pump shall not be started until:

   a. The lead pump is running at full speed.

   b. The level has increased to the point when two pumps are required to handle the flow.

3. With two pumps operating simultaneously, both shall run at same speed.

4. On decreasing level and more than one pump in operation, all the "Lag" pumps shall turn off sequentially in reverse order (last "On" shall be first "Off"). However, no pump shall operate below 60% of SRPM for a period of time exceeding 300 seconds.

5. Pumps shall not run below 60% of SRPM. When a pump is running at this speed on decreasing level, the pump shall keep that speed until the level reaches a preselected low level point when the pump shall be turned off.

6. To prevent excessive cycling of the pumps, adjustable time delays shall precede the restating of the pumps after a shut down.

7. Pump speed and wet well levels that indicate control actions shall be adjustable.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. .

B. "Square D" VFD (Variable Frequency Drive). EATON VFD (Variable Frquency Drive).

C. Or approved equal.

2.02 GENERAL

A. Furnish complete VFD as specified herein or in the equipment schedule for loads designated to be variable speed. VFD"s shall be both constant and variable torque rated.

B. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC induction motors. The VFD shall be a eighteen-pulse input design, and the input voltage rectifier shall employ a full wave diode bridge; VFD"s utilizing controlled Silicone Control Rectifiers (SCR) rectifiers shall not be acceptable. The output waveform shall closely approximate a sine wave. The VFD shall be a Pulse Width Modulated (PWM) output design utilizing current Industrial Grade Bipolar Transistor (IGBT) inverter technology and voltage vector control of the output PWM waveform.

C. The VFD shall include a full-wave diode bridge rectifier and maintain a displacement power factor of near unity regardless of speed and load.

D. The manufacturer of the VFD shall demonstrate a continuous period of manufacturing and development of VFD's for a minimum of 10 years. VFD"s that are brand-labeled are not acceptable.

E. The VFD shall produce an output waveform capable of handling maximum motor cable distances of up to 1,000 ft. (unshielded) without tripping.

F. The VFD shall utilize VVCPLUS, an output voltage-vector switching algorithm, or equivalent, in both variable and constant torque models. VVCPLUS provides rated RMS fundamental voltage from the VFD. This allows the motor to operate at a lower temperature rise, extending its thermal life. The VFD"s that cannot produce rated RMS fundamental output voltage or require the input voltage to be increased above motor nameplate value to achieve rated RMS fundamental output voltage are not acceptable.

G. The VFD selected must be able to source the motor's full load nameplate amperage (fundamental RMS) on a continuous basis and be capable of running the motor at its nameplate RPM, voltage, current, and slip without having to utilize the service factor of the motor.

H. The VFD will be capable of running either variable torque (VT) or constant torque (CT) loads. In variable torque applications, the VFD shall provide a CT-start feature and be able to provide full torque at any speed up to the base speed of the motor. In either CT or VT mode, the VFD shall be able to provide its full rated output current continuously and 110% of rated current for 60 seconds.

I. An Automatic Energy Optimization (AEO) selection feature shall be provided in the VFD to minimize energy consumption in variable torque applications. This feature shall dynamically adjust output voltage in response to load, independent of speed. This feature shall incorporate power factor compensation. Output voltage adjustment based upon frequency alone is not acceptable for single motor VT configurations.

J. An initial ramp function shall be available to provide a different beginning ramp time, up to 360 seconds, for application requiring a faster or slower ramp than normal operation.

K. Switching of the input power to the VFD shall be possible without interlocks of damage to the VFD at a minimum interval of 2 minutes.

L. Switching of power on the output side between the VFD and the motor shall be possible with no limitation or damage to the VFD and shall require no additional interlocks.

M. The VFD shall have temperature-controlled cooling by an air conditioning system to minimize internal losses.

N. VFD shall provide full torque to the motor given input voltage fluctuations of up to +10 percent of the rated input voltage. Additionally, sustained line voltage reductions up to 15 percent shall not cause the VFD to trip.

O. A control power transformer shall be sized to handle the entire load connected to the control circuits.

P. The operator panel shall be either discrete push buttons and selector switches or a direct access soft-touch keyboard type with the following functions as a minimum:

1. Run-Stop-Auto-Manual or Hand-Off-Auto
2. Display motor speed, motor amp, and output volts
3. Indicating lights for drive run, drive fault, and power on
4. Ability to read and change the operating function settings and monitor the operating conditions of the drive.
5. Ability to change function setting while the motor is running.
6. Monitor conditions at faults.

2.03 HARMONICS

A. The VFD shall provide dual built-in DC link reactors to minimize power line harmonics and to provide near utility power factor. VFD"s without a DC link reactor shall provide a 5 percent impedance line side reactor.

B. The VFD shall be provided with harmonic reduction, as required, to insure that the current distortion limits, as defined in table 10.3 of IEEE 519-1992, are met. PCC1, defined as the low voltage side of the distribution transformer, is used for purposes of calculation and referred, by the turn's ratio of the transformer, to the PCC defined by the IEEE Recommended Practices as the Consumer-Utility interface. The tables of limits set forth therein are with reference to the PCC (primary side of the main transformer).

C. Harmonic solutions shall be designed to withstand up to 2 percent line imbalances with the maximum Current Distortion not to exceed 11 percent at 100 percent load.

D. Harmonic solutions shall be capable of withstanding up to 2 percent ambient voltage distortion with the maximum Current Distortion not to exceed 12 percent at 100 percent load.

2.04 INTERFACE FEATURES

A. VFD shall provide an alphanumeric backlit display keypad which may be remotely mounted using standard 9-pin cable. VFD may be operated with keypad disconnected or removed entirely. Keypad may be disconnected during normal operation without the need to stop the motor or disconnected power to the VFD.

B. VFD shall display all faults in plain texts; VFD"s which can display only fault codes are not acceptable.

C. The keypad shall feature a 4-line display, and be capable of digitally displaying up to four separate operational parameters or status values simultaneously (including process values with the appropriate engineering unit) in addition to Hand/Off/Auto, Local/Remote, and operating status.

D. Two lines of display shall allow “free text programming” so that a description, or the actual name, of the equipment being controlled by the VFD can be entered into the display.

E. Keypad shall provide an integral H-O-A (Hand-Off-Auto) and Local-Remote selection capability, and manual control of speed locally without the need for adding selector switches, potentiometers, or other devices.

F. VFD keypad shall be capable of storing drive parameter values in non-volatile RAM uploaded to it from the VFD, and shall be capable of downloading stored values to the VFD to facilitate programming of multiple drives in similar applications, or as means of backing up the programmed parameters.

G. VFD shall indicate which digital inputs are active, and the status of each relay.

H. VFD display shall indicate the value of any voltage or current signal connected to the analog input terminals.

I. VFD display shall indicate the value of the current on the analog output terminals.

J. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.

K. Dual protection shall be provided to prevent unauthorized changes to the programming of the VFD. The parameters can be locked via a digital input and/or the unit can be programmed not to allow an unauthorized user to change the parameter settings.

L. A quick setup menu with factory preset typical parameters shall be provided n the VFD to facilitate commissioning. Use of macros shall not be required.

M. A digital elapsed time meter and kilowatt hour meter shall be provided in the display.

N. VFD shall proved full galvanic isolation with suitable potential separation from the b power sources (control, signal, and power circuitry within the drive) to ensure compliance with PELV requirements and to protect PLC"s and other connected equipment from power surges and spikes.

O. All inputs and outputs shall be optically isolated. Isolation boards between the VFD and external control devices shall not be required.

P. There shall be eight fully programmable digital inputs for interfacing with the systems external control and safety interlock circuitry.

Q. The VFD shall have two voltage analog signal inputs and one current signal input, and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include 0-10 V dc, 0-20 mA and 4-20 mA.

R. Two programmable analog outputs shall be provided for indication of drive status. These outputs shall be programmable for output speed, voltage, frequency, motor current and output power. The analog output signal shall be 0-20 mA or 4-20 mA.

S. The VFD shall provide two user programmable relays with 31 selectable functions. One form „A" 50VAC and form „C" 230VAC/2A rated dry contact relay outputs shall be provided.

T. Floating point control interface shall be provided to increase/decrease frequency in response to external switch closures.

U. The VFD shall accept a NC motor temperature overtemperature switch input, as well as possess the capability to accept a motor thermistor input.

V. The VFD shall store in memory the last 20 faults and record all operational data.

W. Run permissive circuits shall be provided to accept a "system ready" signal to ensure that the VFD does not start until isolation valves, seal water pumps or other types of auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.

X. The VFD shall be supplied with a standard RS-485 serial communications data port. Windows7 compatible software to display all monitoring, fault, alarm, and status signals shall be available. This software shall allow parameter changes, storage of all VFD operating and setup parameters, and remote operation of the VFD.

2.05 DESIGN FEATURES

A. The VFD shall be provided with additional features described below:

1. Power loss ride-through capability for power loss of 0.2 second.

2. Additional devices and functions as follows:

a. Drive system disconnect operators.

b. HAND-OFF-AUTO selection.

c. System speed control selector switches (LOCAL/REMOTE) (When in LOCAL position, speed controlled by a manual speed potentiometer).

d. Switch for Pump 1, Pump 2 or automatic alternation.

e. Switch for BYPASS/MANUAL mode.

f. Door intrusion alarm system for VFD cabinet.

g. Alarm lights.

3. Drive shall be sized to the KVA requirements of the motor and shall be sized such that the drive does not exceed 90 percent nameplate rating under any load condition.

4. Drive shall be provided with built-in PID controller.

5. The VFD shall be designed to operate from a three-phase 240 or 480 volt, 60 Hz supply and to control a standard 230 or 460 volt three-phase 60 Hz squirrel cage induction motor with a 1.15 service factor without derating or requiring any motor modification. The VFD shall vary both the AC voltage and frequency simultaneously to operate the motor at required speeds.

6. The VFD shall be specified designed for use with the variable or constant torque load it serves.

7. The VFD shall be provided with “voltage boost” at low frequency and adjustable voltage/frequency ratios.

8. The VFD shall be provided with adjustable minimum speeds between 4 and 40 Hz and maximum speeds between 40 and 80 Hz. Factory minimum and maximum settings shall be 24 and 60 Hz, respectively. Unless otherwise approved by the Department, minimum speed for Variable Frequency Drive pumps shall be set at 60 percent of maximum speed.

9. The minimum VFD efficiency shall be at least 95 percent at 100 percent speed, and 85 percent at 50 percent speed.

10. The VFD shall shut down in an orderly manner when a power outage occurs. Upon restoration of power, the motor shall restart and run at the speed corresponding to the current process input signal.

2.06 ADJUSTMENTS

A. The VFD shall have an adjustable output switching frequency.

B. Four complete programming parameter setups shall be provided, which can be locally selected through the keypad or remotely selected via digital input(s), allowing the VFD to be programmed for up to four alternate control scenarios without requiring parameter changes.

C. In each programming set up, independent acceleration and deceleration ramps shall be provided. Acceleration and deceleration time shall be adjustable over the range from 0 to 360 seconds to base speed.

D. The VFD shall have four programmable “skip frequencies” with adjustable bandwidths to prevent the driven equipment from running at a mechanically resonant frequency.

E. VFD shall include an automatic acceleration and deceleration ramp- time function to prevent nuisance tripping and simplify start-up.

F. In each programming setup, independent current limit settings, programmable between 50% and 110% of the drives output current rating, shall be provided.

G. An automatic “on delay” function may be selected from 0 to 120 seconds.

H. The VFD will include a user-selectable Auto-Restart function that enables the VFD to power up in a running condition after a power loss, to prevent the need to manually reset and restart the VFD.

2.07 AIR MOVING EQUIPMENT

A. All air moving equipment shall be in accordance with Section 15860.

2.08 PROTECTION FEATURES

A. The VFD shall have, as a minimum, the following protection features:

1. The main circuit breaker shall be mechanically interlocked with the VFD enclosure door. The circuit breaker shall be sized to have a short-circuit interrupting capacity of the motor control centers or switchgear to which the VFD is connected. The breaker shall be provided with provisions for locking open with a padlock.

2. VFD shall have input surge protection utilizing MOV"s, spark gaps, and Zener diodes to withstand surges of 2.3 times line voltage for 1.3 msec.

3. VFD shall include circuitry to detach phase imbalance and phase loss on the input side of the VFD.

4. VFD shall auto-derate the output voltage and frequency to the motor if an input phase is lost if it is desirable to maintain operation without decreasing the life expectancy of the VFD. The use of this feature shall be user selectable and export a warning during the event.

5. VFD shall include current sensors on all three-output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.

6. VFD shall auto-derate the output voltage and frequency to the motor in the presence of sustained ambient temperatures higher than the operating range, so as not to trip on an inverter temperature fault. The use of this feature shall be user selectable and a warning will be exported during the event.

7. The VFD shall have the option of an integral RFI filter. Enclosures shall be made of metal to minimize RFI and provide immunity.

8. Protection against single phasing, power outage, and reverse phase rotation

9. Instantaneous overcurrent protection

10. Electronic overcurrent protection

11. Ground fault protection

12. Overtemperature protection and alarm for electronics

13. Protection against internal faults

14. Ability to start into rotating motor

15. Additional protection and control as required by the motor and driven equipment.

16. The VFD will include a user selectable Reset function, which enables the selection of between zero and twenty restart attempts after any self-clearing fault condition (under-voltage, over-voltage, current limit, inverter overload and motor overload) or the selection of an infinite number of attempts. The time between attempts shall be adjustable from 0 through 600 seconds.

2.09 ELAPSED TIME METER

A. Provide, in addition to the elapsed time meter arrangement described below, a device for measuring and recording pump operation speed.

B. An elapsed time meter for each pump should record the amount of running time in “hours” and “tenths of hours” that occurs when each pump is running.

2.10 FACTORY TESTING

A. General:

1. All components shall be 100 percent tested. All printed circuit boards shall be burned in continuously for five hours at 50 degrees C. The printed circuit boards shall be tested after burn-in to insure they are functioning within specification.

2. Control power shall be applied to microprocessors, printed circuit boards, diagnostic boards and similar devices including software to test for proper operation, sequencing, logic and diagnostics.

3. All wiring shall be checked for continuity and for compliance with the wiring diagrams.

B. Testing shall proceed in the order given below:

1. Motor test: VFD, along with the actual AC motor to be provided (of VFD manufacturer test motor) shall be tested with the system logic and a dynamometer load to simulate field operation conditions at 25, 50, and 100 percent full load current.

2. VFD test: After dynamometer tests are complete, the VFD shall be load-tested in a heat room maintained at 40 degrees C for 5 hours. The motor shall be loaded at 100 percent full load current for 1 hour. Motor and dynamometer need not be in the elevated temperature room with the VFD.

3. Provide above-stated tests in addition to the manufacturer's normal factory tests.

4. Provide certified documentation of all tests performed.

5. Failure of any component during this test requires repair and commencement of a new test.

2.11 SPARE PARTS

A. The Contractor shall furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number.

B. During the term of this contract the Contractor shall notify the Design Engineer in writing about any Manufacturer's modification of spare part numbers, interchangeabilities, or model changes. If the Engineer determines that the modified parts no longer apply to the equipment provided, the Contractor shall furnish other applicable parts at no increase in cost to the Owner.

C. The following spare parts shall be furnished:

1. Two (2) lamp lenses of each color.
2. Two dozen (24) pilot lamps.
3. One (1) of each type of circuit board:
    a. Control board.
    b. Power board.
    c. Diode board.
    d. Transistor module.
    e. One (1) of each power diode and transistor.

2.12 SERVICES OF THE MANUFACTURER

A. An authorized service representative of the Manufacturer shall be present at the site to furnish, in entirety, the services listed below.

B. The authorized service representative shall supervise the following and certify that the equipment and controls have been properly installed, aligned, adjusted, and readied for operation.

1. Inspection, checking, and adjusting the equipment
2. Startup and field testing for proper operation
3. Performing field adjustments to insure that the equipment installation and operation comply with requirements

C. Manufacturer shall provide all appropriate O&M manuals, interconnect drawings, service information and service representative phone numbers necessary for the continued operation and maintenance of the VFD installation.

PART 3 EXECUTION

3.01 INSTALLATION AND EXAMINATION

A. Conduit stub-ups for interconnected cables and remote cables shall be located and terminated in accordance with the drive manufacturer's recommendations.

B. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer’s recommendations shall be verified.

C. VFD Cable (3 stranded tinned copper circuit conductors plus (3) symmetrical bare copper ground wires, XLPE insulation, two spiral copper tape shield (100 percent coverage) ~ sun-and oil-resistant PVC jacket) shall be used in applications other than submersible pumps.

D. The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

3.02 START-UP AND WARRANTY

A. A factory-authorized service technician shall perform start-up on each drive. (“Start- up” shall not include having the technician perform installation or termination of either power or control wiring.) The service technician shall perform start-up on up to 8 drives per day. The bid item for selling and delivering drives shall include start- up costs, which shall include time and travel for the estimated number of visits required, but shall not be less than at least one half-day with travel. Additional labor or return trips to the site shall be billed at to the Contractor, at no additional cost to the County. Upon completion, a start-up service report shall be provided.

B. The drive manufacturer shall provide a 6-year on-site warranty such that the County is not responsible for any warranty costs including travel, labor, parts, or other costs for a full 6 years from the date of manufacture of the Drive. The cost of the warranty shall be included in the bid.

3.03 FIELD TESTING

A. Testing, checkout and startup of the VFD equipment in the field shall be performed under the technical direction of the Manufacturer's service representative. Under no circumstances are any portions of the drive system to be energized without authorization from the Manufacturer's representative.

B. Harmonic analysis shall be performed at unit full load using a harmonic analyzed by Hewlett Packard, or equal. Tests shall prove that the harmonic distortion is limited to a magnitude of 5 percent of the fundamental with line reactors or isolation transformer in the circuit as indicated. The report shall include the following:

1. Expected harmonic current (THD) through the 9th harmonic, calculated with and without line reactors or isolation transformer.

2. Actual RMS value and measured percentage of the THD in the field.

C. Provide a copy of the field test data and certify that the unit(s) are installed and tested properly and meet manufacturer's requirements.

END OF SECTION

SECTION 16280

OVERCURRENT PROTECTIVE DEVICES 600 VOLT

PART 1 GENERAL

1.01 QUALITY ASSURANCE

A. Materials shall bear UL labels.

1.02 SUBMITTALS

A. Submit for review properly identified manufacturer's literature giving materials, finishes, accessories and installation directions where required.

PART 2 PRODUCTS

2.01 MATERIALS

A. Circuit Breakers:

1. Circuit breakers shall conform to Fed. Spec. WC-375, UL 489 and NEMA AB1, and shall be a circuit interrupting device which shall operate both manually, for normal switching functions, and automatically under overload and short circuit conditions. It is to provide circuit and self protection when applied within its ratings.

2. Provide at voltage, phase, number of poles and amps indicated, with symmetrical amperes interrupting rating to be equal or larger than that shown on drawings or specified. Control and signaling function may be incorporated by use of accessories.

3. Operating mechanism shall be entirely trip-free so that contacts cannot be held close against an abnormal over-current or short circuit condition.

4. Operating handle of circuit breaker shall open and close all poles of a multi-pole breaker simultaneously. These breakers shall meet applicable NEMA AB-1 and UL specifications.

5. Each circuit breaker shall have a trip unit to provide overload and short circuit protection. Trip element shall operate a common trip bar which shall open all poles in case of an overload or short circuit through any one pole. Two-pole and three-pole circuit breakers shall have a common trip bar; handle ties will not be accepted. Main Circuit Breaker shall be LSI (Long Time, Short Time & Instantaneous)

6. Ampere rating shall be clearly visible; contacts shall be of non-welding silver alloy.

7. Circuit breakers to be used in switchboards, lighting and power panelboards, distribution panelboards and individually enclosed shall be 1, 2, or 3 poles as indicated on drawings and draw-out type.

B. Molded Case Circuit Breakers:

1. Molded case circuit breakers shall be bolt-on type, mounted in distribution, lighting and power panelboards and individually enclosed units.

2. Molded case circuit breakers shall be quick-make, quickbreak action.

3. Molded case circuit breakers for panelboards shall have the following minimum ampere interrupting capacities (RMS):

a. 120 volts - 14,000 AIC.

b. 277/480 volts- 22,000 AIC.

4. Each molded case circuit breaker shall have a thermal magnetic trip device with trip ratings as shown on Drawings.

C. Current Limiting Circuit Breaker:

1. Bolt-on type, mounted in switchboard.

2. Circuit breaker shall be quick-make, quick-break.

3. Unit shall be rated to withstand 100,000 AIC RMS faults.

D. Separately enclosed circuit breakers shall be of the handle through cover type.

PART 3 EXECUTION

3.01 INSTALLATION

A. Circuit breakers shall be installed in strict accordance with manufacturer's recommendations.

B. Separately enclosed circuit breakers shall be in NEMA 12 in INDOOR dry areas and NEMA 4 stainless steel enclosures for outdoor and wet or corrosive areas.

C. Separately enclosed circuit breakers shall be identified with a black and white phenolic nameplate with 1/2 IN high letters, indicating equipment served.

D. All overcurrent protective devices in the electrical power distribution system shall be selectively coordinated to avoid tripping of devices other than those which would isolate a fault within the system.

END OF SECTION

SECTION 16420

STATIONARY ENGINE GENERATOR MODIFICATIONS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install a new control panel and new stationary engine-generator system, as is indicated on the drawings, which will start automatically upon interruption of normal electrical service.

B. Engine-generator systems shall be furnished to provide pump station standby power, when required in accordance with Subsection 1.09-H of Section UC-500.

1.02 SUBMITTALS

A. Prepare and submit complete set of shop drawings of all generator equipment to be provided on this project to the Engineer for approval.

B. Submit complete manufacturer's product data of all material and systems, consisting of complete product description and specifications, complete performance test.

C. All Shop Drawing shall have clearly marked the appropriate specification number of Drawing designation for identification of the submittal.

D. Any notations marked on submission of the equipment as outlined in this Section by reviewing authority must be responded to, in writing, by the equipment manufacturer.

E. Complete engineering submittal, catalog cuts, wiring diagrams, interface drawings, unit drawings, AC and DC schematics, termination chamber drawings, terminal strip drawings, foundation plans, annunciator panel layout and wring, etc., must accompany all Shop Drawings.

1.03 QUALITY ASSURANCE

A. In the best interest of the Monroe County, the supplier of this equipment shall maintain a full-time "in-house" parts and service organization within 50 miles of the job site. Equipment offered by those who do not have an "in house" parts and service organization and who depend on others to provide services shall not be considered. This supplier shall have his name, address and telephone number clearly and visibly located on all equipment. Service shall be available on a 24 HR/7-day a week basis.

B. The supplier of the equipment shall provide information and/or supervision required for the proper installation of the equipment, testing of equipment and training of operating personnel.

C. All components shall bear UL labels.

D. The controls and Generator shall be designed, fabricated, tested and furnished by one manufacturer to assure one source of responsibility. The manufacturer shall have been regularly engaged in the production of generator controls for generators for a minimum of five years.

1.04 GUARANTEE

A. The equipment furnished under this Specification shall be new, unused, of the latest design. The associated controls shall be warranted for a minimum of five years or 1,500 operating hours. The supplier of the system shall have a parts and service facility within fifty miles from the jobsite to assure the Owner continuity of service.

1.05 REFERENCE STANDARDS

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section and are hereby incorporated into, and made a part of, the Contract Documents:

1. NFPA 70: National Electrical Code.
2. NFPA-110: Emergency and Standby Power Systems.
3. NFPA-101: Life Safety Code.
4. NFPA-AB1: Molded Case Circuit Breakers.
5. NFPA MG1: Motors and Generators.
6. NFPA 250: Enclosures for Electrical Equipment (Maximum 1,000 Volts).
7. NFPA 30: Flammable and Combustible Liquids Code.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Automatic Starting System: Furnish a DC electric starting system with positive engagement drive and of the voltage recommended by the engine manufacturer. Provide fully automatic generator set start-stop controls in the generator control panel, 30-second single cranking cycle limit with lockout and automatic exercise function to start the generator once a week, run idle for ten minutes, run at full speed for 1 HR, return to idle for ten minutes, and automatically shut down.

1. Provide a lead-acid storage battery set of the heavy-duty diesel starting type. A battery set of voltage compatible with the starting system, of sufficient capacity to provide for 1-1/2 minutes total cranking time without recharging and rated no less than 220 Amp/HRS. A battery rack and necessary cables and clamps shall be provided.
2. Furnish a current limiting battery charger to automatically recharge batteries. Charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressor, DC ammeter, and fused AC input. AC input voltage shall be 120 Volts, single phase, 60 Hertz. Amperage output shall be no less than 5 amperes.

B. Control Panels: Provide a generator-mounted NEMA 1-A type, vibration isolated, dead front, 14 gage steel control panel. Panel shall contain, but not be limited to the following:

1. Voltmeter, 3-1/2 IN, 2 percent accuracy.
2. Ammeter, 3-1/2 IN, 2 percent accuracy.

3. Ammeter-Voltmeter phase selector switch.

4. Frequency meter, 3-1/2 IN, dial type.

5. Running time meter.

6. Automatic starting controls, as herein before specified.

7. Voltage level adjustment rheostat.

8. Dry contacts for remote alarms wired to terminal strips.

9. Fault indicators for low oil pressure, high water temperature, overspeed and overcrank.

10. Three position function switch marked "auto", "run" and "Stop".

11. Generator circuit breaker/contactor with shunt-trip by protective devices.

C. Automatic Load Transfer Switches: Shall be rated for continuous duty and for all classes of load, with sufficient ampere rating to handle the capacity of the loads being transferred. The control components shall be compatible with the electrical requirements of the emergency generator set and shall provide the following functions:

1. Upon power line interruption, automatically initiate starting of the generator set and when the set comes up to speed and voltage, disconnects the load circuit from the utility and transfers it to the emergency generator set's output.

2. Upon utility voltage re-establishment, automatically transfers the load circuit back to the utility and initiates shutdown of the emergency generator set.

3. Mechanically interlocked with break-before-make action and shall have permanently mounted handles to allow for safe manual switching under full rated load. When in either the "Normal" or "Emergency" position, the transfer mechanisms shall be mechanically locked at that position. An interlocking steel beam shall prevent contact closure on both positions simultaneously. The main contacts shall be of high pressure silver alloy construction. Provide arc interruption by multiple leaf arc chutes with covers to prevent flashover between phases. Main contacts shall be rated 600 VAC, capable of carrying 100 percent of its current rating continuously and constructed such that they can be visual inspected behind a safety shield whether contacts are open or closed. Provide a plug type connector to allow for maintenance disconnection to control section. Supply a full neutral bar with connecting lugs in the switch cabinet. Auxiliary switches shall be provided on both sides of the transfer switch to operate peripheral equipment; switches shall be single pole, double throw, rated 10 amperes, and shall be wired to an accessible terminal block.

4. Incorporate a programmed transition control to provide a disconnect period beyond the normal six cycle transfer time between "Emergency" and "Normal" position to allow residual voltages generated by inductive loads to decay to safe levels before these loads are re-energized. The transition period shall be field adjustable from 0.5 to 5 seconds. Phase angle dependent controls which do not compensate for induction motor slip shall not be accepted.

5. Incorporate a solid state electronic control system with the following:

   a. Adjustable under voltage sensors to monitor all phases of both the Normal and Emergency sources.

   b. Adjustable time delay on engine starting to prevent staring of the set in the event of momentary loss of Normal power.

   c. Adjustable time delay on transferring to Emergency, allowing generator set to stabilize before application of load.

   d. Adjustable time delay on retransfer to Normal, to prevent power interruption in case of momentary re-establishment of Normal power.

   e. Adjustable time delay on stopping generator set, allowing engine to cool down by running unloaded.

   f. Starting dry contacts, one N.O., one N.C. for two wire, 24 VDC, engine control.

   g. Normal-Test switch.

   h. Adjustable exerciser clock for periodic testing of generator set with "With-load, Without-load" selector switch.

   i. Voltage regulated SCR battery charger with float, taper, and equalize charge settings, inherently self-protected, rate 6 amperes, 24 VDC.

   j. Normal-Emergency position indicating lamps.

   k. Diagnostic lights for monitoring control sequence. The automatic load transfer switch shall be provided in NEMA 12, 14 gage welded steel construction cabinet, with key locking door. Wiring space in the interior of the cabinet shall comply with N.E.C., Table 373-6(b).

D. Factory Tests: Certified factory full load test results shall be provided (not less than 4 HRS continuous full-load test at rated KW). All pertinent temperature readings shall be presented, including but not limited to generator stator, generator rotor, (after shut-down), all main bearings, engine cooling water inlet and outlet of radiator, lubricating oil, engine compartment, generator compartment. The MD-WASD's representative shall have the privilege of witnessing these tests and the Engineer shall be notified in writing not less than 14 calendar days before the anticipated test. 48 HRS prior to test, confirmation of test date shall be made. Tests shall be performed in the manufacturer's facility in the continental U.S.A.

E. Initial Start-up: The complete installation shall be initially started and checked out for operational compliance by a factory-trained representative of the manufacturer.

F. Upon completion of the initial start-up and system checkout, perform a field test, with the Engineer notified in advance, to demonstrate full specified power, stability, voltage, and frequency. The generator set shall be tested for a period of 4 HRS using a portable, dry resistive load bank which shall be capable of incremental loading. The load bank instrumentation shall be used to check the meters on the generator. The generator set shall be capable of assuming its full rated KW load when applied in one step. The generator set shall also run for a period of 4 HRS continuously with all available load connected through the automatic load transfer switch. Records shall be maintained throughout the testing periods on coolant temperature, lubricating oil pressure, ambient air temperature, voltage, current, frequency and kilowatts. This data shall be recorded at 15 minute intervals throughout the tests. There shall be a 30 minute unloaded run at the conclusion of each test to allow the engine to cool down before shutdown. Three (3) copies of the field test data shall be furnished to the Engineer. The Contractor shall make all necessary connections to facilitate the field tests and provide all necessary fuel. The generator shall be tested under a simulated power failure by setting the control switch on the automatic position and then started by means of the test switch on the automatic transfer switch. The generator set shall then run for the duration of all time delays on the transfer switch and the automatically shut down.

PART 3 EXECUTION - (NOT APPLICABLE TO THIS SPECIFICATION SECTION)

END OF SECTION

SECTION 16439

DISTRIBUTION, POWER PANELBOARDS

PART 1 GENERAL

1.01 QUALITY ASSURANCE

A. Materials shall bear UL labels.

1.02 SUBMITTALS

A. Submit for review, properly identified manufacturer's literature and shop drawings giving panelboard type, phase, voltage, ampacity, mounting, dimensions, interrupting rating and data on all included circuit breakers.

1.03 MANUFACTURER

A. 480/277V Distribution panelboard shall be 600 volts AC, Square “D”, Type “I” Line or approved equal.

B. 480/277 V panelboards shall be 600 Volts AC, General Electric type CCB with breakers TFK and TED, or approved equal.

C. 240/120 & 208/120 V panelboards shall be 240 Volts AC, General Electric type AQ with THQB and THQB-GF breakers, or approved equal.

D. Panelboards to be as specified, Square D, General Electric, Westinghouse or approved equal.

PART 2 PRODUCTS

2.01 GENERAL

A. Furnish and install distribution, power and lighting panelboards of the type, voltages and size noted on the Contract Drawings, indicated on the riser diagram and listed in the panelboard schedule.

2.02 MATERIALS

A. Panelboards shall be dead front, safety type construction and shall conform to Federal Specification WP-115, NEMA PB1, ANSI C33.38 and UL67.

B. All circuit breakers shall be thermal magnetic, temperature compensated, bolt-on type with quick-make quick-break mechanism, of the frame and size indicated.

C. Panelboard assemblies shall be enclosed in code gauge galvanized steel cabinets with surfaces trim and ample wiring gutters on top, bottom and sides, cabinet doors shall be equipped with spring type latches and directories.

D. All buses shall be copper, including neutral and ground bus with 1/8-inch or larger terminal screws and with neutral terminals stamped with number corresponding to branch circuit numbers.

E. Panels shall be provided with equipment ground bar as and many spare breakers and spaces as shown in the schedule.

F. Furnish panelboard with flush chromium plated combination type cylinder lock and latch. Panels are to be keyed alike.

G. Fronts shall have adjustable indicating trim clamps and complete with door, surface or flush mounted as indicated on the Drawings.

H. Any two single pole circuit breakers shall be replaceable by one two pole circuit breaker and any three single pole breakers shall be replaceable by a three pole circuit breaker. Handle ties will not be accepted.

I. All panels shall have a circuit directory card mounted on the frame with plastic cover mounted on the inside of the door and all directory cards shall be filled in by the Contractor, using a typewriter, and indicating areas and/or devices served by each circuit.

J. Circuit breakers minimum interrupting ratings shall be 22,000 A for 277 volts systems and 14,000 A for 120 volt systems. Circuit breaker minimum rating shall be 20A single pole unless otherwise noted.

K. Lighting and Receptacles Panelboards shall be a minimum of 20 inches wide, 5-3/4 inches deep; side gutters shall be 4 inches minimum width, and top and bottom gutters shall be 6 inches minimum height, to adequately accommodate conduit, wires and cables entering and leaving.

L. Distribution Panelboards shall be a minimum of 30 inches wide, 8 inches deep, side gutters shall be 8 inches minimum width, and top and bottom gutters shall be 8 inches minimum height to adequately accommodate conduit, wires and cables entering and leaving. Distribution panelboards shall have a minimum interrupting capacity of 30,000 amperes or as stated on the Drawings.

M. Panels shall be main lug or circuit breaker type, of the size noted on the Drawings, equipped with solderless lugs. The function of each circuit breaker shall be clearly defined by a number corresponding to the number and circuit description typed on the directory. The directory shall be protected by clear plastic and mounted in a metal holder located in a convenient position on the panel door. All panel mains and conductors shall be copper.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install panelboards in accordance with manufacturer's instructions.

B. Panel circuit numbers are intended as guides for the Contractor and to show switching group requirements. After completion of the job, test the panel under load and establish approximately equal ampere loading per phase leg rearranging circuits to breakers as required.

C. Numbering on panelboard circuits shall be by spaces and not be breaker units. Panelboards with spaces in two columns shall have odd-number spaces on the left and even-numbered spaces on the right; numbering shall be from top to bottom and shall be permanently attached.

D. In flush mounted panelboards, make provision for future circuits installing four 1 inch conduits from panelboard into accessible ceiling space of space designated to be ceiling space in the future.

E. Mount panelboards where shown on the drawings with the top of the cabinet at a height of not over 7'-0" and shall be of the dead front type.

F. Provide a typewritten directory for each panelboard. Locate directory on inside of cover.

G. Provide black and white laminated plastic nameplate for panelboard.

H. Neatly route, harness and support conductors in gutters, wiring spaces and compartments. Conductor bending radius shall not be less than the minimum recommended by the conductor manufacturer.

I. No panel shall be installed that has a capacity to receive more than 42 overcurrent devices. If design conditions dictate the use of more than 42 overcurrent devices, two or more panelboards shall be used.

END OF SECTION

SECTION 16460

LOW VOLTAGE TRANSFORMERS - DRY TYPE

PART 1 GENERAL

1.01 QUALITY ASSURANCE

A. Materials shall bear UL labels.

B. Transformers shall conform to the applicable requirements of ANSI, IEEE, and NEMA Standards.

C. Dry type transformer installation shall conform to NFPA 70 National Electrical Code and NEMA Standard TR-27.

1.02 SUBMITTALS

A. Submit for review properly identified manufacturer's literature giving KVA, voltage, phase, taps, sound levels, temperature rise, percent impedance, and losses at 1/4, 1/2, 3/4, and full load.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Transformers shall be as manufactured by Square D, General Electric or approved equal.

2.02 MATERIALS

A. Core and coil assembly shall be vacuum impregnated with Class H insulation for maximum resistance to moisture. These transformers shall be provided with a drip-proof enclosure, which has a durable finish and a rust-proof diagrammatic nameplate. Wiring compartments shall have adequate space for terminating cables and shall be front connected for easy accessibility.

B. Core of this unit shall be of high quality, cold-rolled, grain oriented steel, annealed by manufacturer, of low loss and exciting current. Laminations shall be formed to eliminate burrs and annealed to reduce losses to a minimum. Winding copper conductors shall be annealed and insulated by transformer manufacturer. Conductor surfaces shall be free from slivers, burrs, and other irregularities.

C. Transformers shall be dry type, three phase, or single phase of the size and voltage indicated on the Drawings, 60 Hertz, with four 2-½% FCBN taps, 2 above and 2 below normal. KVA rating shall be as shown on Drawings.

D. Transformer insulation shall be Class H and 115º Centigrade temperature rise.

E. Transformer sound level shall not exceed following values: 0 to 9 KVA-36 db, 10 to 45 KVA-42 db, 50 to 100 KVA-45 db.

PART 3 EXECUTION

3.01 INSTALLATION

A. Dry type transformers shall be installed by Contractor in accordance with manufacturer's instructions.

B. Transformer enclosures and secondary neutral shall be securely grounded.

C. Floor mounted transformers shall be bolted to floor.

D. Wall mounted transformers shall be bolted to steel bracket angles.

E. Dry type transformers shall be installed with wiring compartment to the front.

F. Primary and Secondary connections shall be made with flexible conduit. Flexible conduit to be a minimum of 24 inches long.

G. Transformers shall be vibrational isolated from building structure by means of neoprene isolation pads.

H. Adjust primary taps to provide a secondary voltage within $\pm$ 5% of nominal voltage.

END OF SECTION

SECTION 16496

AUTOMATIC TRANSFER SWITCH

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Install where indicated, Automatic Transfer Switch (ATS) with number of poles, amperage, voltage, enclosure, withstand and close-on rating as shown on Drawings or required for the application. It will consist of an inherently double throw power transfer switch mechanism and a microprocessor controller to provide automatic operation. The transfer switch shall automatically transfer its load circuit to an emergency or alternate power supply upon failure of its normal or preferred source or following the sequence indicated on the Drawings.

B. The Contractor is responsible for the erection, installation and start-up of the equipment covered under this Specification.

1.02 RELATED SECTIONS

A. 16010 Basic Electrical Requirements.

B. 16060 Grounding.

1.03 REVIEW

A. Equipment designed, built and tested to meet the latest applicable IEEE, NEMA and ANSI Standards.

B. Equipment manufactured within scope of Underwriters Laboratories, conforming to UL Standards and with UL listing marks.

C. Equipment complies with NFPA 70, “National Electrical Code,” for components and installation, NFPA 110, Emergency and Standby Power Systems, IEEE Standard 446 Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications and NEMA Standard ICS10 for automatic transfer switches.

D. Equipment manufactured by Automatic Switch Co., Russelectric, Westinghouse, or approved equal.

E. Review manufacturer’s literature and shop drawings:

1. Dimensioned outlined drawings (Plan and Elevations).
2. Internal construction drawings and details.
3. Standards’ compliance.
4. Protective device’s characteristics and curves.
5. Short circuit rating.
6. Installation instructions.
7. Spare parts list.
8. Operating and maintenance manuals.

PART 2 PRODUCTS

2.01 GENERAL EQUIPMENT DESCRIPTION

A. Standard product of accepted manufacturers with necessary adjustments to comply with requirements.

B. Service rated when indicated or required by the application.

C. Draw-out type, single solenoid electrically operated, mechanically held and interlocked to ensure only one of the two possible positions.

D. Furnished with manually operated “Connected-Test-Disconnected” positions and with bypass isolation switch with matching electrical ratings. Switches to be draw-out type.

E. All main contacts of silver composition.

F. Switches rated 600 amperes and above shall have front removable and replaceable contacts that must be protected by separate arcing contacts.

G. Provide 2 sets of normally open and normally closed transfer switch auxiliary contacts.

H. Inspection of contacts shall be possible from the front of the switch without disassembly or power disconnection.

I. Where neutral conductors must be switched the transfer shall be provided with fully rated overlapping neutral transfer contacts for a period not to exceed 100 milliseconds. When neutral conductors are solidly connected provide a neutral conductor plate with fully rated copper pressure connectors.

J. Monitor each line of normal source voltage and frequency. Initiate transfer when voltage is below 90% or frequency varies more than 3% from nominal value.

K. Monitor each line of alternate source voltage and frequency. Inhibit transfer when voltage is below 90% or frequency varies more than 3% from nominal value.

L. The controller’s sensing and logic to be provided by a single built-in microprocessor capable of operation over a temperature range of -20 to +60 ºC. Voltage sensing to be true RMS type.

M. Provide three position “Test-Auto-Reset” modes selector switch. The test position to simulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal.

N. Include pilot lights indicating available power source and to which source the ATS is connected.

O. The controller must have the capability of being monitored or commanded remotely.

2.02 CONSTRUCTION

A. Enclosure to be NEMA 1 for air-conditioned indoor areas and NEMA 12 for other indoor areas with an electro coating process applied over a rust-inhibitor phosphated base coating, color to be ANSI 61 gray. For outdoor use a non-corrosive NEMA 4X enclosure is required.

B. Enclosure provided with hinged, gasketed and key lockable door.

C. Provide front access to all equipment.

D. Cable entrance top or bottom as shown on drawings.

E. All external connections to be wired to a common terminal block.

F. The controller shall be connected to the transfer switch by an interconnecting wiring harness that shall include a keyed disconnect plug.

2.03 AUTOMATIC SEQUENCE OF OPERATION

A. Initiate time delay (0 to 10 seconds adjustable) to start engine generator or to transfer to alternate source, upon initiation by normal source monitor.

B. Initiate transfer load to alternate source after initiation by normal source monitor and permission by alternate source monitor.

C. Initiate retransfer load to normal source upon permission by normal source monitor and/or by manual selector switch.

D. Time delay before transfer to normal power (0-30 minutes adjustable). Bypass time delay in event of alternate source failure.

E. Engine warm-up (5 seconds to 3 minutes adjustable), with override switch. Engine cool-down (1 to 60 minutes.)

F. Two-time delay modes adjustable independently shall be provided, one for actual normal power failures and the other for the test mode.

G. All time delays to be adjustable using the LCD display and keypad or with a remote device connected to the serial communications port.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment on a pad in place shown on drawings following manufacturer's instructions and recommendations.

B. Install equipment plumb and in alignment with pad.

C. Grout mounting channels to pad surface.

D. Provide every metal conduit terminating at the ATS with a grounding bushing attached and bonded to the ground bus.

E. Retighten current carrying bolted connection and enclosure support framing and panels to manufacturer's recommendations.

F. Monitor each line of normal (alternate) source voltage and frequency. Initiate (inhibit) transfer when voltage is below 90% or frequency varies more than 3% from nominal value.

END OF SECTION

SECTION 16940

CONTROL AND INSTRUMENTATION PANEL

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install a control and instrumentation panel, complete with all the equipment and devices as shown on the Plans or required by the process.

B. The contractor is responsible for the erection, installation and start-up of the equipment covered under this spec.

1.02 RELATED SECTIONS

A. Section 16010 - Basic Electrical Requirements.

B. Section 16050 - Basic Wiring and Methods.

C. Section 16942 - Alarm Annunciator Panel

1.03 QUALITY ASSURANCE

A. Furnish equipment designed, built and tested by a firm with at least ten years of experience manufacturing this type of equipment.

B. Comply with NFPA 70, NEC, for components and installation.

C. Furnish equipment that bears the UL label.

1.04 SUBMITTAL

A. Submit for review, properly identified manufacturer's literature and Shop Drawings including but not limited to the following:

1. Dimensioned Outlined Drawings (Plan and Elevations)
2. Itemized Bill of Materials
3. Manufacturers' Literature and Shop Drawings for Every Piece of Equipment Mounted on the Panel
4. Enclosure Construction Details
5. Operation and Maintenance Manuals
6. Detailed External Wiring Diagram and Sequence of Operation

PART 2 PRODUCTS

2.01 GENERAL

A. The panel shall contain all the instrumentation, control and indicating devices called for in these Specifications, shown on Plans or otherwise required for the functioning of the system.

B. The system shall have the capability and be easily programmed to produce a more complex control sequence where some or all of the pumps could operate on high speed, or operate on a mixed pattern with some pumps running in low and others in high speed.

C. When a pump is called for in high speed, it shall start in low speed and after reaching full speed, switched without delay to high speed. This requirement if properly coordinated with the motors starters manufacturer, could be made part of the starter.

D. Start stop the pumps by auxiliary relays contacts connected to the automatic circuit of the respective motor starters following the operational system or when the start-stop are remotely by-passed by Monroe County radio telemetry system.

E. Include also (4-20 mA) signal conditioner so both suction pressure readings are available for telemetry monitoring.

F. To prevent excessive pumps cycling, provide adjustable time delays of the start-stop signals.

G. The control panel shall operate from the station battery back up system for continued operation without incoming station power. The battery pack if provided by other must be designed and build to supply this extra load.

H. If due to voltage discrepancies the control panel manufacturer prefers to use 120 volts AC supply, the system shall be backed-up with and uninterruptible power supply (UPS). The UPS shall consist of an inverter with internal redundancy, solid state transfer switch, battery charger, energy storage transformer and filter and sealed lead calcium batteries. Size the UPS to maintain full load for 15 minutes and include a low battery alarm.

I. The Plans shows the general arrangement of front mounted components and approximate dimensions of the control panel.

2.02 CONSTRUCTION

A. House the control panel in a NEMA type 12 enclosure, with 12 gauge sheet steel top and side panels and 10 gauge thick front panel. Panel construction shall be of sheet steel welded to steel frames with all seams ground smooth. Suitable panel stiffeners shall be installed as required to prevent buckling and to maintain a flat surface.

B. To provide easy access to components, provide front full-height gasketed doors with 3-point latches and continuous hinges. If ventilation is required, doors shall be provided with louvers in the top and bottom. The louvers shall be fitted with washable filters.

C. All hardware including hinges, 3- point latches and handles shall be of non-corrodible metal.

D. Perform all punching, reaming, cutting and fabricating before any finish is applied. Prior to painting, clean, degrease and phosphate all panels. For final finishing, not less than three coats of semi-gloss polyurethane paint shall be applied over a rust inhibitor primer. Panel interior to be white with exterior surfaces of light gray ANSI-61.

E. Panels shall be provided with properly sized circuit breakers and lightning arresters connected to incoming power terminals. The panel shall be provided with an isolation transformer. The panel interior shall have at least two duplex convenience outlets and lights with a switch.

F. Provide print pocket inside the panels to hold detailed wiring and interconnecting diagrams. One copy of the relevant plans shall be provided and placed in these pockets.

G. Wiring to be stranded copper with 600 volt rated thermoplastic insulation. Power wiring shall be No. 14 AWG and control wiring No. 16 AWG minimum. Electronic signal wiring shall be No. 18 AWG twisted and shielded pairs. Wiring shall not be spliced. Wiring shall be tagged for identification with printed wire sleeves or self-stick labels.

H. Color Coding to be as follows:

Black	AC Hot (Line Feed and Load Circuits)
White	AC Neutral
Green	Bonding Ground
Red	AC Control Circuits
Yellow	Wiring with Foreign Voltage

I. All wiring to and from field mounted devices shall be terminated at terminal strips, not directly connected to devices. Use plastic wireway Panduit, or equal to route wire within the panel. Wireway shall be run in continuous length with snap-on covers, with AC and DC power wiring in separate wireways.

J. Protect all devices against damage from electrical transients induced in interconnecting lines by lightning discharges and nearby electrical equipment. Surge suppressors shall be provided at least at any interconnection of AC power and electronic equipment and at every analog signal input with circuits extending outside the building.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment on a pad in place shown on Plans following manufacturer's instructions and recommendations.

B. Install equipment plumb and in alignment with the pad and grout bottom channels to the pad surface.

3.02 SYSTEM CHECK OUT

A. After installation, the manufacturer's field service representative shall calibrate and check all control and instrumentation and provide Monroe County with a letter certifying proper operation of every component.

3.03 TRAINING

A. The manufacturer's field service representative shall train Monroe County Instrumentation technicians, in the testing, servicing, and operating of every control and instrumentation component both software and hardware.

B. MDWASD shall receive no less than three (3) programming diskettes and after completion of the training be capable to make operational changes.

END OF SECTION

SECTION 16950

ELECTRICAL TESTING

PART 1 GENERAL

1.01 CODES AND STANDARDS

A. The following is a list of standards that may be referenced in this section:

1. American National Standards Institute (ANSI)

a. 450, Recommended Practice for Maintenance, Testing, and Replacement of Large lead Storage Batteries for Generator Stations and Substations

b. C2, National Electrical Safety Code

c. C37.20.1, Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear

d. C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear

e. C37.20.3, Metal-Enclosed Interrupter Switchgear

f. C62.33, Standard Test Specifications for Varistor Surge-Protective Devices.

2. American Society for Testing and Materials (ASTM)

a. D665, Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water

b. DS77, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

c. D923, Standard Test Method for Sampling Electrical Insulating Liquids

d. D924, Standard Test Methods for A-Class Characteristics and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids

e. D971, Standard Test Method for Interfacial Tension of 0.1 Against Water by the Ring Method

f. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration

g. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

h. D1500, Standard Test Method for ASTM Color of Petroleum Products

i. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field

j. D1533, Standard Test Methods for Water in Insulating Liquids

k. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes

l. D2285, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop-Weight Method.

3. Institute of Electrical and Electronics Engineers (IEEE)

a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery

b. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators

c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

d. 95, Recommended Practice for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage

e. 118, Standard Test Code for Resistance Measurement

f. 400, Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field

4. National Electrical Manufacturers Association (NEMA)

a. AB 4, Guideline for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications

b. PB 2, Deadfront Distribution Switchboards

c. WC 7, Cross-Linked-Thermosetting-Polyethylene- Wire and Cable for the Transmission and Distribution of Electrical Energy

d. WC 8, Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

5. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

6. National Fire Protection Association (NFPA)

a. 70, National Electrical Code (NEC)

b. 70E, Standard for Electrical Safety Requirements for Employee Workplaces

1.02 SUBMITTALS

A. Administrative Submittals: Submit 30 days prior to performing inspections or tests.

1. Schedule for Performing Inspection and Tests

2. List of References to be Used for Each Test.

3. Sample Copy of Equipment and Materials Inspection Form

4. Sample Copy of Individual Device Test Form

5. Sample Copy of Individual System Test Form

B. Quality Control Submittals: Submit within 30 days after completion of test: Test or inspection reports and certificates for each electrical item tested.

C. Contract Closeout Submittals: Operation and Maintenance Data.

1. In accordance with Section 01730, Operation and Maintenance Instrumentation.

2. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in operation and maintenance manual.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications

1. Corporately and financially independent organization functioning as an unbiased testing authority.

2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.

3. An employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.

4. Supervising engineer accredited as Certified Electrical Test Technologist by National Institute for Certification of Engineering Technologists (NICET), or International Electrical Testing Association and having a minimum of 5 years testing experience on similar projects.

5. Technicians certified by NICET or NETA.

6. Assistants and apprentices assigned to project at ratio not to exceed two certified to one non-certified assistant or apprentice.

7. Registered Professional Engineer to provide comprehensive project report outlining services performed, results of such services, recommendations, actions taken, and opinions.

8. In compliance with OSHA Title 29, Part 1907 criteria for accreditation of testing laboratories or a full Member Company of International Electrical Testing Association.

B. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment are to be:

1. Scheduled with Engineer prior to de-energization.

2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Engineer at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Tests specified in this section are to be performed in accordance with the requirements of Division 1-General Requirements.

B. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer’s tolerances.

2. Installation operates properly.

3. Equipment is suitable for energization.

4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, and ANSI C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate protective relays, circuit breakers, fuses, and other applicable devices in accordance with values established by the short circuit and coordination study.

E. Adjust mechanisms and moving parts for free mechanical movement.

F. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents.

H. Ensure all equipment is level, properly aligned, and securely anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Provide proper lubrication of applicable moving parts.

L. Inform Engineer of working clearances not in accordance with NFPA 70.

M. Investigate and Repair or Replace (at not cost to Monroe County).

1. Electrical items that fail tests.

2. Active components not operating in accordance with manufacturer's instructions.

3. Damaged electrical equipment.

N. Electrical Enclosures

1. Remove foreign material and moisture from enclosure interior.

2. Vacuum and wipe clean enclosure interior.

3. Remove corrosion found on metal surfaces.

4. Repair or replace, as determined by Engineer, door and panel sections having dented surfaces.

5. Repair or replace, as determined by Engineer, poor fitting doors and panel sections.

6. Repair or replace improperly operating latching, locking, or interlocking devices.

7. Replace missing or damaged hardware.

8. Paint and touch-up all scratches to electrical enclosures.

a. Provide matching paint and touch up scratches and mars.

b. If required due to extensive damage, as determined by Engineer, refinish the entire assembly.

O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents.

P. Replace transformer-insulating oil not in compliance with ASTM D923.

3.02 DRY TYPE TRANSFROMERS

A. The Contractor shall test in accordance with Section 16460-Transformers- Dry Type and as specified herein.

B. Visual and Mechanical Inspection

1. Physical and insulator damage.

2. Proper Winding Connections.

3. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.

4. Defective wiring.

5. Removal of shipping brackets, fixtures, or bracing.

6. Free and properly installed resilient mounts.

7. Verify that tap-changer is set at correct ratio for rated output voltage under normal operating conditions.

8. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

C. Electrical Tests

1. Insulation Resistance Tests

a. Applied megohmeter DC voltage in accordance with NETA ATS, Table 7.2.3 for each:

1) Winding-to-Winding

2) Winding-to-Ground

b. l0-minute test duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.

c. Results temperature corrected in accordance with NETA ATS, Table 7.2.4.

d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

e. Insulation resistance test results to compare within 1% of adjacent windings.

3.03 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection

1. Inspect Each Individual Exposed Power Cable No. 6 and Larger for:

a. Physical damage.

b. Proper connections in accordance with single-line diagram.

c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.

d. Color coding conformance with specifications.

e. Proper circuit identification.

2. Inspect Mechanical Connections for:

a. Proper lug type for conductor material.

b. Proper lug installation.

c. Bolt torque level in accordance with NETA ATS, Table 10. 1, unless otherwise specified by manufacturer.

3. Inspect Shielded Instrumentation Cables for:

a. Proper shield grounding.

b. Proper terminations.

c. Proper circuit identification.

4. Inspect Control Cables for:

a. Proper termination.

b. Proper circuit identification.

5. Cables Terminated Through Window Type CT's: Verify that neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger

1. Insulation Resistance Tests

a. Test each conductor with respect to ground and to adjacent conductors per IEEE 118 procedures for 1 minute.

b. Evaluate ohmic values by comparison with conductors of same length and type.

c. Investigate values less than 50 megohms.

d. Utilize 1,000 VDC megohmmeter for 600 V insulated conductors.

2. Continuity test by ohmmeter method to ensure proper cable connections.

3.04 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection

1. Proper blade pressure and alignment.

2. Proper operation of switch operating handle.

3. Adequate mechanical support for each fuse.

4. Proper contact-to-contact tightness between fuse clip and fuse.

5. Cable connection bolt torque level in accordance with NETA ATS, Table 10.1.

6. Proper phase barrier material and installation.

7. Verify that fuse sizes and types correspond to one-line diagram.

8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing.

B. Electrical Tests

1. Insulation Resistance Tests

a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.

b. Phase-to-phase and phase-to-ground for 1 minute on each pole.

c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Contact Resistance Tests

a. Contact resistance in microhms across each switch blade and fuse holder.

b. Investigate deviation of 50% or more from adjacent poles or similar switches.

3.05 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 70 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection

1. Proper mounting.

2. Proper conductor size.

3. Feeder designation according to nameplate and one-line diagram.

4. Cracked casings.

5. Connection bolt torque level in accordance with NETA ATS, Table 10.1.

6. Operate breaker to verify smooth operation.

7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.

8. Verify that terminals are suitable for 75°C rated insulated conductors.

C. Electrical Tests

1. Insulation Resistance Tests

a. Utilize 1,000-volt dc megohmmeter for 480 and 600 volt circuit breakers and 500-volt DC megohmmeter for 240-volt circuit breakers.

b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.

c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.

d. Test values to comply with NETA ATS, Table 10.2.

2. Contact Resistance Tests

a. Contact resistance in microhms across each pole.

b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Primary Current Injection Test to Verify

a. Long-time minimum pickup and delay.

b. Short-time pickup and delay.

c. Ground fault pickup and delay.

d. Instantaneous pickup by run-up or pulse method.

e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.

f. Trip times shall be within limits established by NEMA AB 4, Table 5-3.

g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4.

3.06 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection

1. Visually Check Current, Potential, and Control Transformers for:

    a. Cracked insulation.

    b. Broken leads or defective wiring.

    c. Proper connections.

    d. Adequate clearances between primary and secondary circuit wiring.

2. Verify Mechanically that:

    a. Grounding and shorting connections have good contact.

    b. Withdrawal mechanism and grounding operation, when applicable, operate properly.

3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests

1. Current Transformer Tests

    a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.

    b. Polarity test.

2. Potential Transformer Tests

    a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 7.1.1 for 1 minute on:

        1) Winding-to-Winding

        2) Winding-to-Ground

    b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.

3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 7.1.1.

3.07 METERING

A. Visual and Mechanical Inspection

1. Verify meter connections in accordance with appropriate diagrams.

2. Verify meter multipliers.

3. Verify that meter types and scales conform to Contract Documents.

4. Check calibration of meters at cardinal points.

5. Check calibration of electrical transducers.

3.08 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection

1. Equipment and circuit grounds in motor control centers, panelboards, and switchgear assemblies for proper connection and tightness.

2. Ground bus connections in motor control centers, panelboards, and switchgear assemblies for proper termination and tightness,

3. Effective transformer core and equipment grounding.

4. Accessible connections to grounding electrodes for proper fit and tightness.

5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests

1. Fall-Of-Potential Test

a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.

b. Main ground electrode system resistance to ground to be no greater than 5 ohms.

2. Two-Point Direct Method Test

a. In accordance with IEEE 81, Section 8.2. 1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.

b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.

3.09 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 horsepower and larger.

B. Visual and Mechanical Inspection

1. Proper electrical and grounding connections.

2. Shaft alignment.

3. Blockage of ventilating air passageways.

4. Operate motor and check for:

a. Excessive mechanical and electrical noise.

b. Overheating.

c. Correct rotation.

d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionality and proper operation.

e. Excessive vibration.

5. Check operation of space heaters.

C. Electrical Tests

1. Insulation Resistance Tests

a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 10.2 for:

1) Motors above 200 horsepower for l0-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.

2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 and 60 seconds.

b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.

2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.

3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.

4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.

5. Over-potential Tests

a. Applied dc voltage in accordance with IEEE 95.

b. Limited to 4,000-volt motors rated 1,000 horsepower and greater.

c. Test results evaluated on pass/fail basis.

3.10 LOW VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection

1. Proper barrier and shutter installation and operation.

2. Proper operation of indicating and monitoring devices.

3. Proper overload protection for each motor.

4. Improper blockage of air cooling passages.

5. Proper operation of drawout elements.

6. Integrity and contamination of bus insulation system.

7. Check Door and Device Interlocking System by:

    a. Closure attempt of device when door is in “Off” or “Open” position.

    b. Opening attempt of door when device is in “Off” or “Open” position.

8. Check Key Interlocking Systems for:

    a. Key captivity when device is in “On” or “Closed” position.

    b. Key removal when device is in “Off” or “Open” position.

    c. Closure attempt of device when key has been removed.

    d. Correct number of keys in relationship to number of lock cylinders.

    e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.

9. Check Nameplates for Proper Identification of:

    a. Equipment Title and Tag Number with Latest One-Line Diagram

    b. Pushbuttons

    c. Control Switches

    d. Pilot Lights

    e. Control Relays

    f. Circuit Breakers

    g. Indicating Meters

10. Verify that fuse and circuit breaker sizes and types conform to Contract Documents.

11. Verify that current and potential transformer ratios conform to Contract Documents.

12. Check Bus Connections for High Resistance by Low Resistance Ohmmeter and Thermographic Survey:

    a. Ohmic value to be zero.

    b. Bolt torque level in accordance with NETA ATS, Table 10.1, unless otherwise specified by manufacturer.

    c. Thermographic survey temperature gradient of 2°C, or less.

13. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems by:

a. Closure attempt for locked open devices.

b. Opening attempt for locked closed devices.

c. Key exchange to operate devices in ”Off” normal positions.

14. Verify performance of each control device and feature furnished as part of the motor control center.

15. Control Wiring

a. Compare wiring to local and remote control, and protective devices with elementary diagrams.

b. Check for proper conductor lacing and bundling.

c. Check for proper conductor identification.

d. Check for proper conductor lugs and connections.

16. Exercise Active Components

17. Inspect Contactors for:

a. Correct mechanical operations.

b. Correct contact gap, wipe, alignment, and pressure.

c. Correct torque of all connections.

18. Compare overload heater rating with full-load current for proper size.

19. Compare motor protector and circuit breaker with motor characteristics and power factor correction capacitors for proper size.

20. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests

1. Insulation Resistance Tests

a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2.

b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.

c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.

d. Started section phase-to-phase and phase-to-ground on each phase with started contacts closed and protective devices open.

e. Test values to comply with NETA ATS, Table 10.2.

2. Over-potential Tests

a. Maximum applied ac or dc voltage in accordance with NETA ATS, Table 7.1.2.

b. Phase-to-phase and phase-to-ground for 1 minute for each phase of each bus section.

c. Test results evaluated on pass/fail basis.

3. Current Injection through Overload Unit at 300% of Motor Full-Load Current and Monitor Trip Time

a. Trip time in accordance with manufacturers published data.

b. Investigate values in excess of 120 seconds.

4. Control Wiring Tests

a. Apply secondary voltage to control power and potential circuits.

b. Check voltage levels at each point on terminal boards and each device terminal.

c. Insulation resistance test at 1,000 volts DC on control wiring except that connected to solid state components. Insulation resistance to be 1 megohm minimum.

5. Operational test by initiating control devices to affect proper operation.

3.11 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection

1. Check doors and panels for proper interlocking.

2. Check connections for high resistance by low resistance ohmmeter.

3. Check positive mechanical and electrical interlock between normal and alternate sources.

4. Check for Proper Operation

5. Verify settings and operation of control devices.

B. Electrical Tests

1. Insulation Resistance Tests

a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 10.2 for each phase with switch “closed” in both source positions.

b. Phase-to-phase and phase-to-ground for 1 minute.

c. Test values in accordance with manufacturer's published data.

2. Contact Resistance Test

a. Contact resistance in microhms across each switchblade for both source positions.

b. Investigate values exceeding 500 micro-ohms.

c. Investigate values deviating from adjacent pole by more than 50%.

3. Set and Calibrate in Accordance with Specifications

a. Voltage and frequency sensing relays.

b. Time delay relays.

4. Perform Automatic Transfer Tests by:

a. Simulating loss of normal power.

b. Return to normal power.

c. Simulating loss of alternate power.

d. Simulating single-phase conditions for normal and alternate sources.

5. Monitor and Verify Operation and Timing of:

a. Normal and alternate voltage sensing relays.

b. Timing delay upon transfer and retransfer.

c. Interlocks and limit switch functions.

3.12 THERMOGRAPHIC SURVEY

A. Provide a thermographic survey of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 2 and larger at each:

1. Switchgear

2. Low Voltage Motor Control Center

3. Panelboard

B. Provide a thermographic survey of feeder conductors No. 2 and larger terminating at:

1. Motors Rated 30 Horsepower and Larger

2. Switchgears

3. Low Voltage Disconnect Switches

4. Transfer Switches

C. Remove necessary enclosure metal panels and covers prior to performing survey.

D. Perform with equipment energized during periods of maximum possible loading.

E. Do not perform survey on equipment operating at less than 20 percent of rated connected operating load.

F. Utilize Thermographic Equipment Capable of:

1. Detecting emitted radiation.

2. Converting detected radiation to visual signal.

3. Detecting 1 degree C temperature difference between subject area and reference point of 30 degrees C.

G. Temperature Gradients of:

1. 3°C - 7°C indicates possible deficiency that warrants investigation.

2. 7°C - 15°C indicates deficiency that is to be corrected as time permits.

3. 16°C and above indicates deficiency that is to be corrected immediately.

H. Provide Written Report of:

1. Areas surveyed and the resultant temperature gradients.

2. Locations of areas having temperature gradients of 3° C or greater.

3. Cause of heat rise and actions taken to correct the cause of heat rise.

4. Detected phase unbalance.

END OF SECTION

SECTION 16990

POWER SYSTEM STUDY AND PROTECTION RELAY ADJUSTMENT

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall provide the Engineer with six bound copies of a power system study report which shall be made by the manufacturer of the switchgear equipment and shall contain:

1. A short-circuit study performed on a digital computer to check the adequacy and to verify correct application of circuit protective devices and other system components specified.

2. A protective device time-current coordination study with coordination plots of key or limiting devices plus tabulated data including ratings of settings selected. In the study a professional engineering balance shall be achieved between the competing objectives of protection and continuity of service for the system specified, taking into account the basic factors of sensitivity, selectivity, and speed.

3. A motor starting study for each pertinent motor or motor group to determine voltage dip or power inrush limitations at selected locations due to motor starting.

B. The studies shall include representation of the power company's system, the base quantities selected, impedance source-date, calculation methods and tabulations, one-line and impedance diagrams, conclusions and recommendations. Short-circuit momentary duties, when applicable, and interrupting duties shall be calculated on the basis of an assumed bolted three-phase short-circuit at each medium-voltage switchgear bus, medium-voltage controller, low-voltage switchgear bus, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard, other significant locations throughout the systems. The short-circuit tabulations shall include significant X to R ratios, asymmetry factors, KVA, and symmetrical fault current.

C. The coordination plots required shall graphically indicate the coordination proposed for the several systems centered on full scale log forms. The coordination plots shall include complete titles, representative one-line diagrams, and legends, associated power company's relay or system characteristics, medium-voltage motor controller fuses and relays, significant motor starting characteristics, complete parameters for power, network and substation transformers, complete operating bands for low-voltage and circuit breaker trip devices, fuses, as applicable, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required. The short-time region shall indicate the medium-voltage relay instantaneous elements, the magnetizing in-rush, and ANSI withstand transformer parameters, the low-voltage circuit breaker and instantaneous trip devices, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault currents. Each primary protective device required for a delta-to-wye connected transformer shall be selected so that the characteristic or operating band is within the feasible transformer parameters, which shall include a parameter equivalent to 58 percent of the ANSI withstand point to afford protection for secondary line-to-ground faults. Medium voltage relays shall be separated, where feasible, by a 0.3 second time margin when the maximum three-phase fault flows, to assure proper selectivity. The protective device characteristics or operating bands shall be suitably terminated to reflect the actual symmetrical and asymmetrical fault currents sensed by the device.

D. Discrepancies shall be called to the attention of the Engineer in the conclusions and recommendations in the report.

E. The Contractor shall provide the Department with all the information required to incorporate this facility into the computerized Coordination Study and Electrical Power Distribution System Analysis.

F. This information shall include, but not limited to: current transformers' ratio, type and trip of circuit breakers, fuses and circuit breakers curve, busses bracing, damage curves of motors and transformers, motors starting characteristics, complete parameters for substations and motor control centers, etc.

G. The data shall be provided on the forms attached to these specs at the end of this section. The applicable forms shall be completed in their entirety.

H. This information shall be delivered within eight weeks after award of the contract and before submission of Shop Drawings to allow equipment suppliers to consider the information when they select protective devices indicated by the Coordination Study.

I. The Contractor shall be responsible for providing an Integrations Engineer, and furnish any information required to satisfactorily complete the Coordination Study.

J. Integration Engineer shall report any discrepancy found between the Coordination Study conclusions and recommendations and proposals from the equipment manufacturers or suppliers shall be reported to the Engineer for resolution.

K. The Contractor shall have this information reviewed for accuracy and format by a registered Electrical Engineer in the State of Florida. Prior to submitting it to the Department, forms shall be signed and sealed.

1.02 SCHEDULE

A. The study shall be reviewed, signed and sealed by a Registered Electrical Professional Engineer in the State of Florida and submitted with eight weeks after award of the contract and before submission of Shop Drawings.

1.03 ARC FLASH STUDY REPORT:

A. Provide arc flash study in conjunction with short circuit and protective device coordination study.

1. Include all electrical distribution equipment in study including but not limited to:

a) Distribution and branch circuit panel boards.

b) Motor control centers.

c) Individual circuit breakers disconnect switches and molded case switches.

d) Utilization equipment with integral disconnects or panels such as adjustable frequency drives, packaged mechanical equipment and UPS.

e) Automatic transfer switches.

B. Arc flash boundary distances and incident energy at each device shall be determined by worst case incident energy at that device resulting from maximum and minimum available fault current at main distribution switchgear or switchboard for each valid system operating/switching mode under all probable source conditions. For low voltage equipment (600 volt and below), incident energy calculations shall be made at 100 percent and 85 percent arcing current per IEEE 1584.

C. Arc flash analysis shall be performed in accordance with NFPA 70E with calculations performed in accordance with IEEE 1584A.

D. Provide following data for each bus analyzed.

1. Flash Bus Name.

2. Protective Device Name.

3. Bus Operating Fault Current.

4. Protective Device Bolted Fault Current.

5. Protective Device Arcing Fault Current.

6. Trip/Delay Time (SEC).

7. Breaker Opening Time (SEC).

8. Ground.

9. Equipment Type.

10. Gap (mm).
11. ARC Flash Boundary (IN).
12. Working Distance (IN) consistent with Owner's arc flash policy.
13. Incident Energy (CAL/cm2).
14. Required Protective FR Clothing (PPE) Category.

E. Provide following data on each arc flash hazard warning label:
1. Flash Hazard Protection Boundary.
2. Incident Energy Level.
3. Required Personal Protective Equipment Category with brief description.
4. Shock hazard when cover is removed.
5. Limited Approach Boundary.
6. Restricted Approach Boundary.
7. Prohibited Approach Boundary.
8. Include date of calculation, utility short circuit capacity and voltage as of that date.

F. Provide Arc flash hazard warning label on each piece of electrical equipment.

G. Identify arc flash protection boundaries in front of all panel boards, motor control centers, UPS distribution panels, automatic transfer switches and individual disconnects and circuit breakers. Provide outline of arc flash protection boundaries with 2 IN wide strip of red/white Seton M6356 OSHA warning tape or equivalent.

H. A preliminary arc flash study was performed with an example label as shown on the Drawings. Final labels shall incorporate data from the arc flash study provided as a requirement of this Section.

PART 2 PRODUCTS - (NOT APPLICABLE TO THIS SPECIFICATION SECTION)

PART 3 EXECUTION

3.01 CALIBRATION AND ADJUSTMENTS

A. The Contractor shall be responsible for calibrating and making the initial settings of the equipment protective relays and other protective devices.

B. Relays adjustment shall be done in strict compliance with the Coordination Study recommendations and settings.

C. The Contractor shall submit to the Engineer, a list of all equipment he proposes to use to calibrate relays along with the qualifications of the personnel that will do the calibrations. After Department approval, no substitutions will be permitted without written authorization from the Department.

END OF SECTION