Faro Pit Dewatering System Basis of Design

PREPARED FOR: Government of Yukon

PREPARED BY: CH2M HILL Canada Limited

DATE: August 27, 2014

PROJECT NUMBER: 472645.09.CC.01

Overview

This technical memorandum (TM) is submitted in response to Task Authorization Component 009-CC, Faro Pit Dewatering System Basis of Design. This TM describes the requirements for installation of a skid-mounted pump for pumping water from Faro Pit to the Interim Water Treatment System (IWTS). This design assumes the installation and future relocation of the dewatering equipment will be completed by Tlicho Engineering and Environmental Services Ltd. (TEES). The basis for use of a skid-mounted pump is described in *Faro Pit Pumping Barge Analysis* Technical Memorandum (CH2M HILL, 2014).

Faro Pit Dewatering Requirements

Water Level Drawdown

The water level in Faro Pit has been steadily increasing since September 2012, due to decommissioning of the Faro Mill Water Treatment Plant and the need to store Intermediate Pond Dam (ID pond) water and Emergency Tailings Area (ETA) water in Faro Pit. As of January 13, 2014, the Faro Pit water level was at elevation 1,148.2 metres (m) (TEES, 2014). The typical water level operating range is between 1,141 m and 1,143 m.

Beginning in the summer of 2014, water will be pumped from Faro Pit and treated at a new IWTS located below the old Faro Mill, in the area previously used for concentrate load out. By this time the water level in Faro Pit is expected to be near 1,150 to 1,151 m. Results of GoldSim modelling suggest it will take until the summer of 2016 to return the water level to the typical operating range. This will necessitate moving the skid-mounted pump progressively down the pit ramp as the water level is lowered, as well as possibly backing it up at the end of the treatment season to allow for water level rebound. Pumping requirements from Faro Pit to the IWTS are provided in the following section.

Interim Water Treatment System

Startup and Capacity

It is planned that the IWTS will start operation towards the end of July 2014. Initial operation will consist of using one of the two treatment trains (Train 1) while the other (Train 2) is being constructed. Each train will have a maximum capacity of 11,350 litres per minute (L/min) (3,000 United States gallons per minute [USgpm]), for a combined capacity of 22,700 L/min (6,000 USgpm). Train 2 is expected to start operation mid-to late-August 2014. Startup and commissioning of Train 1 is expected to be performed at about 7,570 L/min (2,000 USgpm) using Faro Pit water, and will be increased once performance has been demonstrated. Train 2 will be started similar to Train 1.

Three sources of water will be piped to the IWTS and blended in a tank (known as the break pressure tank) located just south of Faro Mill above the IWTS. Water from Faro Pit will be pumped up the pit ramp and then flow by gravity to this tank. Water from the ID Pond and ETA will pumped in separate pipelines to the

The document contained herein should be considered Final as approved by the Government of Yukon on August 27, 2014 with no changes made since the draft submission.

tank using existing pumping systems. The blended water will flow by gravity out of the tank and down the slope to the IWTS, where valves and piping inside the IWTS building will allow the flow to be proportioned between the two trains. The flow rate to each train will be measured and recorded using flow meters.

The capacity of the ID Pond pumping system is about 8,200 L/min (2,170 USgpm), and the ETA system capacity is about 1,000 L/min (260 USgpm) (CH2M HILL, 2013). Therefore, the Faro Pit skid-mounted pumping system should have a flexible flow rate to reach full IWTS capacity.

It is recommended that the Faro Pit system be able to provide about 2,000 to 6,000 USgpm. This range meets the Train 1 and Train 2 startup condition, as well as provides flexibility for managing flow to the IWTS depending if the ID Pond and ETA pumping systems are operating.

Operating Season

The typical operating season for the Faro Pit pumping system and the IWTS is assumed to be from mid-May to mid-October, depending on weather and the ambient temperature. The Faro Pit pumping system is not being designed for winter operation.

Dewatering Pump System Design

Skid-Mounted Pump

The recommend pump is a Cornell 10NNT constructed in cast iron with a 350-horsepower (hp) motor and a variable frequency drive (VFD), having an impeller diameter of 17.5 inches, a 10-inch suction, and a 10-inch discharge. The pump quotation and performance curve is provided in Attachment 1.

The pump should be purchased as a skid-mounted unit with all the necessary fitting and controls incorporated to facilitate installation, limit field connections, and simplify future relocation. This includes the following:

- Discharge check valve
- Isolation valve
- Inlet and outlet pressure gauges
- VFD suitable for climatic conditions
- National Electrical Manufacturers Association (NEMA) 3R enclosure
- Control panel with:
  - on/off switch
  - fault indicator light
  - speed control
  - speed indicator
- Flow meter and discharge isolation butterfly valve (on a separate skid)
- 100 millimetres (mm) knife gate valve with cam and groove coupling for draining of the discharge pipe
- Duplex convenience receptacle
- Lighting
- Electric heater for control panel and VFD

The pump should be provided with Hand/Local/Remote/Off control. Hand control allows the operator to manually select a constant speed for the pump. In local auto control, the operator enters a flow set point at the skid and the VFD automatically modulates the pump speed based on the flow meter 4-20 milli amperes (mA) output. In remote auto control, the VFD accepts an external flow or speed set-point and adjusts the pump speed accordingly. A remote signal will not be installed at this time but the option will be provided at the skid if a signal is provided in the future.

The receptacle, lighting, and heater must be confirmed as they require the addition of a mini-power center with separate breakers.

Materials of Construction

It is recommended that the pump and impeller be constructed of cast iron due to lead-time constraints. This material will provide many years of service at the current water quality of Faro Pit. A spare impeller, volute, and backplate constructed of CD4MCu stainless steel is recommended so the pump can be used in more acidic water applications.

Pump Location

The pump skid will be located on the Faro Pit ramp, as close to the water as possible to minimize the number of relocations as water level decreases. It is assumed that the pump skid can be situated on a relatively level portion of the pit ramp or the location can be graded appropriately onsite. The pump will not be placed on a concrete pad. Depending on the suction pipe arrangement used, the pump will be located either near the pit edge with the suction pipe routed over the edge or near the pit wall with the suction pipe routed down the ramp. Locations 'A' and 'B' are shown in Attachment 2. Suction configurations are discussed further in this TM.

The skid location at the end of the operating season must be carefully chosen because the pit water level will increase during the off-season. Care must be taken that the skid or ancillaries do not become flooded. The pump should be moved up the pit ramp if needed.

Suction and Discharge Pipe Routing

Because site-specific conditions are unknown until the pump is installed, two suction piping arrangements are described. Their selection depends on water level, ramp width, and ramp edge shape. Pump location 'A' routes the suction pipe over the edge of the pit. Pump location 'B' routes the pipe down the pit ramp. 'A' provides the shortest route; however, it may be necessary to cut the bank and provide a means to secure the pipe to the pit wall to avoid excess strain on the pump flange. 'B' requires a longer pipe, weighted collars placed on the ramp, and has greater potential to draw grit into the pump. Both of these options have been discussed with TEES staff. TEES will develop a recommended approach based on site-specific ramp conditions and availably of suction piping components.

The pump discharge will be routed to the hillside edge of the ramp, turn 90 degrees, and connect to the existing pipe at a new reducer. The elbow allows the existing pipe to expand and contract with limited impact on the skid. Thrust blocking may be required at the elbow. Additional thrust blocks may be required at the pipe immediately adjacent to the pump skid to prevent large forces from stressing the skid connection.

Piping

The suction pipe is to be 450-mm high-density polyethylene (HDPE) with a reducer to suit the 10-inch suction flange. The wall thickness should be at least DR17 to sustain a suction pressure of 30 kilopascal (kpa) (4.3 pounds per square inch [psi]).

The discharge pipe connecting to the 750-mm pit ramp pipe can be between 18- and 24-inches depending on what pipe is available at the site or is available for purchase. This range allows use of the onsite HDPE pipe welding machine which has a maximum size of 24 inches. An appropriately-sized reducer to connect to the 750-mm pipe will be needed. Note that the end of the existing 750-mm pipe has an existing flange connection.

Wall thickness is determined by the design discharge pressure. The normal max operating discharge pressure at low pit water level and 100-percent pump speed is approximately 415 kilopascal gauge (kpag) (60 pounds per square inch gauge [psig]). The discharge pressure at shutoff will be about 930 kpag (135 psig). A pipe dimension ratio (DR) of 13.5 or smaller (higher pressure rating) is needed.

Flow Meter Skid

A discharge flow meter is recommended and will allow the pump skid to operate in auto mode with the VFD controlling the discharge flow rate, and allows the total volume pumped to be tracked over time. A 400-mm

magnetic flow meter with hard rubber or polyurethane lining will be installed on the pump discharge. The meter will be mounted on a dedicated skid between two 400-mm T316L SST pipe spools with reducing-type 450 mm ANSI CL 150 flange to connect to 450 mm DR 17 HDPE pipe. A 400 mm CF8M SST butterfly type isolation valve is upstream of the spool discharge flange. The flow meter is specified in the pump quotation.

The dedicated skid allows the meter to be moved independently from the pump skid or to be used if the pump is out of service. The meter skid can also be pinned to the pump skid. Placing the meter independent of the pump can eliminate relocation of the meter with the pump as the water level fluctuates. However, new power and control cables to the meter would be required as the distance from the pump changes. Pinning the skids together requires more effort when relocating the skids but simplifies the power and control wiring and provides better connections between the equipment.

If a meter is not installed, the pump can be operated in manual mode with the operator selecting the speed. The discharge flow rate can be approximated from the pump curve or measured using the IWTS inlet flow meters provided by Veolia Water Solutions and Technologies Canada, assuming that the IP Pond and ETA flows are known.

Power Supply

A new skid-mounted transformer will step power down from 4,160 volts (V) to 600 V. 500 kilovolt-ampere (kVA) is sufficient for the new 260 kilowatts (kW) (350 hp) skid-mounted pump or, if the existing barge is reconnected when the pit water level is returned to the normal operating range since only one of the 168 kW (225 hp) barge pumps will be used at a time. The size is sufficient for additional minor loads such as a pole light. The transformer will be suitable for the climate and, if necessary, placed in a prefabricated enclosure for weather protection. The enclosure will not be insulated or heated. A specification for the transformer is included in Attachment 3.

The transformer is to be installed at the base of the second hydro pole (Figure 1) and protected by bollards. The cable from the transformer to the pump will be direct-buried or laid in a conduit where it crosses the pit ramp and then routed above grade along the edge of the ramp to the pump. A berm will protect the above-grade section of cable from vehicles. A grounding rod or coil will be required for the transformer.

Voltage drop will occur when the length of cable between the transformer and load exceeds 30 m. However, voltage drop can be limited by increasing the 600-V cable gauge. This is less expensive than relocating the transformer and increasing the 4,160 V cable length as the pit water level decreases. A cutsheet for the electrical cable is provided in Attachment 3.

Pump Relocation

The Faro Pit skid-mounted pump will produce a maximum suction lift of approximately 3 m. Once this drawdown is achieved it will be necessary to relocate the skid to avoid cavitating the pump. Relocation requires disconnecting power, inlet pipe, and suction pipe. If the flow meter skid is pinned to the pump skid, both skids will be relocated to a new level, gravel pad close to the water surface. The suction pipe will be relocated and reconnected to the pump skid. A new length of flanged discharge pipe will be bolted between the relocated skid and existing pipe or, alternatively, the existing pipe can be cut and a new length of HDPE pipe welded in. Power will be reconnected by extending the 600-V cable.

The pump may also need to be relocated at the end of the operating season to avoid flooding the pump as the pit water level rises. However, careful placement of the skid before the end of the operating season may avoid this extra relocation.

Works Cited

CH2M HILL Canada Limited (CH2M HILL). 2014. *Faro Pit Pumping Barge Analysis*. Draft. Technical memorandum. Prepared for Government of Yukon. March.

Attachment 1
Pump Quotation and Performance Curve

Pump Data Sheet - Cornell

Company:

Name:

Date: 1/14/2014

Pump:

Size: 10NNT

Type: Encl Solids Handling
Synch speed: 1800 rpm

Speed: 1780 rpm
Line: 16.44"

Curve: 10NNT18

Impeller:

Specific Speeds:

Ns: 2750
Nss: ---

Dimensions:

Suction: 10 in
Discharge: 10 in

Pump Limits:

Temperature: 250 °F
Pressure: 125 psi g
Sphere size: 3.38 in

Power: ---
Eye area: ---

Search Criteria:

Flow: 6950 US gpm

Head: 145 ft

Fluid:

Water
SG: 1
Viscosity: 1.105 cP

Temperature: 60 °F
Vapor pressure: 0.2563 psi a
Atm pressure: 14.7 psi a

NPSHa: ---

Motor:

Standard: NEMA
Enclosure: TEFC

Size: 350 hp
Speed: 1800
Frame: 449T

Sizing criteria: Max Power on Design Curve

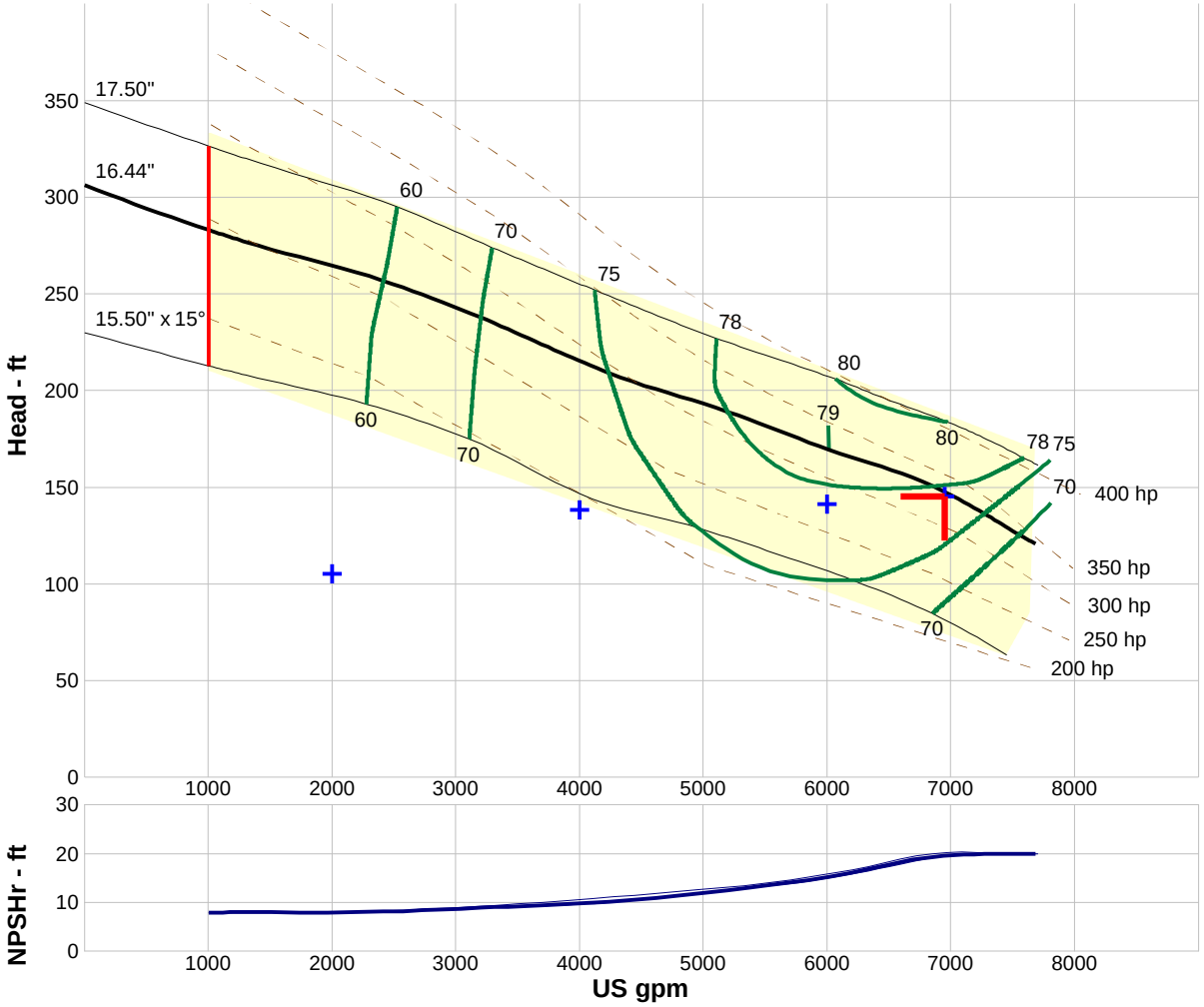
Pump Selection Warnings:

Pump shutoff dP exceeds limit for the pump.

---- Data Point ----	
Flow:	6950 US gpm
Head:	147 ft
Eff:	77%
Power:	334 hp
NPSHr:	19.5 ft

---- Design Curve ----	
Shutoff head:	306 ft
Shutoff dP:	133 psi
Min flow:	1000 US gpm
BEP:	79% @ 6013 US gpm
NOL power:	344 hp @ 7683 US gpm

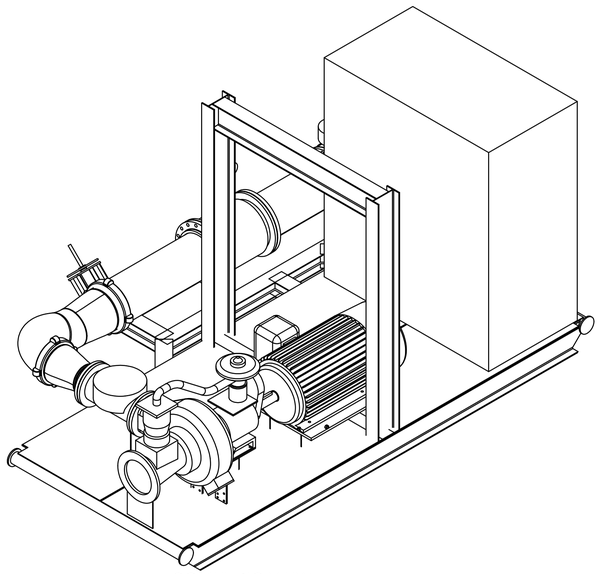
-- Max Curve --	
Max power:	406 hp @ 7257 US gpm



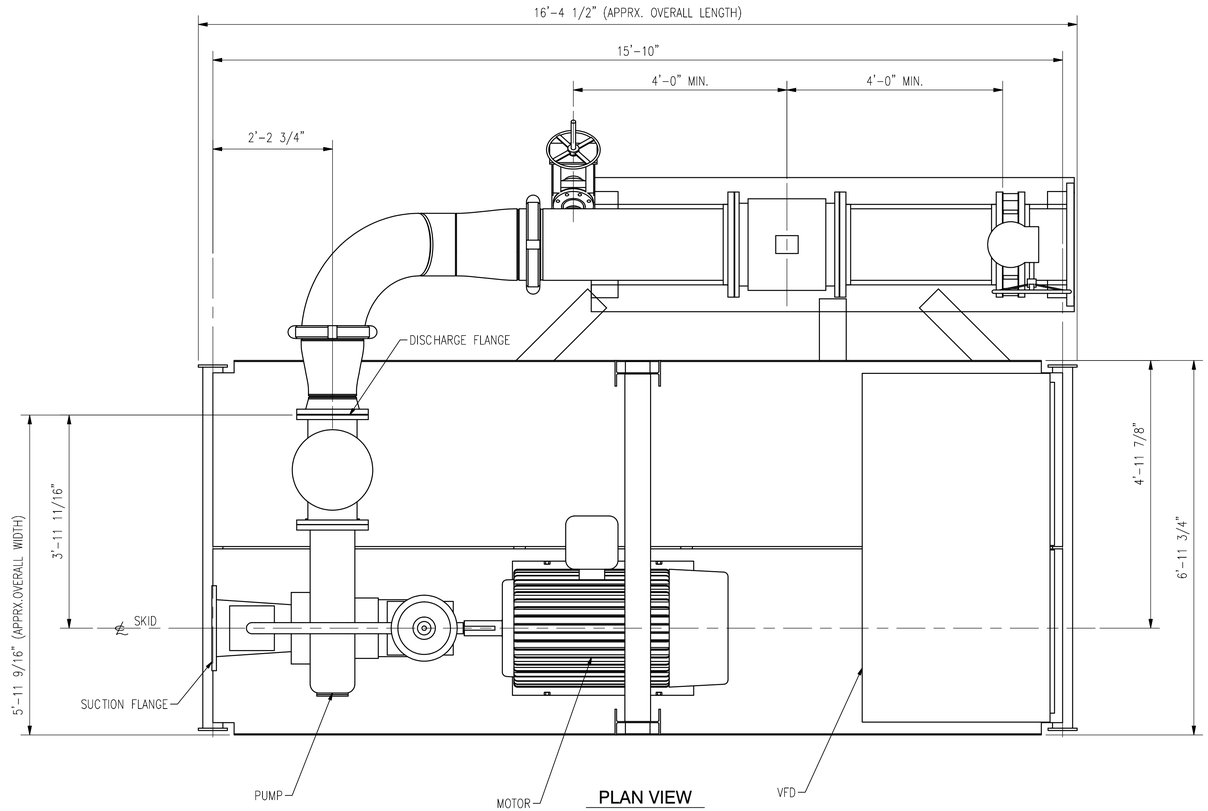
Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
8340	1780	---	---	---	---
6950	1780	147	77	334	19.5
5560	1780	180	78	321	13.8
4170	1780	211	75	297	10.1
2780	1780	248	65	267	8.51

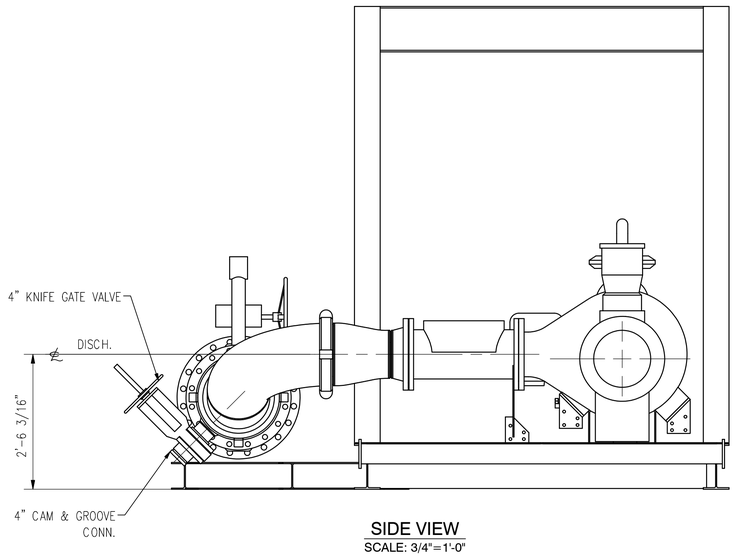
Selected from catalog: Cornell.60 Vers: 3.0



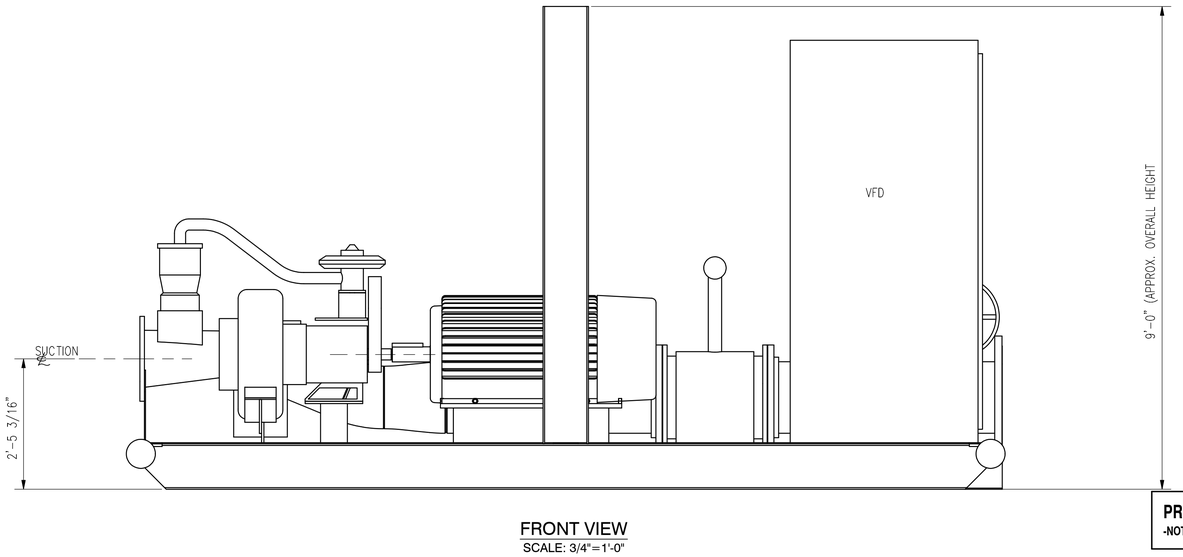
ISOMETRIC VIEW
SCALE: N.T.S



PLAN VIEW
SCALE: 3/4"=1'-0"



SIDE VIEW
SCALE: 3/4"=1'-0"



FRONT VIEW
SCALE: 3/4"=1'-0"

PRELIMINARY
-NOT FOR CONSTRUCTION-

DWG. NO.	REFERENCES

NO.	REVISION	BY	DATE

NO.	REVISION	BY	DATE
B	ADDED 4" DRAIN	TWS	3/7/14
A	ISSUED FOR REVIEW	TWS	1/30/14

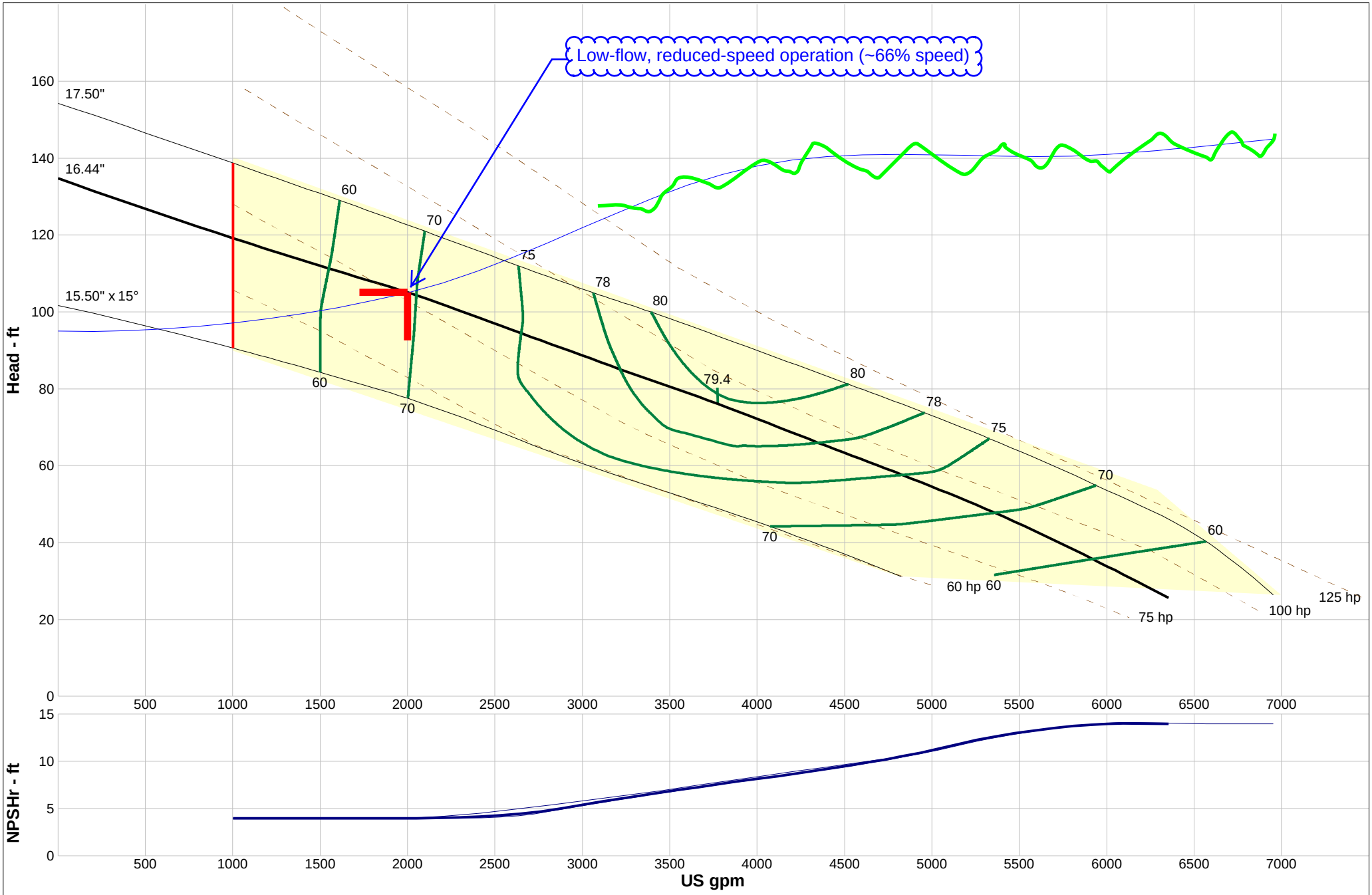
JOB NO. 14M009		DATE
DESIGNED BY	TWS	1/30/14
DRAWN BY	TWS	1/30/14
Q.C. CHECK BY		
ENG. CHECK BY		
DIM. CHECK BY		
APPROVED BY		

MILLER ENGINEERING
A Division of Miller Sales & Engineering, Inc.
3801 N. HIGHWAY DR., TUCSON, ARIZONA 85705

FARO MINES

CH2M HILL	SCALE: AS NOTED	SHT SIZE D
PUMP SKID LAYOUT	DRAWING NUMBER: 14M009-SK-01	REV. B

LAST UPDATED: 1/30/2014 FILE NAME: 14M009-SK-01.idw



Company:
Name:
3/12/2014

Cornell
Catalog: Cornell.60, Vers 3.1
Encl Solids Handling - 1200
Design Point: 2000 US gpm, 105 ft

Size: 10NNT
Speed: 1180 rpm
Line: 16.44"
Curve: 10NNT12

CORNELL®

QUOTATION

Miller Sales & Engineering, Inc
3801 N. Highway Drive
Tucson, AZ 85705
Ph: 520-888-2605
Fax: 520-888-5984
By: Bruce Greene

FARO Mine
Pump Skid

Date: 12-Mar-14
Quote No: 14M009-R1
Sheet 1 of
Delivery: 16-18 wks
FOB: Tucson, AZ

ITEM	QTY	U/M	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
			Max Rate: 6950 gpm @ 147 ft (44.8m) with 16.4" impeller trim, 60Hz **Design Rate: 6000 gpm @ 141 ft TDH (42.97m)** **Secondary Design Rate: 4000 gpm @ 138 ft TDH (42.06m)** **Fluid: Mine water, ambient, pH <7, minimal solids** **Elev: 1280m (4200 ft)**		
1	1	ea	**Pump Skid to include:** (1) Cornell self priming centrifugal pump. model 10NNT, Cast iron construction, CD4MCU Float box on Priming system, 316 SS Discharge check valve (1) 350 hp, TEFC, 575v/3/60, Prem eff motor (1) Toshiba AS1 VFD, 575v, rated 350 hp at 1200m elev., NEMA 3R enclosure, includes Contactor Bypass and Rotating Beacon (1) Local control keypad option 0-10VDC signal to VFD for setpoints (1) Future remote control option included (1) Fabricated steel skid, Motor Coupling, Guard, Shop Paint (1) Mounting, Hardware, Wiring and Conduit (1) VFD shop testing (1) O&M Manuals	$154,400.00	$154,400.00
2	1	ea	**Spare Motor, 350hp, TEFC, 575v/3/60, Prem eff, for VFD duty**	$18,948.00	$18,948.00
3	1	ea	**316 SS Pipe Spool, Flow Meter, Control Valve Assembly** (1) Ultrasonic Flow Meter: Sparling Tigermag, polyurethane lined 16" , 316 SS electrodes, 150# flanges, digital return signal & display (1) Control Valve: 16" Butterfly, 316 SS, lug style w/ gear operator Piping: 316 SS, Sch 40 to include: (1) 12 x 14 reducer, flg x vic (1) 14" 90 long radius el with14 x 16 reducer, vic x vic (2) 16" flanged pipe spools, before & after flow meter (1) 16" flg pipe spool after control valve with 18" 150# RF flg bored to 16" for connection to HDPE pipe (1) 4" drain with full port gate valve (1) Flange Gaskets, Grooved Couplings and Hardware (1) Fabricated steel pipe skid, skid to be shipped separate and will have provision to bolt to pump skid, piping pre-assembled	$36,120.00	$36,120.00
			Ship In: 16-18 weeks		
4	1	ea	**Estimated freight**	$18,000.00	$18,000.00
			Spare part list and pricing to follow.		
			Payment Terms: US$ >50% down payment net 30 ARO >Final payment (50%) net 30 days from ship date Quotation firm for thirty (30) days	Total	$227,468.00

Attachment 2
Faro Pit Dewatering Design
Configuration A and B

Preliminary drawing, not for construction until stamped and sealed

FARO PIT WATER SURFACE

PREVIOUS SHORELINE

EXISTING BARGE PUMP (DISCONNECTED)

ASSUMED CURRENT SHORELINE

PUMP SKID

NEW HDPE SUCTION PIPE:
MIN. DIAMETER 450mm
MIN. DR17;
INSTALL CONCRETE SADDLES
AS NEEDED TO WEIGH PIPE DOWN

SURFACE MOUNTED 600V CABLE

NEW HDPE DISCHARGE PIPE:
MIN. DIAMETER 450mm
MIN. DR 13.5

FLOW METER SKID

REDUCER

BURIED 600V CABLE

NEW SKID MOUNTED TRANSFORMER WITH BOLLARDS OR BARRIERS AT CORNERS

EXISTING 750mm HDPE DISCHARGE PIPE

EXISTING 4160V OVERHEAD POWER

FARO PIT WATER SURFACE

SITE LAYOUT
1:500

0 5 10 15 20 25m

NO.	DATE	REVISION	DR	CHK	BY	APVD
DSGN						

CH2MHILL®

FARO MINE REMEDIATION
FARO PIT DEWATERING
GOVERNMENT OF YUKON
DESIGN

FARO PIT PUMP CONNECTION CONFIGURATION A

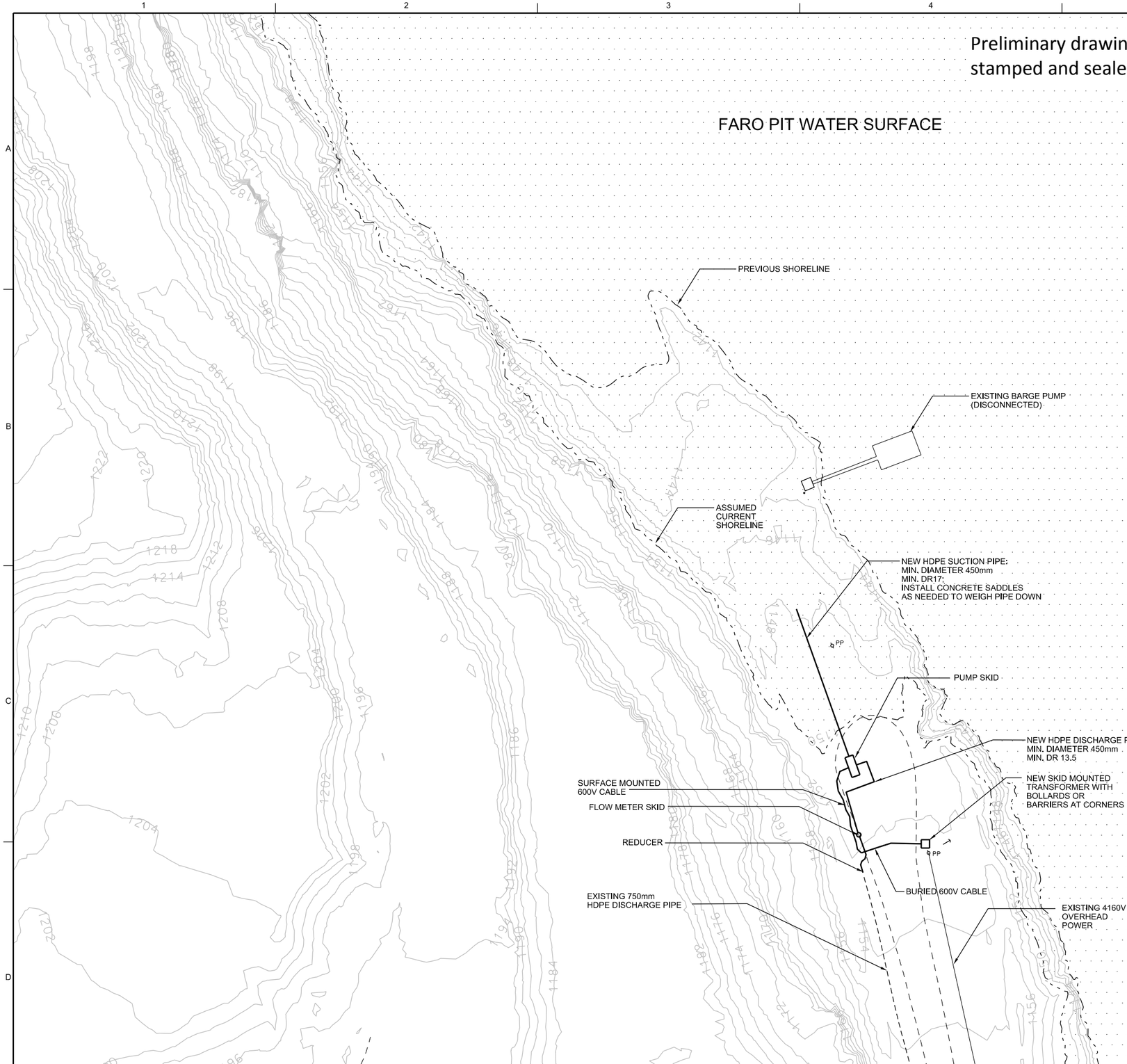
VERIFY SCALE
BAR IS 25mm ON ORIGINAL DRAWING.
0 25mm

DATE	MARCH 2014
PROJ	TA013-427716
DWG	
SHEET	

FILENAME: X-Faro-Pit-DewateringB.dgn PLOT DATE: 2014\03\28 PLOT TIME: 3:01:46 PM

Preliminary drawing, not for construction until stamped and sealed

FARO PIT WATER SURFACE



FARO PIT WATER SURFACE

SITE LAYOUT

1:500

0 5 10 15 20 25m

NO.	DSGN	DATE	DR	REVISION	CHK	BY	APVD
					APVD		

CH2MHILL®

FARO MINE REMEDIATION
FARO PIT DEWATERING
GOVERNMENT OF YUKON
DESIGN

FARO PIT PUMP CONNECTION CONFIGURATION B

VERIFY SCALE

BAR IS 25mm ON ORIGINAL DRAWING.
0 25mm

DATE	MARCH 2014
PROJ	TA013-427716
DWG	
SHEET	

FILENAME: X-Faro-Pit-DewateringB.dgn PLOT DATE: 2014\03\28 PLOT TIME: 2:42:10 PM

Attachment 3
Transformer Specification and Cable Cutsheet

SECTION 26 12 13

PREPURCHASED LIQUID FILLED TRANSFORMER

PART 1

PART 2 GENERAL

2.1 SUMMARY

A. Comply with Division 1 - General Requirements.

2.2 REFERENCES

A. CAN/CSA-C88 Power Transformers and Reactors.

B. Applicable sections of ANSI Standard C57.

2.3 SUBMITTALS

A. Shop Drawings
   1. Submit the following shop drawings and data for each transformer:
      a. Data sheet.
      b. Base plan, outline and assembly arrangement drawings.
      c. Lifting, jacking, hauling, rolling and skidding data.
      d. Required services and connection points.
      e. Core and coil assembly drawings.
      f. Schematic and wiring diagrams.
      g. Nameplate, connection and voltage phasor diagrams.
      h. Centres of gravity.
      i. Details of ancillary devices.

B. Operating and Maintenance Manuals
   1. Prior to shipping equipment, submit Operating and Maintenance Manuals, including, but not limited to the following:
      a. Installation, operation and maintenance instructions.
      b. Parts list with details of local service and supply organizations.
      c. Certified test results.
      d. Final record drawings.
      e. Final data sheets.

2.4 QUALITY ASSURANCE

A. Subject transformer to standard factory tests and production tests as specified by CSA C88. Perform additional tests as indicated on data sheets.

B. Prior to shipment, submit four copies of certified test results.

PART 3 PRODUCTS

3.1 ACCEPTABLE MANUFACTURERS:

A. ABB Canada Inc.

B. Ferranti-Packard Transformers

C. Federal Pioneer Limited

D. Northern Transformer Inc.

E. Carte International

3.2 MANUFACTURED UNITS

A. Comply with Liquid Filled Transformer Performance Data Sheets.

B. Comply with CAN/CSA-C88.

C. Terminating Facilities
1. Primary and secondary termination fittings: To carry maximum full load current, and overload capabilities.
2. Tank-mounted bushings: With threaded studs.
3. Cable connections: Steel, air-filled junction boxes of suitable size to accommodate conductors from top, adequate space for installation of cable termination devices and lightning arresters.
4. Entry plates: Removable, non-magnetic.
5. Terminal construction: Permit rotation around bushing stud.
6. Bushings: To EEMAC GL1-3.
7. Grounding terminals or pads: Two, positioned at diagonally opposite corners of tank, accommodate #2/0 AWG to 500 kcmil copper ground conductors.
8. Neutral: Connect Wye point of winding to fully rated neutral bushing.

D. Insulating Liquid
1. Insulating liquid: Mineral oil or environmentally friendly fluid. Supply one filling.
2. Do not ship liquid separately unless required by shipping limitations.
3. Mineral oil: 1 ppm PCB maximum.

E. Tank
1. Welded seam construction, oil-tight under normal operating conditions, pressure relief vent and alarm contact on sealed tank design.

F. Current Transformers
1. Phase current transformers: Accuracy class for application and burden indicated, 5A secondary.
2. Neutral bushing current transformer: Multi-ratio, relaying accuracy for burden of relays indicated, 5A secondary.

G. Filter, Sampling and Drain Connections
   1. Provisions: Drain, filter and sampling valves.

H. Accessories
   1. Standard accessories: CAN/CSA-C88.
   2. Winding temperature indication: Local hot-spot gauge indication with separate alarm and trip dry contacts, rated 120 V, for control requirements in addition to cooling system requirements.
   3. Top liquid temperature indication: Local gauge indication with separate alarm and trip dry contacts, rated 120 V, for control requirements in addition to cooling system requirements.
   4. Liquid level indication: Local gauge indication with separate low level alarm and trip dry contacts, rated 120 V.
   5. Sudden pressure device: Trip contacts, 120 V.
   6. Gas detector: Bucholtz type, for detecting internal faults, separate alarm and trip contacts, rated 120 V.
   7. Pressure/Vacuum indication: Local gauge indication with separate alarm and trip contacts, rated 120 V.
   8. Lightning arresters: Tank mounted with brackets attached to main tank, adjacent and connected to associated bushings.

I. Indicating and Alarm Devices
   1. Indicating devices: Visible and legible from grade level.
   2. Resettable devices: Operable from grade level.

J. Tap Changer
   1. Manual type: Lockable, operable from grade level, position indicator visible and legible from grade level.

K. Surface Preparation and Coatings
   1. Finish: Prime and finish paint transformer and appurtenances to manufacturer's standard specifications, suitable for operating environment.
   2. Cabinet enclosure: Matte white interior finish, exterior finish matching transformer exterior.
   3. Field touch-up paint: One litre of original paint from transformer manufacturer.

L. Nameplates and Warning Signs
   1. Warning signs: Engraved plastic with 13 mm white letters on red background, on cover of high and low voltage junction boxes and bus terminals. The engraving on warning signs to indicate switching devices to be opened to de-energize transformer.
   2. Nameplates: Non-corroding material to indicate transformer rating and connection diagrams, together with Owner's equipment number. Separate lamacoid nameplates for identification of devices and components.

PART 4 EXECUTION

4.1 INSPECTION AND TESTING

A. Check connections of transformer assembly, including tap changer, for mechanical security and electrical continuity.

B. Check insulating liquid for correct quantity.

C. Measure primary and secondary voltages at each tap setting and verify nameplate values. Operate no-load tap changers only when transformer is de-energized.

D. Set tap changer to provide rated secondary voltage at no load corresponding to value of primary voltage available.

PART 5 DATA SHEETS

5.1 SHEET #1

EQUIPMENT NUMBER		SERVICE DESCRIPTION	
DESCRIPTION	**REQ'D**	**DESCRIPTION**	**REQ'D**
SITE CONDITIONS		COOLING SYSTEM	
Location		Medium: **Mineral Oil**	YES
Ambient Design Temperature	Minus 40°C TO +40°C	CSA Designation: **O**NAN	ONAN
Elevation: above sea-level	1200 m	Cooling Fan Controls excluded.	Excluded
		Control Location Tank mtd	Tank
		Tank Design: [**S**ealed, **C**onserv. tank]	S
		Temperature Rise at rated kVA	55°C
DESIGN CONDITIONS			
Rating	500 kVA		
No. of Phases	3		
Frequency	60 Hz	WINDINGS	
Primary Voltage	4.16 kV	Material	Copper
Secondary Voltage	600 V		
Primary Configuration **D**elta	D		
Secondary Configuration **W**ye	Y		
Primary BIL	60 kV	PRIMARY CONNECTIONS	
Secondary BIL	30 kV	Type: [Cover Mounted Bushings/Throat and Transition Section/Bus Duct/Cable Terminal Box]	CMB
Neutral Grounding Method [**S**olid, **L**ow Res., **H**igh Res.]	S		
Impedance at Base kVa	5.75%		
		Cable Termination Method	
		Conductors: Number and Size/Phase	
TAPS			
Type [**Off**-load, **On**-load]	Off	SECONDARY CONNECTIONS	
Operation [**M**anual, **A**uto]	M	Type: [Cover Mounted Bushings/Throat and Transition Section/Bus Duct/Cable Terminal Box]	CMB
Number, FCAN	2- 2 ½ %		
Number, FCBN	4- 2 ½ %	Primary & Secondary Cable Entry	BOTTOM
		Cable Termination Method	
		Conductors: Number and Size/Phase	500KCMIL
		Neutral Conductor: Type and Size	
REMARKS:			

5.2 SHEET #2

EQUIPMENT NUMBER		**SERVICE DESCRIPTION**	
DESCRIPTION	**REQ'D**	**DESCRIPTION**	**REQ'D**
NEUTRAL GROUNDING RESISTOR	**NO**	CONTROL CABINET	
Voltage Class	V	Enclosure Type:	
Rated Current	A	Anti-Condensation Heaters:	
Duty: [Cont, 10 sec.]		120 V, 100 W Lamp	
Elements [**C**ast Iron, **S**tainless Steel]		Duplex, 120 V, 15A U-Ground receptacle	
Enclosure Type	NEMA 3R, Outdoor	Auxiliary Supply: Voltage	
Location: [**T**ransformer Mounted/**R**emote]		No. of Phases	
		Frequency	
LIGHTNING ARRESTERS		Source	
Location [**P**rimary, **S**econdary, **B**oth Windings]	P		
Voltage Class	9 kV		
Class [Station, Inter, Dist.]	Dist		
		TESTS	
ACCESSORIES AND FEATURES		Standard Production Tests	Y
Tank Top [**W**elded/**B**olt-on]	B	Temperature Rise Test	Y
Tank Construction	Double wall Outdoor Use	Sound Level Test	Y
Primary Bushing C.T.	NO	Coolant Tests	Y
Secondary Phase Bushing C.T.	YES	BIL Test	Y
Neutral Bushing C.T.	YES		
Pressure Relief Device c/w 2 Form C Contacts	YES		
Liquid Level Indicator	YES		
Top Liquid Level Temperature Indicator	YES		
Hot Spot Winding Temperature Indicator	YES		
Sudden Pressure Relay	YES		
Gas Detector Relay	YES		
Pressure/Vacuum Bleed Device	YES		
Finished Colour	Manufacturer's Standard		
REMARKS:			

PART 6 VENDOR'S DATA SHEETS

6.1 SHEET #1

	DESCRIPTION OF DATA REQUIRED	UNIT	ITEM NO.:	ITEM NO.:
	PHYSICAL DATA			
	Overall height (incl. bushings etc.)	mm		
	Overall length (incl. terminal box, throat etc.)	mm		
	Overall width (incl. radiators)	mm		
	Tank height	mm		
	Tank length	mm		
	Tank width	mm		
	Weight, core and coils	kg		
	tank and fittings	kg		
	conservator tank	kg		
	cooling medium (oil, etc.)	kg		
	total	kg		
	Insulation Class	-		
	Voltage taps (No., % step, type)	-		
	Primary/secondary winding arrangement	-		
	Winding material - primary/secondary	-		
	Coolant quantity	l		
	Liquid preservation system (sealed/conser.)	-		
	Radiators	-		
	TECHNICAL DATA			
	Cooling medium (LNAN, ONAF, etc.)	-		
	Temperature rise at service condition	°C		
	Transformer impedance at base rating	%		
	Transformer ratings at service condition	kVA		
	No load loss	kW		
	Load loss @ 25/50/75/100/110% of full load	kW		
	Basic impulse level - primary winding	kV		
	Basic impulse level - secondary winding	kV		
	Primary Voltage	kV		
	Secondary Voltage	kV		
	Regulation @1.0/0.8 PF	%		
	Efficiency @ 125/100/75/50/25 %	%		
	Sound level - base kVA/max. kVA	dBa		
	Windings Phase Displacement (angled/conser.)	degrees		
	Hot Spot Temperature Detector Type	-		
REMARKS:				

6.2 SHEET #2

	DESCRIPTION OF DATA REQUIRED	UNIT	ITEM NO.:	ITEM NO.:
	CURRENT TRANSFORMER			
	Manufacturer's Name	-		
	Primary Current Ratio(s)	-		
	Secondary Phase Current Ratio(s)	-		
	Neutral Current Ratio(s)	-		
	Accuracy	-		
	LIGHTNING ARRESTERS			
	Manufacturer's Name	-		
	Type	-		
	Voltage Class	kV		
	Impulse spark-overvoltage	kV		
	Front-of-wave spark-overvoltage	kV		
	GROUNDING RESISTOR			
	Manufacturer's Name	-		
	Type	-		
	Current Rating/Duration	A/Sec		
	Enclosure Type	-		
	Mounting (transformer/remote)	-		
	Element Type and Resistance	Ohm		
	SUPPLEMENTARY COOLING DATA			
	Number of Cooling Fans	-		
	Motor Rating	kW		
	Motor Supply V/ph/Hz	-		
	Location of Controls: Transformer/Remote	-		
	Method of Control, Top Liquid/Winding Temp.	-		
	Fans on at:	°C		
REMARKS:				

END OF SECTION

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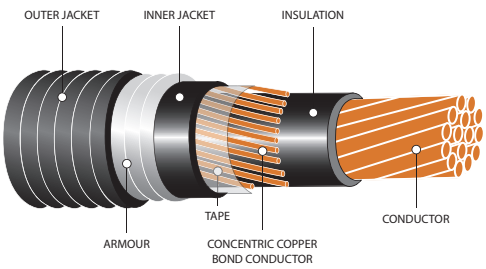
Single Conductor 1000V

XLPE/PVC/AIA/PVC



SPECIFICATIONS

- CSA FT1 & FT4
- CSA C22.2 No. 131 & 174
- IEEE 383 & 1202 (70,000 BTU/hr) Flame Test
- ICEA T-30-520 (70,000 BTU/hr) Vertical Flame Test

*Refer to CE Code for details

HL

CONSTRUCTION

Conductor: Bare copper Class B compact or compressed stranded

Insulation: Cross-Linked Polyethylene (XLPE) Type RW90

Ground (Bonding) Conductor: Concentric serving of solid bare copper wires applied over the insulation

Inner Jacket: Flame-retardant and moisture resistant Polyvinyl Chloride (PVC)

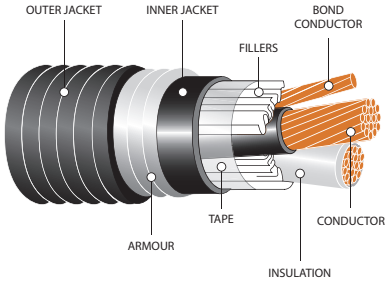
Armour: Aluminum Interlocked Armour (AIA)

Outer Jacket: Low-temperature, moisture and sunlight resistant Polyvinyl Chloride (PVC), black

Options: Other coloured outer jacket and constructions available upon request

Part Number	AWG Size		Insulation Thickness (in.)	Approximate Diameter (Over)				Copper Content		Net Weight w/ Armour		Amp. (30°C Ambient)
	Cond.	Bond Wire		Insul. (in.)	Inner Jacket (in.)	Armour (in.)	Outer Jacket (in.)	LB/ MFT	KG/ KM	LB/ MFT	KG/ KM	
05018-13-010	**4**	6	0.060	0.350	0.490	0.730	0.810	211	314	410	610	140
05018-17-010	**3**	6	0.060	0.380	0.520	0.760	0.840	244	363	450	680	165
05018-21-010	**2**	6	0.060	0.420	0.560	0.780	0.870	286	426	510	760	190
05018-25-010	**1**	4	0.080	0.490	0.660	0.880	0.960	390	581	680	1010	220
05019-01-010	**1/0**	4	0.080	0.530	0.690	0.910	1.000	458	682	760	1130	260
05019-05-010	**2/0**	4	0.080	0.580	0.710	0.950	1.040	544	810	860	1280	300
05019-09-010	**3/0**	3	0.080	0.630	0.810	1.030	1.120	685	1020	1080	1610	350
05019-13-010	**4/0**	3	0.080	0.690	0.860	1.080	1.170	820	1220	1270	1890	405
05020-01-010	**250**	2	0.090	0.750	0.990	1.210	1.290	980	1459	1490	2210	455
05020-05-010	**300**	2	0.090	0.770	1.040	1.280	1.370	1112	1655	1920	2857	500
05020-09-010	**350**	1	0.090	0.815	1.120	1.360	1.445	1340	1994	1910	1910	570
05020-13-010	**400**	1	0.090	0.850	1.155	1.395	1.480	1499	2231	2088	3107	615
05020-21-010	**500**	1/0	0.090	0.925	1.200	1.475	1.560	1841	2604	2510	3740	700
05020-25-010	**600**	1/0	0.090	1.005	1.305	1.545	1.655	2173	3234	2877	4281	780
05020-41-010	**750**	2/0	0.090	1.160	1.370	1.590	1.690	2570	3825	3510	5230	885
05021-01-010	**1000**	2/0	0.090	1.310	1.590	1.810	1.900	3340	4970	4430	6590	1055

Note: All dimensions are nominal and are subject to normal manufacturing tolerance.
Specifications are subject to change without prior notice.



Two Conductor 1000V

XLPE/PVC/AIA/PVC

SPECIFICATIONS

- CSA FT1 & FT4
- CSA C22.2 No. 131 & 174
- IEEE 383 & 1202 (70,000 BTU/hr) Flame Test
- ICEA T-30-520 (70,000 BTU/hr) Vertical Flame Test

*Refer to CE Code for details

HL

CONSTRUCTION

Conductor: Bare copper Class B compact or compressed stranded

Insulation: Cross-Linked Polyethylene (XLPE) Type RW90

Ground (Bonding) Conductor: Uninsulated stranded bare copper conductor

Inner Jacket: Flame-retardant and moisture resistant Polyvinyl Chloride (PVC)

Armour: Aluminum Interlocked Armour (AIA)

Outer Jacket: Low-temperature, moisture and sunlight resistant Polyvinyl Chloride (PVC), black

Options: Galvanized Steel Interlocked Armour (GSIA)
Other coloured outer jacket and constructions available upon request

Part Number	AWG Size		Insulation Thickness (in.)	Approximate Diameter (Over)				Copper Content		Net Weight w/ Armour		Amp. (30°C Ambient)	Recommended Connector*	
	Cond.	Bond Wire		Insul. (in.)	Inner Jacket (in.)	Armour (in.)	Outer Jacket (in.)	LB/ MFT	KG/ KM	LB/ MFT	KG/ KM		TMC2	TMC2X
05015-01-010	**14**	14	0.045	0.170	0.430	0.650	0.730	39	58	219	326	25	2/2A	2/2A
05016-01-010	**12**	14	0.045	0.180	0.470	0.690	0.770	55	82	255	380	30	2/2A	2/2A
05017-01-010	**10**	12	0.045	0.210	0.510	0.730	0.810	86	128	291	433	40	2/2A	2/2A
05018-02-010	**8**	10	0.045	0.240	0.600	0.820	0.900	137	204	392	584	55	2/2A	2/2A
05018-10-010	**6**	8	0.060	0.310	0.720	0.940	1.020	215	320	556	827	75	3/3A	3/3A
05018-14-010	**4**	8	0.060	0.350	0.850	1.070	1.160	312	464	744	1107	95	4/4A	4/4A
05018-18-010	**3**	6	0.060	0.380	0.930	1.150	1.230	415	618	905	1347	115	4/4A	4/4A
05018-22-010	**2**	6	0.060	0.420	0.980	1.200	1.280	502	747	1030	1533	130	4/4A	4/4A
05018-26-010	**1**	6	0.080	0.490	1.120	1.340	1.420	612	911	1235	1838	145	5/5A	5/5A
05019-02-010	**1/0**	6	0.080	0.530	1.230	1.450	1.530	740	1101	1425	2120	170	5/5A	5/5A
05019-06-010	**2/0**	6	0.080	0.580	1.280	1.500	1.580	922	1372	1660	2470	195	5/5A	5/5A
05019-10-010	**3/0**	4	0.080	0.630	1.370	1.590	1.690	1190	1771	1995	2969	225	6/6A	6/6A
05019-14-010	**4/0**	4	0.080	0.690	1.480	1.700	1.790	1466	2182	2350	3497	260	6/6A	6/6A
05020-02-010	**250**	4	0.090	0.750	1.620	1.840	1.930	1709	2543	2779	4135	290	7/7A	7/7A
05020-06-010	**300**	4	0.090	0.760	1.765	2.005	2.115	2018	3003	3341	4972	320	8/8A	8/8A/8B
05020-10-010	**350**	3	0.090	0.860	1.870	2.090	2.180	2373	3561	3650	5431	350	8/8A	8/8A/8B
05020-14-010	**400**	3	0.090	0.850	1.945	2.185	2.295	2687	3999	4147	6171	380	8/8A	8/8A/8B
05020-22-010	**500**	3	0.090	0.990	2.110	2.330	2.450	3316	4935	4895	7284	430	9/9A	9/9A/9B
05020-42-010	**750**	1	0.090	1.160	2.450	2.670	2.790	4941	7353	6872	10226	535	10/10A	10/10A
05020-46-010	**1000**	1	0.090	1.310	2.760	2.980	3.100	6562	9766	8993	13382	615	10/10A	10/10A

Note: All dimensions are nominal and are subject to normal manufacturing tolerance.
Specifications are subject to change without prior notice.

** See pages 28 & 29 for corresponding connector.*

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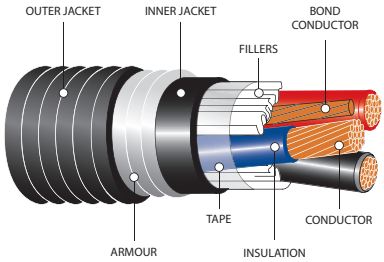
Three Conductor 1000V

XLPE/PVC/AIA/PVC



SPECIFICATIONS

- CSA FT1 & FT4
- CSA C22.2 No. 131 & 174
- IEEE 383 & 1202 (70,000 BTU/hr) Flame Test
- ICEA T-30-520 (70,000 BTU/hr) Vertical Flame Test

*Refer to CE Code for details

HL

CONSTRUCTION

Conductor: Bare copper Class B compact or compressed stranded

Insulation: Cross-Linked Polyethylene (XLPE) Type RW90

Ground (Bonding) Conductor: Uninsulated stranded bare copper conductor

Inner Jacket: Flame-retardant and moisture resistant Polyvinyl Chloride (PVC)

Armour: Aluminum Interlocked Armour (AIA)

Outer Jacket: Low-temperature, moisture and sunlight resistant Polyvinyl Chloride (PVC), black

Options: Galvanized Steel Interlocked Armour (GSIA)
Other coloured outer jacket and constructions available upon request

Part Number	AWG Size		Insulation Thickness (in.)	Approximate Diameter (Over)				Copper Content		Net Weight w/ Armour		Amp. (30°C Ambient)	Recommended Connector*	
	Cond.	Bond Wire		Insul. (in.)	Inner Jacket (in.)	Armour (in.)	Outer Jacket (in.)	LB/ MFT	KG/ KM	LB/ MFT	KG/ KM		TMC2	TMC2X
05015-02-010	**14**	14	0.045	0.170	0.470	0.670	0.760	52	77	261	388	25	2/2A	2/2A
05016-02-010	**12**	14	0.045	0.180	0.510	0.720	0.800	75	112	299	445	30	2/2A	2/2A
05017-02-010	**10**	12	0.045	0.210	0.590	0.790	0.880	124	185	374	557	40	2/2A	2/2A
05018-03-010	**8**	10	0.045	0.240	0.630	0.860	0.940	189	281	486	723	55	2/2A	2/2A
05018-11-010	**6**	8	0.060	0.310	0.780	1.030	1.130	300	447	724	1078	75	3/3A	3/3A
05018-15-010	**4**	8	0.060	0.350	0.910	1.160	1.250	447	665	970	1444	95	4/4A	4/4A
05018-19-010	**3**	6	0.060	0.380	0.970	1.220	1.300	582	866	1136	1691	115	4/4A	4/4A
05018-23-010	**2**	6	0.060	0.420	1.020	1.280	1.370	710	1056	1311	1951	130	5/5A	5/5A
05018-27-010	**1**	6	0.080	0.490	1.210	1.440	1.540	866	1288	1593	2371	145	5/5A	5/5A
05019-03-010	**1/0**	6	0.080	0.530	1.290	1.560	1.680	1069	1590	1906	2837	170	6/6A	6/6A
05019-07-010	**2/0**	6	0.080	0.580	1.380	1.650	1.770	1327	1974	2225	3311	195	6/6A	6/6A
05019-11-010	**3/0**	4	0.080	0.630	1.490	1.750	1.870	1670	2485	2666	3967	225	7/7A	7/7A
05019-15-010	**4/0**	4	0.080	0.690	1.600	1.860	1.980	2109	3138	3207	4772	260	8/8A	8/8A/8B
05020-03-010	**250**	4	0.090	0.750	1.800	2.050	2.170	2470	3675	3800	5655	290	8/8A	8/8A/8B
05020-07-010	**300**	4	0.090	0.760	1.885	2.125	2.235	2961	4406	4460	6637	320	8/8A	8/8A/8B
05020-11-010	**350**	3	0.090	0.860	2.010	2.260	2.400	3437	5114	4979	7409	350	9/9A	9/9A/9B
05020-15-010	**400**	3	0.090	0.850	2.075	2.315	2.455	3948	5875	5719	8511	380	9/9A	9/9A/9B
05020-23-010	**500**	3	0.090	0.990	2.270	2.520	2.660	4839	7200	6586	9798	430	9A	9A/9B
05020-28-010	**600**	2	0.090	1.005	2.410	2.650	2.790	5868	8733	7948	11828	475	10/10A	10/10A
05020-43-010	**750**	2	0.090	1.160	2.760	2.890	3.030	7225	10751	9267	13790	535	10/10A	10/10A
05021-03-010	**1000**	1	0.090	1.310	3.080	3.280	3.440	9612	14303	12184	18130	615	11/11A	11/11A

Note: All dimensions are nominal and are subject to normal manufacturing tolerance.
Specifications are subject to change without prior notice.

** See pages 28 & 29 for corresponding connector.*