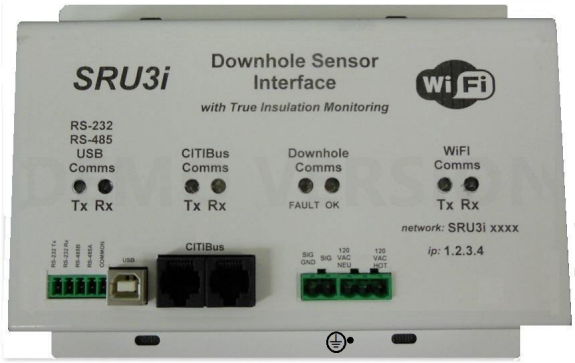
ACE Downhole

ESP Downhole Sensor System

Installation, Configuration and Operation Manual



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ACE Sensors are covered by patents 8149552, 9602100, 10012551 with other patents pending.

SRU / SRU2i / SRU3i / HVI Components Conforms to UL Std. 61010-1

SRU / SRU2i/ SRU3i / HVI Components Certified to CAN/CSA Std. C22.2# 61010-1

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Safety Instructions

Warnings in this manual appear in either of two ways:

1. *Danger warnings* – The danger warning symbol is an exclamation mark enclosed in a triangle which precedes letters spelling the word “DANGER”. The Danger warning symbol is used to indicate situations, locations and conditions that can cause serious injury or death:

DANGER

2. *Caution Warnings* - The caution warning symbol is an exclamation mark enclosed in a triangle which precedes letters spelling the word “CAUTION”. The Caution warning symbol is used to indicate situations and conditions that can cause operator injury and/or equipment damage:

Other warning symbols may appear along with the Danger and Caution symbol and are used to specify special hazards. These warnings describe particular areas where special care and/or procedures are required in order to prevent serious injury and possible death.

Electrical Warnings – The electrical warning symbol is a lightning bolt mark enclosed in a triangle. The electrical warning symbol is used to indicate high voltage locations and conditions that may cause serious injury or death if proper precautions are not observed:

For the purposes of this manual and product labels, a **Qualified Person** is one who is familiar with the installation, construction, operation and maintenance of the equipment and the hazards involved. This person must:

1. Carefully read and understand the entire manual.

2. Be trained and authorized to safely energize, de-energize, clear faults, ground, lockout and tag circuits and equipment in accordance with established safety practices.

3. Be trained in the proper care and use of protective equipment such as safety shoes, rubber gloves, hard hats, safety glasses, face shields etc. in accordance with established safety practices.

4. Be trained in rendering first aid.

SPECIFICATIONS

(Specifications are subject to change)

Downhole Instruments (without motor adapter)

	Ace Mid Range	Ace Xtreme	ACE Xtreme Dual
Intake Pressure	0-5000 psi	0-6000	0-8000 psi
Intake Pressure Accuracy	+/- 0.25% BFSL 1% FS	+/- 0.1% Typical 0.2% FS	+/- 0.1% Typical 0.2% FS
Intake Pressure Resolution	1 PSI SRU, 0.1psi SRU2, 0.01psi Spooler & SRU3i	1 PSI SRU, 0.1psi SRU2, 0.01psi Spooler & SRU3i	1 PSI SRU, 0.1psi SRU2, 0.01psi Spooler & SRU3i
Transducer Type	Silicon Strain Gauge	Digital Strain Gauge	Digital Strain Gauge
Discharge Pressure Range	N/A	0 – 6000 psi (optional)	0-8000 psi (optional)
Discharge Pressure Accuracy	N/A	+/- 0.1% Typical 0.2% FS (optional)	+/- 0.1% Typical 0.2% FS (optional)
Discharge Pressure Resolution	N/A	1 PSI SRU, 0.1psi SRU2	1 PSI SRU, 0.1psi SRU2
Intake Temperature Range	32°F - 257°F, 0°C - 125°C	32°F - 350°F, 0°C - 177°C	32°F - 350°F, 0°C - 177°C
Intake Temperature Accuracy	3.5°F, 2°C	3.5°F, 2°C	3.5°F, 2°C
Intake Temperature Resolution	1°F SRU, 0.1°F SRU2, 0.01°F Spooler & SRU3i	1°F SRU, 0.1°F SRU2, 0.01°F Spooler & SRU3i	1°F SRU, 0.1°F SRU2, 0.01°F Spooler & SRU3i
Motor Winding Temperature Range	32°F - 600°F, 0°C - 316°C	32°F - 600°F, 0°C - 316°C	32°F - 600°F, 0°C - 316°C
Motor Winding Temperature Accuracy	3.5°F, 2°C	3.5°F, 2°C	3.5°F, 2°C
Motor Winding Temperature Resolution	1°F SRU, 0.1°F SRU2, 0.01°F Spooler & SRU3i	1°F SRU, 0.1°F SRU2, 0.01°F Spooler & SRU3i	1°F SRU, 0.1°F SRU2, 0.01°F Spooler & SRU3i
Vibration Range	0-10G (optional)	0 – 10G	0 – 10G
Vibration Accuracy	N/A	0.5%	0.5%
Vibration Resolution	N/A	0.01G	0.01G
ESP Insulation Resistance	50 KOmhs-60 MOhms. Indicates <50 KOmhs and 60 MOhms.> if IR is outside of the range.	50 KOmhs-60 MOhms. Indicates <50 KOmhs and 60 MOhms.> if IR is outside of the range.	50 KOmhs-60 MOhms. Indicates <50 KOmhs and 60 MOhms.> if IR is outside of the range.
Maximum Motor Voltage	4160 VAC	4160 VAC	4160 VAC
Physical Diameter	3.72”	3.72” or 3.94” **	3.94” **
Physical Length	18.5”	18.5”	23.0”
Physical Weight	35 lbs, 16 kG	42 lbs, 19 kG	44 lbs, 20 kG
Material	1020 CS, 316 SS	316 SS	316 SS

**ACE Xtreme sensors with 3.94” OD are rated up to 11,000 PSI.

Downhole Adapters (connects instrument to motor)

Motor Size	Diameter	Length	Weight	Metallurgy
375	3.75”	7.5”	11 lbs.	1020 CS or 316 SS
456	4.56”	8.0”	17 lbs.	1020 CS or 316 SS
540	5.4”	8.0”	20 lbs.	1020 CS or 316 SS
562	5.62”	8.0”	22 lbs.	1020 CS or 316 SS
456/540/562 Generic	4.56”	4.5”	9 lbs.	1020 CS or 316 SS

Surface Readout SRU

Power Required	115VAC +/- 15% 50/60Hz
Display Type	6 digit Alpha Numeric LED
Motor Controller Connection (Isolated)	iCON Series Interface. Support for legacy (F3/F5 Commander series) controllers.
Modbus RS-485 (Isolated)	3 Wire standard.
Modbus RS-232 (Isolated)	3 wire, no handshaking required.
Operating Temperature	0°F - 158°F, -18°C to 50°C
Dimensions	6.00” x 5.25” x 2.25”
Weight	1.5 lbs
UL Certification	Conforms to UL Std. 61010-1
CSA Certification	Certified to CAN/CSA Std. C22.2# 61010-1
Note: SRU does not support ESP insulation resistance monitoring	

Surface Readout SRU2i

Power Required	115VAC +/- 15% 50/60Hz
Display Type	8 digit Alpha Numeric LED
Motor Controller Connection (Isolated)	iCON Series Interface. Support for legacy (F3/F5 Commander series) controllers plus additional RS-485 Modbus port.
Modbus RS-485 (Isolated)	3 Wire standard.
Modbus RS-232 (Isolated)	3 wire, no handshaking required.
USB Modbus (Isolated)	Standard USB ‘B’
Ethernet Modbus (Isolated)	Standard CAT5E 8 Pin connector.
Analog Outputs (Isolated)	4x 0-20mA User configurable (SRU2 sources power)
Relay Outputs (Isolated)	2x Form C User configurable 240VAC / 8 Amps
SD Datalogger	Up to 32 GByte (SDHC mode supported).
Internal Memory (SRU2X version)	32 GByte
Operating Temperature	0°F - 158°F, -18°C to 50°C
Dimensions	9.50” x 5.75” x 1.75”
Weight	2.0 lbs
ESP Insulation Resistance Monitoring Range. Used for ESP motor and cable run life prediction.	50 KOhms to 60 Meg Ohms. (displayed in KOhms). If IR is less than 50 KOhms, it displays <50MOhm. If IR is greater than 60MOhm, it displays 60MOhm >.
ESP Insulation Resistance Resolution	1000 Ohms.
UL Certification	Conforms to UL Std. 61010-1
CSA Certification	Certified to CAN/CSA Std. C22.2# 61010-1

Surface Readout SRU3i

Input Power	115 VAC +/- 15% 50/60Hz
Modbus RS-485 (Isolated)	3 wire standard
Modbus RS-232 (Isolated)	3 wire standard
USB Modbus (Isolated)	Standard USB-A
CITIbus VSD Interface (Isolated)	Transparent pass through, emulates RDCM
CITIbus Power Consumption	Zero
CITIbus Centinel Interface Module Compatible	Yes - Recycle CIM recommended
CITIbus Centinel Power Supply Compatible	Yes - Recycle GCS Centinel PS recommended
CITIbus RDCM Compatible	No - Recycle or scrap RDCM
CITIbus Modes Supported	GCS Legacy CITIbus & Advantage CITIbus
WiFi Interface	Standard worldwide, license free 802.11 b/g/n
Cable Insulation Measurement Range	200 KOhms to 60 Megs Ohms
Cable Insulation Measurement Resolution	1K Ohms
Cell Network Required	None
Mobile Data Required	None
Operating Temperature	0°F to 158°F, -18°C to 50°C
Dimensions	7.38”x 5.75” x 1.75”
Weight	2 lb
ESP Insulation Resistance Monitoring Range. Used for ESP motor and cable run life prediction.	50 KOhms to 60 Meg Ohms. (displayed in MOhms). If IR is less than 50 KOhms, it displays <50MOhm. If IR is greater than 60MOhm, it displays 60MOhm >
ESP Insulation Resistance Resolution	1000 Ohms.
UL Certification	Conforms to UL Std. 61010-1
CSA Certification	Certified to CAN/CSA Std. C22.2# 61010-1

SRU3i Model 2

Additional features with the SRU3i Model 2

SRU3i Model 2 Datalogging rate	All readings stored every 10 seconds
SRU3i Model 2 Log data depth	In excess of 10 years
SRU3i Model 2 Time Source	Internal GPS, antenna mounts on VSD
SRU3i Model 2 GPS Location saved in data file	Yes - paste into Google maps to find VSD
SRU3i Model 2 GPS Location visible via WiFi	Yes.

High Voltage Interface (HVI)

Maximum AC Voltage	5000 VAC
Fuse Rating	1/8 Amp (Buss HVJ-1/8)
MOV type	Field replaceable.
Enclosure Type	NEMA 4, 4X, 12, 13
Operating Temperature	0°F - 158°F, -18°C to 70°C
Dimensions	18” x 16” x 9”
Weight (in enclosure)	53 lbs
UL Certification	Conforms to UL Std. 61010-1
CSA Certification	Certified to CAN/CSA Std. C22.2# 61010-1

SRU / SRU2i / SRU3i / HVI Conform to UL Std. 61010-1

SRU / SRU2i / SRU3i / HVI Certified to CAN/CSA Std. C22.2# 61010-1

INTRODUCTION

The ACE downhole monitoring system collects downhole fluid and equipment data, transmitting it in real time to the surface for display, control and logging purposes. The system operates in conjunction with electrical submersible pumps, transmitting the downhole data to the surface via the motor power cable.

The ACE instrument uses a patented electronic method that protects the device during damaging high Voltage and motor current overloads which often prove fatal to other instruments. As a result of this new technology the ACE downhole instrument is much more reliable than competing units as well as being less than half the size and weight.

The ACE downhole unit is a completely sealed, welded device. The instrument electronics are not exposed to damaging well fluid caused by leaking threads, seals, o-rings or drain/fill valves. Neither are the electronics exposed to the motor oil, so a failed or contaminated motor will not subject the ACE electronics to the destructive fluid. ACE tools are routinely pulled from destroyed, contaminated motors and re-run immediately on new motors without requiring factory or shop service.

Industry compatibility. The downhole instrument with suitable motor adapter will bolt directly on all brands of oil field submersible pump motors. The surface high Voltage protection package will directly mount inside or out on most switchboards, variable speed drives or high Voltage transformer packages. ACE systems will operate accurately and reliably with all brands of VSD or switchboard.

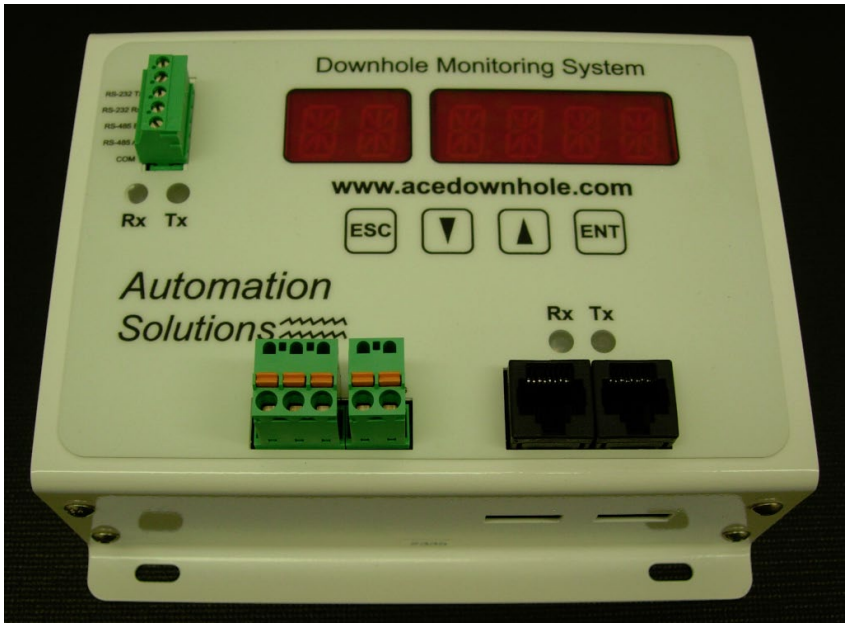
The compact surface readout options provide direct connection to the industry standard iCON motor controller as well as supporting direct connection to the legacy Commander F3/F5 series controllers. All readings from the surface readout are automatically accessible in the motor controller where they may be used for motor control and data logging.
In addition, the surface readout (SRU) provides optically isolated RS-485 and RS-232 Modbus ports for remote connections to RFScada and virtually all other wireless or wired SCADA control systems. The premium SRU2 readout includes all the features of the SRU then adds a higher resolution display, Ethernet, USB, analog outputs and relays plus built in datalogging that will record unlimited readings from the downhole device to removable SD memory cards. The SRU2i includes all the features of the SRU2 and adds 32 GBytes of fixed internal memory for logging the readings in addition to the removable SD memory cards. The SRU3i adds direct CITIbus connection to Baker Hughes VSD’s, plus adds WiFi local connection.

There are three portable test units available. A self powered surface readout and downhole tester provides quick and easy verification of system integrity, typically used during equipment run in. The compact instrument simulator allows quick verification of the installed surface equipment and simulates signals for testing connections to control and scada systems. The pressure test unit safely generates test pressures to verify correct sensor operation in the field or shop.

SYSTEM OVERVIEW

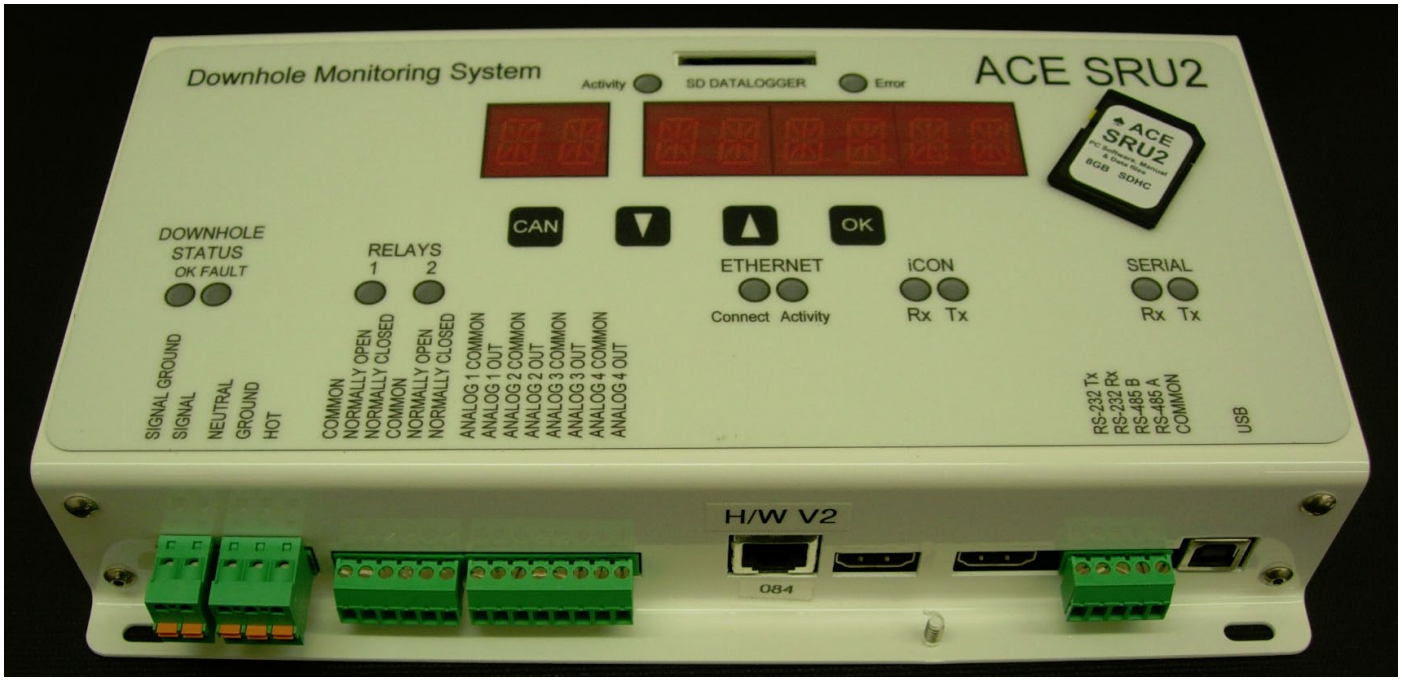
There are four main components to the ACE system, two are installed at the surface, two are mounted to the pumps motor and go downhole.

ACE Surface Readout (SRU), Advanced Readout (SRU2i) & SRU3i WiFi / BH Interface



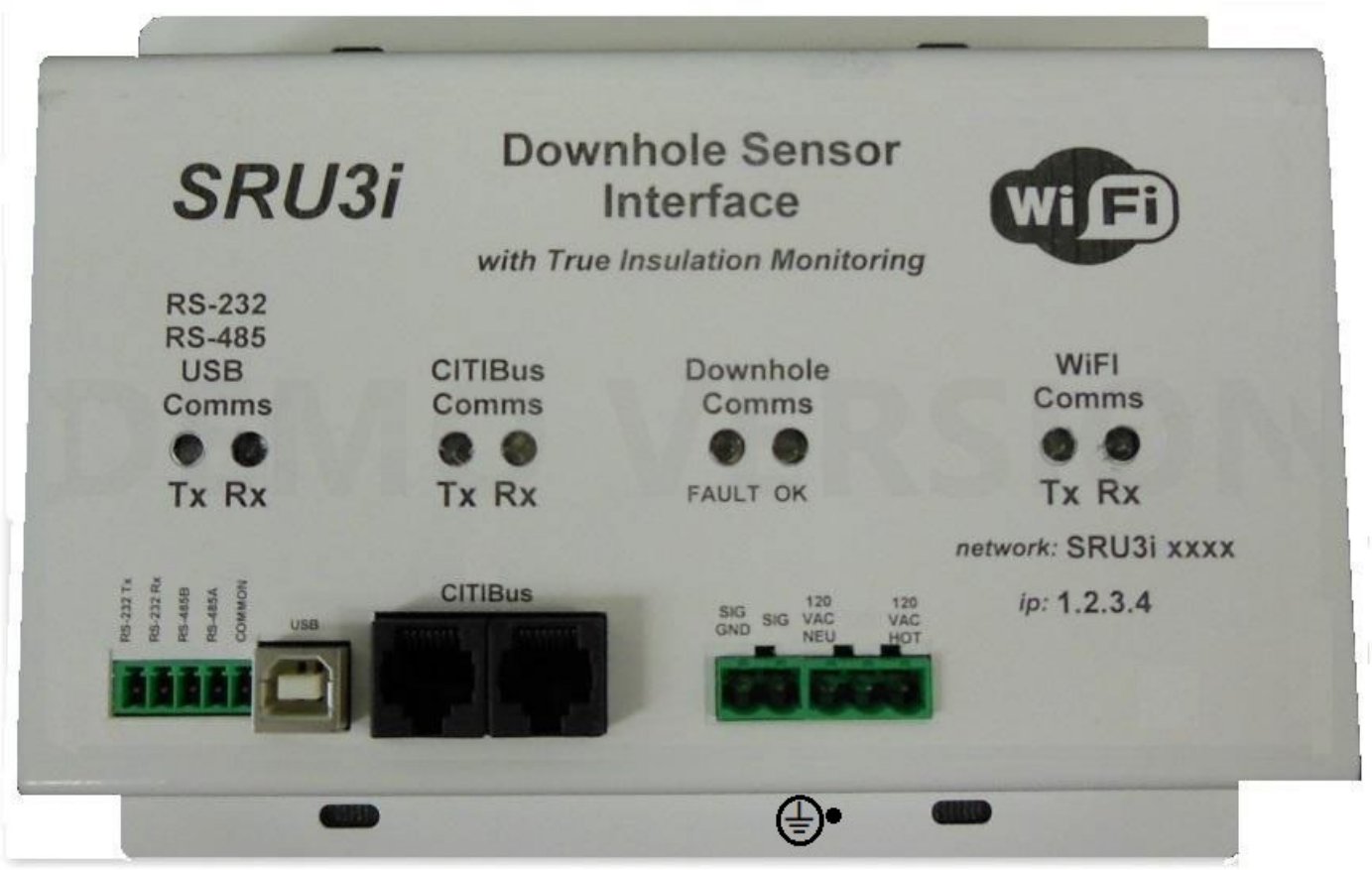
Just one of these units is required at the surface; the SRU2 provides more advanced functionality than the SRU. Either one may be used with any of the downhole sensor options. The surface device serves several functions. First it provides signal power to the downhole device, decodes and verifies encrypted information from the downhole unit, and displays the results on an alpha-numeric LED display. It can also provide the downhole data to additional devices via industry standard Modbus RS-232 and RS-485 ports (both optically isolated). Another built in interface is provided, which connects directly to the iCON industry standard motor controller; and with a suitable adapter cable it can connect to the older generation legacy Commander / F5 series controllers which were sold under several different names. Finally the SRU and SRU2 may provide diagnostic information to assist in troubleshooting. Transmit and receive LED's are associated with each of the communication ports to indicate all communication activity. The SRU's operates from nominal 120 VAC 50/60Hz line voltage.

The SRU2 also includes Ethernet and USB connectivity, user programmable relays, analog outputs and unlimited



datalogging for all readings using removable SD data cards.

The SRU3i interface connects directly to a Baker Hughes / GE Advantage or GCS drive, plus provides WiFi connectivity for all readings



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High Voltage Interface (HVI).

The ACE high Voltage interface (HVI) connects between the motor power cable and the SRU. It provides an artificial wye-point from the motor power cable at the surface then translates it into a safe signal level for connection to the SRU. The HVI also provides the protective safety interface between the high-voltage three-phase ESP power and the SRU, containing a fuse and protective circuitry to limit possible damaging levels of energy from being applied to the SRU if a phase-to-ground fault occurs in the motor or motor power cable. The HVI is not required for testing the ACE system on the surface when not connected to any Voltage source. However the HVI is required to be used if connected to a motor with high Voltage applied. It may be ordered as separate components to be installed in an existing high Voltage cabinet such as an out put transformer.

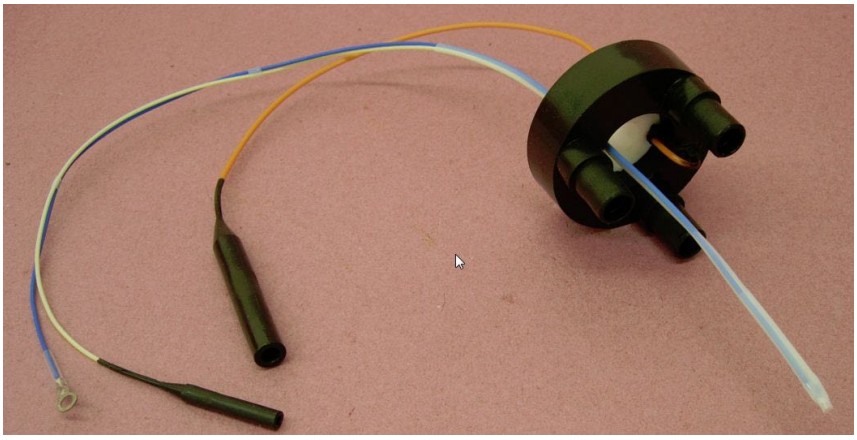
Downhole Instrument.

The instrument itself consists of a completely sealed steel cylinder approximately 18 inches long (22 inches for the dual pressure input version) and 3.75" in diameter. It contains various transducers plus the device electronics, there are no user serviceable parts inside. The bottom of the instrument has an industry standard 2 3/8” 8 RND EUE female thread that may be used to mount any additional downhole components such as sacrificial electrodes. The top, or head of the instrument houses two high Voltage

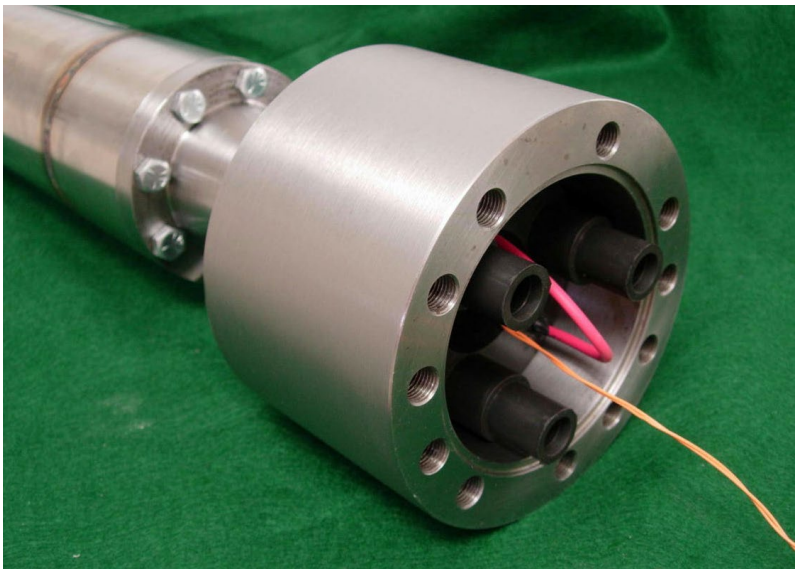
and pressure rated electrical connector pins, the larger one provides electrical connection to the motor adapter and the smaller one to a winding or motor oil temperature transducer. Also in the head are a pressure port and a safety relief valve. The instrument bolts to the motor adapter, which in turn is then bolted to the motor.

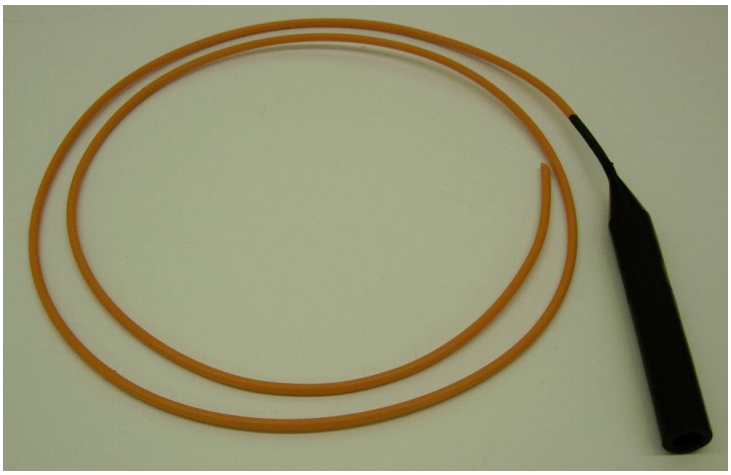
Motor Adapters.

The ACE downhole instrument may be operated with several different sizes of motor.



To accommodate this several motor adapters are available that couple the motor to the instrument. Inside the adapters a motor 'wye' point is usually mounted which serves as the junction of the three motor windings. This electrically isolated wye point is typically a rubber coated ring with three terminals that plugs onto the bottom of the motor (this type of motor is typically called an upper tandem configuration). Attached to the wye point is an 'instrument wire' terminated with a rubber boot connector. This rubber boot is passed through the center of the motor adapter and plugs onto the larger of the two instrument connector pins, it provides the electrical connection for the instrument up through the motor and onto the motor power cable. For motors that are not upper tandem configuration (ie the three phases are wound together without using a wye ring junction) the instrument wire may be directly wrapped into the motor lead junction during motor assembly. In this case the motor adapter is still required to physically mount the instrument; however the wye ring is not needed. The molded boot is available as an individual item for OEM installation.





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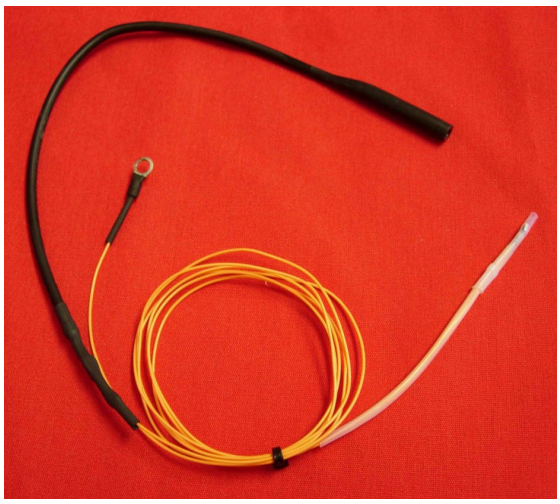
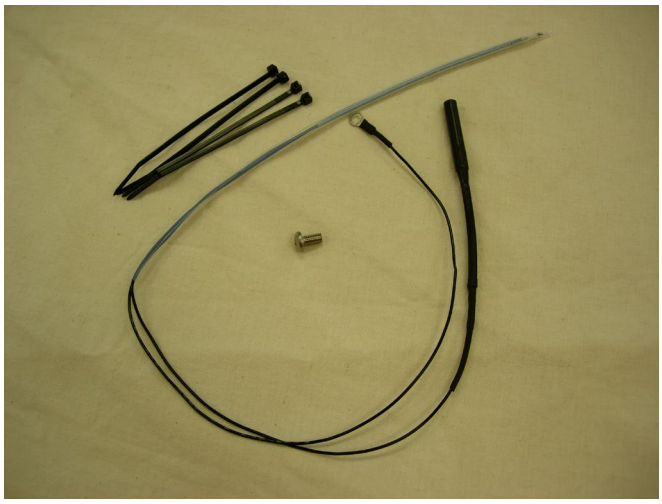
Motor Winding Temperature Transducer.

The transducer used for motor winding measurement is known as a platinum RTD (not a J or K thermocouple as typically used in older technology downhole sensors). There are several reasons for using an RTD rather than a common thermocouple. First an RTD is more accurate, has greater repeatability and is more stable than a thermocouple. Secondly RTD's do not require complex electronic cold junction compensation that thermocouples require; eliminating the electronics required for thermocouples increases system reliability and accuracy. Thirdly thermocouples require two distinct connections electrically isolated from ground; this means two high Voltage and pressure feed through pins are required from the main housing to the motor oil chamber rather than one; doubling the possible failure points in the system. Fourthly RTD's are not polarity sensitive whereas thermocouples will give incorrect readings if the connections are reversed; using an RTD eliminates another possible failure mode that thermocouples are prone to. Although thermocouple transducers are low cost they result in reduced reliability and performance; therefore the ACE sensor utilizes a platinum RTD transducer. Depending on the motor manufacturer and order of assembly two motor temperature transducer options are available. The first, known as the 'OEM winding temperature' option, has a transducer that is typically embedded in the motor winding slot before the motor is varnished. The second, called the 'motor oil / winding' temperature transducer may be installed in motors that have been pre assembled without removing the lower motor bearing. This transducer measures the temperature of the motor oil, as it extends into an oil circulation hole. Depending on the brand of motor the transducer may be placed directly in the lamination slot with one less winding in than the others, so it can also measure motor winding temperature without requiring to be 'wound in' during motor assembly. The transducer leads are secured by the support disk located beneath the wye point, which maintains the transducer in a suitable location and prevents it rubbing on the motor shaft. Sections in this manual explain assembly and installation of both types of transducer.



OEM Winding Temperature Transducer



Motor Oil / Winding Temperature Transducer

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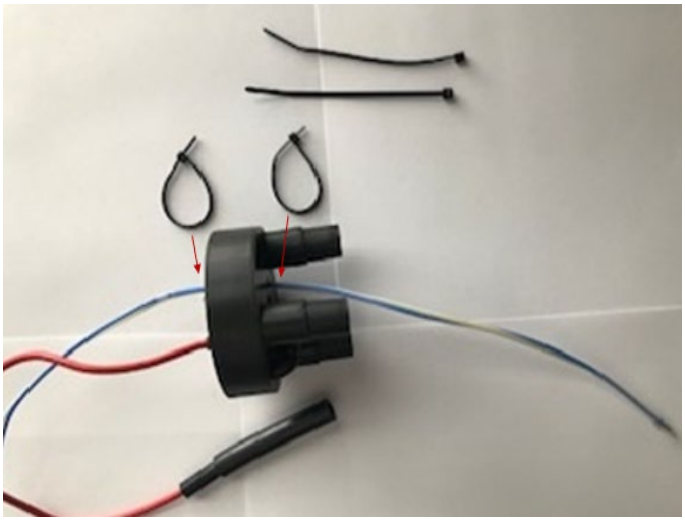
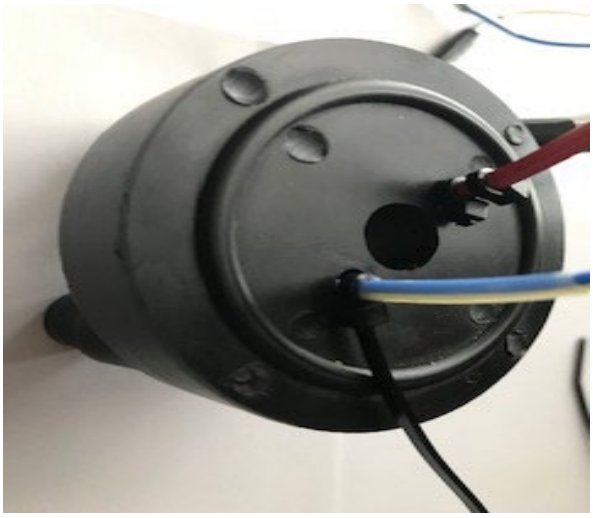
Insert the RTD probe into a small hole in the ACE wye point ring so that it extends to the correct length for the motor being used since it will vary from motor to motor. Install tie wraps on both ends of the ACE wye point ring and tighten them up. This will prevent vertical movement of the RTD probe during operation. Cut off the excess length of the tie wraps.





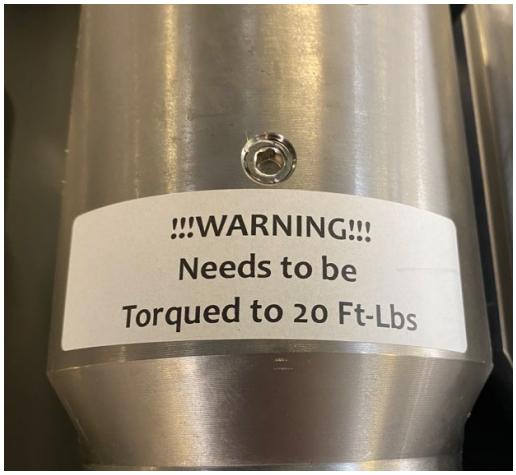
WARNING: Not installing tie wraps properly can lead to damage of the probe and loss of motor temperature reading during operation.

Discharge Tubing Assemblies.

If a dual pressure input system is being used then a discharge pressure assembly is also required.

¼” capillary tubing connects between the sensor lower port and the discharge assembly which is mounted in the string above the pump. The discharge assembly has a male thread on one end and a female thread on the other so it may be inserted in the tubing string above the pump. The discharge assembly has two machined groves to allow the motor power cable to route past the assembly on either side. Discharge assemblies are available in 2-3/8” 8 RND-EUE, 2-7/8” 8 RND-EUE, 3-1/2” 8 RND-EUE and 4-1/2” 8 RND-EUE sizes.

Directly below the pressure port is a 1/8" NPT hole plugged with a hollow Hex 1/8" NPT SS hollow Hex plug. The plug comes hand-tight from the factory for easy removal. The plug must be torqued to 20 Ft-Lbs before installation.



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An installation test kit is available to assist during device installation and during run-in. The kit also contains components allowing test and simulation for the surface equipment. There are five main components to the test kit.

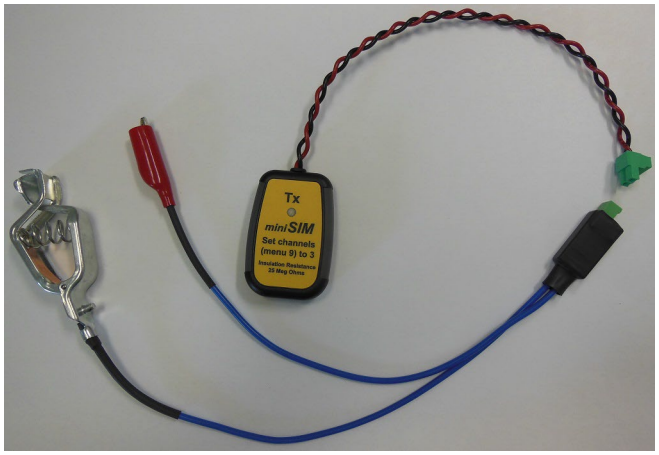
Portable Surface Readout Unit (PRSU).

The ACE portable surface readout unit consists of a robust, portable case containing a built in SRU and additional components to simulate the HVI. Also inside the case is a rechargeable battery that can provide standalone power and a built in battery charger. A mechanical timer switch is used to energize power to the SRU, so it cannot be accidently left on for extended times and drain the battery. Applying AC power to the device will recharge the battery, and AC power may be safely left connected as the internal charger will switch to trickle charge once the battery is fully charged. The PRSU is ideal for testing a system during equipment run in, as it may be quickly connected directly to the motor power cable to verify cable and instrument integrity and operation without requiring AC power at the well head or spooler.

Signal Simulator.

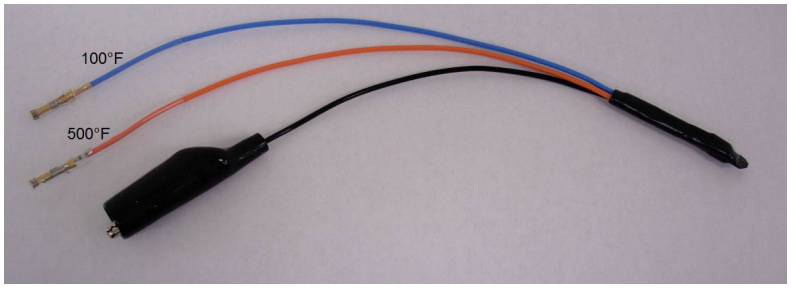
The ACE signal simulator allows quick and easy verification of the SRU functionality. It also allows for simulating downhole signals when configuring or testing control systems that may be connected to the SRU and require simulated downhole data. The three control knobs allow variable values to be set. The simulator may be directly connected to the SRU or it may be connected via the HVI.

miniSIM Signal Simulator.



The miniSIM simulates a sensor to allow quick and easy verification of all surface equipment. Once the motor is shut off the miniSIM may be connected at the junction box and if good readings appear at the SRU the surface equipment is verified. The miniSIM may also be plugged directly into a surface readout to verify correct operation. The miniSIM always generates three fixed values, an intake temperature of 250°F, a pressure half of the full scale readout setpoint and a winding temperature of 500°F

Temperature Simulator.



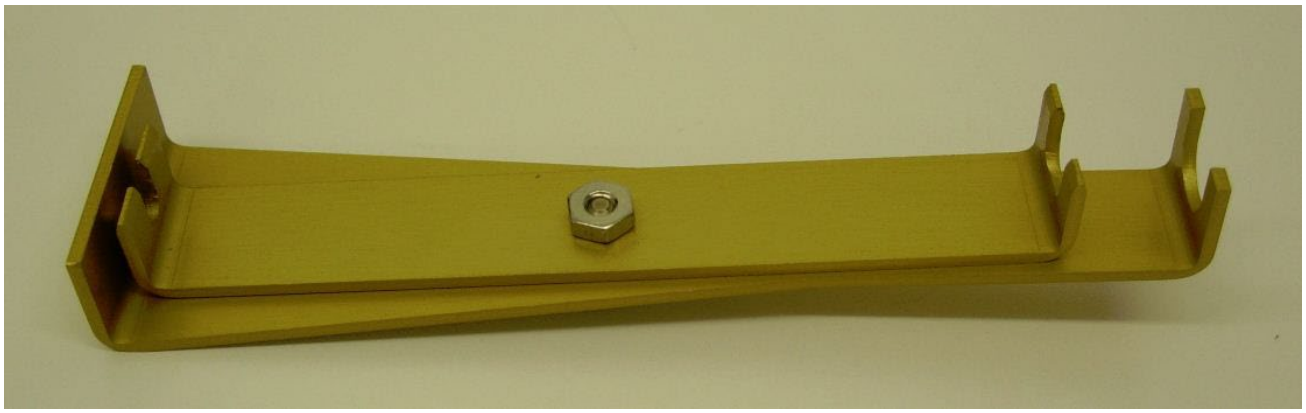
The winding/oil temperature simulator allows quick and easy verification of the system with a winding temperature transducer. This allows simulating two fixed temperatures (100°F and 500°F) to quickly verify accurate, positive

operation of the sensor. If a temperature transducer has already been installed in a motor to be run, but the motor is not convenient to the instrument this simulator may be used. Connect the orange wire to the small motor temperature transducer pin on the instrument and the black wire with alligator clip to one of the threaded bolt holes to simulate 500°F. Alternately connect the blue wire to the small motor temperature transducer pin on the instrument to simulate 100°F. The simulated temperatures will be visible on the SRU; typically within +/- 2°F.

Downhole Sensor Pressure Test Unit (PTU).

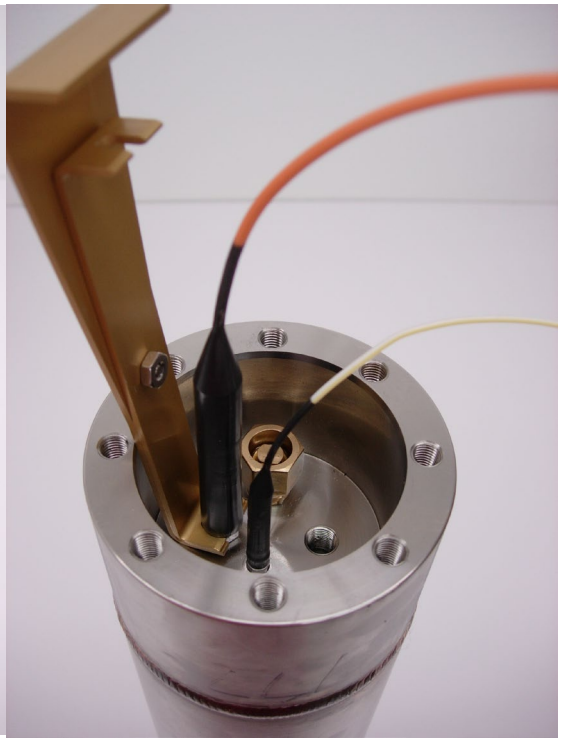
The Pressure Test Unit may generate a hydraulic test pressure to enable system verification on the surface. It would typically be used to verify equipment that has been pulled from a well before re-running the sensor. The operating manual for the device is included in this manual.

Boot Removal Tool.



After being downhole under high pressure and temperature it may be difficult to remove the connecting boots from the signal lead and temperature sensor. Pulling at the top of the boots or by the wire causes the boots to grip tighter and may cause damage. The boot removal tool allows easy removal by applying lifting force underneath the boots, where fingers and other tools will not reach. This allows the boots to be removed without damage to the boot or the pins, the sensor may then be re-run without requiring any service. The tool has a thin grooved and wide grooved pulling tongue, so the same tool may be used to remove the large and the small boots.

Boot Removal Process:

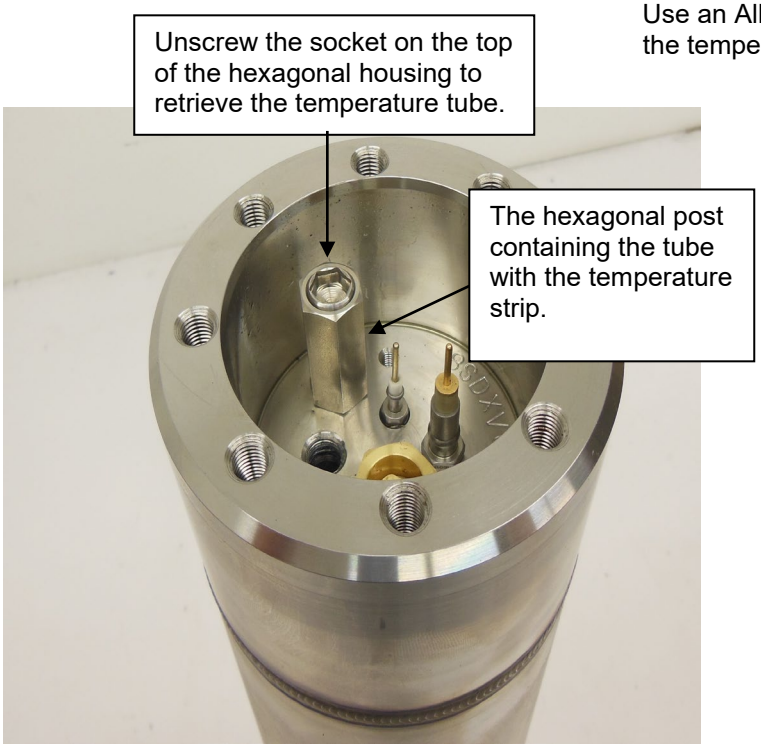


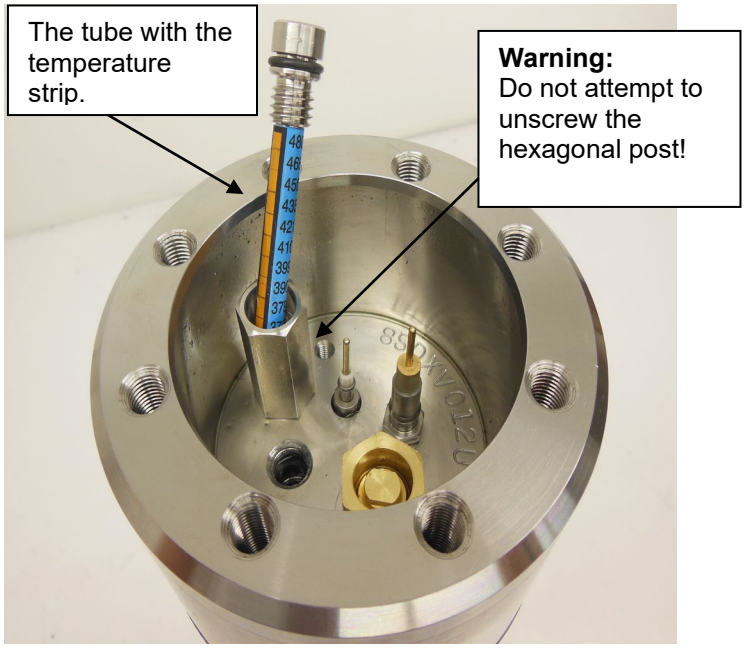
For the small pin locate the tool with the small grooved puller below the boot. It may take some pressure to slide it under the boot if the boot has hardened, which may occur if the boot has been exposed to certain well fluids and chemicals. Once the tool is located simply pull up on the sliding part which will cause the boot to pop off the pin. For the larger pin turn the slide around, so the large groove is to be located beneath the boot. It may be necessary to remove the temperature transducer grounding screw first, as it may block access for the tool to reach under the boot. Repeat the sliding process to remove the large boot.

Temperature tube.

The temperature tube is contained in the hexagonal post in the head of the sensor as shown in the below picture. A temperature strip is attached to the tube. An Indication on the temperature strip allows you to quickly check the maximum temperature the sensor has been exposed to. This feature is very useful especially in cases where ESP motor has failed due to overheating as a result of pump-off or gas lock. Temperature strip indication will add confidence in your decision to whether re-install the sensor without service or not.

Use an Allen key to unscrew the socket on top of the the temperature post. Retrieve the tube.



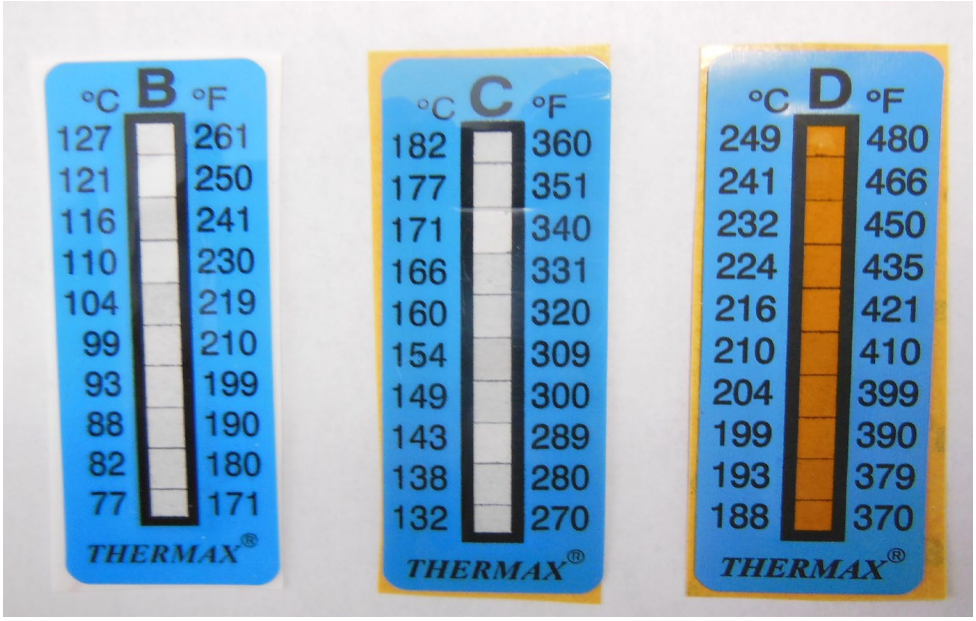


The temperature strip on the tube will indicate the maximum ambient temperature the sensor was exposed to before motor failure and compare it to the maximum ambient temperature rating for your sensor model before making a decision to re-install the sensor with a new motor.

Before re-installing ACE sensor with a new ESP, remove the used temperature strip and wrap a new temperature strip around the tube. Spare temperature strips can be ordered from ACE Downhole. Depending on the sensor temperature rating the following part numbers should be used:

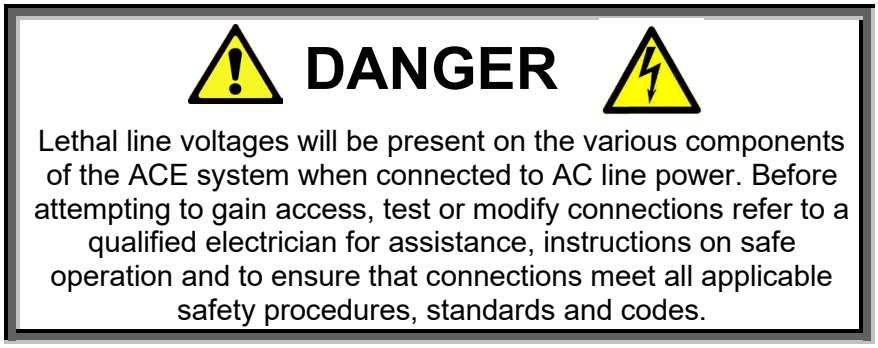
B (P/N 1170111) for 125C sensors.
C (P/N 1170113) for 150C sensors
D (P/N 1170115) for 177C sensors.

The below picture shows three types of temperature strips.



The below picture shows a tube with a temperature strip removed.

SYSTEM INSTALLATION, SURFACE TEST AND DOWNHOLE RUN IN



Surface Readout Unit (SRU, SRU2i or SRU3i) Installation.

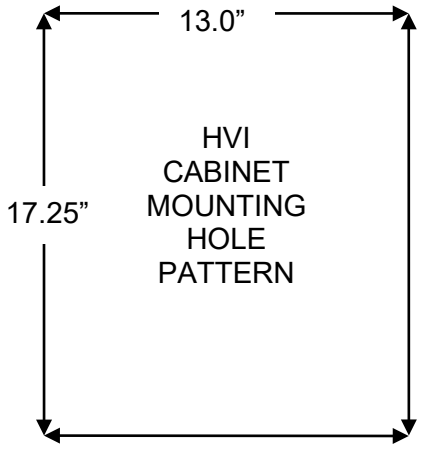
This is typically mounted in the low Voltage section of the VSD or switchboard, protected from the environment. It may also be mounted inside a weatherproof NEMA 4X rated cabinet mounted to the side of the VSD or switchboard. It should be connected to a 115VAC (50 or 60Hz) fused at 2 Amp power source via a suitable disconnect. If mounted inside a weatherproof NEMA 4X rated cabinet mounted to the side of the VSD or switchboard separate protective conduits for the power and signal cable using shielded instrumentation wire are used to connect between the SRU/SRU2 and HVI. These conduits also provide strain relief at each end. See appendix A for typical wiring schematics.

High Voltage Interface (HVI) Installation.

WARNING

THE HIGH VOLTAGE INTERFACE (HVI) WEIGHS IN EXCESS OF 40 POUNDS / 18 kG. TO AVOID INJURY TWO PEOPLE ARE REQUIRED TO CARRY AND INSTALL THE UNIT.

The HVI is typically mounted inside or on the outside of the switchboard, VSD or transformer. If the high Voltage wires leave the enclosure of the switchboard, VSD or transformer to connect to the HVI cabinet they must be inside protective conduit with no other power or signal cables. The ground termination in the HVI must be connected to the wellhead ground, this is typically done at the main ground connection on the transformer. In addition to the supplied hardware four 5/16”-18 1” long 316L stainless steel bolts and matching 316L stainless steel nuts and lock washers are required, plus suitable conduit for connecting wires. To mount the HVI first drill four holes each 3/8” diameter in the cabinet where the HVI is to be mounted using the following pattern.

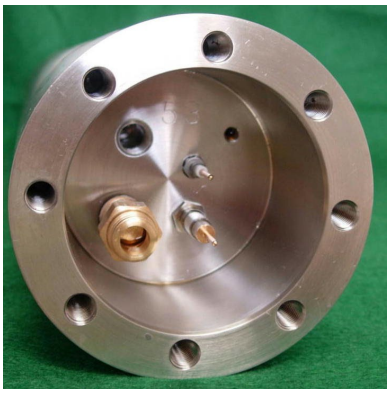


Then the four mounting brackets are secured to the rear corners of the cabinet using the stainless steel screws (supplied). Using assistance to lift the cabinet and secure to the switchboard or VSD cabinet using the 5/16” hardware. Drill 2 holes in the HVI cabinet to accommodate both conduits, then run the shielded instrumentation wires inside one conduit and the high Voltage wires plus ground in the other.
The three, high Voltage wires and ground are connected to the motor power cable, they must be on the secondary side of the transformer windings. A 5 kV 1/8 Amp fuse type Buss HVJ-1/8 is in series with each of these three wires. See appendix A for typical wiring schematics.

Instrument Identification.

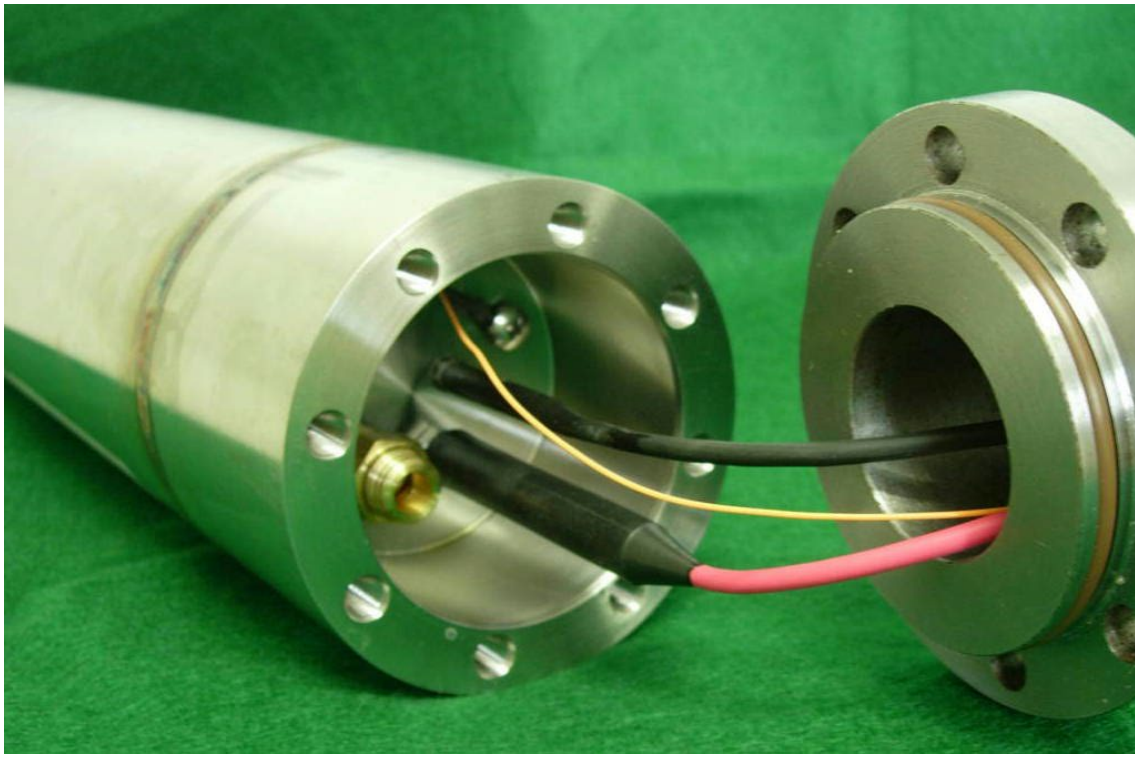
Each downhole sensor is uniquely identified with a serial number applied during manufacture; the number is located in the connection cavity. This serial number identifies the unit capabilities, nomenclature is explained as follows.
The first digit identifies the pressure rating in 1000 PSI, and may be 1,3,5,6 or 8. The second character identifies the metallurgy, either C for carbon steel or S for stainless steel. Some optional indicators may be next. D indicates dual pressure input, H is for high temperature rating, X is for extreme temperature rating, and V means the unit has vibration measurement capability. The last 3 or 4 digits refer to the serial number of this particular configuration. As an example the unit above has s/n 5SDHV030. This means it is a 5000 PSI stainless steel, dual input, high temperature unit that supports vibration measurement. It was the 30th unit manufactured in this configuration.

Instrument and Motor Adapter Installation.



The assembly and connection of these components may vary slightly depending on the manufacturer's motor configuration. The motor adapter and instrument may be coupled together before reaching the well head, then the assembly attached to the motor. Alternately the instrument may be installed at the wellhead by attaching to a motor adapter that is already mounted on a motor.

Finally the complete adapter and instrument may be attached to the motor before it is shipped to the wellhead; this gives a controlled environment for assembly however care must be taken during transit to prevent shipping damage.



CAUTION

THE TWO HIGH VOLTAGE, HIGH PRESSURE SIGNAL PINS MAY BE MADE FROM CERAMIC AND *WILL* BE DAMAGED BY ANY IMPACT OR SIDE FORCE. A CRACK THAT MAY BE DIFFICULT TO VISUALLY DETECT WILL CAUSE HIGH VOLTAGE OR HIGH PRESSURE FAILURE WHEN DOWNHOLE. BE CAREFUL WHEN CONNECTING TO THESE PINS.

To couple the adapter and instrument first smear the o ring groove with a lubricant suitable for the application then place a #229 Viton O ring (supplied) in the adapter groove. Using assistance hold the adapter and instrument close together. With the wye point ring installed in the adapter pass the instrument wire and rubber boot through the center of the adapter. Also pass the two winding transducer wires through the adapter center. Firmly seat the large signal boot on the large signal pin on top of the instrument. It should seat firmly and straight on the pin. Connect the small winding temperature boot to the small pin, and attach the winding temperature terminal ring to the instrument chassis using the stainless 10-32 screw provided. Mate the adapter and instrument together then bolt the two together. Depending on the system metallurgy Monel coated or stainless 1.25" x 5/16-24 bolts should be used.

Once the adapter and instrument are assembled they may be attached to the motor. First the wye ring is attached to the motor leads. Be very careful to ensure the instrument wire is not trapped or caught on any of the assemblies. Any spare instrument wire should be careful slid into the adapter so it will not foul the wye point or motor components. The motor and adapter may be mated together and secured with suitable bolts.

Instrument, Motor and Adapter Testing On Surface.

The instrument coupled to the motor and adapter may be tested on the surface before it is run into the well. Typically the PSRU will be used, however it is possible to use the SRU or SRU2 directly.

DANGER

ENSURE THE MOTOR IS DISCONECTED FROM ANY HIGH VOLTAGE WHILE ATTEMPTING THESE PROCEDURES

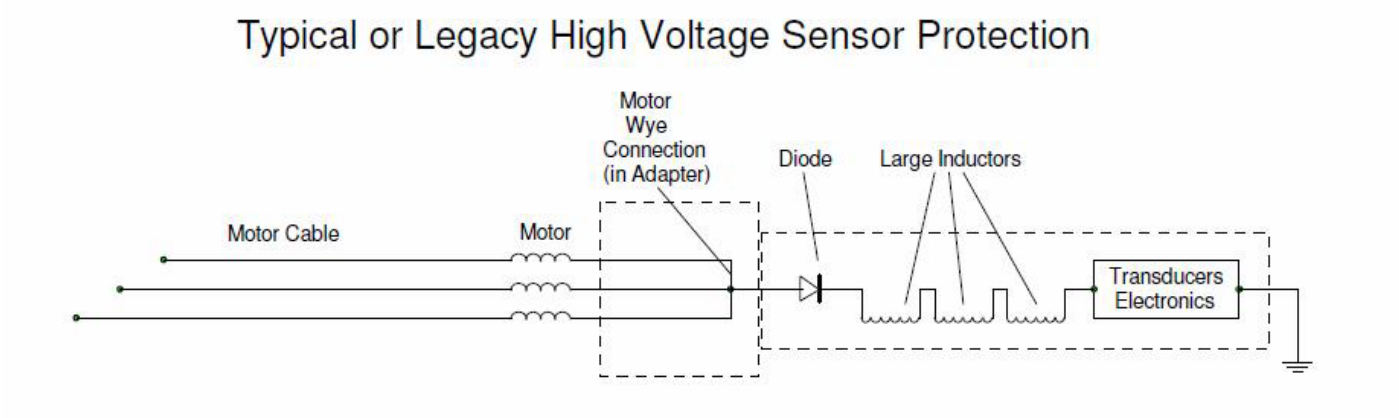
WARNING

DO NOT ATTACH OR REMOVE THE SIGNAL OR GROUND WHILE THE SURFACE READOUT (SRU) OR PRSU IS POWERED ON AS DAMAGE TO EQUIPMENT MAY RESULT. THERE ARE VERY HIGH INDUCTANCES IN THE SYSTEM, CONNECTING OR DISCONECTING THE SIGNAL OR GROUND WIRE WITH POWER APPLIED WILL RESULT IN LARGE ARCS THAT MAY DAMAGE EQUIPMENT. TURN OFF THE SRU BEFORE CONNECTING OR DISCONNECTING THE SIGNAL OR GROUND LEADS.

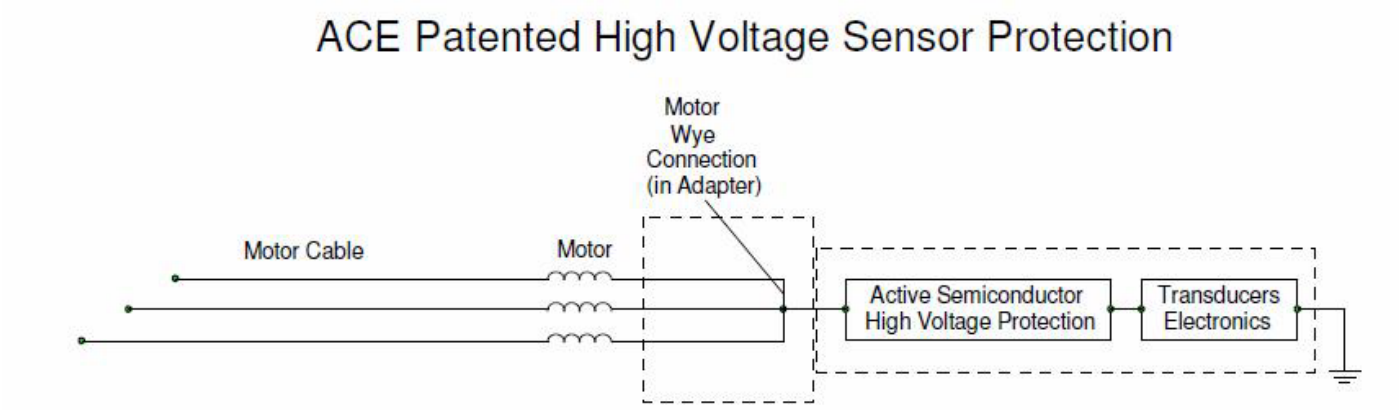
DO NOT APPLY ANY VOLTAGE OR ATTEMPT TO MEGGER TEST THE TEMPERATURE TRANSDUCER PIN (SMALLER ONE) AS DAMAGE TO THE INSTRUMENT WILL RESULT.

ACE High Voltage Insulation Testing.

For decades downhole sensors have typically all used the same method for phase to ground failure protection which causes a large AC Voltage relative to ground to be impressed upon the common motor wye point. This protection typically consists of very large chokes (inductors) wired in series in an attempt to block the AC Voltage from destroying the sensor. To allow the capability of DC HiPot or Megger testing a diode is typically inserted in series with the chokes as shown below. This simple method does have drawbacks however, since the chokes tend to electrically saturate and lose their protection when DC currents are passed through them. The chokes have to be very large; often physically too large for 3.75" diameter systems, and are also prone to failure from electrical breakdown during electrical phase to ground cable and motor faults. With some brands of sensor the diode is blown open circuit during a phase to ground short, so ending the life of the sensor, which of course may remain downhole not working for years, even though the phase to ground short could have been repaired.



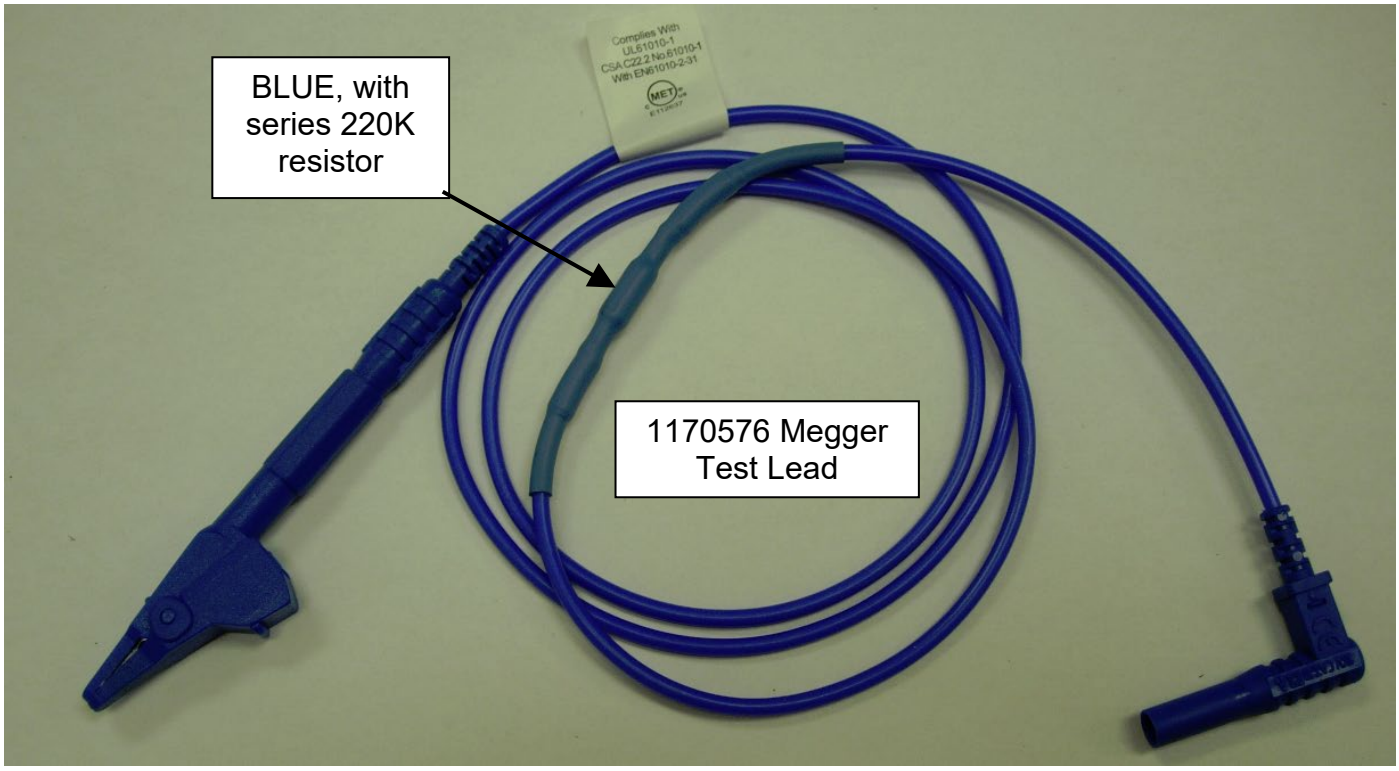
The ACE sensor uses a different method employing active semiconductor circuits to protect the sensor from electrical damage. Its does not require the huge inductances used on prior systems, as a result the sensor is smaller and much more reliable than other designs. It is capable of withstanding over 2700 VAC (this is the Voltage if a 4160 Volt motor had a phase to ground short) indefinitely at the wye point without any damage. Voltages this high typically destroy most other brands of sensor. Once conditions return to normal the ACE sensor will continue to operate.



As part of the protection scheme the circuit will automatically turn on to protect the sensor when the applied DC Voltage at the wye point exceeds approximately 1500 Volts, and it will also turn on to protect the sensor if the applied Voltage has a very fast rise time, typically seen during catastrophic motor / cable phase to ground shorts.

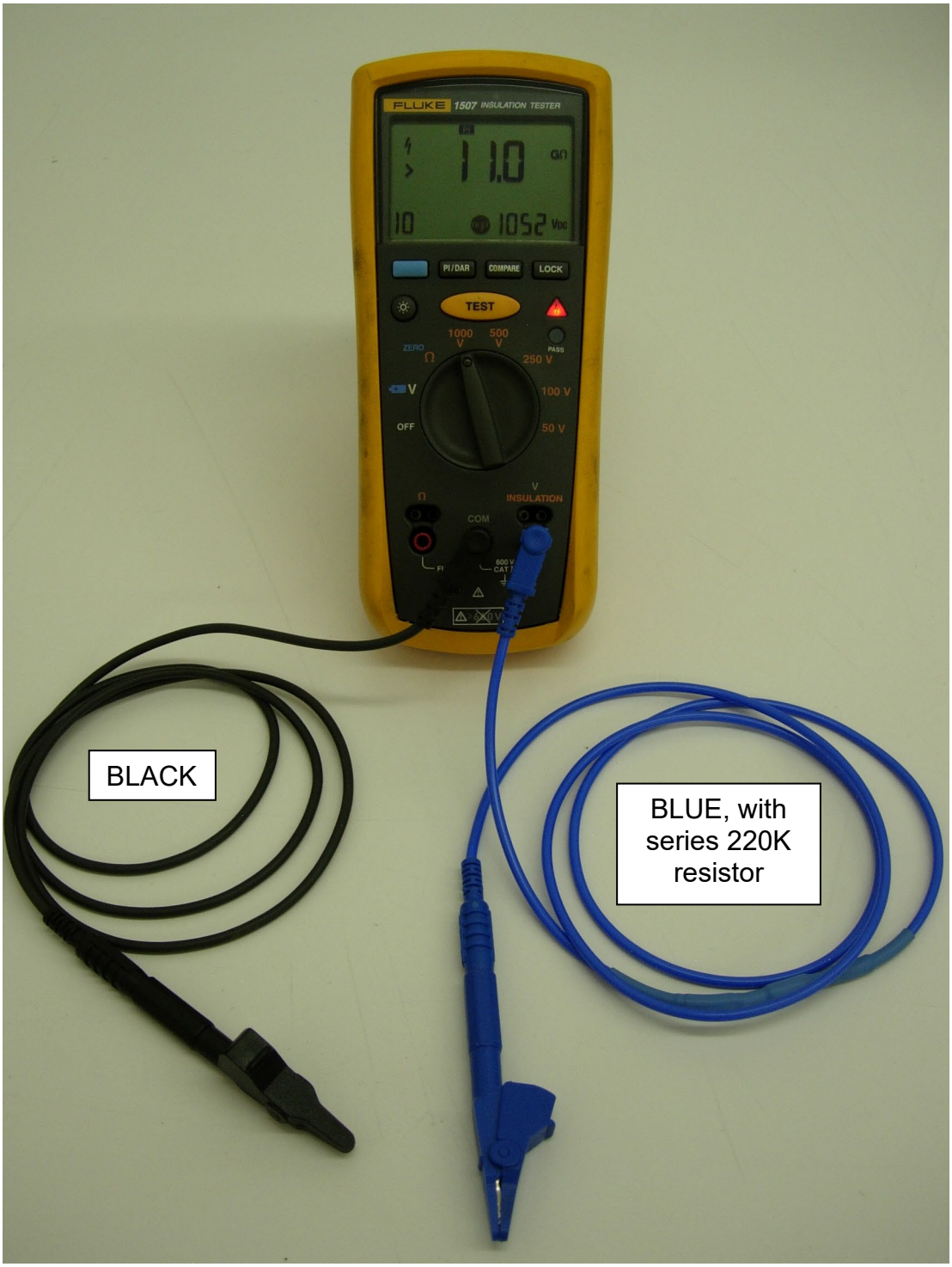
Therefore to test the system an insulation tester rated for 1000 Volts DC maximum should be used; and preferably one that has a limited 'rise time' for the applied DC test Voltage. Using a tester above these ratings will not damage the sensor, but may cause the sensor protection to turn, giving the false impression that the sensor is shorted.

When the sensor is connected to a motor and motor cable there is normally enough capacitance in the motor and cable to limit the Megger signal 'rise time', and the protection circuitry will not turn on. However, if the sensor is tested by itself, without the motor cable, some testers may cause the protection circuits to engage. This varies by insulation tester brand, model and even the tester battery condition, since weaker batteries cause the test Voltage to rise much slower than fresh batteries. To use these testers directly with the standalone sensor may require the addition of a series current limiting resistor in series with the high Voltage test lead that will prevent the ACE high Voltage protection circuit from engaging.
The resistor value is not at all critical, somewhere between 100K Ohms and 250K Ohms is enough to limit the rise time but small enough to have negligible effect on the insulation reading. (e.g. 220K Ohm resistor in series will result in an error of 0.00022 GOhm; most meters only measure to 0.1 GOhm accuracy). Testers such as the Fluke 1550 / 1555 have ramp test capability and may be used directly without requiring a series resistor if the ramp rate is set correctly. When testing installed systems the long length of the motor cable provides a large enough capacitance to slow down insulation tester rise times and will prevent the sensor protection circuit turning on with any brand of tester. A test lead, P/N 1170576 is available to assist in standalone instrument Megger testing, it has an internal resistance of 220 KOhms.



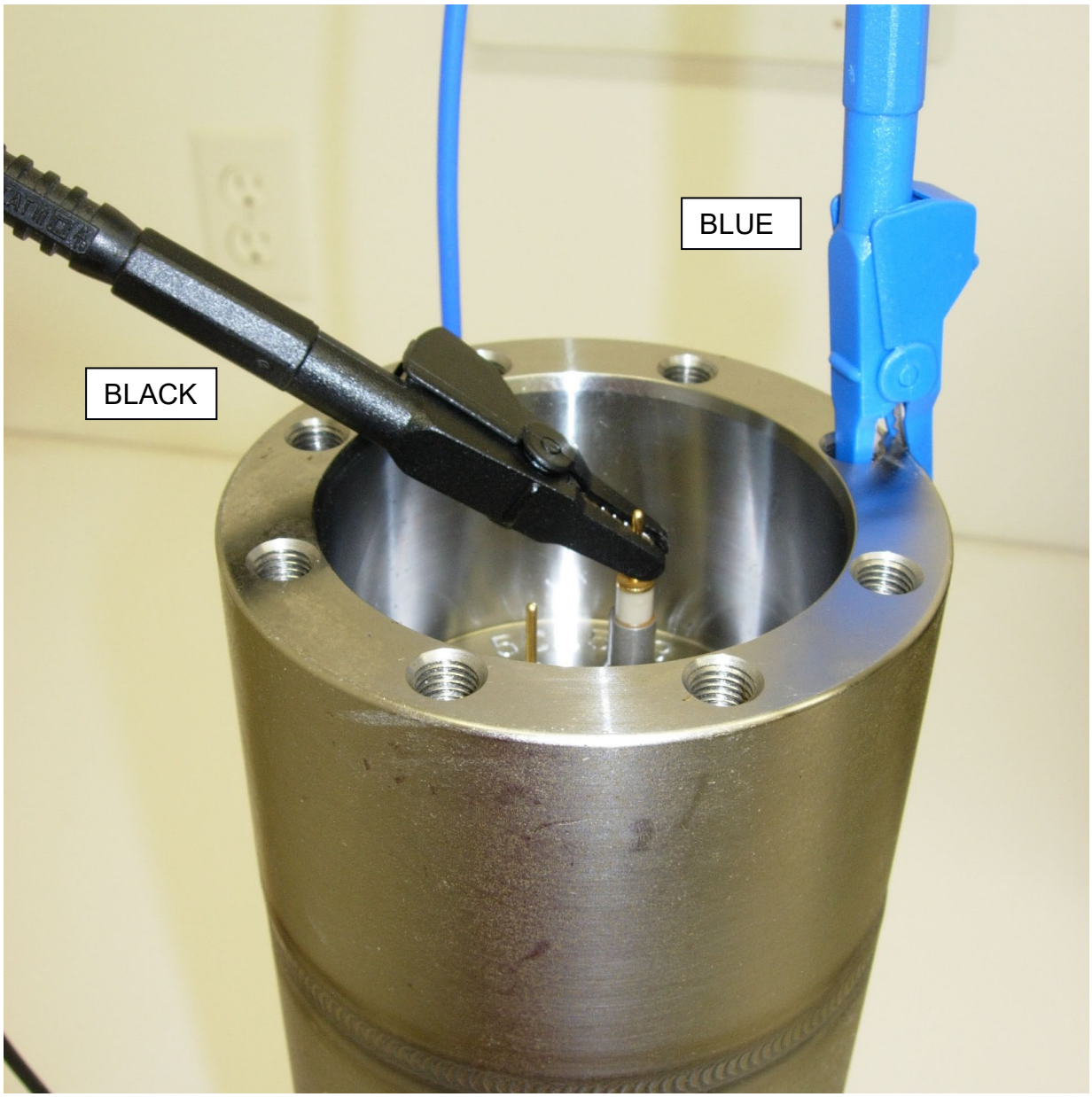
Insulation Test Procedure (On Surface)

The recommended test instrument is the Fluke 1507 insulation tester, however many other brands will perform the same function. The series resistor shown in the picture is only required if the sensor is tested on the surface without a motor cable, since a motor cable would have enough capacitance by itself to slow the Voltage rise time allow testing.



The instrument should be tested with a –Ve polarity, so the test leads should be connected as shown with the 'common' connection going to the large pin. If connected backwards the instrument will not be damaged but the Megger test reading will be zero.

Do not connect any Voltage to the small pin which is used for winding temperature measurement – applying Voltage to the small pin may damage the instrument.



Press and hold the test button on the insulation tester; the test Voltage should go up to around 1000VDC and the insulation resistance slowly climb up to several Gig Ohms. Note that temperature, cable condition, cable type, ambient humidity and other factors will influence the system. The sensor by itself, at room temperature typically has an insulation resistance exceeding 4 Gig Ohms (>4000 Meg Ohms). However once the sensor is downhole combined with the motor and motor cable the insulation resistance reading may be down to well below 20 Meg Ohms, mainly due to the motor cable.

Insulation Test Procedure (On Wellsite)

Once the sensor is connected to the motor and the motor cable is connected to the motor an insulation measurement may be taken. In this case due to the capacitance of the motor cable the standalone test lead will not be required. The insulation tester may be directly connected to the end of the motor cable while it is still on the spool, or as it is being lowered into the well. As explained above the insulation resistance readings will probably be substantially less compared to readings taken directly from the instrument on the surface; this is due to the affect of the motor and cable leakage resistances.

Resistance Testing with a Simpson 260 Analog Meter.

Using an analog type meter is the best method to use for low Voltage testing. Due to active electronics inside the sensor digital multi meters may return ambiguous readings when connected to good, fully functional sensors. Many digital auto-ranging meters cannot display a stable reading, since inductance inside the instrument may cause the meter to keep changing ranges (if using a digital meter and this occurs set the range manually).

To use the Simpson 260 meter proceed as follows. Set the meter to the 10,000 Ohm range, short the two leads together and zero the reading using the adjustment potentiometer. Once zeroed attach the red lead to the sensor ground, and the black lead to the large sensor pin (or the motor lead if the sensor is still connected to the motor). Depending on the type of sensor, and the condition of the Simpson meter battery, readings should be obtained similar to the chart below.

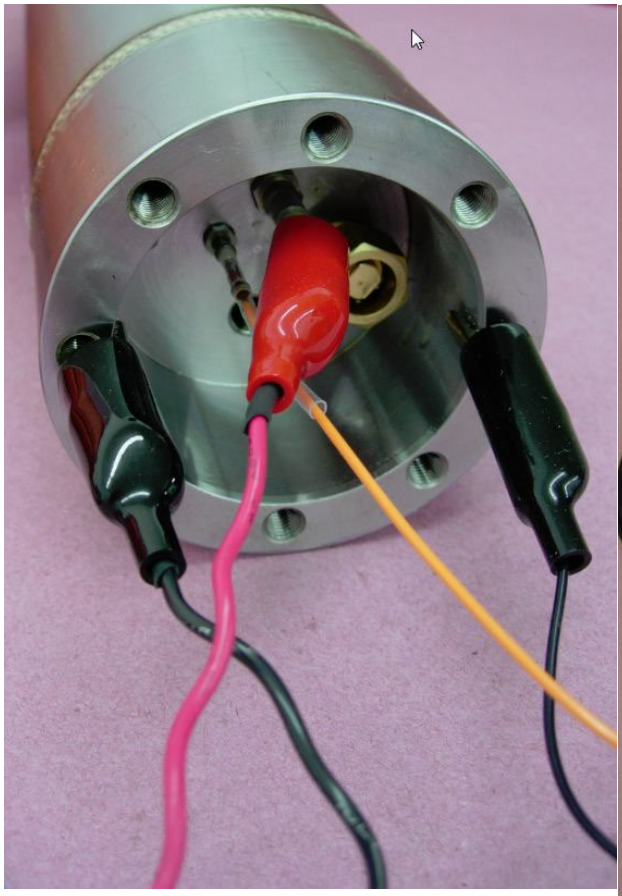
Note that there are three versions of electronics for the three ranges of different temperature rated sensors, the version can be identified by the sensor serial number. If there is an X in the sensor serial number it is an extreme temperature (177°C) version, if the serial number contains the letter ‘H’ it is a high temperature (150°C) version and if neither letters are in the serial number its a standard temperature (125°C) sensor. Unfortunately readings given by the Simpson meter will also fluctuate depending on the state of the Simpson meter 9 Volt battery, even after the meter has been zero’d so the chart shows these variances as well.

Sensor Type	Reading (Simpson battery at 9V)	Reading (Simpson battery at 7.5V)
Standard	24 KOhms	28 KOhms
High Temp (H)	18 KOhms	22 KOhms
Extreme Temp (X)	19 KOhms	23 KOhms

If the meter leads are reversed the meter needle will indicate a brief kick due to capacitance inside the sensor.

System Integrity Test (On Surface)

Ensure that power is off to the surface test unit. If testing the sensor alone connect the signal wire to the large (signal) pin and the black (ground) lead to one of the sensor bolt holes. If available attach the winding temperature simulator black wire to another of the sensor bolt holes. Attach one of the winding temperature simulator leads (orange to

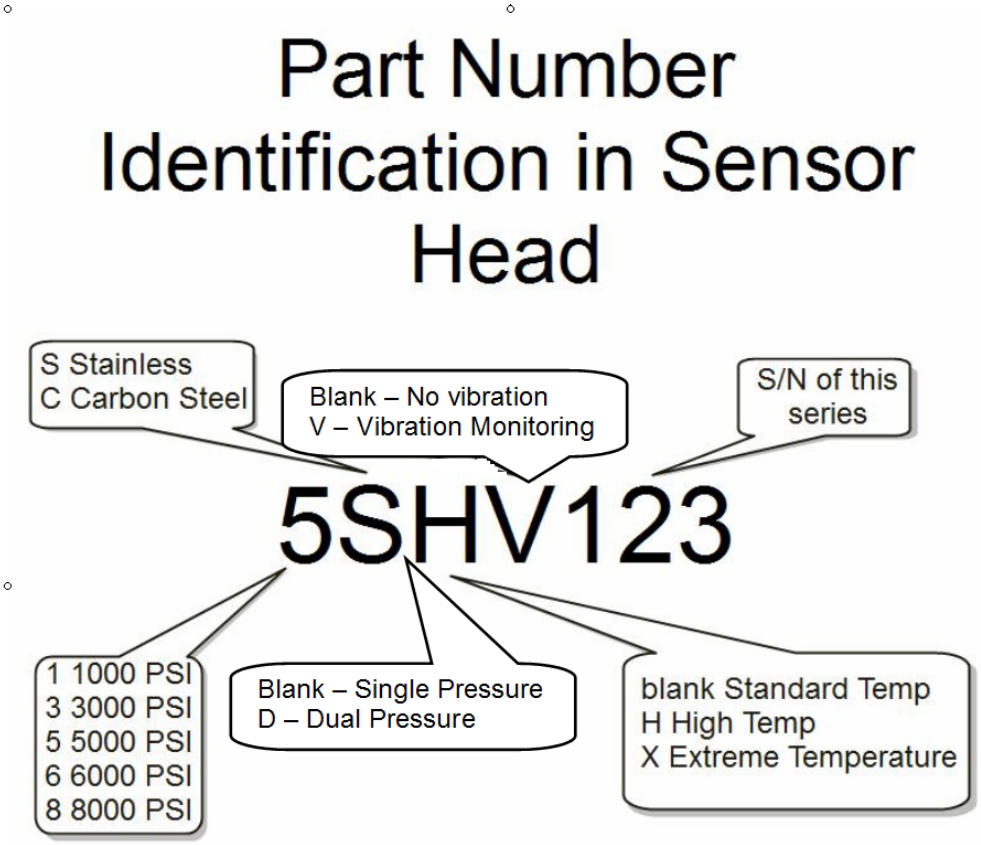


simulate for 500°F as shown in the picture or blue to simulate 100°F) to the small temperature transducer pin. Turn on the electrical test unit and within a couple of minutes readings should appear; if not verify menu 9 is set correctly; see below for further details.

If testing a complete system with sensor attached to the adapter connect the signal ground lead from the SRU to the motor adapter metal, the bolt holes may provide a suitable place to connect. Connect the signal wire to one of the motor adapter wye lead connections, or if the adapter is attached to the motor one of the motor leads. Apply power to the SRU , which will briefly display the firmware version then it will display menu 1, which will show the instrument internal temperature once communications with the sensor have been established.
There are many different versions of sensor available, the SRU / SRU2 must be set to communicate with the correct sensor otherwise no readings will be obtained. Menu 9 is set to match the number of channels of data that the sensor is transmitting, verify it matches the sensor as shown below:

Sensor Type	Menu 9 Setting
2 Channel (Wireline ‘slim’ models)	2
2 Channel Highspeed (wireline PCP model)	2F
3 Channel (most common, 1 pressure, 2 temperatures)	3
4 Channel (discharge capable version; 2 pressures, 2 temperatures)	4
5 Channel standard and high temp (1 pressure, 2 Temperatures, 2 vibrations)	5
5 Channel Extreme Temperature (1 pressure, 2 temperatures, 2 vibrations)	5X
6 Channel High Temperature (2 Pressure, 2 temperatures, 2 vibrations)	6
6 Channel Extreme Temperature (2 pressure, 2 temperatures, 2 vibrations)	6
Future version	7
Future version	8

The Menu 9 setting can be derived from the units serial number and chart above; menu 23 (pressure range) from the first digit of the units serial number.



It will take a minute or two for the SRU to display values from the instrument, depending on the instrument model different channels will contain values. Below are the SRU menus, items marked * are adjustable. To make changes, as an example to change Modbus Baud rate, use the up and down keys to navigate to Menu 19. Press the ‘Enter’ key and the parameter will start to flash. Use the up and down keys to change the parameter. Then pressing Enter will save the modified parameter, or Cancel will leave it unchanged.

SRU AND SRU2i STANDARD MENUS

* = Adjustable items in italics are for diagnostic use

1 Instrument temperature °F (resolution 0.1°F)
2 Intake Pressure PSI (resolution of 1 PSI SRU, 0.1 PSI SRU2)

3 Winding Temperature °F (resolution 0.1°F)
4 X Vibration (x0.001 G)
5 Y Vibration (x0.001 G)
6 Discharge Pressure PSI (resolution of 1 PSI SRU, 0.1 PSI SRU2)
7 Discharge Temperature °F (resolution 0.1°F)
8 Reserved for future use
9 * Number of channels to read
10 * *Output Voltage set point (default 3250)*
11 Measured output Voltage
12 *Instrument current (0-1023)*
13 *Instrument threshold (0-1023)*
14 *Surface unit DC Voltage (does not exist on the SRU2)*
15 Decode state
16 *Cutoff filter frequency*
17 *Total number of data packets received*
18 *Number of bad data packets received*
19 * Modbus Baud rate
20 * Modbus ID
21 * Modbus gap time
22 *Auto Adjust Threshold*
23 * Instrument Pressure Range
24 * *Factory access code*

Menus 25 to 33 are for extended functions of the SRU2, they do not exist on the SRU. See the following table for the complete SRU2 menu map and navigation structure.

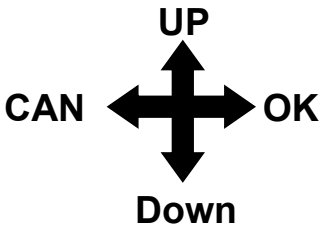
25 Ethernet IP address, net mask and port
26 Real time clock settings, date and time.
27 Relay 1 settings; Modbus register to use, on and off setpoints.
28 Relay 2 settings; Modbus register to use, on and off setpoints.
29 Analog Output 1 settings; Modbus register to use, process and output values.
30 Analog Output 2 settings; Modbus register to use, process and output values.
31 Analog Output 3 settings; Modbus register to use, process and output values.
32 Analog Output 4 settings; Modbus register to use, process and output values.
33 SD Card Datalogging. Card data flush, logging enable, sample rate and filename.
34 Insulation Monitoring. (SRU2xi versions)

Typically up to the first six menus will be used. The remaining menus are for system diagnostics, configuration and troubleshooting. The SRU may be used to directly identify problems in the system, refer to a later section for a detailed troubleshooting guide.

Once the system has been verified remove power to the SRU, wait a couple of seconds then remove the signal and signal ground lead. The system may now be run downhole. Run in may be paused at any time, then insulation and system integrity tests may be performed to verify good downhole cable, motor and instrument integrity. When the installation is complete ensure the SRU is connected to the HVI unit. Power may be applied to the SRU and readings from the downhole instrument should appear within a couple of minutes. The motor may now be started and the system put into service.

SRU Detailed Menu Map

Note: To switch between numeric and alpha menus Press Up and Down Keys together.



Numeric	Alpha	Menu		
1	TI	Intake Temperature	Highest Since Power Up (HI)	Highest Ever (HE)
2	PI	Intake Pressure	Highest Since Power Up (HI)	Highest Ever (HE)
3	TW	Winding Temperature	Highest Since Power Up (HI)	Highest Ever (HE)
4	Vx	Vibration X	Highest Since Power Up (HI)	Highest Ever (HE)
5	Vy	Vibration Y	Highest Since Power Up (HI)	Highest Ever (HE)
6	PD	Discharge Pressure	Highest Since Power Up (HI)	Highest Ever (HE)
7	TD	Discharge Temperature	Highest Since Power Up (HI)	Highest Ever (HE)
8	X8	Option Channel	Highest Since Power Up (HI)	Highest Ever (HE)
9	CH	Number of channels	Adjust setpoint	
10	VS	Voltage Setpoint	Adjust Setpoint	
11	Vo	Voltage Output (Measured)		
12	Io	Current Output (Measured)		
13	Th	Threshold		
14	PS	Internal DC Voltage (SRU only)		
15	dE	Decode state		
16	LP	Lowpass Filter	Adjust Setpoint	
17	PG	Good Packets Received		
18	PB	Bad Packets Received		
19	Bd	Modbus Serial Baud rate	Adjust Setpoint	
20	Id	Modbus ID	Adjust Setpoint	
21	GA	Modbus Gap time (mS)	Adjust Setpoint	
22	22	Comm reset Threshold		
23	Pr	Instrument Pressure Rating	Adjust Setpoint	
24	FA	Factory Diagnostics	Test number – See below	
		IP Address 4 (I4)	Adjust Setpoint	
		IP Address 3 (I3)	Adjust Setpoint	
		IP Address 2 (I2)	Adjust Setpoint	
		IP Address 1 (I1)	Adjust Setpoint	
25	IP-→	Ethernet Enable (IE)	Adjust Setpoint	
		Ethernet TCP Port (IC)	Adjust Setpoint	
		Ethernet RTU Port (IT)	Adjust Setpoint	
		IP Netmask 3 (N3)	Adjust Setpoint	
		IP Netmask 2 (N2)	Adjust Setpoint	
		IP Netmask 1 (N1)	Adjust Setpoint	
		Clock Year (YE)	Adjust Setpoint	
		Clock Day (dA)	Adjust Setpoint	
26	CL-→	Clock Month (MN)	Adjust Setpoint	
		Clock Seconds (SE)	Adjust Setpoint	
		Clock Minutes (MN)	Adjust Setpoint	
		Clock Hours (HR)	Adjust Setpoint	
		Relay 1 On setpoint (ON)	Adjust Setpoint	
27	R1-→	Relay 1 Control Register (RG)	Adjust Setpoint	
		Relay 1 Off setpoint (OF)	Adjust Setpoint	

		Relay 2 On setpoint (ON)	Adjust Setpoint	
28	R2-→	Relay 2 Control Register (RG)	Adjust Setpoint	
		Relay 2 Off setpoint (OF)	Adjust Setpoint	
		Analog1 Process 2 value (P2)	Adjust Setpoint	
		Analog1 Process 1 value (P1)	Adjust Setpoint	
29	A1-→	Analog1 Control Register (RG)	Adjust Setpoint	
		Analog1 Output 2 value (O2)	Adjust Setpoint	
		Analog1 Output 1 value (O1)	Adjust Setpoint	
		Analog 2 Process 2 value (P2)	Adjust Setpoint	
		Analog 2 Process 1 value (P1)	Adjust Setpoint	
30	A2-→	Analog 2 Control Register (RG)	Adjust Setpoint	
		Analog 2 Output 2 value (O2)	Adjust Setpoint	
		Analog 2 Output 1 value (O1)	Adjust Setpoint	
		Analog 3 Process 2 value (P2)	Adjust Setpoint	
		Analog 3 Process 1 value (P1)	Adjust Setpoint	
31	A3-→	Analog 3 Control Register (RG)	Adjust Setpoint	
		Analog 3 Output 2 value (O2)	Adjust Setpoint	
		Analog 3 Output 1 value (O1)	Adjust Setpoint	
		Analog 4 Process 2 value (P2)	Adjust Setpoint	
		Analog 4 Process 1 value (P1)	Adjust Setpoint	
32	A4-→	Analog 4 Control Register (RG)	Adjust Setpoint	
		Analog 4 Output 2 value (O2)	Adjust Setpoint	
		Analog 4 Output 1 value (O1)	Adjust Setpoint	
		SD Logging Rate (LP)	Adjust Setpoint	
		SD Logging Enable (LE)	Adjust Setpoint	
33	LG→	SD Logging Flush Card (LF)	Adjust Setpoint	
		SD Logging File Name (N4)	Adjust Setpoint	
		SD Logging File Name (N3)	Adjust Setpoint	
		SD Logging File Name (N2)	Adjust Setpoint	
		SD Logging File Name (N1)	Adjust Setpoint	
>2	IN→	Insulation Monitoring Reading	Take Measurement	
			Set Automatic Reading Delay	

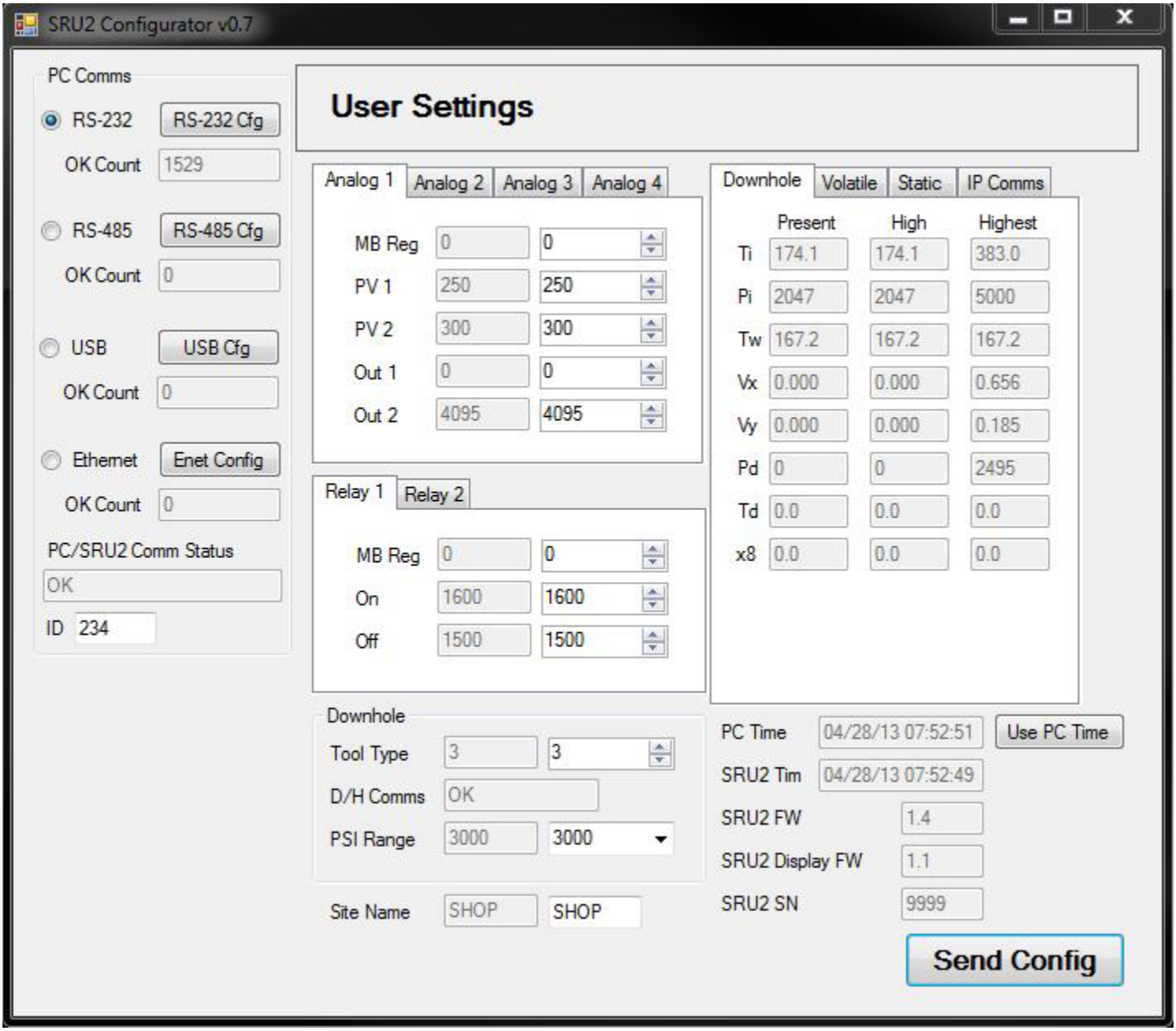
Factory Tests / Diagnostics. Enter following values at menu 24:

0 Exit running test modes
1 Display digit test and SRU2 LED test
2 Display sw versions
14 Display SD card error code
15 Display card error status code
16 Display card error function code
17 Display runtime
19 Display SRU hardware version
20 Resets packet counts
21 Clear highs since power up
22 Clear stored high values. Must be unlocked first
23 Start output test for relays and analog outputs for 2 minutes – use caution!.
30 Starts generating test values for all channels – use caution!.
31 Unlocks readout for 1 minute

Configuration of the SRU2 using the PC Configurator Program.

The SRU2 has many control registers for adjusting its extended capabilities. Although all settings may be made using the built in SRU2 keypad a PC program is also available for easy setup, called the SRU2 Configurator. When starting the program ensure it is 'run as Administrator' otherwise Windows may block correct operation of the program. Once started the screen will look like this.

The connection to the SRU2 may use any of the serial ports or via Ethernet. The connection port may be selected using the PC Comms buttons on the left of the screen; once connected correctly the 'PC/SRU2 Comm Status' will indicate 'OK' and the Tx/Rx LED's on the SRU2 will both be flashing. If connecting via the USB port the PC should install correct serial port drivers automatically, if it does not drivers may be downloaded from http://www.ftdichip.com/Drivers/VCP.htm



At the bottom of the screen are several status displays. Some items may be changed by directly typing the required values into the boxes or using the up/down arrows. Once the correct values are displayed they may be saved to the SRU2 by clicking the 'Send Config' button.

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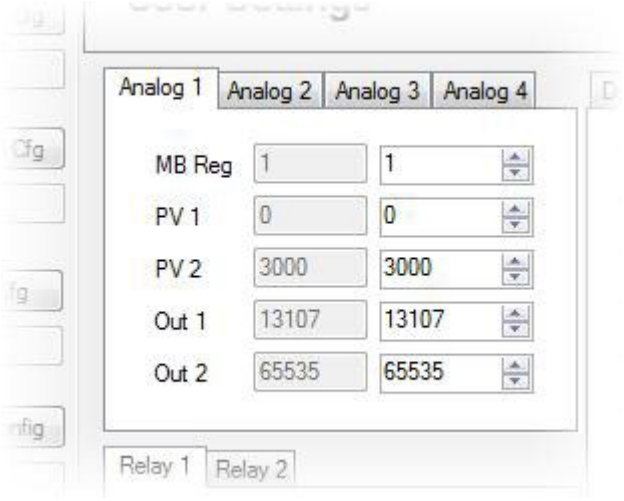
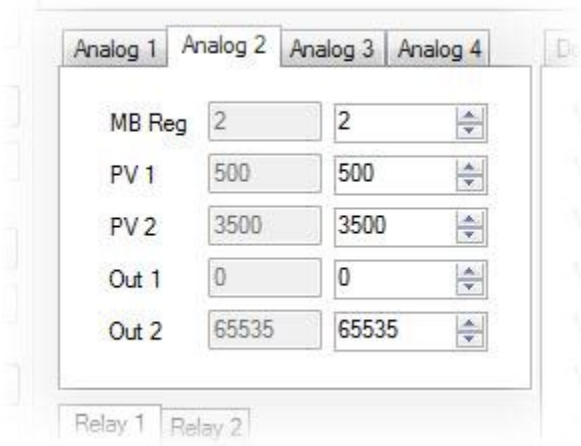
General Status and Controls:

'Tool Type' (keypad menu 9) is set to the number of channels being transmitted to the surface from the downhole sensor; eg 3 = intake temperature, intake pressure and winding temperature. D/H Comms indicates the current state of communications between the SRU2 and the downhole sensor. PSI range (keypad menu 23) is set to the full scale value of the downhole sensor pressure rating. 'Site Name' (sub menu below keypad menu 33) is the name used for the SD datalogging files. By default it is set to the SRU2 serial number; however it may be changed to any 4 character alpha-numeric name typically an abbreviated well name. 'PC Time' shows the current time as reported by the PC. 'SRU2 Time' is the current time in the SRU2, which needs the correct time and date for SD datalogging. The time and date is automatically updated when SRU2 power is off by an internal battery. Clicking 'Use PC Time' will set the real time clock in the SRU2 from the current PC time (for keypad operation see menu 26). There are two boards and software versions in the SRU2. The main board firmware version is shown as 'SRU2 F/W'. The second board controls the display and SD datalogger, its firmware version is 'SRU2 Display F/W'. Both firmware versions may be upgraded in the field, the first may be upgraded using a standard USB cable or RS-232 connection. To upgrade the data logger firmware requires a special cable. Each SRU2 has a unique serial number; this is displayed by 'SRU2 S/N'.

Analog Outputs:

There are four 0 to 20mA analog outputs on the SRU2. Each may be set to operate based on any register in the SRU2, and may be scaled to any values the user may need. In the first example on the right Analog Output 1 is shown. The sensor is a 3000 PSI rated unit and the analog output needs to go from 4mA at 0 PSI to 20mA at 3000PSI. First the 'MB Reg' is set to the register that the control will be based on, in this case it is register 1, the intake pressure, which will vary from 0 to 3000. Process variable 1 'PV1' is the first (typically lower) value to base the output on, in this case it is set to zero. Process variable 2 is the second (typically higher) value to base the output on, shown as 3000. The analog outputs on the SRU2 go from 0 to 20mA, and are scaled by 16 bit registers. Therefore 0.0mA = register value of 0, and 20.0mA = register value of 65535. Since the output needs to start at 4mA not 0mA the first, lower output value 'Out 1' should be (4/20)*65535 = 13107. The second output value, 'Out 2' will be full scale at 65535.



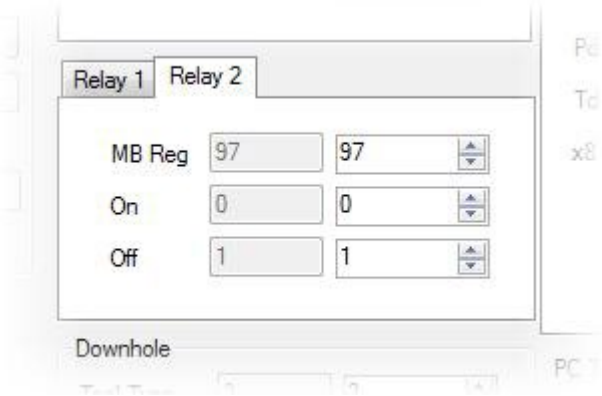


For a second example on the left Analog Output 2 is set to output the Winding temperature but in this case an output of 0 to 10.0 Volts is required. By placing a 500 Ohm 1/2Watt resistor in parallel across the 0-20mA output the SRU2 may output a 0-10VDC signal. Since the temperature register is stored with a precision of 0.1 °F the PV values are multiplied by 10; ie 123.4 °F = register value of 1234. The output is shown configured for 50 °F = 0.0 Volts and 350 °F = 10.0 Volts.

The SRU2 has built in Modbus registers that the user may directly write to for control and testing purposes; these are explained in detail further on, but they are very useful for testing and during analog calibration when connected to other devices. The 'MB Reg' address can easily be set to one of these user registers for testing or control.

Relay Outputs:

There are two general purpose ‘form C’ output relays on the SRU2. Each may be set to operate based on any register in the SRU2, configured in a similar manner to the Analog Outputs. In the example shown to the right Relay 1 is configured to be active, or energized, when the intake temperature rises to above 160.0 °F. The register to base the control on is intake temperature, register 0, so ‘MB Reg’ is set to 0. There are two level set points for the relay control, separate ‘On’ and ‘Off’ which allow the relay control to have hysteresis and therefore avoid chattering if levels move just above and below a single set point. The SRU2 will inspect the On and Off set points, and determine from them the relay ‘polarity’; ie the normally closed or normally open state may be reversed by swapping these two On and Off values. In the example the relay will turn on when the temperature rises above 160.0°F. The relay will remain on until the temperature drops back below 150.0°F.



In the second example to the left relay 2 is configured to be active when the downhole sensor is connected and communicating correctly with verified readings. Register 97 contains the status of the downhole sensor, with a value ranging from zero to 4. 0 corresponds to correct, verified communications and values from 1 to 4 indicate other states, such as beginning communication. By setting the ‘On’ level to 0 and the ‘Off’ level to 1 the relay will only be active when good, verified communications exist, and it will be off for all other states. Using a relay with this register can be useful with 4-20mA output signals; as passing an analog 4-20mA signal from the SRU2 through the relay will mean the 4-20mA signal will drop to zero if there is a downhole fault condition. Most SCADA and control systems will recognize a 4-20mA signal dropping down to zero as a fault condition.

User Registers - Volatile and Static:

There are eight user volatile and eight user static Modbus registers. These may be used for any general control purpose; for example when used to drive relays or analog outputs they allow remotely stopping, starting or controlling the speed of a VSD attached to the SRU2. These registers may be written to at any time; the volatile ones will retain values until power is cycled then reset to zero upon power being returned. The static ones will retain values through power fails.

MODBUS CONNECTION TO THE SURFACE READOUT UNIT.

The SRU has a built in support for Modbus connections. There are two physical connections available, two wire RS-485 and RS-232, but just one may be used at a time. Both of these connections are optically isolated to prevent ground based noise and provide electrical protection.

The SRU2 has a built in support for several Modbus connections. There are four physical connections available. Three of them share the same 'port' so only one of these three may be used at a time. These three are RS-485, RS-232 and direct USB connection. All of these connections are optically isolated from the rest of the controller to prevent ground based noise and provide electrical protection; they are electrically connected to each other. The settings for Modbus ID, Baud rate and gap time are in menus 19, 20 and 21. The ‘gap time’ is a delay in mS before the SRU will respond to a Modbus command. Adjustment may be required when radios are used in the Modbus link, since radios will introduce additional delays in the communications timing.

The forth Modbus connection on the SRU2 is via Ethernet, and it uses a completely separate 'port' to the first three connections, therefore simultaneous Modbus activity via Ethernet and any of the other three serial ports is possible. The Ethernet configuration is setup using menu 25 and its submenus.

The SRU acts as a Modbus RTU slave, and responds to the following commands. It may be polled using command 3 or 4, (typically 4xxxx, 3xxxx addresses) the returned values are the same. All are 16 bit unsigned integers. A few are 32 bit unsigned, stored as consecutive 16 bit registers. Some, but not all, of the Modbus registers may be written to typically for configuration changes and setpoints. Note that the configuration program, described later, allows quick and easy SRU2 setup without requiring any Modbus knowledge.

Commonly used registers are shown below; a full Modbus Map is shown in the appendix.

Register	Contents
1	Instrument measured temperature x 10 in °F. eg. 1234 = 123.4 °F
2	Instrument measured pressure in PSI. e.g. 4327 = 4327 PSI
3	Winding temperature x 10 in °F. eg. 3476 = 347.6 °F
4	X Vibration (x0.001 G) e.g. 3789 = 3.789G
5	Y Vibration (x0.001 G) e.g. 1234 = 1.234G
6	Discharge Pressure PSI e.g. 3668 = 3668 PSI

There are further Modbus registers in the SRU. Appendix C contains the complete register map.

ESP INSULATION MONITORING

It is possible get an approximate indication of the condition of the motor cable by measuring the insulation between ground and the three motor cable conductors. Insulation monitoring readings may be useful over extended time periods, as gradual deterioration can indicate impending cable failures. The SRU2xi readout has this capability built in, and it can take the reading with any sensor whether the motor is running or stationary.

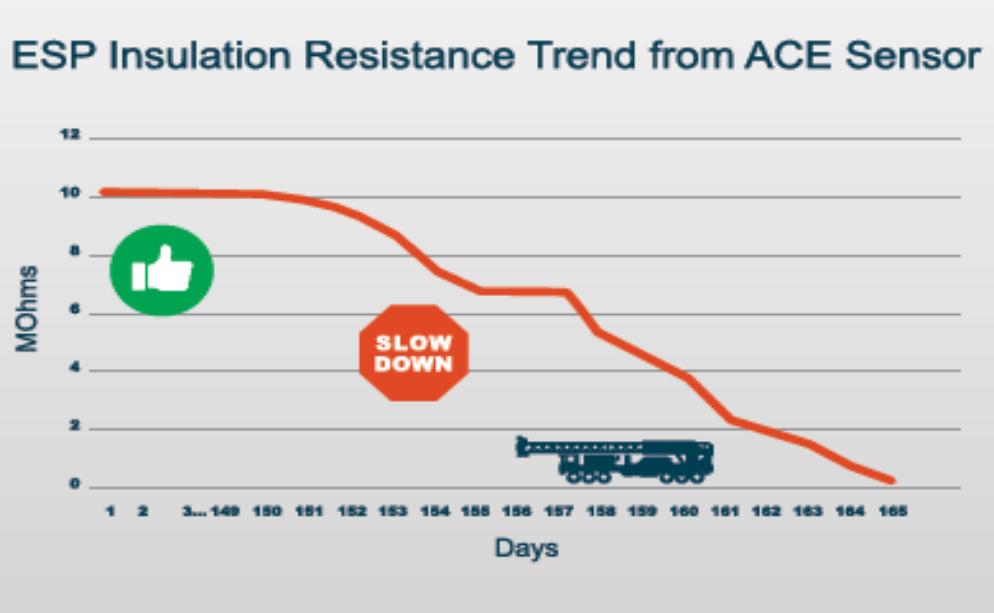
The last reading taken may be viewed by going to the last menu, displayed as '>2' (or 'IN' if the readout is in alpha-numeric mode) and the last reading taken will be shown displayed in Kilo Ohms. The measurement range goes from 200K Ohms to 60000K Ohms (60 Megs Ohms). A new reading may be taken manually at any time by pressing the 'Enter' key on menu >2. The display will change to >3 MEASUR, pressing 'Enter' again will display a flashing "--NO--". Use the Up/Down keys to select "YES" and press "Enter" again to start taking the reading. The display will show 'MEASUR', then 'WAIT' with a count that will increment as the reading is taken. After approximately a minute the reading will be completed.

The SRU2xi may be set to automatically take readings every 1 to 2160 Hours (90 days). To do this when displaying the >3 ('ME') menu press up or down and >4 ('dE') will display the number of hours between taking readings. Press "Enter" to change to delay; setting it to zero will disable automatic insulation readings (display will show "NoAuto"). If automatic readings are enabled (i.e. not zero) the SRU2xi will also take a reading upon power up, it will not take a reading at power up if automatic readings are disabled.

ESP Insulation Monitoring for ESP Motor and Cable Run Life Prediction

The ACE sensor uses a very accurate true measurement technique to arrive at the insulation reading; providing a reverse DC Voltage and measuring the current to arrive at the resistance. To take the reading the SRU2i has to turn off power effectively disconnecting the sensor, reverse the sensor DC power, take the measurement then restore power to the sensor. It will then take a minute or two for the sensor to resume communication to the surface. Therefore it takes up to 3 minutes to obtain an insulation measurement and during this time readings from the sensor are not updated. For this reason and the fact that typically insulation resistance may change very slowly over long time periods its suggested the readings are taken perhaps every 24 hours or longer; they may of course be taken on demand at any time.

Operators and ESP companies use ACE ESP insulation resistance monitoring to predict and optimize ESP motor and cable run life. They set alarm settings in their SCADA system to be alerted about rapid decline of ESP insulation resistance. These alarms give them an opportunity to reverse a rapid ESP insulation decline trend by changing ESP well operating conditions (VSD frequency, surface pressure, transformer output Voltage, etc..) to prevent premature ESP motor and cable failure and/ or plan for a work-over.



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Some other brands of sensors do not use a true measurement technique. Rather they measure the current supplied by the surface readout and compare it to current measured downhole by the sensor, and assume the difference is leakage current. Unfortunately this is not an accurate measurement, since there are so many measurement inaccuracies between the surface and downhole equipment, due to downhole temperature changes, induced noise from VSD's and motor cables introduces more errors.
In addition, this type of sensor, using analog transmission methods, is extremely sensitive to current leakage so a small leakage resistance cause large signal errors and communication failure. The ACE sensor using digital transmission is far more immune to these insulation leakage problems and will continue to transmit checksum verified readings to the surface long after an analog type transmission system had failed. Typically the ACE sensors still operate accurately with 5 to 8 times the leakage current that causes competing units to fail.

Some sensors can only take a reading during the power up cycle, so although the display may show a reading shortly after power up the same reading will still be on the display months or years later. The measurement cannot be taken again so even if the cable has been shorted for months the incorrect reading is still displayed which is worthless.

MOTOR CONTROL CONNECTIONS

Direct Connection with iCON Advanced Motor Controller.

In addition to the serial and Ethernet connections the SRU and SRU2 have built in support for direct connection to the iCON advanced motor controller. Simply plug the SRU or SRU2 into the iCON controller or accessory and it will automatically appear in the iCON display and menus.
The eight readings from the SRU or SRU2 will automatically appear in the iCON display as ACE Channels. Alarms, shutdowns, restarts, data logging may all use the ACE downhole instrument readings. Additionally the SRU / SRU2 firmware version and serial number can be displayed directly in the motor controller, plus readings will be logged to the SD memory card by the iCON controller.

Direct Connection with the Commander Series and Similar Obsolete Motor Controllers.

The SRU may plug directly into these controllers using an 8 pin shielded (Ethernet type) cable. The SRU2 may use an adapter cable to communicate with these obsolete legacy motor controllers. Simply plug the daisy chained interconnect cable into the SRU2 from the motor control or a motor control accessory. In these motor controllers eight readings from the SRU will typically appear as MODIF channels 1 to 8. Some parameters, such as temperature will be multiplied by 10 in these motor controllers which are unable to display decimal points. Some alarms and shutdowns may be set to use the ACE downhole instrument readings by using the Modif channels.
It is suggested to replace the obsolete motor controller with an iCON controller for better speed, accuracy and performance, improved connectivity, increased reliability and extended data logging capabilities.

THIRD PARTY SURFACE INTERFACE WITH ACE SRU

SRU Emulation of Wood Group Smartguard with the Vector 7 VSD.

The SRU and SRU2 are capable of emulating a Wood Group Smartguard surface interface, so direct readings will appear in the Vector 7 drive without any software changes to the VSD. This lets a failed Smartguard downhole sensor and surface interface be replaced with a higher resolution, higher accuracy and more reliable ACE system but still allow the existing Vector display to show downhole readings; which are also available via scada if the Vector is connected to a scada system. There are no changes to the Vector software required; as well as displaying the ACE results the SRU will also emulate a WG Smartguard interface, so the Vector drive will display readings on its LCD display.

DANGER

Lethal line voltages will be present on the various components of the ACE system and Vector VSD when connected to AC line power. Before attempting to gain access, test or modify connections refer to a qualified electrician for assistance, instructions on safe operation and to ensure that connections meet all applicable safety procedures, standards and codes.

Note The SRU requires F/W 1.9 or later to support WG emulation.

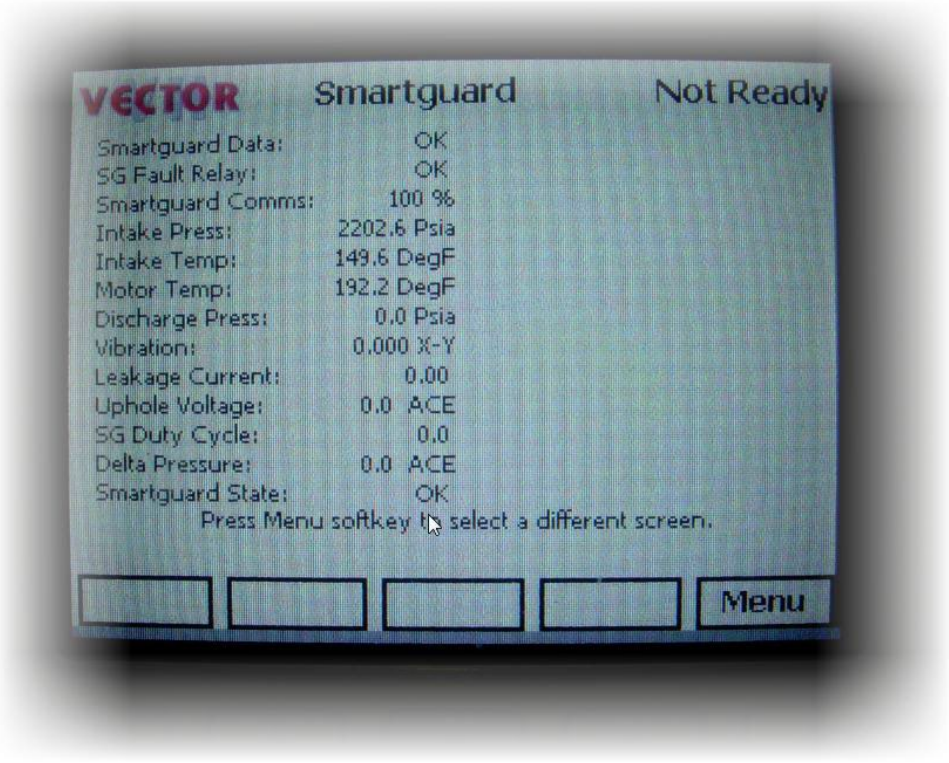
Connections:
Disconnect WG Smartguard interface board and dispose of it. The ACE SRU connects as follows to the Vector 7 controller board.

ACE SRU or SRU2	WG Controller Comms Port 6 pin connector (next to SD card)
Comms Port Common	Comms Pin 1 (right hand pin)
Comms Port RS-485 A	Comms Pin 2 (second from right pin)
Comms Port RS-485 B	Comms Pin 3 (third from right pin)

The ACE serial interface should be set to 9600, MB address 1, gap time 3 which allows connection with default Vector VSD settings. The drive power should be cycled to recognize the ACE SRU.

Cautions when using the WG Vector display

Although the Vector drive and SG system claim a resolution of 0.1 PSI (and similar resolutions for the other parameters) this is not true. As parameters get into higher ranges so the resolution drops, for example above 2000 psi the WG pressure resolution is actually 16 PSI. e.g. if the SRU measures a pressure between 2185 and 2201 PSI the SRU will correctly display the pressure to 1 PSI resolution (0.1 PSI on SRU2); however the WG systems will always show 2186.6 PSI. When the SRU pressure drops below 2185 the WG system will display 2170.6 PSI, and when the pressure rises above 2201 the WG will display 2202.6 PSI. This characteristic is a limitation of the WG equipment, not the SRU or ACE sensor which has high resolution across the complete signal ranges. Although the Vector display may be useful for approximate downhole parameter display for highest accuracy readings with true resolution always refer to the ACE SRU display.



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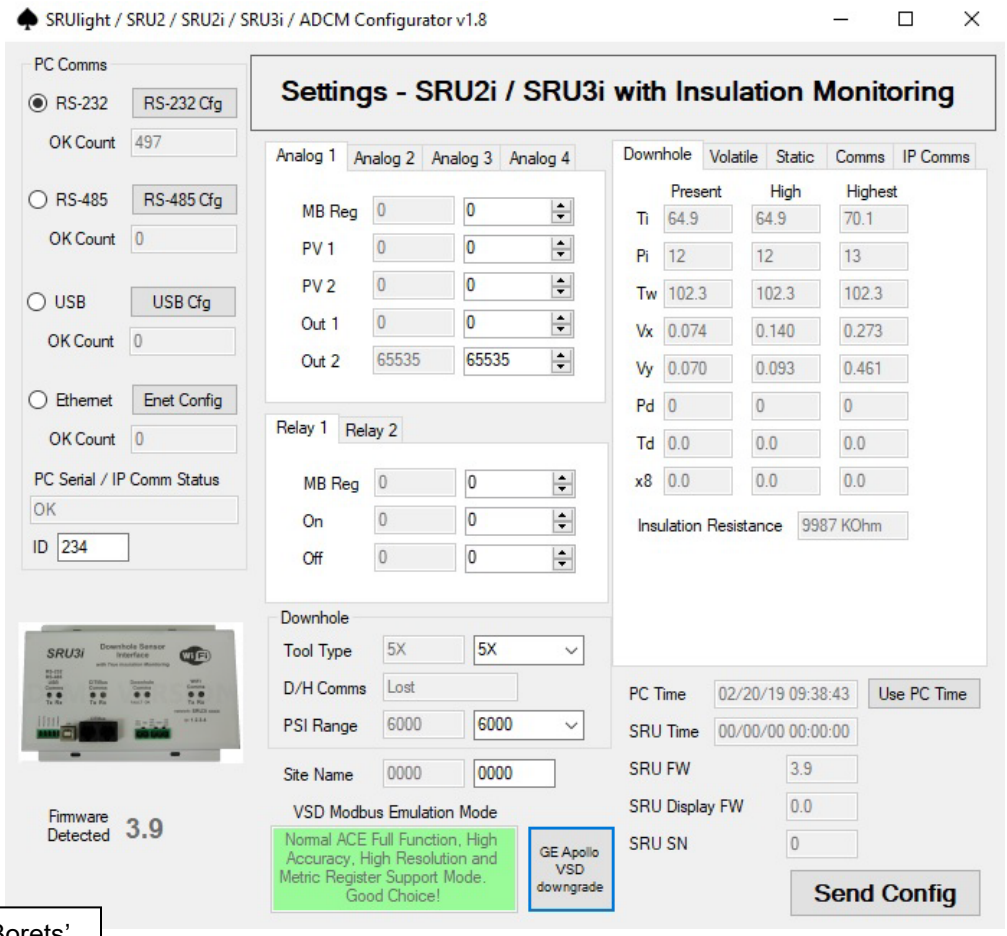
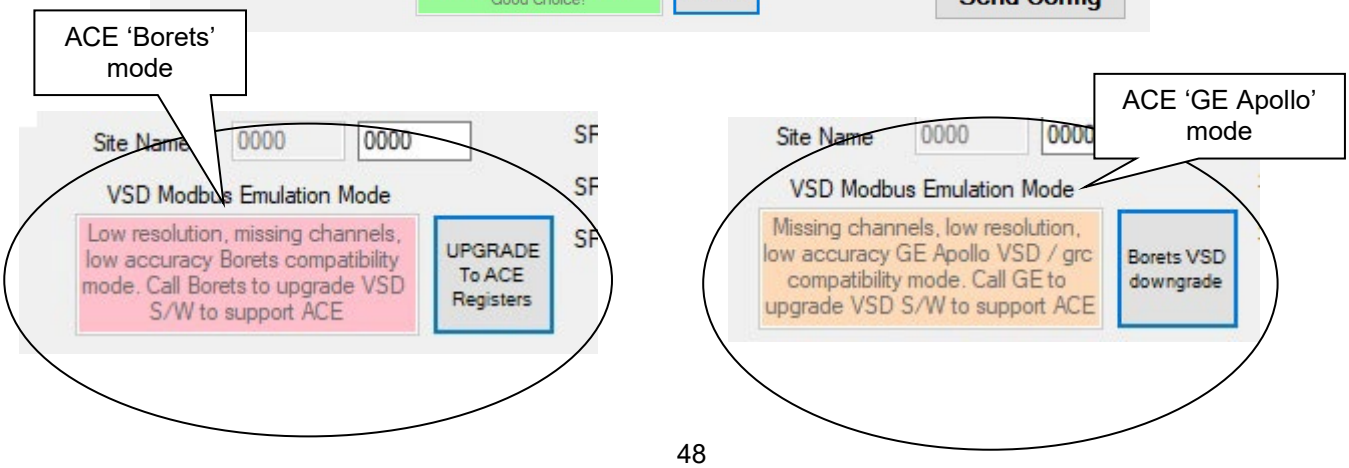
SRU Operation with GE Apollo and Borets VSDs.

The SRU2i and SRU3i are not normally recognized by some Wood Group, Apollo or Borets VSD's with older software. Unfortunately Modbus registers that are polled by these VSD's are used in the ACE readouts for metric values, diagnostics and high resolution readings which these drives do not support. Please ask the Apollo or Borets vendor to upgrade the VSD software to support the ACE high resolution, high accuracy readings with additional channels not supported by the drives, such as insulation measurement readings.

If the VSD cannot be upgraded to newer software then the SRU configuration program may be used to downgrade the SRU2i / SRU3i and set it in emulation mode, where these high performance registers are sacrificed so the ACE readout can supply the VSD's with low accuracy basic sensor readings that are equivalent to the Wood Group, Apollo and Borets sensor registers. Use the configuration program to enable these (requires SRU2i / SRU3i F/W 4.0 or later) or menu 24 as described below.

Note the ACE SRU2i readout display and SRU3i WiFi readings will all still support hi-res and metric readings, its just the VSD's that don't support it.





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The current emulation mode may be displayed on the SRU2i by going to menu 24 and entering 34, and “Normal”, “Apollo” or “Borets” will be displayed. The current mode may be changed by going to menu 24 and entering 134, which will toggle to the next mode.

The Modbus address 1066 contains the current setting, 0x0BAD (2989) for Apollo 0x0DAB (3499) for Borets, anything else is ACE mode.

BAKER HUGHES / CENTRILIFT CENTINEL SURFACE INDUCTOR PACKAGE & OTHER INDUCTOR PACKAGES

⚠ WARNING

The ACE High Voltage Interface (HVI) is specifically designed to protect the operator from lethal Voltages and the surface readouts from damage during motor or cable fault conditions. The HVI is certified to conform to UL & CSA safety standards, and every one is tested at 7000VAC during manufacture. Other brands are not certified nor are safe, and will not protect the surface readouts from being damaged or possibly exposing operators to lethal Voltages. Specifically the GRC/Sercel ESP Surface Package, which is a direct copy of an obsolete REDA design from 40 years ago, is not certified, is not safe and does not protect the surface readouts from damage during fault conditions. This unit should *never* be used with ACE equipment.

It is possible to use some other brands, the Schlumberger package typically works and the Centrilift package may also work.

When some customers upgrade from Baker Hughes / Centrilift brand downhole sensors to ACE downhole sensors it may be possible to utilize an existing Centinel Surface Inductor Package, saving the cost and time required to install an ACE High Voltage Interface. To use the Centinel Surface Inductor Package (referred to as ‘CSIP’) with an ACE system requires a simple kit to be added to the CSIP, called the BH Interface Module P/N 1170661.

> Caution: Inside the CSIP is a transient surge arrestor which is frequently damaged by high Voltage surges. If this device is already shorted out it will prevent operation of the ACE and any other brand of sensor from operating correctly. If it is already blown open circuit there will be reduced High Voltage protection available from the CSIP. Verify this device has not been damaged before trying to use the CSIP.

Installation Instructions:

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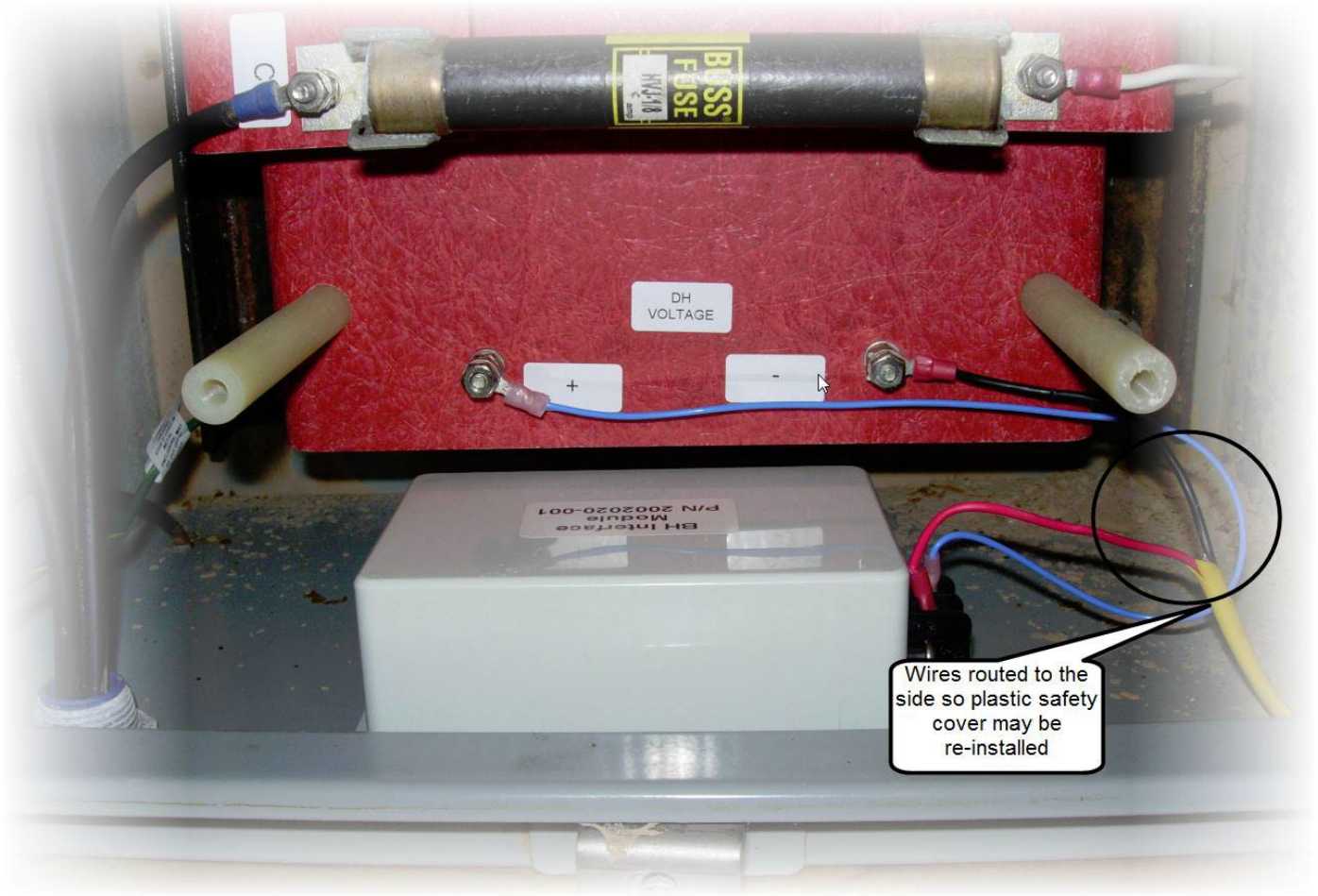
DANGER

Lethal Voltages will be present on the various components of the ACE system and Centinel Surface Inductor Package when connected to AC line power. Before attempting to gain access, test or modify connections refer to a qualified electrician for assistance, instructions on safe operation and to ensure that connections meet all applicable safety procedures, standards and codes.

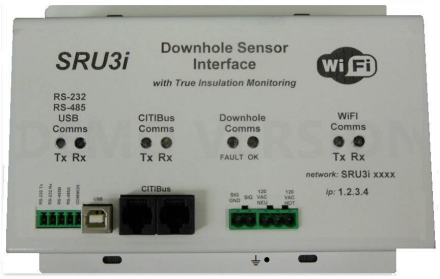
Remove and lockout all power to the system. Gain access to the Centinel Surface Inductor Package and remove the plastic safety cover. Remove the existing signal wire from the + terminal by the 'DH Voltage' label. Attached the blue wire from the BH Interface Module to the + terminal by the 'DH Voltage' label.



Attach the signal wire that was removed from the + terminal to the open terminal on the BH Interface Module. Route the wires so the plastic safety cover may be reinstalled. Re-install the plastic safety cover and close the enclosure.

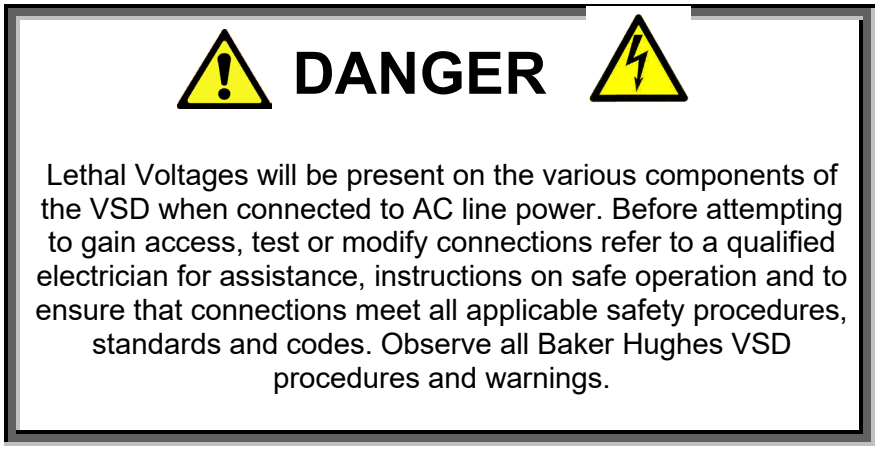
SRU3I - INSTALLATION AND OPERATION WITH BAKER HUGHES / CENTRILIFT GCS / ADVANTAGE VSD

When a Baker Hughes / Centrilift VSD is being used there are several ways to bring the ACE sensor signal into the VSD. There are many versions, depending on age and installed options of the BH VSD. Early drives, without any digital I/O capability may use analog inputs driven by an ACE SRU2 readout, however this usually limits the sensor channels that may be monitored to 2. Some drives are capable of interfacing to an ACE SRU or SRU2 via a Baker Hughes option called a Remote Data Communication Module (RDCM). Programming of the RDCM is required to connect to the ACE sensor SRU or SRU2, consult BH documentation for details.



The SRU3i is an ACE sensor interface that makes connection to a BH VSD fast, easy, more economical and adds features. The SRU3i has a built in high speed, direct interface to the Baker Hughes VSD internal data bus (referred to as 'CITIbus'). When using the SRU3i all sensor readings will appear directly on the GCS drive and are available for all VSD / SCADA control and monitoring functions. The RDCM interface is *not* required. In addition the SRU3i has a built in WiFi server and establishes a local WiFi network so operators close by are able to make adjustments and view readings directly from a phone or tablet. No cell phone service, mobile data or internet access is required to use this feature. Like the SRU2i, the SRU3i provides accurate system insulation resistance monitoring. See the SRU2i section on insulation monitoring for further details. Standard electrically isolated Modbus RS-232, RS-485 & USB interfaces are also provided so the SRU3i may also be used in other brands of VSD. The SRU3i Version 2 adds GPS plus data logs of every sensor reading ever taken, all accessible from WiFi.

Installation Instructions



Remove and lockout all power to the system. If an RDCM is installed disconnect and recycle it. If a Centinel power supply and Centinel Interface are installed they may also be disconnected and recycled. Install the SRU3i in a suitable location with screws to one of the metal panels, it will require 120VAC power and be connected via a CAT5 cable in series with the other CITIbus modules. If replacing an RDCM it can connect to the 2 cables that were plugged into the RDCM, if not the 2ft long 8 conductor CITIbus cable (supplied with SRU3i) will allow it to be located close to the other modules and connected in series with them. Note the VSD display is always the last device in the CITIbus chain, since it only has one 8 pin connector. Connect the SRU3i signal and SRU3i signal ground (note this is not connected to the SRU3i safety ground stud which only connects to the SRU3i metal case) to the sensor high Voltage interface (HVI), typically located in the transformer. Connect a source of 120VAC from the VSD, typically from a control transformer to the SRU3i. It could also come from the 2 disconnected Centinel interfaces. Once the installation is complete the VSD may be securely closed and powered back up.

Setup Instructions

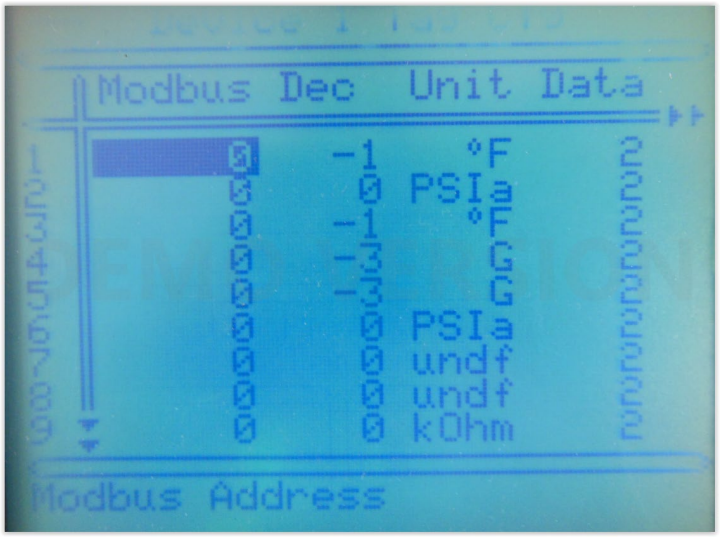
To maintain compatibility with the many hardware and software versions of the BH VSD that exist the SRU3i interfaces to the CITIbus by emulating an RDCM, except with more intelligence. The sensor readings and diagnostic information will all appear on the BH VSD RDCM screens.

Note. If the sensor readings are only to be monitored via WiFi or SCADA there is no need to enter scaling and units for the BH VSD screen.

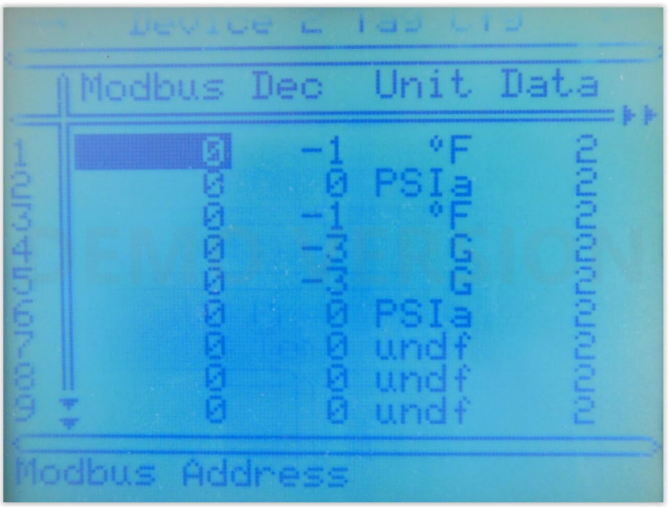
To display the correct scaling and units proceed as follows.

Note. Depending on existing VSD settings some of the changes may be locked out by the VSD . To unlock and allow changes proceed as follows. On the main VSD screen select Scada / Security. Then change the User, Level 1 and Level 2 passwords to 0. Next scroll to the right to find "User Menu Level" and set it to Advanced.

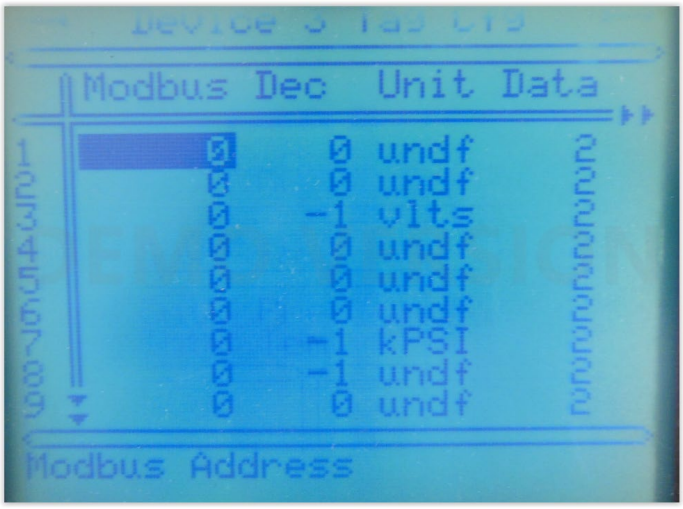
On the main screen select select GCS Modules->GCS Module Status. Ensure that the "Remote Data Com" is enabled so the VSD will communicate with the SRU3i. Press the Menu key to return to the previous menu, then select 'Remote Data Com Module'. This will take you to the 'Device 1 Tags', which shows all live sensor readings, its the first of 4 screens relating to the SRU3i, similar to the picture shown on the right. There are 3 Device screens and one RDCM setup screen. In the example shown the results have been scaled to show the best resolution that the BH VSD display is capable of (note that SRU3i WiFi screens have full resolution for all parameters), and units are visible for some parameters. To set the scale and units use the left or right keys to get to the 'RDCM Setup Screen'. Then select 'Device 1 Setup' which will show a screen full of parameters related to RDCM setup. The SRU3i will automatically configure itself to communicate and none of these items have any effect or meaning except 'Tag Cfg'. and 'Device Type'. To allow setting correct units and scaling enter 'cstm' for 'Device Type'. Once this has been done select 'Tag Cfg' to bring up a screen similar to below.



Use the cursor, edit and menu keys to change the display to match the 'Dec', 'Unit' and 'Data' columns. Note the Data field determines if the VSD handles the register as a 15 bit signed register (if set to 1) or a 16 bit unsigned register (if set to 2), these should all to be set to 2. For example, the insulation reading goes up to 60,000 KOhms so it needs to be set to 2 otherwise there will be negative readings once the insulation is above 32767 KOhms, for some of the other parameters it has no effect. Select what needs to change, press the enter key then use up/down to change. Press enter again to stop editing that parameter. Note that depending on the version of sensor connected, the PSIa units may be changed to PSIg. Sensors with an X in the serial number (6K & 8K) use PSIa, all others PSIg. Once Device 1 has been setup back out using the menu key. Repeat the above procedure to set up the similar screen for 'Device 2' (which is a 'high readings' screen). Again use the cursor keys, edit and menu keys to change the display to match the 'Dec' and 'Unit' columns. Repeat the procedure a final time for 'Device 3' (the diagnostics screen).

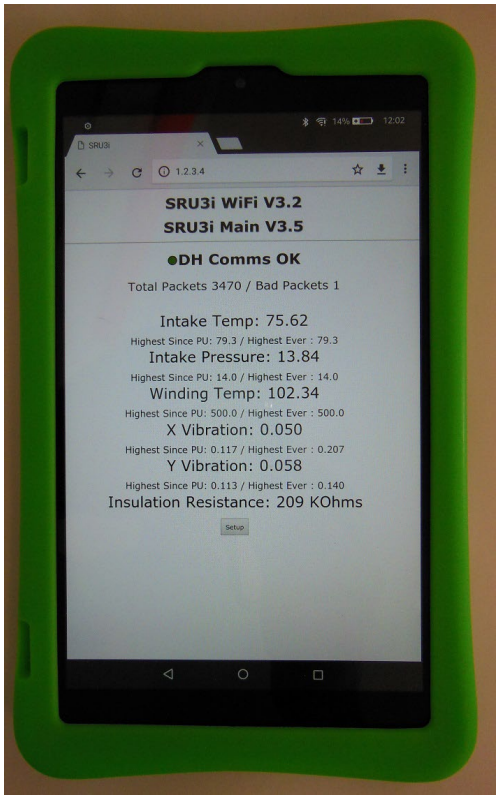


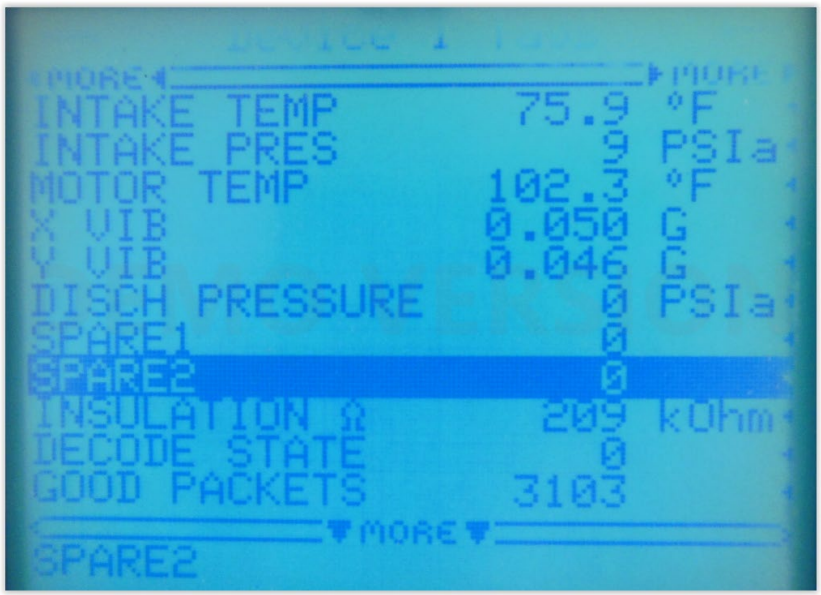
Device 2 setup screen



Device 3 setup screen

The complete setup may be saved to a PCMIA card and easily loaded into another VSD to speed installation. At this point the BH VSD screens should be all set correctly.
Using the Baker Hughes VSD display for SRU3i Readings:





Once the VSD display has been configured it may be used. To see current readings navigate to the RDCM menu and select ‘Device 1 Tags’. The first 6 readings correspond to the first 6 menus on a standard ACE SRU or SRU2.

Device 1 Tags:

1 Intake temperature in Deg °F
2 Intake pressure in PSI.
3 Winding temperature in °F
4 X Vibration in G
5 Y Vibration in G
6 Discharge pressure in PSI
7 & 8 Reserved for future use.
9 This is the true insulation resistance measured in KOhms, if its over 60,000KOhms it is effectively open circuit.
10 Comms status of the downhole sensor. 0 = receiving good data. 1 = connecting, 2 = open circuit, 3 = short circuit, 4 = cannot decode data.
11 Number of good readings received from the downhole sensor. *Note, due to the resolution restrictions of the BH VSD the readings will wrap at 65535 (after approximately two weeks).* This count may be reset via scada or from a WiFi key pad.
12 Number of bad readings received from the downhole sensor. This count may be reset via scada or from a WiFi key pad.

Device 2 Tags:

The device 2 tags automatically toggle between 2 sets of readings every few seconds. One set of readings are the highest values recorded since the unit was last powered on. The second set of readings are the highest values ever recorded which are stored inside the SRU3i. Both of these sets may be reset from the WiFi keypad or scada.

1 Intake temperature in Deg °F
2 Intake pressure in PSI.
3 Winding temperature in °F
4 X Vibration in G
5 Y Vibration in G
6 Discharge pressure in PSI
7-12 Reserved for future use.

Device 3 Tags:

The device 3 tags contain diagnostics related to the sensor and CITbus comms.

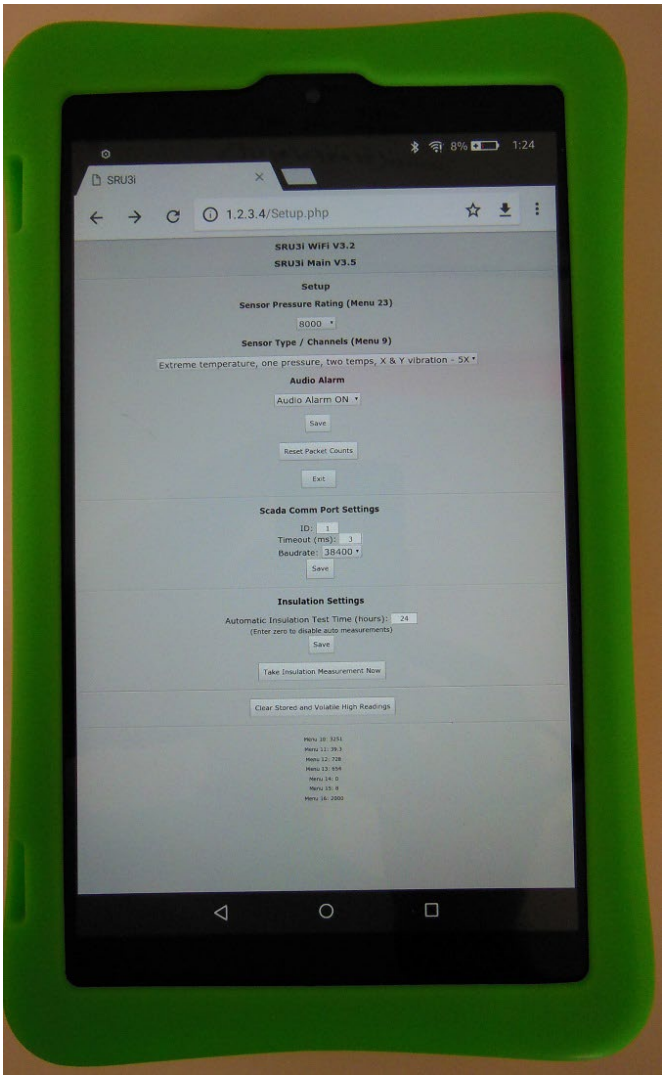
1 Downhole tool type. 2-8 = number of channels, 1 = Xtreme sensor 5 channel.
2 Set Voltage value.
3 Output Voltage.
4 Output current.
5 Mean output current.
6 Decode state
7 Sensor pressure range.
8 SRU3i S/W version
9&10 Count of readings sent to BH VSD via CITIbus. Tag 9 goes up to 9999 (last 4 digits). Tag 10 contains the first digits for the total. e.g. tag 9 = 1234, tag 10 = 567, total = 5671234 readings.
11 Count of CITIbus timeouts when SRU3i has not received data from BH VSD.
12 Spare.

SRU3i WiFi Setup Instructions

The SRU3i may be accessed remotely using any WiFi device, depending on many factors the WiFI range from the BH VSD may range from 50 to 250 feet. This allows monitoring, configuration and diagnostics to be performed without needing to access the VSD either from the key pad or internally. The procedure to initially connect to the SRU3i WiFi network is very similar to connecting to a WiFI Spooler, please refer to the Spooler section for details on initial

connection procedure. The only difference in connecting between the Spooler and SRU3i is that the SRU3i WiFi network is called SRU3i xxxx and the SRU3i IP address is 1.2.3.4

Once connected live (and the highest) readings should be displayed. If readings are not being updated go to the diagnostics screen to see what the problem may be.



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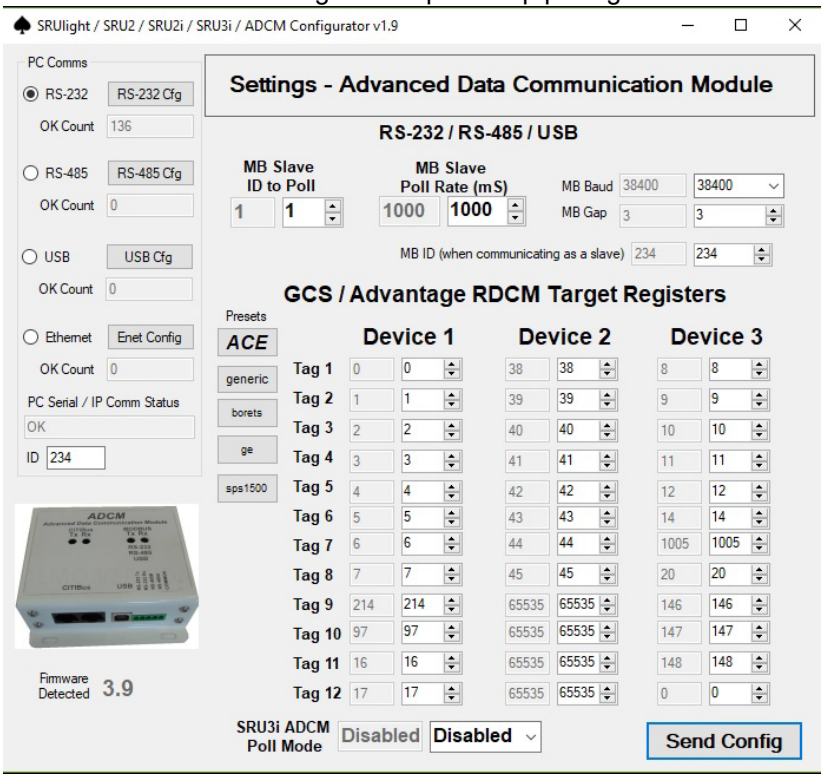
ADVANCED DATA COMMUNICATION MODULE

ADCM Installation and Operation with Baker Hughes / Centrilift GCS VSD

The ADCM is an interface that will directly replace the Baker Hughes RDCM module. It may be used with third party sensors or any Modbus device such as a flowmeter, allowing the device to interface directly into a Baker Hughes / Centrilift VSD. The ADCM operates by impersonating a RDCM module but with more intelligence, and the VSD will display readings as registers as if they came from an RDCM. The ADCM (or SRU3i) typically would be polling a device of interest as a Modbus master, however the ADCM or SRU3i will work just as well as a Modbus slave, so registers from any Modbus device may effectively be pulled into the ADCM (master mode) or they may be pushed into the ADCM (slave mode). The ADCM and SRU3i do this automatically, there is not even a configuration setting required to do this. The registers may be scaled, displayed and used just like standard registers from an RDCM. Unlike the RDCM module however the ADCM contains and stores its own user configuration for settings such as which registers to poll etc. These settings are entered by using the standard SRUlight / SRU2 / SRU3 configuration program (V1.6 or later) rather than having to enter the parameters using the VSD keypad. The settings may also be entered using any standard Modbus PC program that's capable of reading and writing to any of the ADCM / SRU3i's three Modbus ports. The Modbus map is included in the appendices, however ADCM pertinent registers are listed below for reference. Connect to the ADCM using 38400, 8-N-1 using Modbus address 234 (default for SRU2 / SRU3 / ADCM). Note the ADCM (and SRU3i in ADCM mode) may already be transmitting Modbus polls, but will switch to slave mode automatically when it receive an incoming Master poll. Stop polling the ADCM for a few seconds and it will revert back to being a Modbus master and begin polling a device using the user settings.



Etc…

1015 Modbus ID of ADCM/SRU2/SRU3 when a slave (additional user address to default 234).
1016 Modbus silent time when a slave in mS.
1017 Modbus baud rate.

1070 This contains the Modbus register to poll by the ADCM for Device 1 Tag 1
1071 This contains the Modbus register to poll by the ADCM for Device 1 Tag 2

Etc….

1081 This contains the Modbus register to poll by the ADCM for Device 1 Tag 12
1082 This contains the Modbus register to poll by the ADCM for Device 2 Tag 1

1093 This contains the Modbus register to poll by the ADCM for Device 2 Tag 12
This contains the Modbus register to poll by the ADCM for Device 3 Tag 1

Etc…

1105 This contains the Modbus register to poll by the ADCM for Device 3 Tag 12
1106 Modbus address of the device the ADCM will poll, 1-255. Address 234 is reserved.
1107 Contains 0x1234 (4660 dec) to enable polling. Write this to an SRU3i for ADCM functionality, then its polled registers will appear in the VSD rather than SRU3i sensor values. Write anything else to place SRU3i back into normal mode.

The VSD allows up to 36 registers to be displayed. Since few devices have that many registers of interest the ADCM will start polling for Device 1 Tag 1 register. It will continue in sequence until the last register (Device 3 register 12, the 36th), or until it sees a register to poll that has the same address as the first (device 1 Tag 1) register, then it will restart at the first. This way if only a few registers are required it will just keep repeating those polls and not poll unwanted ones. The configuration example screen shown above will set up the ADCM to poll 6 tags, since Device 1 Tag 7 is set to zero, the same as Device 1 Tag 1. Each register will be polled individually rather than via a block read command so they can be polled in any order to match VSD tag preference.

The ADCM (and SRU3i) may be used in another mode. The registers acquired by the ADCM or SRU3i that are to be written to the VSD via CITIbus are in locations 219 - 254 in the ADCM. If a device is set up as a Modbus master connected to the ADCM / SRU3i the master may write to these locations pushing registers into the ADCM and the register contents will then be passed on and appear on the VSD as Device 1 Tag 1 (from ADCM register 219) up to Device 3 Tag 12 (ADCM register 254).

See the SRU3i section for information on setting the VSD tag names, units and resolutions which have to be entered directly on the VSD.

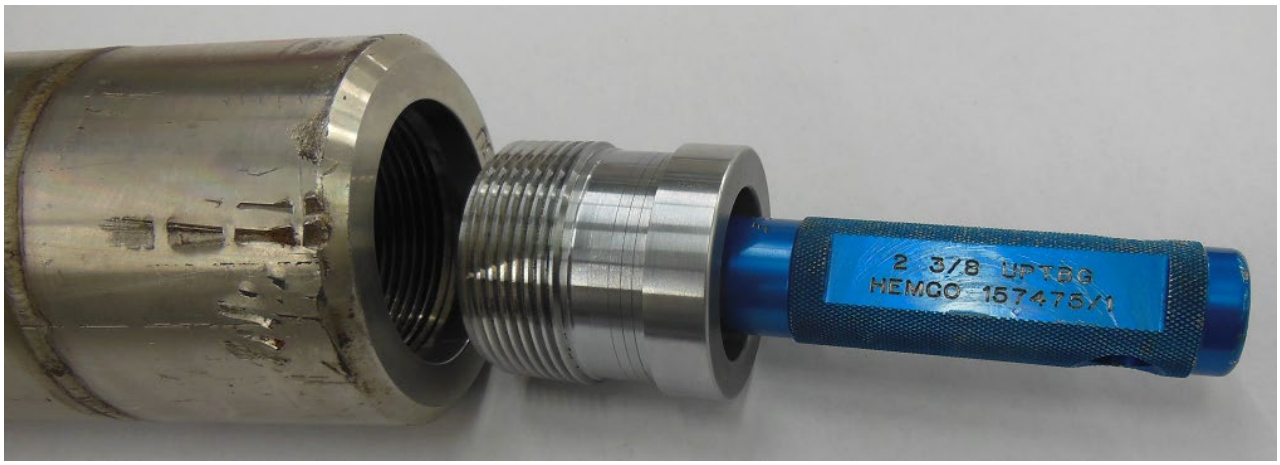
EVALUATION AND RE-RUNNING ACE DOWNHOLE SENSORS

ACE sensors are designed to be re-run with no or minimal service, giving years of reliable operation. As an example, ACE sensor serial number 007, manufactured almost 10 years ago was returned in 2019 for repair, the sensor still operated correctly, was in specification however one of the pins had been broken. It had probably been in a dozen or more wells over the years. The pin was replaced and the sensor returned to service.
This chapter describes the evaluation and test of used sensors. By carefully following these procedures a sensor may be returned to service with a high confidence level that it will provide many more years of correct, accurate operation.

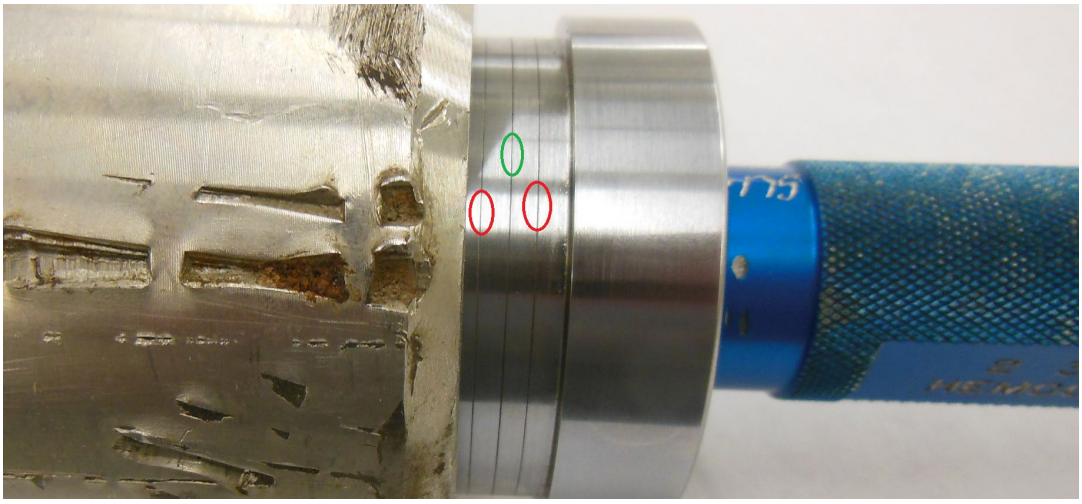
Required Equipment:
Note, some of the items are stocked by Automation Solutions, if they are not stocked a source and part number is given.

1. 1170587 Boot Removal Tool
2. 1170589 Winding Temperature Simulator
3. 1170506 ACE 2G Vibration Simulator with Test Leads
4. 1170567 Field Electrical Test Kit
5. 1170583 Pressure Test Kit
6. 1170576 Megger test Leads
7. Fluke 1507 Insulation Test Meter
8. Simpson 260 Analog Meter
9. 5/16”-24 Go / No Go Thread Gage (McMaster Carr 2366A525)
10. 2x Rubber chocks (McMaster 2267T11)
11. Bottom thread gage (Hemco 2-3/8” 8-RND EUE Plug Gage)
12. Thermometer, Raytek MT-6 (also sold as Fluke 59)
13. Acetone or 90% rubbing alcohol
14. SP400 by SPC anti corrosion spray (for uncoated carbon steel sensors)

1. Remove the motor adapter if attached. Use the boot removal tool to remove the signal and winding temperature transducer leads from the sensor (see section in this manual on the boot removal tool for detailed instructions).
2. Visually inspect the two pins for any sign of physical damage, such as cracks or a bent pin. If a pin is bent it may cause the ceramic seal to crack, that may lead to high Voltage or high pressure breakdown when the sensor is returned to service. If either pin is damaged the sensor should be returned to the factory for repair.
3. Inspect all of the 8 bolt holes in the head of the sensor. Use the 5/16”-24 Go/No Go gage to verify thread condition. If the holes fail to gage correctly or there are any sheared off bolts the sensor should be returned to the factory for repair or scrapped.
4. Inspect the 2 3/8 8 RND EUE thread on the bottom of the sensor.
5. The 2 3/8 8RN-EUE thread on the bottom of the sensor is sometimes damaged by corrosion, impacts or excessive loads. There may be thousands of pounds of suspended equipment below the sensor, and its critical



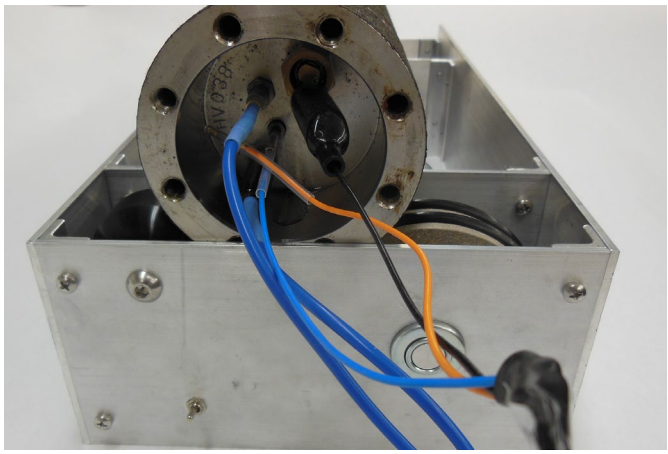
that the threads are in specification to support suspended loads. Clean the threads of any debris, corrosion, sand etc. If the threads appear to be in clean, undamaged condition use the bottom thread gage to verify thread to specifications, threading it in hand tight, do not use any force as this may damage the gage. The end of the sensor base should line up between the two go / no-go groove marks on the gage, identified by the two red ovals in the picture. The ideal position is identified by the green oval. In the example picture above clearly the gage will not engage within specification, so the sensor should be scrapped.

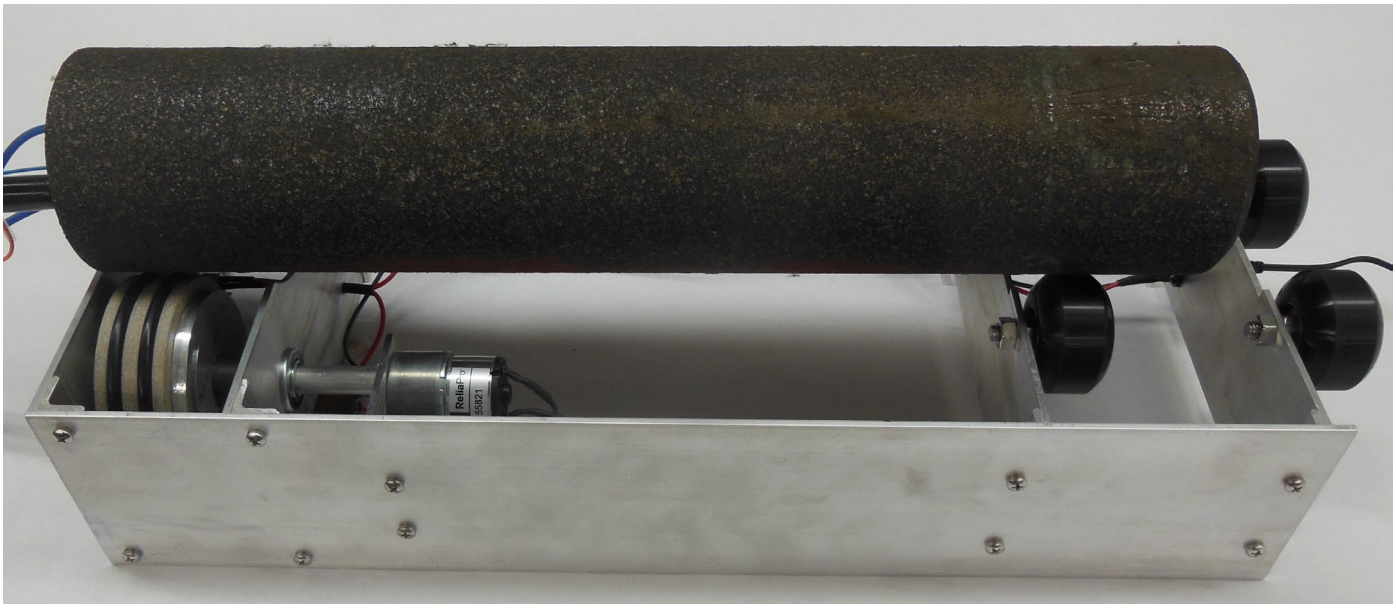


6. Visually inspect the rest of the sensor. Look for signs of deep corrosion or pitting typically caused when uncoated carbon steel sensors have been in chemically aggressive wells, such as shown in the example below.

Heavily pitted, this sensor should be scrapped.

7. Using acetone or 90% rubbing alcohol carefully clean the large pin to remove any residue. Refer to “ACE High Voltage Insulation Testing” chapter in this manual to verify the sensor passes high Voltage test. Note it may be difficult to achieve high insulation resistance readings on used sensors especially if the pins have any moisture on them or in conditions of high humidity.
8. Using a Fluke insulation tester. Test the sensor following the “Insulation Test Procedure (On Surface)” chapter elsewhere in this manual to verify correct readings.
9. Lay the sensor on an indoor, flat, stable workbench using a rubber chock on each side to prevent it rolling. Connect the pressure test kit and test using the instructions in Appendix B, ACE downhole sensor pressure test unit instructions. If the sensor fails to give good pressure readings then the sensor should be scrapped or returned to the factory for repair. For discharge sensors the discharge pressure port may also be tested and verified for correct operation. It is often best not to try to remove the original discharge Swagelok threaded fitting unless it is damaged or severely corroded, it was installed at the factory to a high torque and attempting to remove it may cause the fitting to gall to the sensor. The nut, pressure ring and cone (which will have been compressed and permanently attached to the old 1/4” cap tubing) will be replaced when the sensor is re-run, those parts are supplied in the Discharge Pressure Kit (1170585).
10. If the sensor serial number has the letter ‘V’ in it the sensor supports vibration measurements and next it should be placed on the ACE 2 G vibration simulator. The simulator has extra rolling supports to allow it to operate with standard length or dual pressure reading sensors. If the sensor does not support vibration measurements the simulator is not required but proceed to connect the winding temperature simulator blue wire to the small pin, and the surface readout to the sensor using the flexible harness supplied with the vibration simulator.





The vibration simulator should be turned on, and it will continually rotate the sensor through approximately 1 1/2 turns clockwise then anticlockwise, simulating 2 G's of vibration. By reversing the sensor the connecting wires will not become tangled or twisted. The surface readout should be powered up, set to the correct pressure range, correct sensor type and after a minute or two should start to display readings from the sensor.

Menu 1, the intake temperature should give an ambient reading close to room temperature assuming the sensor has been indoors and has had time to come to room temperature. The temperature may be verified using the IR thermometer, note the internal sensor temperature transducer is inside the sensor head below the 2 pins, and the IR thermometer may give incorrect results if it is pointed at a reflective surface, which the inside of the head may be if it is clean. Menu 2 (and 6 if a dual sensor) were verified in step 8. If the sensor supports vibration menu 4 and 5 should be checked next, and under perfect conditions should indicate 2.000G. Typical values would be between 1.95 and 2.05 G, however other factors will affect the reading. If the sensor has been monel coated the surface is often rough, and this may cause higher readings since the sensor may not roll smoothly. Any tooth marks or gouges in the metal that touch the rollers will also affect readings, as well as dirty rollers or any vibration on the table, such as from someone working nearby on the surface, light taps on the bench surface will affect readings. After the vibration readings have been verified the vibration simulator may be turned off.

Menu 3 is the winding transducer temperature. The simulator, when connected with the blue wire, will generate a resistance equivalent to 100°F. If this is within acceptable range disconnect the blue wire and attach the orange wire (there is no need to power down during the change over). After a short time the winding temperature should be displayed as 500°F, note one or two out of range readings may be shown during the changeover since the simulator was open circuit for some time during the 100°F / 500°F change over.

At this point if the sensor has passed all tests it may be returned to service with a high confidence level. The test results may be recorded, the shipping cap replaced and if the sensor is an uncoated carbon steel one it should be lightly sprayed with SP400 to prevent corrosion.

SPOOLER OPERATING INSTRUCTIONS

Introduction

The ACE Spooler allows continuous, safe monitoring of an ACE ESP downhole sensor, downhole motor and the connecting cable in real time during installation. The unit magnetically mounts inside the rotating cable spool and is electrically connected to the end of the cable inside the spool. The Spooler provides electrically limited power to the downhole sensor via the ESP cable, decodes the sensors transducer readings and monitors the

ESP power cable condition. The Spooler establishes a local WiFi network, so readings may be monitored continuously by any personnel within range using standard cell phones, laptop computers, hand held tablets etc. Multiple personnel may all monitor the system at the same time, anywhere within range of the WiFi signal.

Any fault conditions from the cable, sensor or interconnect during installation will be apparent within seconds to everyone monitoring the system. Rather than having to stop the rig periodically, attach a test unit to the end of the cable, then wait to verify downhole readings any errors are now reported instantly. The unit is battery powered and will typically operate for 15 hours on the field replaceable, rechargeable batteries. A spare set of batteries and charger is provided, so the device may be up and running again within a minute or two of the batteries being changed.

- Savings in rig time typically pay for the unit after being used twice.
- Does not require any internet, wireless or cell phone service to operate.
- No license required to operate anywhere on the planet.
- Error indication within seconds helps pin point a downhole error location.
- Easy for all rig personnel to monitor the system.
- No need for sensor service personnel to remain on site during run in.
- Faster, safer, verified system installs.
- Use any brand of tablet, cell phone or wireless device to monitor with.

WARNING:
Lithium Ion Batteries

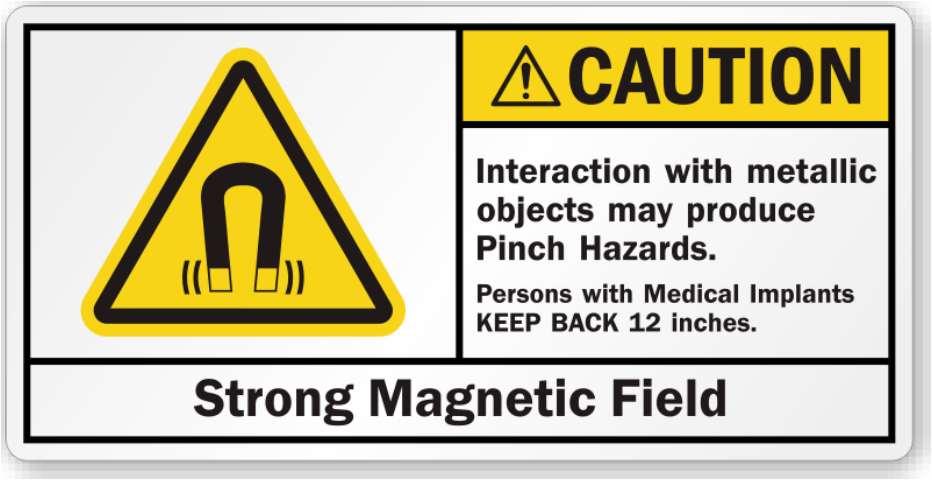
The SPOOLER uses four Lithuim Ion (Li-ion) batteries.
Observe the following warnings for safe operation.

Use caution as misusing or mishandling the battery may cause a FIRE or EXPLOSION which may result in personal injury or property damage. The user must have an appropriate understanding of the potential dangers of LITHIUM ION BATTERIES before purchase and usage. These batteries are manufactured and sold for the intended use in the SPOOLER only which incorporates proper protection circuitry for the batteries. These batteries are neither designed nor intended to be used with an E-CIGARETTE, VAPORIZER, or similar device.

- **DO NOT ship via overnight or air transportation. The Spooler batteries must ship GROUND only and cannot travel by air.**
- **DO NOT USE with E-Cigarette, Vaporizer or similar device.**
- **DO NOT STORE LOOSE OR IN A POCKET, PURSE, ETC. ALWAYS USE THE PROVIDED PROTECTIVE CASES OR BOX FOR STORAGE AND TRANSPORT**
- **WHEN NOT IN USE, ALWAYS STORE LITHIUM ION BATTERIES IN THE PROTECTIVE CASE/BOX IN WHICH BATTERIES WERE DELIVERED**
- **Misusing or mishandling lithium ion batteries can pose a SERIOUS RISK of personal injury or property damage**
- **BATTERIES MAY EXPLODE, BURN, OR CAUSE A FIRE IF MISUSED OR MISHANDLED**
- **ONLY use with proper protection circuitry**
- **DO NOT short circuit intentionally or unintentionally**
- **KEEP AWAY from metal/conductive objects to prevent short circuiting**
- **DO NOT use if PVC wrapper or terminal insulator is damaged or torn**
- **DO NOT use if battery is damaged in any way**
- **DO NOT over-charge or charge above the maximum voltage rating**
- **DO NOT over-discharge or exceed the continuous discharge rating**
- **DO NOT modify, disassemble, puncture, cut, crush, or incinerate**
- **DO NOT expose to liquids or high temperatures**
- **TURN OFF the Spooler before changing the batteries**
- **DO NOT solder onto battery or spot weld to the battery**
- **DO NOT poke or pry the battery with any kind of tool. Use the Spooler ribbon to remove batteries.**
- **DO NOT use force to install or install in reverse/backwards**
- **DO NOT charge the spare batteries close to the wellhead.**
- **ONLY use within manufacturer's specification**
- **KEEP AWAY from pets and children**
- **ALWAYS charge in or on a fire-proof surface and never leave batteries charging unattended**
- **ONLY use a smart charger designed for this specific type of battery**
- **DO NOT mix and match brands and models, old and new, used and unused batteries**
- **STOP immediately if while charging/storing/using the battery it emits an unusual smell, feels hot, changes color or shape, or appears abnormal in any way**
- **If exposed to battery electrolyte, flush with water immediately and/or immediately contact a physician or emergency services**
- **DO NOT throw away in trash; contact your local jurisdiction for proper recycling or disposal**

WARNING:
Strong Magnetic Fields

The SPOOLER uses two strong magnets to secure the device to the inside of a cable spool. Observe the following warnings for safe operation.



- **KEEP AWAY from persons with medical implants**
- **WEAR OSHA / PPE GLOVES when attaching the Spooler to the inside of a cable spool**
- **MAKE SURE Spooler is powered off when attaching or removing Spooler from cable spool.**
- **KEEP AWAY from metal or conductive objects to prevent attachment**
- **DO NOT use if magnet is chipped or broken**
- **DO NOT modify, disassemble, puncture, cut, crush, or incinerate**
- **DO NOT expose to excessive high temperatures**

Spooler Installation and Operation

WARNING:
Spooler Location.

The SPOOLER is not designed or intended to be used within 25 Meters of the well head. When not in storage it may be located inside the cable spool by means of its built in magnets, and the cable spool is located on the spooling truck some safe distance away from the well head. Since the Spooler uses four high capacity Lithium Ion (Li-ion) batteries it should never be taken with 25 Meters of the well head.

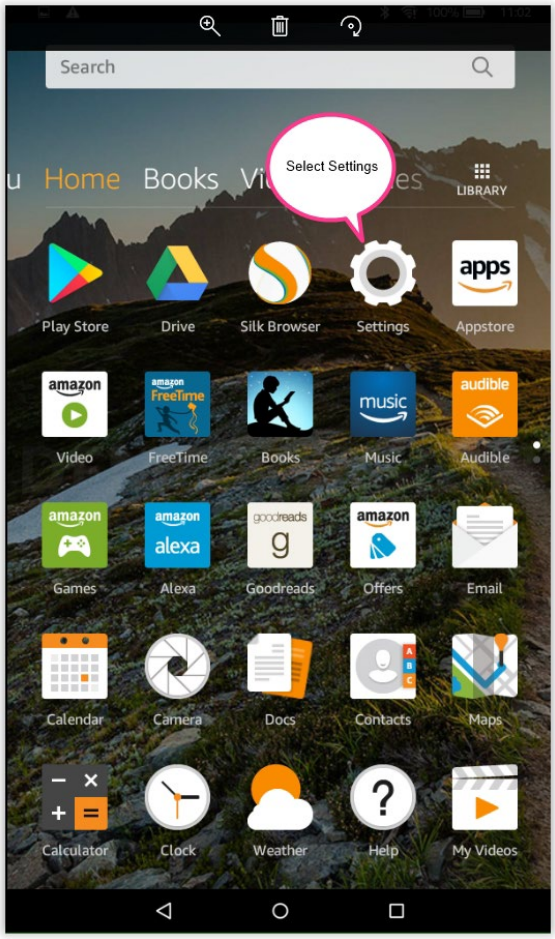
Ensure the Spooler is turned off and four charged batteries are installed correctly. The Spooler is then mounted inside the cable spool using the magnets attached to the Spooler. Locate it close to the end of the cable that comes out of the center of the cable spool. The insulation on the end of the cable needs to be peeled back, and the three cable conductors must be exposed. The brass signal block is then attached to the three cable conductors and the thumbscrews are tightened to grip the conductors securely. The large locking clamp is secured on the cable sheath, tight enough to prevent it coming loose but not so tight as to damage the cable sheath.

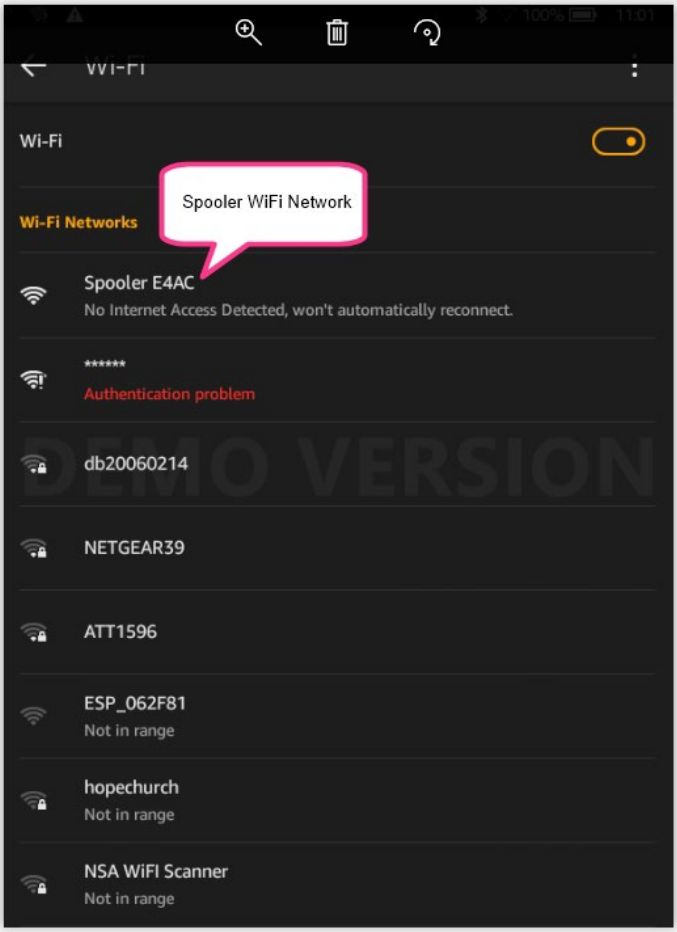
Ensure the brass signal block is well clear of the metal spool holding the cable and will not short to the cable spool during rotation.

Open the Spooler and turn it on by pressing the green push button; LED's should flash as it powers up and attempts to connect to the downhole sensor via the power cable. There are no other adjustments or controls on the Spooler device; they are all provided on any connected WiFi device. Close the Spooler box and snap the two latches closed. Depending if the beeper is enabled the box may chirp until sensor initialization is complete (the beeper may be enabled or disabled remotely via the WiFi device).

WiFi Connection

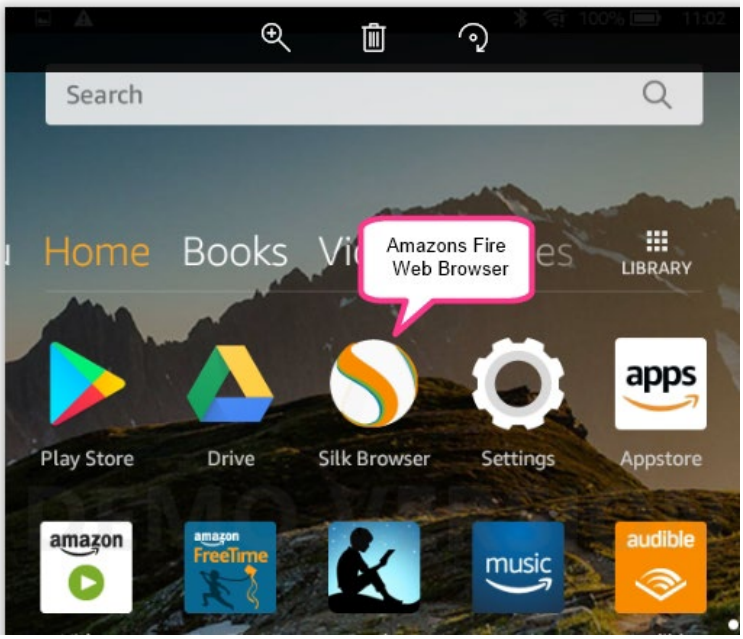
At this point power has been applied to the Spooler and it will begin to generate a standalone WiFi access point. Almost any type of device with WiFi capability may be used to monitor and control the Spooler, such as a modern cell phone, an obsolete cell phone even without cell service, a portable tablet, laptop computer etc. In the examples below a low cost Amazon Fire tablet is being shown, however similar screens would appear on any other type of device.
First the WiFi network has to be located. Choose settings, then the WiFi screen. The location of the WiFi network selection may change depending on the operating system.

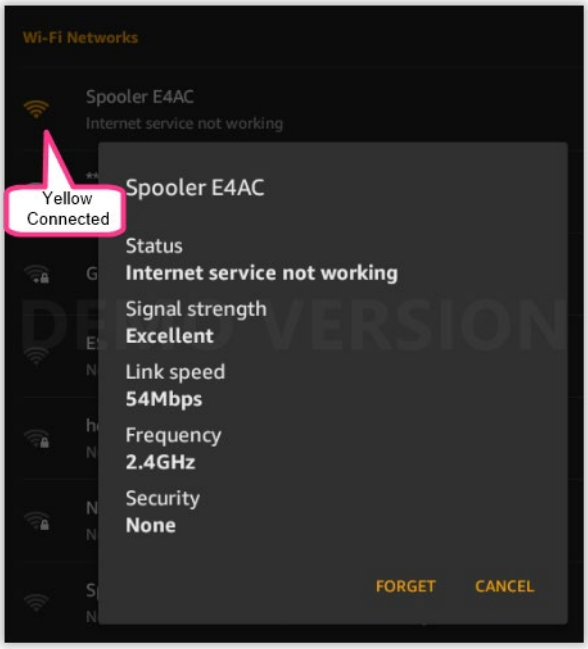




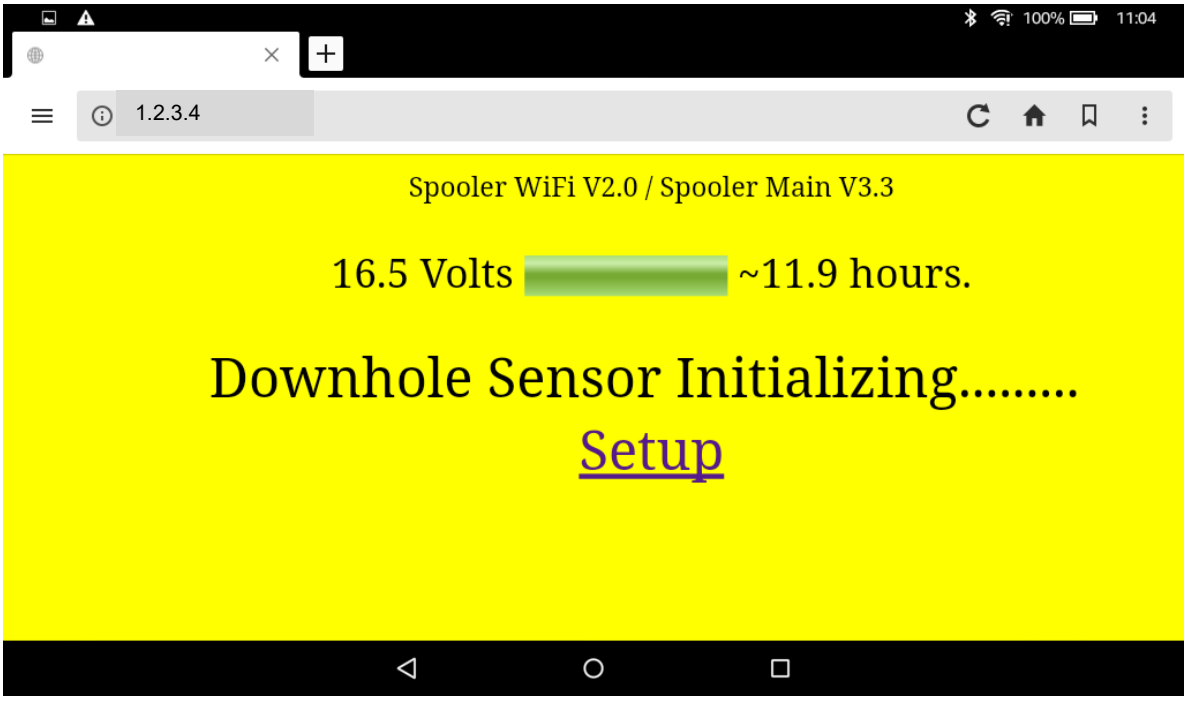
The Spooler network is identified as Spooler XXXX where XXXX is unique to each Spooler device (XXXX are the last 4 digits of the Spooler MAC address). This allows multiple Spooler devices to be operating in close proximity without interfering with one another. Different wireless devices may complain of being unable to access the internet, however the internet is not required to communicate with the Spooler and the message should be ignored. Select the Spooler network and choose connect. On some Apple devices another prompt may need to be acknowledged to connect.

Once connected to the WiFi network a browser window may be opened to access the Spooler. Again different devices have different options for browsers, such as Safari for Apple products and Chrome for many Android devices. In this example on the Fire tablet the browser is called Silk.





Once the browser is started it may try to access the last web page that was displayed and complain again about being unable to access the internet. Since the goal of Apple, Amazon, Google etc. is to connect to their servers and sell you something or sell your information to someone else the browser trys to connect to the internet. Ignore these complaints and in the browser address bar type 1.2.3.4 This is the IP address of the Spooler and it is always the same for all Spoolers. The following screen should then appear, in this case the sensor is still initializing and the background will be yellow. Notice the IP address of 1.2.3.4 in the address bar.



The screen will always show the battery status, with an estimated operating time remaining.

After a minute or so the screen background color should change to green, meaning the configuration is correct and good readings are being received. Readings will be displayed from the sensor, in the example a 5 channel sensor is connected. Each time a set of readings are received from the sensor the total packet count will increment. This count is shown along with the total number of corrupted packets. It is normal to get a few ‘bad’ packets during start up as the Spooler adjusts electrical parameters to match the sensor. The screen will automatically be refreshed every 10 seconds, slightly faster than the sensor readings are updated, so displayed readings will be current. There is just a single control on the screen labeled “Setup”.

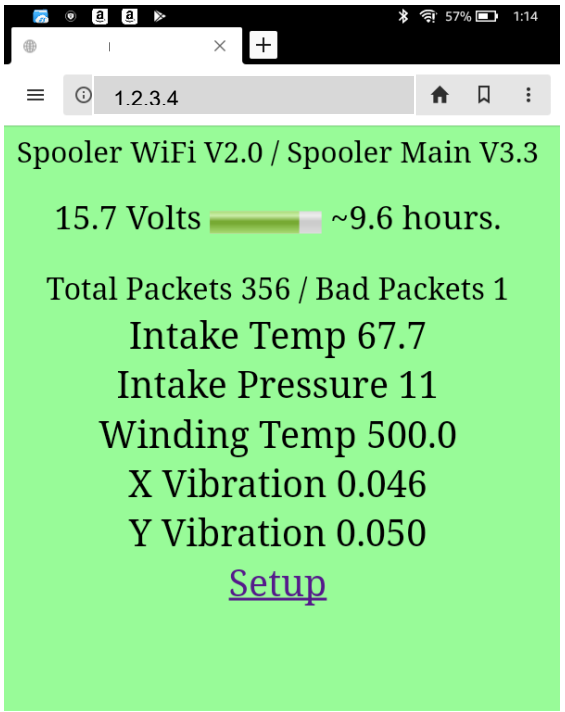
If ‘Setup’ is clicked another screen will appear that has the configuration adjustments and basic diagnostic information. There are just three settings that may need to be changed. The first is the pressure rating of the sensor, and it should match the sensor. The first digit of the sensor serial number indicates the pressure rating, eg 6 would mean its a 6000 PSI rated sensor. Clicking on it will display a drop down menu and a different pressure rating may be selected. If the selection is changed the ‘Submit’ button then has to clicked to write the new setting. Apple products do not use a drop down selector, typically the selections are displayed at the bottom of the screen.

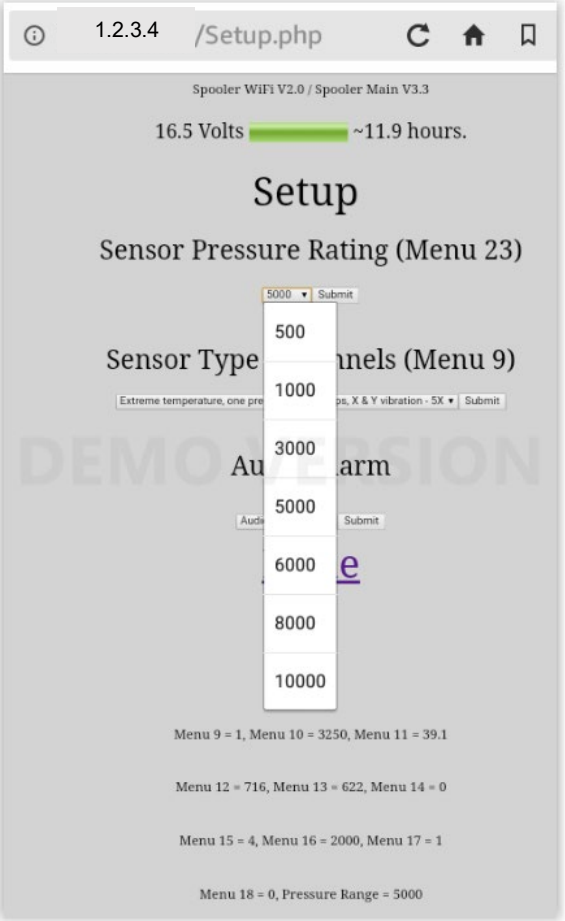
In a similar way the sensor type may be changed using the next drop down menu; again click ‘Submit’ after making a change. If the wrong sensor type is selected the readings will not be decoded. The last setting allows the user to enable or disable the audio warning beeper located inside the Spooler. The beeper will sound if there are any error conditions, so the operator may want to silence the alarm until any errors are corrected. Once the changes are complete ‘Done’ should be selected, and the screen will revert to the main status screen.

The packet count, displayed on the main status screen may be reset.

At the bottom of the Setup screen are some diagnostic displays that correspond to the indicated menu numbers on the SRU and SRU2 readouts. This enables basic diagnostics to be performed by observing these menu items. Note that these will just update by default every 10 seconds. Some, such as the sensor current draw (menu 12), change rapidly so if the user keeps clicking refresh at the top of the the browser window they will be updated quickly.

Always ensure all connected users press ‘Done’ and return to the status screen after making any changes to prevent inadvertent changes to the settings. Be aware that other users that may use their WiFi devices nearby could also change settings.

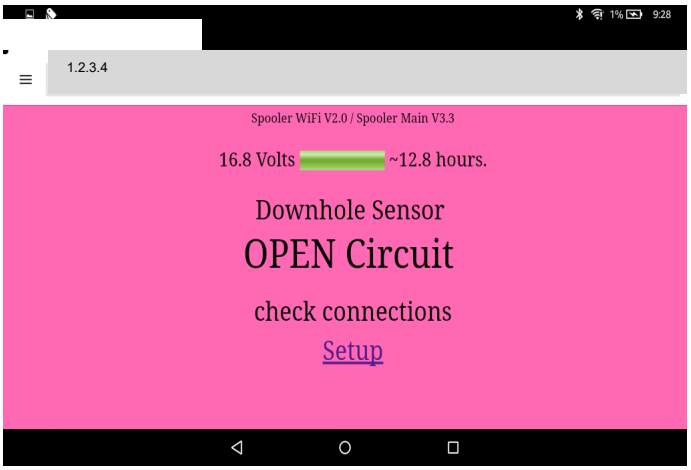


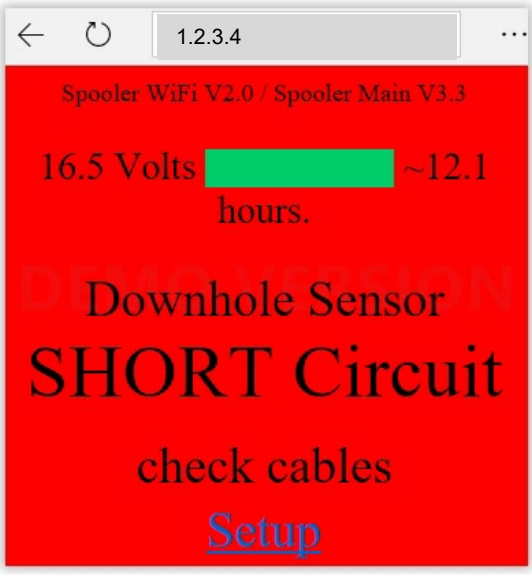


Error Conditions

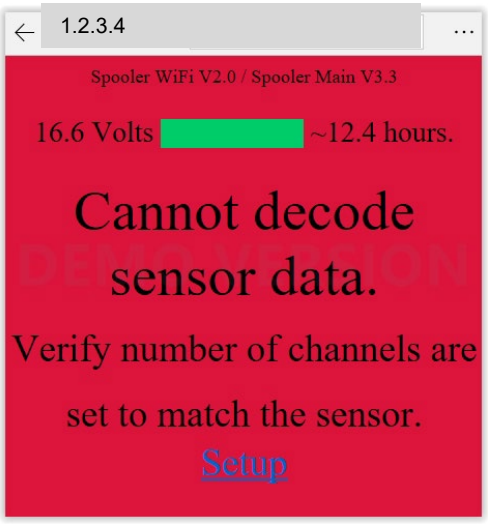
The Spooler is able to identify and display three main causes of errors. If the audible beeper is enabled these will also cause the alarm to sound.

The first error is caused by an open circuit in the system. It may be between the Spooler and the end of the cable, or the cable may be cut either at the surface or downhole. Turn off the Spooler before trying to locate the problem.





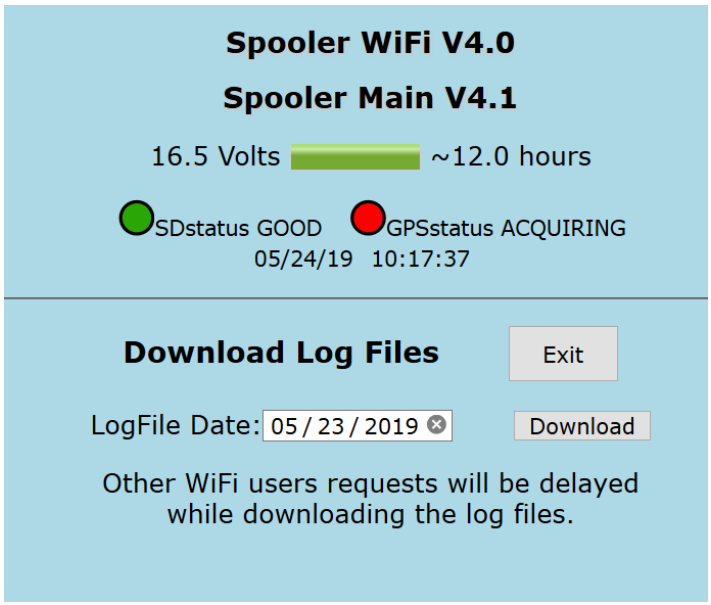
A short circuit again indicates a problem somewhere in the system which may be at the surface or downhole. Turn off the Spooler before trying to locate the problem.



If 'Cannot decode sensor data' screen is displayed it indicates that data is being received from the sensor, however the Spooler cannot decode the data. This may happen briefly as the system is powered up, it may be caused by intermittent contact somewhere, or if the Spooler is not configured correctly to match the attached sensor. Verify the Spooler configuration matches the sensor on the Setup screen.

Always ensure all users connected to the Spooler network ensure they are monitoring the main status screen by clicking 'Done' after making changes on the status screen. If different users are both changing items on the setup screen the Spooler settings may flip back and forth between different users settings, so disrupting good sensor readings.

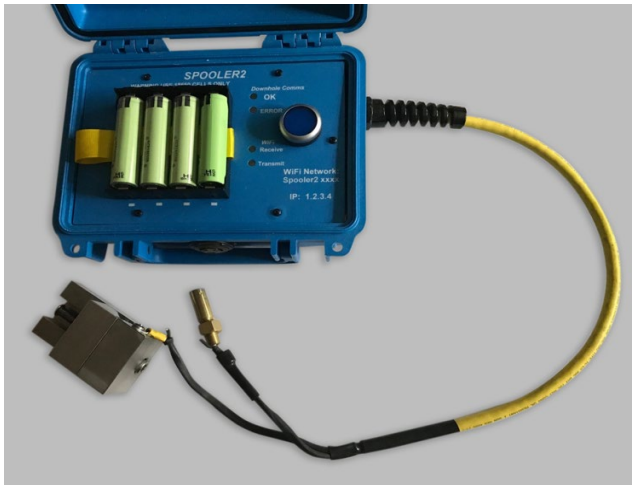
Spooler 2



There is an enhanced version of the Spooler available, the Spooler2. The Spooler2 adds internal data logging of every reading ever taken. In addition the Spooler2 has an internal GPS, which it uses to obtain the well site location as well as the date and time, which are required for data logging. The internal high performance GPS will decode signals from the 4 worldwide GPS systems currently operating (Navstar GPS USA, Glonass Russian, BeiDou Chinese, Galileo European) so the Spooler2 will operate anywhere in the world with enhanced accuracy. Mount the Spooler2 towards the edge of the cable spool, the internal GPS antenna is on the left side of the unit (opposite side from the cable). After powering up the Spooler2 will take up to a minute or two before the GPS has acquired a signal, and then data logging will begin. The data log files are unique for each full day, and each file is approximately 900KB in size, so it will take a few seconds to download the file. Select a date from the pop up calender, the appearance of the screen will vary depending on the tablet, phone, PC etc being used.

The start of a typical file will be as follows. The first line will be the GPS coordinates when the Spooler was first turned on. After that each line will have the date, time and the channel readings, in the example below the Spooler2 was connected to a 2 channel sensor. Readings are stored every 10 seconds. The data is stored on an SD card inside the Spooler2, to extend card life the data is actually written to the card approximately every 3 minutes.

36° 42.73047' N 95° 56.05790' W
05/23/19,09:16:58,72.53,2.20,0.00,0.00,0.00,0.000
05/23/19,09:17:08,72.53,2.20,0.00,0.00,0.00,0.000
05/23/19,09:17:18,72.87,1.84,0.00,0.00,0.00,0.000
05/23/19,09:17:29,72.87,1.84,0.00,0.00,0.00,0.000
05/23/19,09:17:39,72.87,1.33,0.00,0.00,0.00,0.000
05/23/19,09:17:49,72.87,1.03,0.00,0.00,0.00,0.000
05/23/19,09:17:59,72.87,0.98,0.00,0.00,0.00,0.000
05/23/19,09:18:08,73.21,1.37,0.00,0.00,0.00,0.000
05/23/19,09:18:20,73.21,1.37,0.00,0.00,0.00,0.000
05/23/19 09:18:30,73.21,1.04,0.00,0.00,0.00,0.000



GENERAL LI-ION BATTERY RECOMMENDATIONS

Li-ion batteries have become very popular in recent years. They are widely available and sold under many different brands. The most popular application is for operating electronic cigarette 'vaporizers' so many Li-ion batteries are sold for that purpose. Vaporizers however require very large currents, often 10 Amps or more and typically run for a short time so most Li-ion batteries are designed for that purpose. Batteries designed for vaporizers need to have very high output current capability, but generally have a limited capacity (mAh).

The Spooler is just the opposite, as it draws a very low, limited current (0.1 Amp normally, 0.25 Amp maximum) and its desirable for the Spooler to operate as long as possible without changing the batteries. So although the Spooler will operate with 'vape' batteries in an emergency, it is not recommended as the run time will be limited. For the best run time and long term performance Panasonic NCR18650B 3400mAh Flat top batteries are recommended. These cells, which are provided with the Spooler, typically give a run time of approximately 12-16 hours when fully charged. Note there are two versions of this battery, one with a 'button' top, the other with a flat top, either will work but the flat top is preferable as its less likely to short if mishandled. Typically the Panasonic cells have a lifetime of at least 500 charge/discharge cycles, which would be well over a year if used every day.
There are many fakes and mislabeled batteries for sale, one recommended source for genuine replacement Panasonic cells is www.imrbatteries.com

Battery Lifetime:

If properly cared for these batteries will typically last for over 500 charge / discharge cycles. There are a few conditions that will help to preserve the long battery life. The most important is to not allow the cells to become fully discharged, as this rapidly reduces each cells lifetime. Once the battery low warning appears on the WiFi device display screen the Spooler should be turned off and batteries exchanged with charged ones; then the removed ones charged. Do not leave the Spooler turned on with depleted batteries since as this may permanently damage the batteries. When fully charged each cell has an output Voltage of approximately 4.15 Volts, for a total of 16.6 Volts. Once the total gets down around 12.5 Volts (each cell ~ 3.12 Volts) the low battery warning will appear. Although the Spooler will continue to operate when the supply Voltage is as low as 7 Volts DC by this time the batteries may be permanently damaged, so batteries should be exchanged as soon as they become low.

Charging Notes:

The charger supplied with the Spooler will operate from standard 120 VAC or from 12 VDC (car cigarette charger adapter) power, it will charge at the same rate when powered from either source. Typically with cells that have been removed when the "Replace Batteries" warning first appears it will take approximately 3-4 hours to fully charge them. Cells completely discharged may take 5 hours or longer to charge. The charger will start charging at a high rate and slowly reduce the charge current as the cells fill, this increases cell life. Each cell is individually charged and monitored, so it is safe to mix cells of various states of charge in the charger. The state of each cell may be monitored and the charger is also capable of testing the battery condition and capacity, consult the manual supplied with the charger for further details. *Do not* attempt to quick charge at an accelerated rate using a charger or power supply not designed for these cells.

Power Consumption:

ACE sensors consume very little power compared to other brands, one reason the ACE sensors may be powered with portable devices that are battery powered such as the Spooler. The run time before the batteries need exchanging with charged ones will vary depending on many factors, such as age of batteries, the ambient temperature, sensor / cable state (shorted cable causes more power consumption, open circuit less power) and WiFi activity.
The WiFi communication back and forth to the Spooler actually consumes more power than the connected sensor does. So as more users connect to the Spooler power consumption increases resulting in shorter battery run times. Although users are able to refresh their device screens as quickly as they wish the Spooler defaults to updating each device every 10 seconds (unless prompted by a user request), since faster rates increase power consumption.

SYSTEM DIAGNOSTICS

If the system does not provide valid readings the SRU can display diagnostic information to help try to identify the problem. First verify that menu 14 on the SRU is approximately 22 - 24 if operating on AC power, and approximately 12 if using a battery powered test PSRU. These two values will change depending on supply voltage.

Next use menus 11 and 12 to observe readings then use the following table to try and isolate the problem.

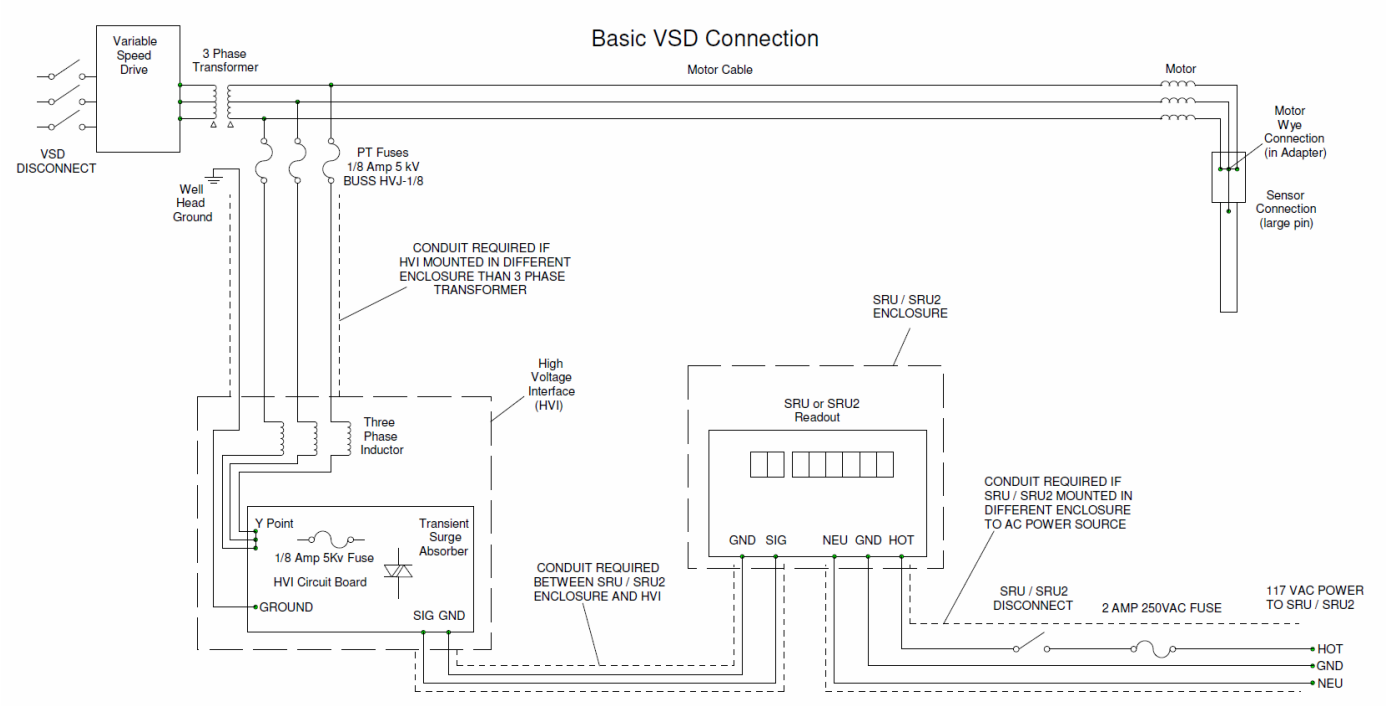
Menu 11 SRU DC Volts	Menu 12 SRU DC Current	*Comments*
38 to 42	180-220	*Signal lead appears open circuit. Check HV fuse, verify signal lead and ground wire. Measure DC Voltage at SRU signal lead to ground, should be ~40VDC.* *Verify menu 10 is 3250. Check signal / ground leads are not reversed.*
Less than 35	180-220	*SRU output may be damaged. Power down SRU, remove signal lead, power SRU back up. If condition still exists replace SRU.*
38 to 42	450 to 600 changes less than ~25.	*Tool does not appear to be transmitting / system impedance may be too high. Try changing menu 10 to 3750 and cycling power to the SRU. Verify 3 phase choke is a genuine Automation Solutions OEM unit.*
38 to 42	450 to 712 changes greater than 100.	*Should be normal operation. Check pressure and 2 temperature readings, if at least 1 of the three is correct then the other channels may have failed in the sensor. If menu 12 is changing but no readings after a couple of minutes verify menu 9, number of channels, is set to match the type of sensor attached. Refer to System Integrity Test for further details with the chart of sensor types and settings.*
Less than 2	760-800 varies less than 25	*SRU output Voltage is shorted out before the signal goes through the three phase choke. Power down SRU, remove signal lead. Power up SRU, if condition continues replace SRU. If fault clears with signal lead removed problem may be MOV on fuse block assembly shorted which may occur if 1 motor leg is shorted to ground or three phase choke failure.*
Between 15 and 25	760-800 varies less than 25.	*Verify SRU as above by trying without signal lead connected. This condition is probably a short at the motor winding / Tool connection point or possibly a phase to ground short.*
25 to 42	750-780 varies less than 25	*Verify SRU as above by trying without signal lead connected. This condition is probably a short to ground inside the Downhole Tool.*

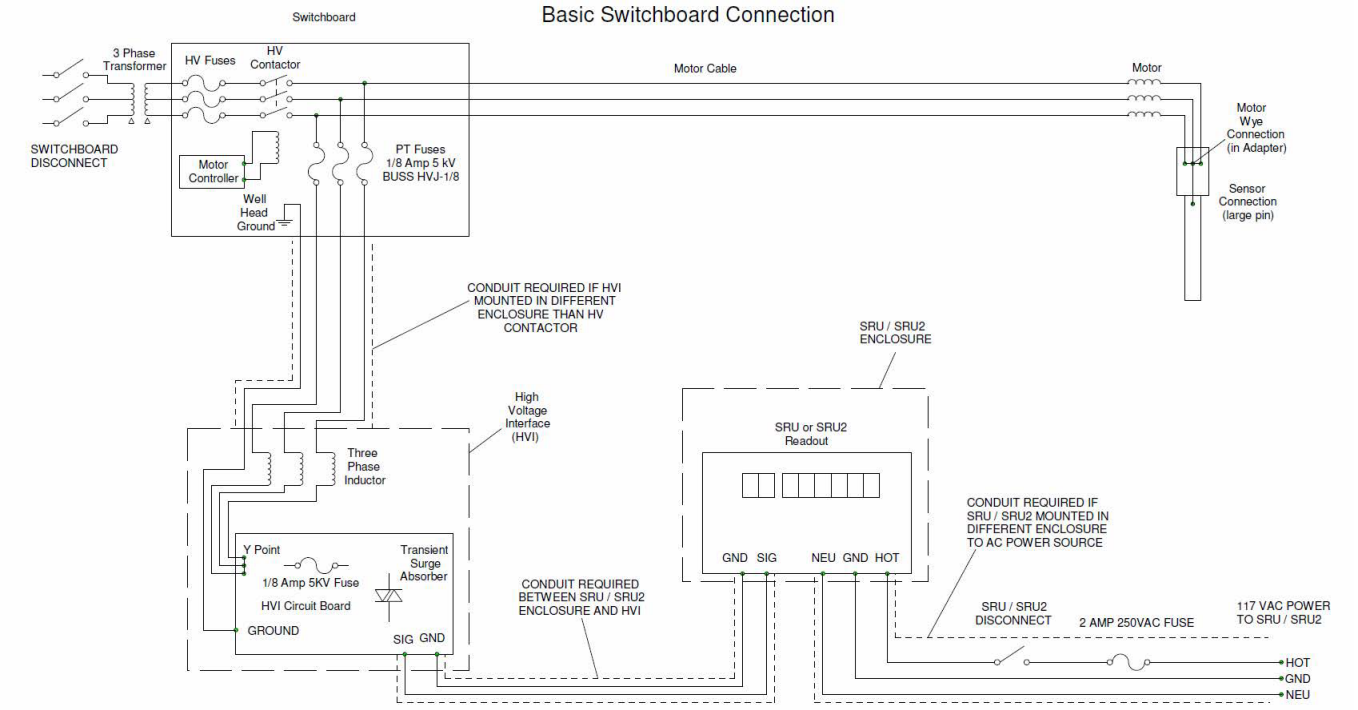
Note: Base current values bellow 712 is a sign of normal operation. When the gauge is transmitting data, it is common to see current spikes above 712. A consistent base current above 750 is an indication of a faulty gauge (see above for diagnostics).

Some Faults and Possible Causes.

1. **HVI Fuse blown / blows when replaced**. Typically caused by phase to ground or partial phase to ground shorts in the motor cable, motor or well head. To isolate cause power down and disconnect the motor from high Voltage system and Megger test the cable/motor/sensor. If system runs then fuse blows after some time may be due to fluid moving in to a damaged area of the cable. To verify power down and disconnect the motor cable from high Voltage system, transformer and HVI. Use DVM to measure DC Voltage between 3 motor leads. DC Voltage should be around 0.0 VDC; if there is a difference (or a Voltage that is slowly increasing/decreasing as well fluid rises or falls) may be due to cable damage and electrolytic reaction between cable conductors.
2. **Brand new HVI fuse is open or opens after a short time**. (When replaced the system runs normally). The HVI fuses are rated for very high Voltage but very low current, as a result they have a long, very thin internal conductor which will fail open circuit if there is excessive vibration. New fuses left in vehicles should be wrapped in cloth, bubble wrap or similar shock absorbing material to protect the internal fusible element. A fuse bouncing around in a pickup truck glove box will be open circuit after a few weeks. Ensure the HVI enclosure is not subject to excessive vibration from attached equipment such as VSD's or cooling fans.
3. **440 / 460 / 480 VAC VSD System, sensor runs until VSD is started.** Ensure an isolated (not auto) three phase transformer is installed between the VSD and motor cable/HVI. The VSD is electrically connected to incoming 3 phase which is grounded at some point; so the sensor requires an isolation transformer.
4. **Electrical test box does not stay charged.** The test box contains a 9AH SLA battery which should stay charged for many hours of operation and for several months of no operation. To charge the unit plug into AC power and the on/off toggle switch must be pressed on '|' symbol. It will not charge if set to 'O'. A just audible 'click' may be heard a second or two after turning on the toggle switch. It does not matter if the clockwork timer is on or off. The test box can remain plugged into AC power and left turned on indefinitely charging as the internal battery charger will switch to trickle charge mode once the battery is fully charged. Note that the SRU displays the state of charge (internal DC Voltage) on menu 14. On normal, charged battery operation the Voltage will typically be 11.8 to 12.5 VDC. While charging the Voltage will slowly rise to about 13.5 VDC. Readings below about 11.3 VDC indicate a discharged battery; if the Voltage does not come back up after charging overnight the battery should be replaced.
5. **Winding Temperature Reading Missing.** (SRU1/3)If the winding temperature is incorrect the reading can help isolate the problem. The winding temperature will be displayed as 0.0 °F if the winding transducer is shorted out. If it displays 1.0 °F the winding transducer is completely open circuit, either not plugged in or the transducer wires may be cut. If 2.0°F is shown the winding transducer is partially, but not fully, open circuit. This may occur if the transducer is unplugged / wire cut and there is water or saltwater in the motor. If the temperature is below 32°F the readout will display 31°F; temperatures below 10°F will display 0.0 °F (the normal winding transducer range is 32 °F to 600°F). The sensor should be heated to temperatures above 32 °F to ensure the winding transducer functions correctly. (SRU2) If the winding temperature is missing and menu 3 readings fluctuate, the winding transducer can considered faulty.
6. **0 Pressure Reading**. Important: If intake temperature is similar to your ambient temperature the transducer is good. If a 0.0 psi intake pressure reading might occur due to transducer tolerances. To ensure the gauge is not faulty, pressure should be applied to the gauge, which will begin to read correctly. This is due to transducer accuracy; for example, an 8,000 psi transducer with a 0.25% accuracy has a 20 psi pressure window (8000 psi x 0.0025 accuracy = 20 psi). At sea level, the standard pressure is 14.7 psi, and the transducer might read 0.0 psi due to transducer tolerances. Temperatures below 40 °F will compound this phenomenon due to elastomers hardening at lower temperatures.

APPENDIX A
System Interconnection Diagrams





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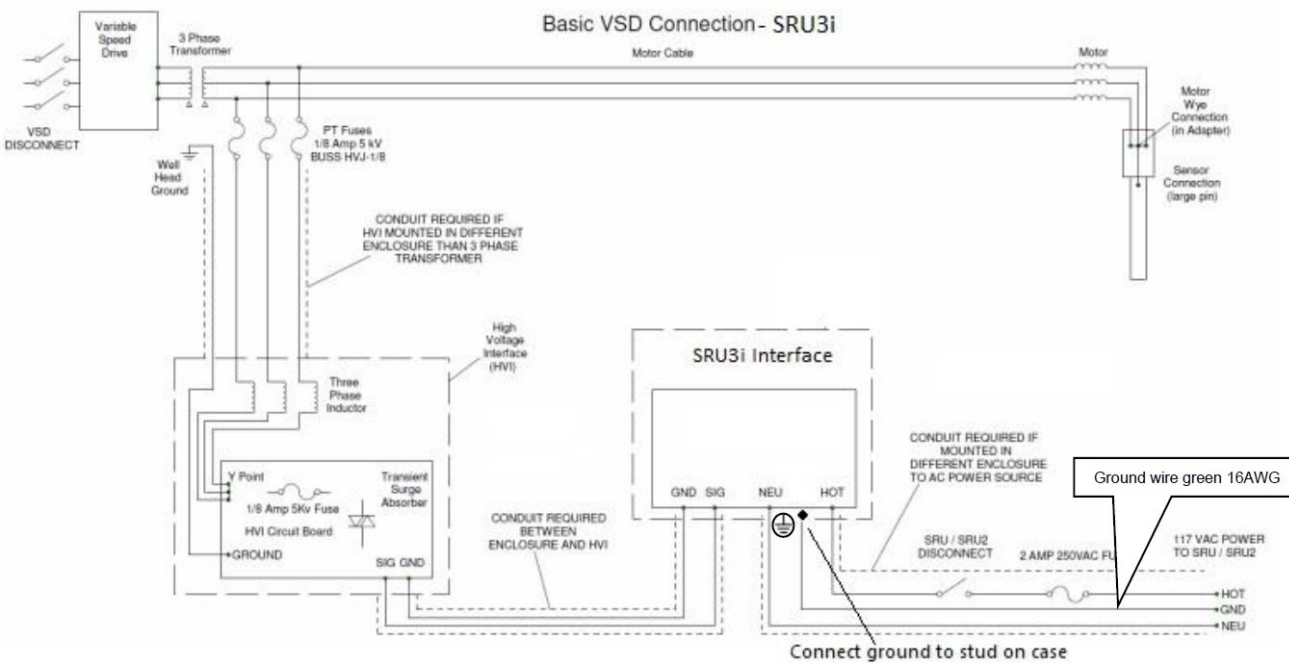
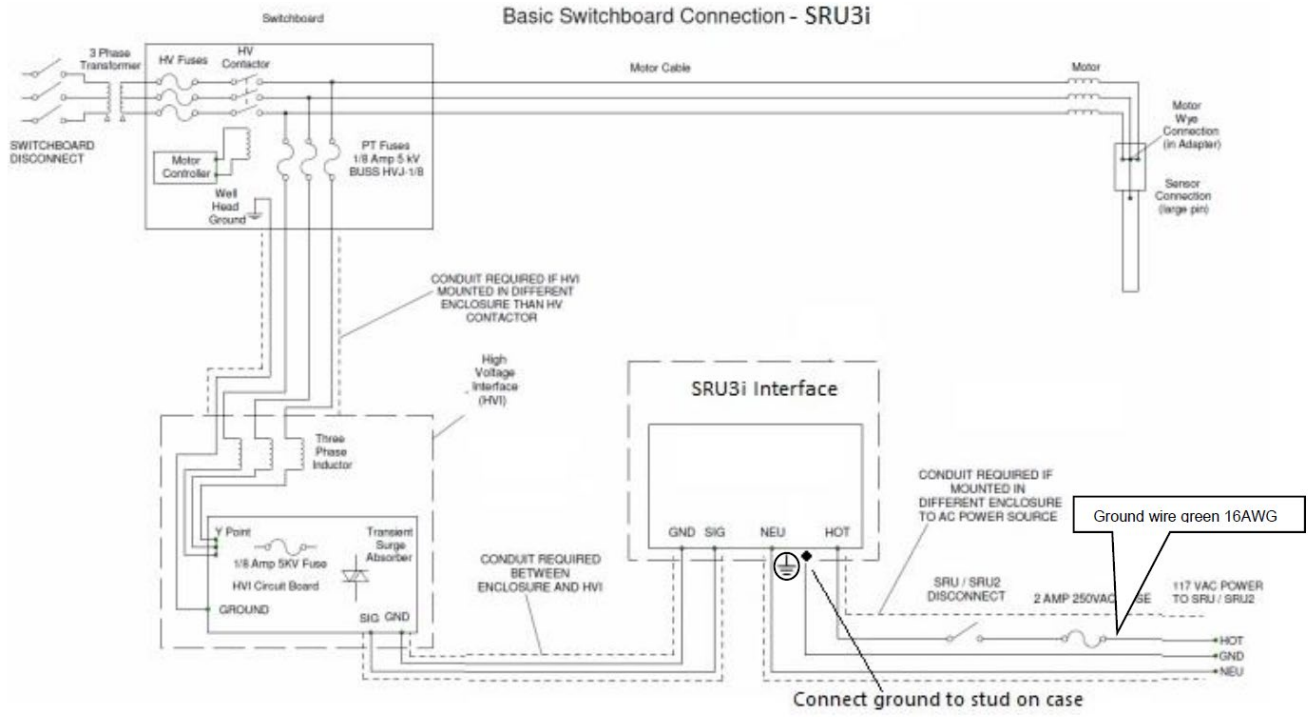

Basic VSD Connection - SRU3i
Variable Speed Drive
3 Phase Transformer
Motor Cable
Motor
VSD DISCONNECT
Well Head Ground
PT Fuses 1/8 Amp 5 kV BUSS HVJ-1/8
Motor Wye Connection (in Adapter)
Sensor Connection (large pin)
CONDUIT REQUIRED IF HVI MOUNTED IN DIFFERENT ENCLOSURE THAN 3 PHASE TRANSFORMER
High Voltage Interface (HVI)
SRU3i Interface
Three Phase Inductor
Y Point
Transient Surge Absorber
1/8 Amp 5Kv Fuse
HVI Circuit Board
GROUND
SIG GND
GND SIG NEU HOT
CONDUIT REQUIRED BETWEEN ENCLOSURE AND HVI
CONDUIT REQUIRED IF MOUNTED IN DIFFERENT ENCLOSURE TO AC POWER SOURCE
Ground wire green 16AWG
SRU / SRU2 DISCONNECT
2 AMP 250VAC FU
117 VAC POWER TO SRU / SRU2
HOT
GND
NEU
Connect ground to stud on case


Basic Switchboard Connection - SRU3i
Switchboard
3 Phase Transformer
HV Fuses
HV Contactor
Motor Cable
Motor
SWITCHBOARD DISCONNECT
Motor Controller
PT Fuses 1/8 Amp 5 kV BUSS HVJ-1/8
Well Head Ground
Motor Wye Connection (in Adapter)
Sensor Connection (large pin)
CONDUIT REQUIRED IF HVI MOUNTED IN DIFFERENT ENCLOSURE THAN HV CONTACTOR
High Voltage Interface (HVI)
SRU3i Interface
Three Phase Inductor
Y Point
Transient Surge Absorber
1/8 Amp 5KV Fuse
HVI Circuit Board
GROUND
SIG GND
GND SIG NEU HOT
CONDUIT REQUIRED BETWEEN ENCLOSURE AND HVI
CONDUIT REQUIRED IF MOUNTED IN DIFFERENT ENCLOSURE TO AC POWER SOURCE
Ground wire green 16AWG
SRU / SRU2 DISCONNECT
2 AMP 250VAC
117 VAC POWER TO SRU / SRU2
HOT
GND
NEU
Connect ground to stud on case

APPENDIX B
ACE Downhole Sensor Pressure Test Unit Instructions.

Safety Instructions

Warnings in this manual appear in either of two ways:

1. *Danger warnings* – The danger warning symbol is an exclamation mark enclosed in a triangle which precedes letters spelling the word “DANGER”. The Danger warning symbol is used to indicate situations, locations and conditions that can cause serious injury or death:

DANGER

2. *Caution Warnings* - The caution warning symbol is an exclamation mark enclosed in a triangle which precedes letters spelling the word “CAUTION”. The Caution warning symbol is used to indicate situations and conditions that can cause operator injury and/or equipment damage:

CAUTION

Other warning symbols may appear along with the Danger and Caution symbol and are used to specify special hazards. These warnings describe particular areas where special care and/or procedures are required in order to prevent serious injury and possible death.

Electrical Warnings – The electrical warning symbol is a lightning bolt mark enclosed in a triangle. The electrical warning symbol is used to indicate high voltage locations and conditions that may cause serious injury or death if proper precautions are not observed:

For the purposes of this manual and product labels, a **Qualified Person** is one who is familiar with the installation, construction, operation and maintenance of the equipment and the hazards involved. This person must:

1. Carefully read and understand the entire manual.
2. Be trained and authorized to safely energize, de-energize, clear faults, ground, lockout and tag circuits and equipment in accordance with established safety practices.
3. Be trained in the proper care and use of protective equipment such as safety shoes, rubber gloves, hard hats, safety glasses, face shields etc. in accordance with established safety practices.
4. Be trained in rendering first aid.

Introduction

The ACE Pressure Test Unit (PTU) functional tester provides a durable, portable source of hydraulic pressure to quickly verify functional operation of an ACE Downhole Sensor. It may be used in the service shop or at the wellhead to verify functionality before running an ACE instrument into a well. Note that the unit is intended to provide a basic functional test, not as a calibrated source of pressure. The maximum pressure that can be generated is 3000 psi.

Kit Contents

1. Pressure pump and gauge. (permanently mounted in the carrying case).
2. Connecting tube with 7/16” deep socket (modified) and cap.
3. 7/16” open-end wrench.
4. Teflon Tape.
5. This manual.

Connecting to ACE Downhole sensor

DANGER

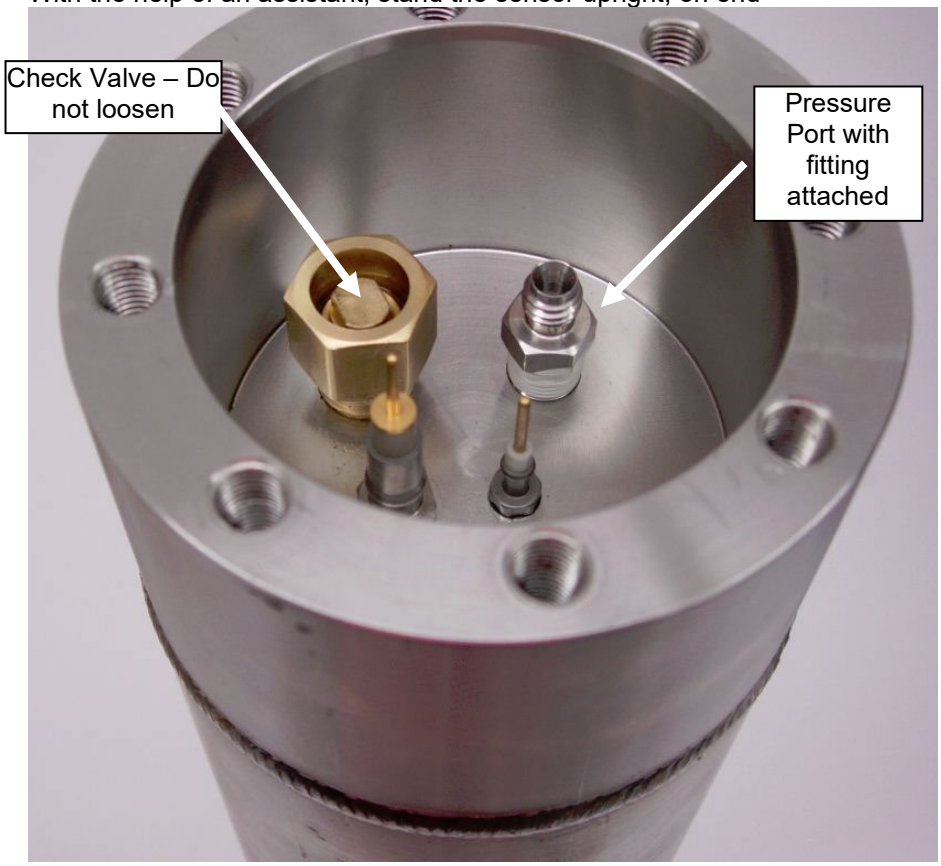
The PTU generates hydraulic pressures that could cause personal injury. Wear face protection when operating the tester. Before attempting to operate the tester refer to a qualified person for assistance, instructions on safe operation and to ensure that connections meet all applicable safety procedures, standards and codes.

The PTU is connected to the Downhole sensor via a 1/8” stainless tube. The interconnecting tube is supplied with a 1/8” NPT fitting loosely attached. The interconnecting tube also has a modified 7/16” deep socket on the ACE sensor end of the tube.

Note

For ACE sensor units with ⅛” NPT thread on the pressure port, use the ⅛” NPT to ⅛” tube fitting. For ACE sensor units with a ¼” NPT on the pressure port use the ¼” NPT to ⅛” tube fitting. (If it is ever necessary to replace these, the fittings are compatible with Swagelok fittings).

Step 1: Gain access to the ACE pressure port. Locate a flat, clear location to work on. Remove the protective shipping cap from the top of the ACE sensor allowing access to the pressure port and electrical connections. Observe which of the two possible sizes of pressure ports are used on the ACE sensor, either ¼” or ⅛" NPT. With the help of an assistant, stand the sensor upright, on end



with the pressure port and electrical connections on top. Fill sensor pressure port hole with oil.(~10 – 30 wt oil)

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Step 2: Screw the appropriate NPT to tube fitting in hole and tighten. Use approximately 3 layers of Teflon tape on the NPT thread of the fitting. If using the ⅛" NPT fitting it may be tightened with the deep socket mounted on the interconnecting tube. Leave the tube fitting nut loose, slip deep socket down so it is on the NPT fitting, and use a 7/16 open-end wrench on the socket flats to tighten the fitting into ACE sensor. For ACE sensors with a ¼" NPT pressure port, use the separate 9/16" deep socket supplied to install the fitting into the sensor pressure port.

Step 3: Connect interconnecting tube to fitting in pressure port:
Position tube so it is pointing opposite the large Y-lead feedthru pin. Use the deep socket located on the tube and 7/16" open-ended wrench to tighten the tubing fitting nut.

⚠ CAUTION

Do not over tighten the tubing nut. Approximately ⅛ turn past finger tight is sufficient. Over tightening tube fitting nut will cause deformation of fitting, making removal difficult.

Step 4: Connect interconne
1cting tube to PTU:
Carefully lay ACE sensor down along the right side of the pressure tester, with the interconnecting tube extending left over the rear of the tester gauge area. Remove and save the ⅛" tube cap from just left of the pressure tester gauge and attach interconnecting tube to fitting. Tighten with 7/16" open-end wrench. Again, do not over-tighten!!

Pressure Testing ACE Downhole sensor

Step 1: Connect ACE sensor to the field test unit that will power the ACE sensor and display readings. Refer to instructions with that unit for connection details. Power up the ACE field test unit and wait until readings appear, which should be within a minute or so. The pressure should be displayed between 0 and 30 PSI for 3KPSI units, and between 0 and 50 PSI for 5KPSI units.

Step 2: Apply Pressure:

CAUTION

The tester is rated for a maximum working pressure of 3000PSI. Be careful not to exceed this pressure as damage to equipment and possible injury could occur. Monitor all fitting connections, if any leaks are noticed first release pressure then tighten any leaking fittings. If leaks persist replace the leaking fittings. Do not leave the system under pressure for extended periods of time. As the temperature rises and falls this will cause the oil in the system to expand and contract, which will cause pressure variances.

Tighten the release valve located on the pump by rotating it clockwise (pressure is released by rotating it counter clockwise). Pressure is applied by slowly pumping the pump handle. Since there is some air in the line it will take several strokes to obtain pressure. Also, since some air is present, even when pressured up, the pressure will slowly drop as air is absorbed into the oil. Carefully applying force to the pump handle will allow a constant pressure to be maintained. The ACE field test unit should display readings that approximately match the pressure gauge.

Note.

Remember the mechanical pressure dial is not a calibrated gauge and the pressure displayed by the field test unit was measured about 15 seconds before it is displayed on the field test unit. Try to maintain constant pressure for 30 seconds or more for the two pressure displays to be in agreement.

When pressure has been applied for sufficient time to check ACE sensor, slowly release the pressure by rotating the release valve knob counter clockwise. Verify the pressure displayed on the surface readout tester drops back to zero pressure display.

Disconnecting Ace sensor from PTU

Turn off the power on the field test unit by rotating the timer switch to OFF. Wait a few seconds then carefully remove the electrical boot connector and ground clip from the ACE sensor.

Disconnect interconnecting tube from PTU, using 7/16” open-end wrench. Replace cap on the fitting near gauge to minimize oil leakage. Place cap on the end of the interconnecting tube to prevent fluid loss.

Use 7/16” open end wrench and deep socket to loosen tube fitting nut from ACE sensor fitting. If using the 1/8” NPT, only loosen fitting nut, then use deep socket to remove fitting from ACE sensor pressure port.
If using the ¼” fitting, completely remove tube from fitting, and then use 9/16” deep socket to remove fitting from Ace sensor.
Place cap over end of fitting or tube and place interconnecting tube in Ziploc bag.

Tilt ACE sensor to remove oil from pressure port hole if desired. Remove Teflon tape residue from ACE sensor pressure port.

Pressure release knob

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APPENDIX C
Modbus Map

All registers are 16 bit integer unless noted. May be accessed using command 3 or 4 (addressed as 4xxxx or 3xxxx). Note depending on SRU version some registers are not valid e.g. SRU2 is the only unit with a real time clock.

Registers 0 to 999 are volatile; i.e. the values will be reset upon power up. Only the ones marked * may be written to.

```
0      Intake temperature
1      Intake Pressure
2      Winding temperature
3      Vibration X
4      Vibration Y
5      Discharge Pressure
6      Discharge Temperature
7      Spare
8      Number of channels
9      Set Voltage (0 to 4095)
10     Output Voltage measured (0 to 50 VDC, e.g. 407 = 40.7 VDC)
11     Output Current Measured (0-1023)
12     Threshold level (0-1023)
13     Internal bus DC Voltage (typically 23.0 Volts, or 12.0 VDC on battery powered tester)
14     Digital data decode state
15     Low pass cut off frequency
16     Total downhole data packets received since power up.
17     Total bad downhole data packets received since power up.
28     SRU model (2 = SRU2)
38     Intake temperature highest value recorded since power up.
39     Intake pressure highest value recorded since power up.
40     Winding temperature highest value recorded since power up.
41     Vibration X highest value recorded since power up.
42     Vibration Y highest value recorded since power up.
43     Discharge pressure highest value recorded since power up.
44     Discharge temperature highest value recorded since power up.
45     Spare highest value recorded since power up.
76     Analog out 1 present calculated output value
77     Analog out 2 present calculated output value
78     Analog out 3 present calculated output value
79     Analog out 4 present calculated output value
82     Special factory code register
83     Read Real time clock year (0-99) Read only, see RTC write regs below to set RTC.
84     Read Real time clock month. (1-12) Read only, see RTC write regs below to set RTC.
85     Read Real time clock date. (1-31) Read only, see RTC write regs below to set RTC.
86     Read Real time clock hour (0-23) Read only, see RTC write regs below to set RTC.
87     Read Real time clock minute (0-59) Read only, see RTC write regs below to set RTC.
88     Read Real time clock second (0-59) Read only, see RTC write regs below to set RTC.
89     * RTC Year write
90     * RTC Month write
91     * RTC Day write
92     * RTC Hour write
93     * RTC Minute write
94     * RTC Second write
95     * RTC Write Command. After presetting RTC write regs write 54321 to update clock.
97     D/H status. 0 = OK. 1 = Connecting. 2 = Open circuit. 3 = Shorted. 4 = Cannot decode.
99     * Test values enable. Write 1 to enable test values.
100    Test value 1
101    Test value 2
102    Test value 3
103    Test value 4
104    Test value 5
105    Test value 6
106    Test value 7
107    Test value 8
110    * User volatile register 1 (resets to 0 upon power fail)
```

```
111    * User volatile register 2 (resets to 0 upon power fail)
112    * User volatile register 3 (resets to 0 upon power fail)
113    * User volatile register 4 (resets to 0 upon power fail)
114    * User volatile register 5 (resets to 0 upon power fail)
115    * User volatile register 6 (resets to 0 upon power fail)
116    * User volatile register 7 (resets to 0 upon power fail)
117    * User volatile register 8 (resets to 0 upon power fail)
120    High precision downhole intake temperature, LSW of 32-bit
121    High precision downhole intake temperature, MSW of 32-bit
122    High precision downhole pressure, LSW of 32-bit
123    High precision downhole pressure, MSW of 32-bit
124    High precision downhole winding temperature, LSW of 32-bit
125    High precision downhole winding temperature, MSW of 32-bit
126    High precision X vibration, LSW of 32-bit
127    High precision X vibration, MSW of 32-bit
128    High precision Y vibration, LSW of 32-bit
129    High precision Y vibration, MSW of 32-bit
130    High precision downhole discharge pressure, MSW of 32-bit
131    High precision downhole discharge pressure, LSW of 32-bit
132    High precision downhole discharge temperature, MSW of 32-bit
133    High precision downhole discharge temperature, LSW of 32-bit
134    High precision spare, LSW of 32-bit
135    High precision spare, MSW of 32-bit
140    Metric intake temperature, °C Eg 234 23.4°C
141    Metric intake pressure, kPA. Eg 1234 = 1234 kPA
142    Metric winding temperature, °C Eg 234 23.4°C
143    Metric X vibration, m/s². Eg 321 = 0.321 m/s²
144    Metric Y vibration, m/s². Eg 321 = 0.321 m/s²
145    Metric discharge pressure, kPA. Eg 1234 = 1234 kPA

200    Software Version (main SRU2/3 board)
201    Serial number
202    Software Version (Display / SD Datalogging board)
203    Site name – first letter
204    Site name – second letter
205    Site name – third letter
206    Site name – forth letter
211    State of insulation measurement sampling 1 to 11; 0 when not taking a reading (write
       1 to force a reading via Modbus. Wait until the state reverts to 0 to get result).
214    Calibrated last insulation measurement result, in KOhms.
219    Register that will be written to BH GCS/Advantage VSD Dev 1 Tag 1 (SRU3i / ADCM)
220    Register that will be written to BH GCS/Advantage VSD Dev 1 Tag 2 (SRU3i / ADCM)
       etc
254    Register that will be written to BH GCS/Advantage VSD Dev 3 Tag 12 (SRU3i / ADCM)


304    Intake pressure in PSI (BH Centinel compatible)
305    Intake temperature °C x10 (BH Centinel compatible)
306    Motor winding temperature °C x10 (BH Centinel compatible)
440    Vibration X x100 (BH Centinel compatible)
441    Vibration Y x100 (BH Centinel compatible)
468    Discharge pressure in PSI (BH Centinel compatible)
```

Registers 1000 and above are non-volatile; i.e. the values will be remain the same after power cycle. The ones marked # cannot be written to.

```
1000   # Serial number
1002   Set Voltage (0-4095)
1003   Tooltype; i.e. number of channels
1005   PSI rating. eg 3 = 3000PSI
1006   These are highest ever values recorded
1006   Intake temperature highest value ever recorded.
1007   Intake pressure highest value recorded.
```

1008 Winding temperature highest value recorded.
1009 Vibration X highest value recorded.
1010 Vibration Y highest value recorded.
1011 Discharge pressure highest value recorded.
1012 Discharge temperature highest value recorded.
1013 Spare highest value recorded.
1014 Runtime (hours)
1015 Modbus ID, 1 to 254. The controller will also always respond to Modbus address 234 with relaxed timing settings, so the controller may be remotely accessed even if timing settings have been entered that are too stringent for the connected equipment such as modems or the Modbus address is unknown.
1016 Modbus silent time in mS. Adjusts for breaks in packets caused by modems etc
1017 Modbus baud rate in baud. e.g. 19200 = 19200 baud.
1018 Ethernet Enable. 1= Enable IP comms, 0 = disable IP comms
1019 First part of IP address
1020 Second part of IP address
1021 Third part of IP address
1022 Fourth part of IP address
1023 First part of IP netmask
1024 Second part of IP netmask
1025 Third part of IP netmask
1026 Fourth part of IP netmask
1027 IP Port, RTU Prototcol. (See 1063 for TCP/IP Protocol).
1028 Write 22 to reset all EE values to defaults. Use with caution!
1029 Relay 1 source register
1030 Relay 1 on setpoint
1031 Relay 1 off setpoint
1032 Relay 2 source register
1033 Relay 2 on setpoint
1034 Relay 2 off setpoint
1035 Analog out 1 source register
1036 Analog out 1 process value 1
1037 Analog out 1 process value 2
1038 Analog out 1 output value 1
1039 Analog out 1 output value 2
1040 Analog out 2 source register
1041 Analog out 2 process value 1
1042 Analog out 2 process value 2
1043 Analog out 2 output value 1
1044 Analog out 2 output value 2
1045 Analog out 3 source register
1046 Analog out 3 process value 1
1047 Analog out 3 process value 2
1048 Analog out 3 output value 1
1049 Analog out 3 output value 2
1050 Analog out 4 source register
1051 Analog out 4 process value 1
1052 Analog out 4 process value 2
1053 Analog out 4 output value 1
1054 Analog out 4 output value 2
1057 Site name, first character in ASCII. Eg 65 decimal, 0x41 hex = 'A'
1058 Site name, second character in ASCII. Eg 66 decimal, 0x42 hex = 'B'
1059 Site name, third character in ASCII. Eg 67 decimal, 0x43 hex = 'C'
1060 Site name, forth character in ASCII. Eg 68 decimal, 0x44 hex = 'D'
1062 SRU2 Hardware version
1063 IP Port, TCP/IP Protocol. (See 1027 for RTU Protocol).
1065 Hours between automatic insulation measurements (SRU2i & SRU3i). 0 = disable
1066 0xDAB for Borets emulation. 0xBAD for Apollo emulation. Anything else normal.
1070 Address of Modbus register to become CITIbus Device 1 Tag 1 (SRU3i / ADCM)
1071 Address of Modbus register to become CITIbus Device 1 Tag 2 (SRU3i / ADCM)
1070 Address of Modbus register to become CITIbus Device 1 Tag 1 (SRU3i / ADCM)
|| etc. For Device 1,2,3 Tags 1-12
1105 Address of Modbus register to become CITIbus Device 3 Tag 12 (SRU3i / ADCM)
1106 ID of Modbus device to poll for CITIbus transmission (SRU3i / ADCM)
1107 Write 0x1234 to enables Modbus device polling for CITIbus transmission (SRU3i)

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```
1110   User static register 1 (retains values after power cycles)
1111   User static register 2 (retains values after power cycles)
1112   User static register 3 (retains values after power cycles)
1113   User static register 4 (retains values after power cycles)
1114   User static register 5 (retains values after power cycles)
1115   User static register 6 (retains values after power cycles)
1116   User static register 7 (retains values after power cycles)
1117   User static register 8 (retains values after power cycles)
```

Appendix D

ACE End of Line Acceptance Criteria

Example of acceptance criteria and values of the ACE end of line test. This check list can be used to evaluate an ACE gauge that has been used to ensure the sensor still operates correctly.

ACE DOWNHOLE

Sensor Standalone Test **Serial:** Test Date:

Resistance Test	Criteria	Values
Insulation Resistance (1kV Megger)	>4.0GΩ	

Functional Test	Criteria	Values at Ambient
Menu 1 Intake Temp	±5F Ambient	
Menu 2 Intake Pressure measured at 4,300 ft elevation	5k(0 to 62), 6K(0 to 27), 8k(0 to 32) psi	
Menu 3 Winding Temp	100, 500 F	
Menu 4 X-Vibration	Rolling 1.75 - 2 Stationary < 0.2	
Menu 5 Y-Vibration	Rolling 1.75 - 2.7 Stationary < 0.2	
Menu 6 Discharge Pressure measured at 4,300 ft elevation	6K(0 to 27), 8k(0 to 32) psi	
Menu 9 Number of channels to read	3, 5, 5X 6	
Menu 10 Output Voltage set point	Must be set to 3250	
Menu 11 Measured Output Voltage	39.7 V	
Menu 13 Avg DC Current	Range based on SN scheme	

Accepted By:	

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