Field Installation Manual

ESP MONITORING SYSTEMS

GRC
A SERCEL BRAND

ESP MONITORING SYSTEMS
FIELD INSTALLATION MANUAL

Gauges:
ESP-1500, ESP-2500, ESP-3500, Spy Pro

Surface Equipment:
SPS-1500, Scout-3000, Data Pro

NOTICE

This manual is intended for private information only, with the understanding that any other use of the subject matter, in whole or in part, by reference or otherwise, shall be only with the prior knowledge and approval of ***Sercel-GRC Corp,*** and with the further understanding that this manual is for informational purposes only and that suggestions and recommendations contained herein shall not be understood or construed as a guarantee or warranty of any method, product or device.

Any questions concerning the content of this manual, equipment operation, field maintenance, maintenance assistance and operation or maintenance training courses should be directed to Sercel-GRC.

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Sercel-GRC Corp.
13914 E. Admiral Place, Ste. B
Tulsa, OK 74116-2107 USA
E-Mail: sales@Sercel-GRC.com or support@Sercel-GRC.com
Telephone: (1) 918-834-9600 / Fax: (1) 918-838-8846
Visit our web page at www.Sercel-GRC.com

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INTRODUCTION

This field installation manual will explain in detail the operation and installation of all Sercel-GRC ESP Monitoring Systems. ESP gauge instructions are for the following gauge models: ESP-1500, ESP-2500, ESP-3500, and Spy Pro.

ESP Downhole Gauge Pressure Measurement

The intake pressure measures the pressure inside the motor housing. Motor oil protects the intake pressure port from well fluid contamination.

The discharge pressure measures the pressure at the pump discharge port via a hydraulic line connection to the discharge port on the pump. This connection is available only on Dual Pressure gauges such as the ESP-3500, and Spy Pro 9 and 11.

Surge panel and surface choke

Surface interface

For detailed surface interface instructions, refer to:

Scout-3000 Field Operation Manual PN: 006-0191-00
SPS-1500 Operation Manual PN: 006-0202-00
Data Pro Operations Manual PN: 10029355

A system installation checklist is shown in ***APPENDIX 3*** of this manual. This checklist will provide the installer with the ability to follow and record the installation of the monitoring system. Please follow this guide and use the checklist provided when installing all ESP Sensor Systems.

Customer Service/Support

If assistance is needed, please contact one of our centers listed below. The engineers and technicians will be more than happy to provide you with any assistance needed.

SITE	LOCATION	PHONE	EMAIL
Tulsa, USA	6540 E. Apache Street Tulsa, OK 74115 USA	+1.918.834.9600	sales@sercel-grc.com
Dubai, UAE	Jebel Ali - Free Zone Dubai, UAE	+971 4 8832142	grc.dubai@sercel.com

BENCH TESTING AND VERIFICATION PROCEDURES

Note: Bench test and verification procedures are applicable to all ESP sensors.

Tools Required

- Power Supply 110 VAC/12-24VDC
- Surface Readout (Scout-3000, SPS-1500, Data Pro, Field Test Box)
- Signal and Ground wires
- Alligator Clips
- Simpson 260 analog type meter
- Fluke 1550C insulation tester

Process Steps for Bench Test and Verification

1. **To prevent injury, proper PPE should always be worn. Use caution when working near or handling equipment. Utilize proper lifting techniques to prevent injuries to personnel or equipment.**
2. Remove the top shipping cap from the ESP Sensor.
3. Connect a signal wire from the Surface Readout to the signal wire on the sensor in ***Figure 1***, or if using a WYE Point adapter connect to one of the three pins inside the WYE adapter in ***Figure 2***. Connect the ground wire to the sensor housing. Connect a motor RTD to the two white motor temperature wires.
4. Power on the Surface read out.
5. Data will display on the Surface Readout in approximant 2-5 minutes.
6. Record the parameter readings on the ESP Sensor Checklist in ***APPENDIX 3*** of this manual, for test verification records.
7. ESP Sensor Pass/Fail Criteria is shown in ***APPENDIX 5***.
8. See ***APPENDIX 6*** **SPS-1500 Synchronization and Startup** for the complete SPS-1500 startup sequence.

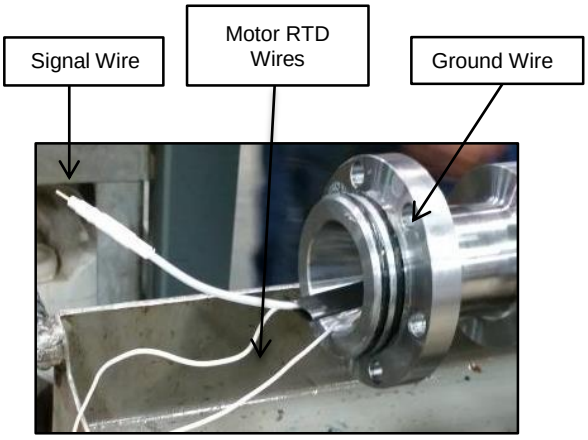


Figure 1: I-Wire Connection

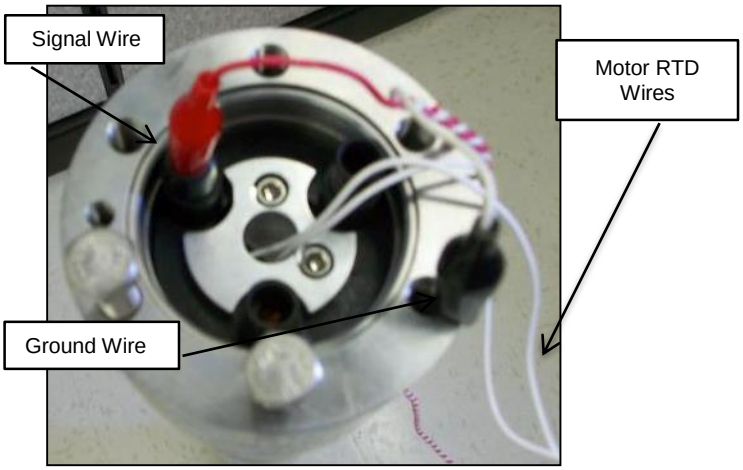


Figure 2: WYE Connection

Process Steps for Insulation Test with Megger Tester (Fluke 1550C) on Surface

9. Connect the Megger Tester in reverse polarity by connecting the red wire to the housing of the gauge and the black wire to the signal pin.
10. Apply voltage for 30 second duration.
11. ESP Sensor Megger Pass/Fail Criteria is shown in ***APPENDIX 5***.

NOTE: MEGGER TEST THE SENSOR IN REVERSE POLARITY ONLY!!

LIMIT MEGGER VOLTAGE TO 5KV MAX

Process Steps for Resistance Test with Analog Type Meter (Simpson 260) on Surface

12. Connect the Analog Multimeter (on Rx10,000) in forward polarity by connecting the black wire to the housing of the gauge and the red wire to the signal pin.
13. ESP Sensor Simpson Pass/Fail Criteria is shown in ***APPENDIX 5***.

INSTALLATION PROCEDURES FOR DOWNHOLE GAUGE

Installing the ESP Sensor with WYE Point Adapter to the Motor

It is recommended that the sensors be installed in a controlled environment or shop prior to being sent to the field. If a sensor must be installed in the field, follow the procedures outlined below for sensors equipped with WYE point adapters.

1. Layout the sensor so that the three female connections on the hockey puck are aligned with the three pins coming out of the motor, and the holes on the motor base are aligned with the holes on the motor head as shown in ***FIGURE 3***.
2. Insure the O-ring has no sign of damage and install or replace with a new O-ring if there are any signs of damage.

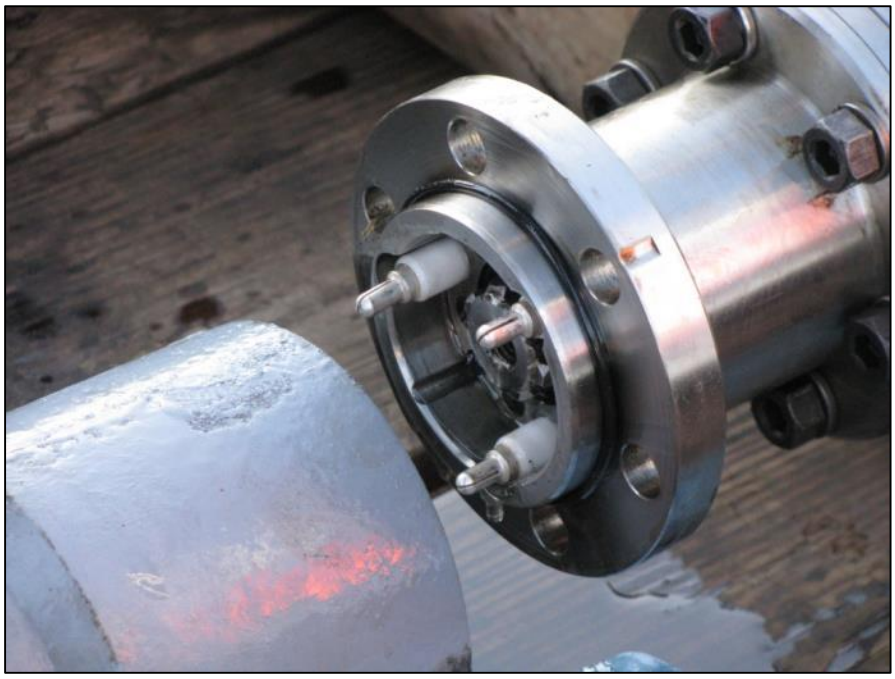


Figure 3: Aligning the motor pins to the Hockey Puck

3. Carefully stab the sensor into the motor, watching closely that the three pins mate up with the three female connections on the hockey puck. **IT IS VERY IMPORTANT DURING THIS STEP YOU DO NOT TWIST THE SENSOR WHILE STABBING INTO THE MOTOR BASE. DOING SO WILL RESULT IN DAMAGING THE HOCKEY PUCK AND RUINING COMMUNICATION TO THE SENSOR ONCE THE MOTOR IS STARTED.**

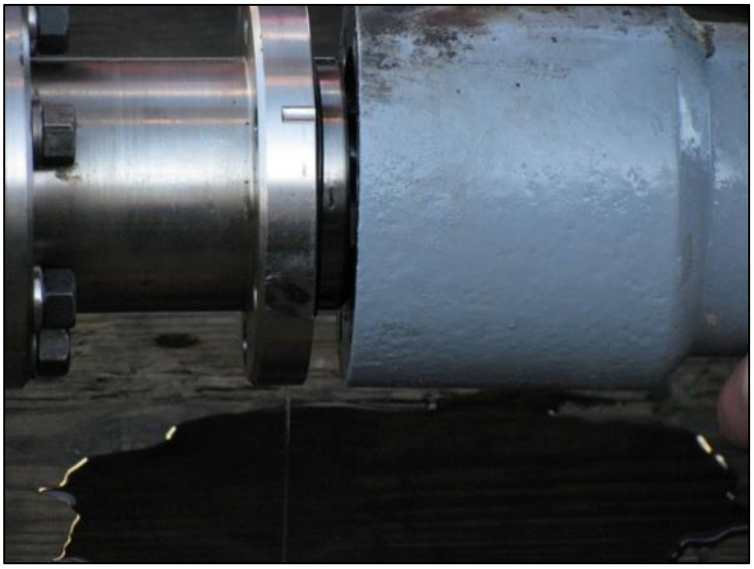
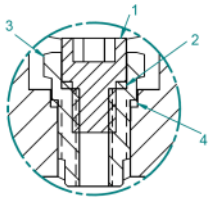


Figure 4: Gauge Stabbed into the Motor Base

4. Once the sensor has been stabbed as far as shown in ***FIGURE 4***, finger-tighten two of the motor base bolts at the top and bottom of the sensor to help support the sensor weight. **DO THIS BEFORE PROCEEDING TO STAB THE SENSOR FULLY INTO THE MOTOR BASE.**
5. Fully insert the sensor into the motor base making sure not to cut or pinch the O-ring.
6. Install remaining bolts torque to minimum 25ft-lbs to ensure proper seal.
7. To fill the sensor with oil, use either the drain and fill valve located at the bottom of the sensor or through the drain and fill valve located on the motor.

Table 1: Drain and Fill Valve Part Numbers

Item #	Part Number	Description	
1	089-0252-00	PLUG, VENT & DRAIN	
2	089-0254-00	GASKET, VENT & DRAIN LEAD SEAL	
3	089-0251-00	VALVE, DRAIN & FILL	
4	089-0253-00	GASKET, LEAD SEAL	

Note: Both gaskets (Items 2 and 4) listed above are single-use components.

Item 3 (valve) should be torqued to 210 in-lbs, and Item 1 (plug) should be torqued to 100 in-lbs.

8. After the sensor is installed verify sensor readings using a Surface Readout and record the values on the ESP Sensor Checklist in ***APPENDIX 3***.

Installing the Motor Temperature Sensor

All ESP Gauges monitor Motor Temperature with a Platinum 1K RTD. Spy Pro gauges are available with a Platinum 1K RTD or Type – J Thermocouple motor temperature sensors. Field connection instructions are included below. Motor Temperature probes are connected inside the gauge assembly and the probe is placed close to the Motor Windings for maximum temperature transfer and fast response The factory installed RTD is a Probe Style RTD with a stainless steel shielded sheath.

Motor RTD Installation Instructions for factory installed RTD

Since the RTD is factory installed. Determine where to place the RTD probe in the base of the motor. The shielded RTD cable can be coiled inside the motor base. Remember to keep the wire away from the motor shaft to prevent damage to the RTD cable.

Motor Thermocouple Connection Instructions (Spy Pro Only – Field Installed)

The Spy Pro thermocouple optional Type – J thermocouple must be installed prior to the gauge being connected to the ESP motor. The gauge will come with a red and white wire attached to gauge and with a butt splice connection installed on the wires. The thermocouple sensor should be connected red to red and white to white. See ***FIGURE 5.***

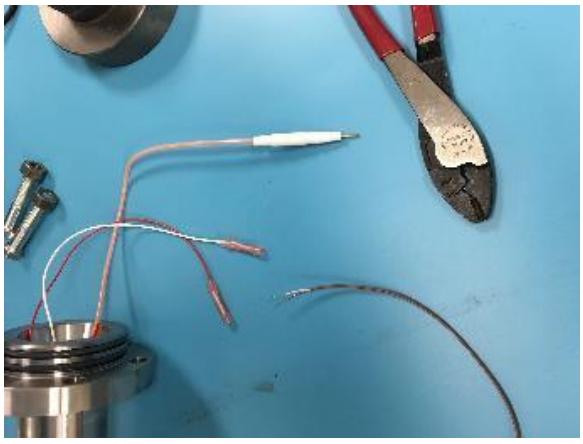


Figure 5: Spy Pro Thermocouple Crimp Connections

Crimp the red thermocouple wire to the red wire from the gauge and crimp the white thermocouple wire to the white wire from the gauge using a barrel crimp tool. Using a heat gun, shrink the tubing of the butt splice. See ***FIGURE 6.***

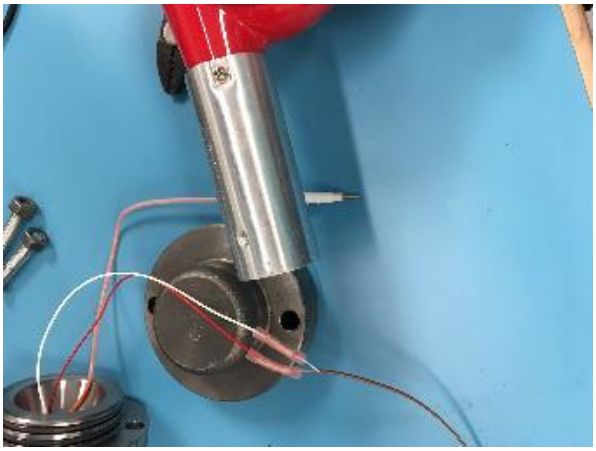


Figure 6: Shrink Butt Splice Connections

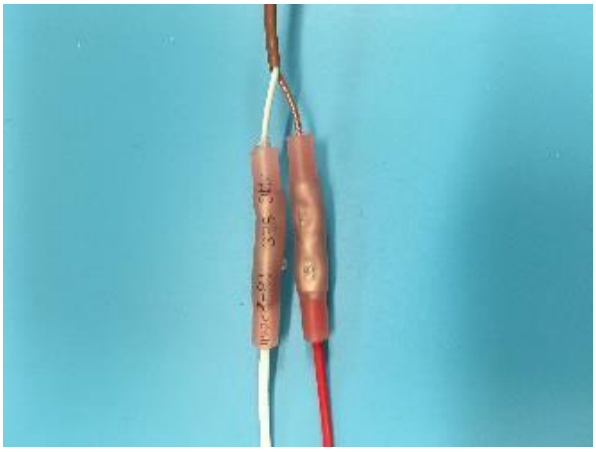


Figure 7: Spy Pro Thermocouple Completed Connections

The Spy Pro gauge will auto-sense whether the attached motor temperature probe is an RTD or thermocouple sensor. A thermocouple will be included in the spare parts kit on the thermocouple models.

To test the thermocouple polarity, connect the probe to the gauge and connect to the surface readout (SPS-1500). Once the gauge data is being displayed, heat the probe with hot water or a hot air tool. Monitor the motor temperature display and verify the motor temperature is increasing. If the displayed temperature does not increase, swap the two thermocouple wires and retest. This test must be performed before connecting the gauge to the motor.

Motor RTD Connection Instructions (ESP-1500/2500/3500)

1. The first step is to determine where the RTD is going to be placed. It can be either inside the ESP motor oil passage or inside the Sercel-GRC gauge. Inside the gauge is the safest and is the least likely to come in contact with rotating

motor components. But it will be slower in responding to temperature variations of the ESP motor. Placing the RTD inside the motor oil passages provides faster response times to temperature changes, but runs the risk of making contact with rotating parts.

2. Shorten the two wires coming from the gauge for the RTD to match where you have determined to place the RTD. If it's going inside the motor oil passage secure the wiring and its excess to insure that the RTD is not drawn further into the oil passage by the oil flowing through it. This prevents the RTD from coming in contact with the rotating internal parts of the motor. Also insure that the wiring will not come in contact with the end of the rotating motor shaft located where the motor and ESP gauge are mated together. If the RTD is being placed inside the gauge do not coil up the excess wire inside gauge but instead shorten the wires and then insert the RTD and wiring back into the gauge. The reason for not coiling the excess wire up and placing it inside the gauge is this can possibly allow motor noise to show up on the motor temperature readings.
3. Strip 1/4" to 3/8" of insulation from the RTD and gauge wires.
4. Cut a piece of high temp heat shrink tubing, around 2.5", and slide it over and past both stripped gauge wires.
5. Using two more pieces of high temperature heat shrink tubing, around 1.5" long, slide each piece over and past each individual gauge wire. The result should look like the example in ***FIGURE 8***

Figure 8: Three Pieces of Shrink Tubing on the Gauge Wires

6. Twist one RTD wire and one RTD gauge wire together creating a splice so that it appears as a straight wire and not two wires side by side. At this time solder the two wires together using high temp solder. Do the same step for the other two wires (one from the RTD and the other from the gauge).
7. Slide the heat shrink tubing down over each individual soldered bare wire and heat shrink the two pieces of tubing using a hot air gun (heat gun). The solder joint should be located in the center of the length of the tubing and the result should appear as shown in ***FIGURE 9***.

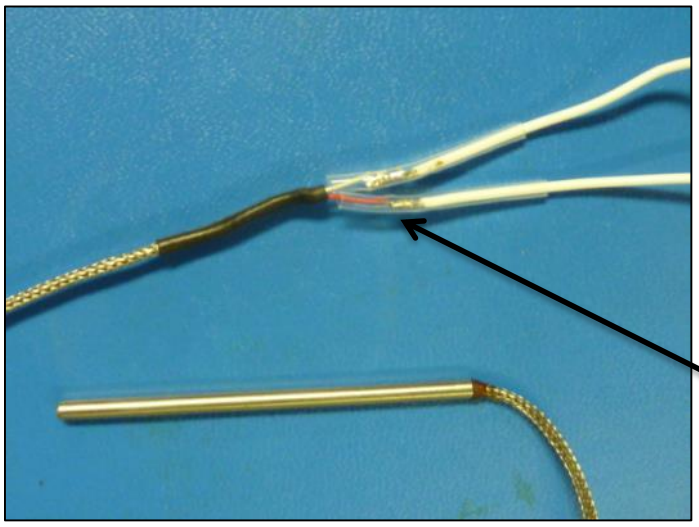


Figure 9: Heat Shrink Tubing Over the Solder Joints

8. Slide the longer piece of heat shrink tubing over both wires so that the solder joint is centrally located inside the tubing as shown in ***FIGURE 10***.

Figure 10: Long Piece of Heat Shrink Tubing Over Both Wires

Finally, replace the WYE point if you have removed it. Attach the Scout-3000 or portable Scout to any of the motor terminals of the WYE point or to the gauge wire if not using our WYE point. Turn on the Scout and check/record gauge readings.

Place the RTD in the position you had determined and reassemble the gauge and motor. Re-check and record readings using the Scout attached to the top of the motor on one motor lead.

Installing the ESP Sensor with Single Wire to the Motor

It is recommended that the sensors be installed in a controlled environment or shop prior to being sent to the field. If a sensor must be installed in the field, follow the procedures outlined below for sensors equipped with a single signal pin.

Spy Pro gauges are pre-wired with a connector pigtail adapter and waterproof boot seal attached to the gauge signal pin (see illustrations below). For optimum performance, connect the motor WYE point or I-Wire directly to the gauge pin. This will require removal of the gauge motor head adapter (if fitted) to access the I-Wire pin on the gauge and re-fit of the motor head adapter. If the motor head adapter is removed, re-torque the head as required for your application.

1. Connect the male end connector by fully inserting into the female connector from the motor I-Wire. See ***FIGURE 11.***

Figure 11: Connect the Motor I-Wire to the Gauge

2. Neatly bundle the RTD and signal wires and secure using high-temperature zip ties. See ***FIGURE 12.***

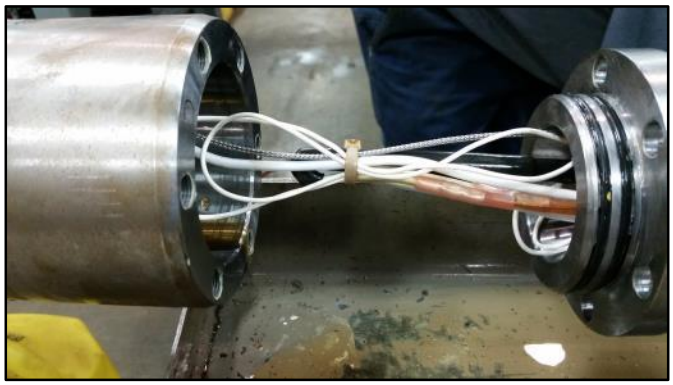


Figure 12: Bundle the Wires and Zip Tie

3. Slide the wire bundle into the head of the gauge. See ***FIGURE 13.***

Figure 13: Slide Wire Bundle into the Head of the Gauge

4. Lubricate the O-rings. Carefully stab the sensor onto the motor. Care must be taken to **NOT PINCH** the wires or damage the O-rings.
5. Insert the top and bottom bolt and finger tighten. See ***FIGURE 14.***
6. Insert remaining bolts and tighten all bolts to 25 ft/lbs.

Figure 14: Insert Top and Bottom Bolts

7. Perform bench testing through the pothead using GRC surface readout. See ***FIGURE 15.*** Log the data to the ESP Sensor Checklist in ***APPENDIX 3***.

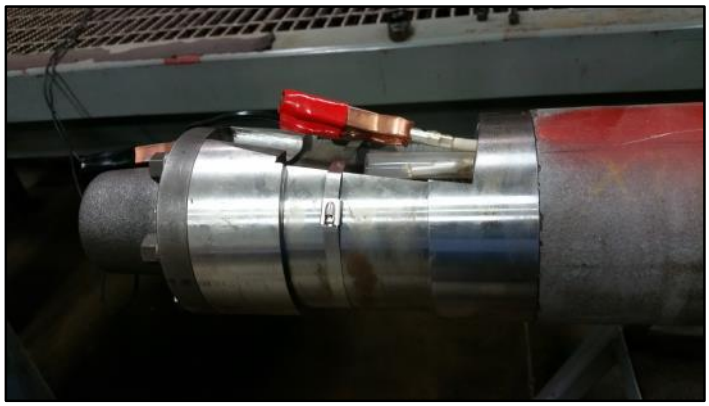


Figure 15: Bench Test Through the Pothead

Discharge Port Connection (ESP-3500 only)

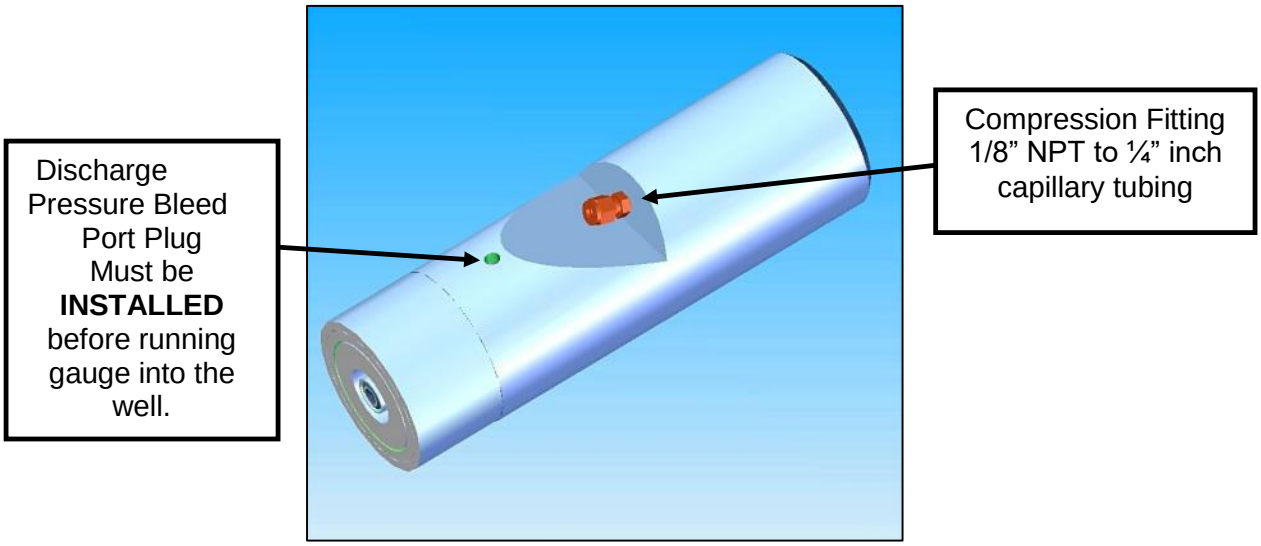


Figure 16: Discharge Tubing Connection

THIS OPERATION NEEDS TO BE COMPLETED IN ITS ENTIRETY BEFORE THE MLE IS CONNECTED TO THE MOTOR.

1. Pre-fill the discharge tubing with dielectric oil by using a hydraulic hand pump to pump oil into the tubing until there is a steady flow coming out the opposite end.
2. Cap off the ends of the discharge tubing to ensure oil remains inside.
3. Remove the fitting and ensure that the NPT threads have been Teflon taped.
4. Install the NPT fitting back into the base.
5. Remove the compression nut and ferrules from the fitting and capped off discharge tubing.
6. Install compression nut and ferrules onto the capillary tubing **ensuring the correct ferrule orientation.**
7. Place the capillary tubing with nut and ferrule into the fitting and hand tighten nut then using a 9/16" wrench tighten the nut 1-1/4 more turns.
8. Remove the NPT plug directly above the NPT fitting.
9. Remove the capped off end of discharge tubing and reconnect to hydraulic hand pump.
10. Pump oil through the discharge tubing until a steady stream of oil without bubbles is flowing through discharge pressure bleed port.
11. Reapply Teflon Tape to NPT plug and reinstall the NPT plug back into the pressure bleed port.
12. Band the discharge line~6in above the pressure bleed port and then every 3ft to the top of the ESP.
13. Nipple up the discharge sub.
14. Cut the discharge line to appropriate length and install into the velocity fuse fitting.
15. Tighten velocity fuse using a 9/16" wrench tighten the nut 1-1/4 more turns after hand tight.

Discharge Port Connection (Spy Pro only)

Follow the steps below to attach the Discharge Port Tubing on the Spy Pro gauge.

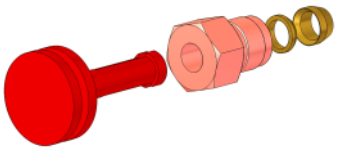
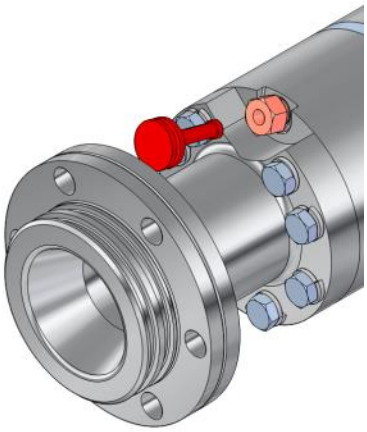
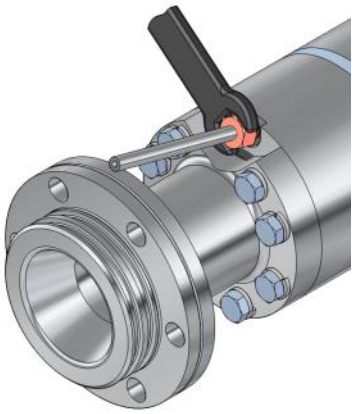


Illustration of plastic retainer and Hydraulic fitting. Do not remove the fitting. If removed, parts must be placed in order.



Tighten fitting finger tight and then remove plastic retainer.

Insert tube into fitting until firmly seated against shoulder inside pressure head.



Tighten nut to 25 ft•lbs. Or, tighten nut finger tight, mark the nut, and tighten nut one full revolution.

Figure 17 Spy Pro Discharge Port connection

Testing the ESP Sensor While Installing Tubing

Megger testing motor and cable

The motor and cable may be Megger tested if required using the following guidelines:

The output voltage of a Megger will exceed the breakdown voltage of the protective MOV mounted on the fuse block. The MOV will conduct if a Megger is used, giving incorrect readings. Disconnect the three-phase choke and fuse block from the motor cable before testing. **Do not Megger test the downhole equipment while any of the surface components are connected to the motor power cable.**

NOTE: MEGGER TEST THE SENSOR IN REVERSE POLARITY ONLY!!

LIMIT MEGGER VOLTAGE TO 5KV MAX

Follow the steps below to test the gauge through the ESP cable spool **once the cable has been connected to the motor.**

- Since the SCOUT is powered by 110 VAC, an external power supply will be needed.
  ONLY CONDUCT THIS CHECK WHILE THE SPOOL IS NOT MOVING.
  - **NEVER AT ANY TIME STEP OVER THE 3 PHASE ESP CABLE.**

1. Connect the signal wire to one of the exposed copper conductors on the 3 phase ESP cable.
2. Connect the ground wire to the exterior lead shielding of the ESP cable.
3. Power on the Surface Readout.
4. Record the parameter readings on the ESP Sensor Checklist given in the Appendix of this Manual.
5. It is recommended to continue monitoring the sensor by verifying downhole sensor readings with a Sercel-GRC Surface Readout approximately every 1000ft (~33 joints).

Figure 18: Spooling Unit

INSTALLING THE SURFACE INTERFACE EQUIPMENT

Wiring Detail

FIGURE 19 shows a typical wiring and installation schematic for the ESP surface equipment.

ESP Gauge and Surface Control Interface Diagram Components

1. ESP Gauge Surface Readout Interface (SPS-1500/Scout-3000/Data Pro)
2. Surge Panel Equipment (Surge Suppressor and Fuse Protection #90D2215 or #90B2175)
3. Surface Choke - 3-phase choke (P/N 99B990)
4. Motor Head Adapter and WYE point connection
5. Downhole Choke and Sensor Module (Gauge)

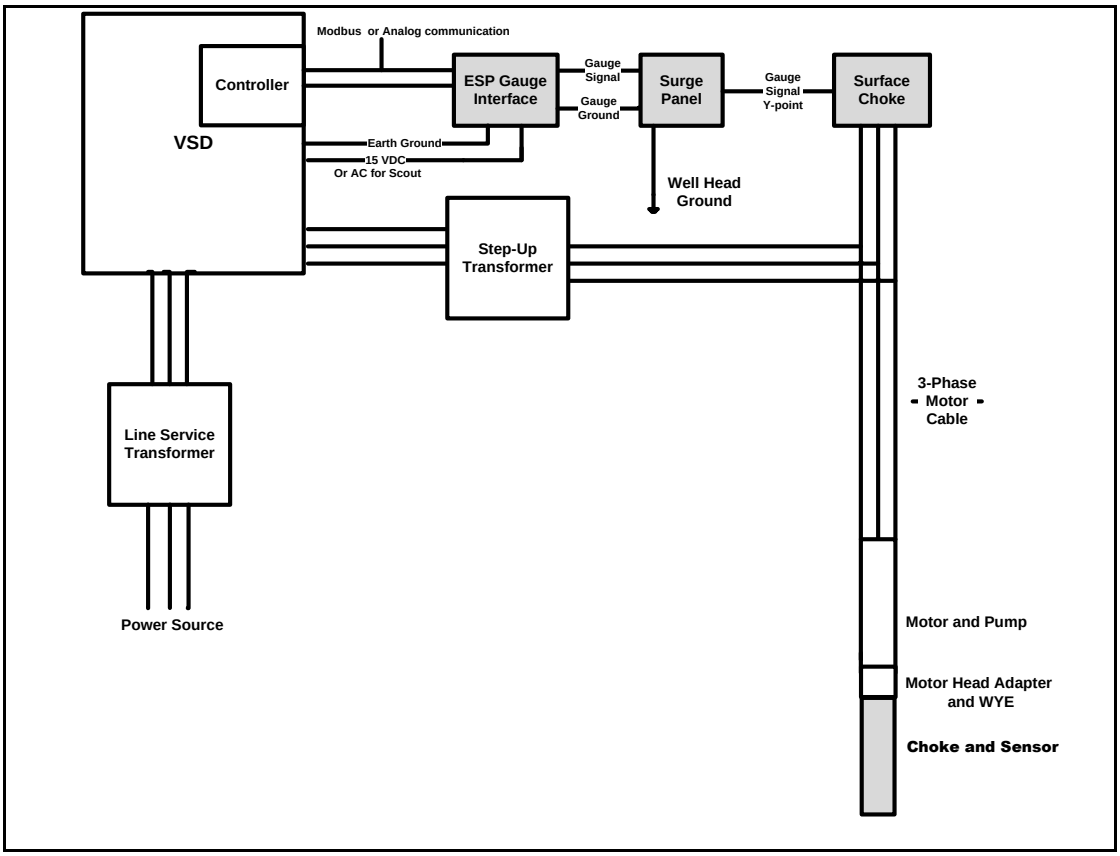


Figure 19: Surface System Wiring Diagram

INSTALLING THE SURGE SUPPRESSOR AND SURFACE CHOKE

! CAUTION ! Lethal Voltages Present Inside Enclosure.
Remove power anytime the front panel of the Scout-3000 is removed.
There are potentially dangerous voltages present!

The ESP gauge surface readout equipment such as the Scout-3000 connects to the downhole tool via the motor power cable through the Surge Suppressor and Surface Choke. Communication and power are provided via a “Comms-On” technique; meaning the communication and power are both transmitted through the motor cable. The surface readout equipment provides “Comms-On” power to the ESP gauge and is

connected to the ESP Surge Protection Equipment via the gauge signal and wellhead ground.

Surface Choke

The surface choke, shown in ***FIGURE 20***, is connected between the VSD 3-phase power and the Surge Panel or Surge Protector. The purpose of the surface choke is to allow the ESP Gauge Interface to provide power to and communicate with the downhole tool. The ESP Gauge Interface provides between 30-80VDC to the Neutral wire on the Surface Choke to power the downhole gauge. The Surface Choke is designed to block AC voltages from entering the ESP Surface Equipment as well as creating a virtual ground via WYE point for direct connection for downhole communication.

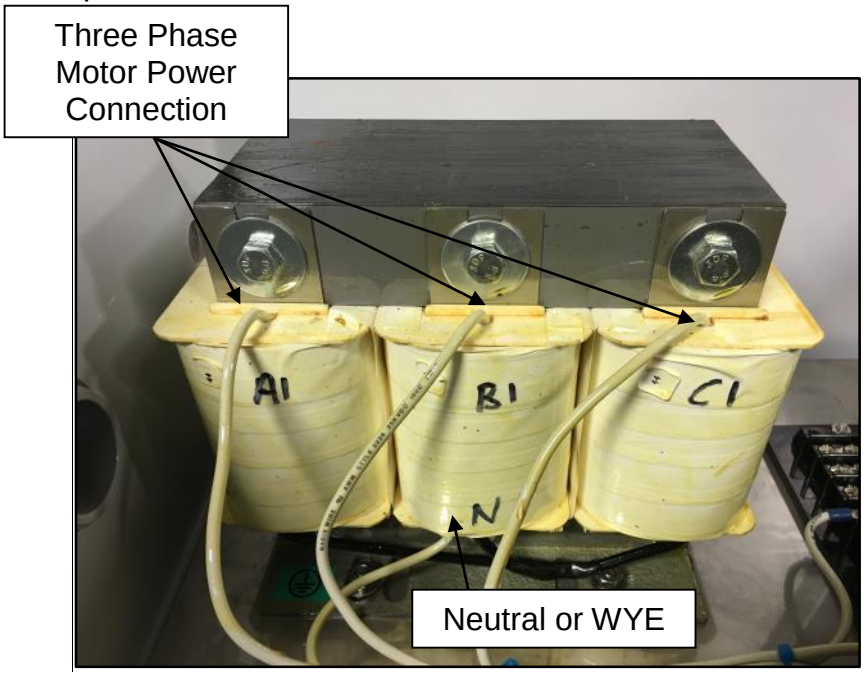


Figure 20: Surface Choke Part Number #99B990

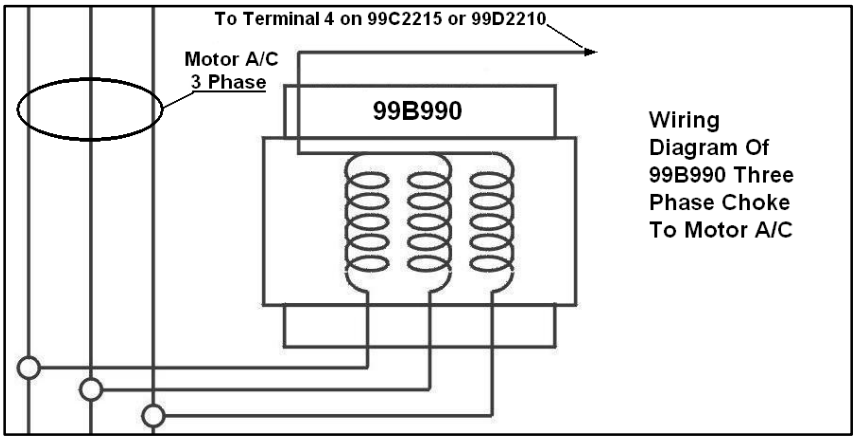


Figure 21: Three Phase Surface Choke Connections

Surge Panel Protector/Suppressor

The Surge Panel (*FIGURE 22)* provides protection for the ESP Surface Interface equipment from several failures including; overvoltage from imbalance, transient voltage pulses, and switching spikes.

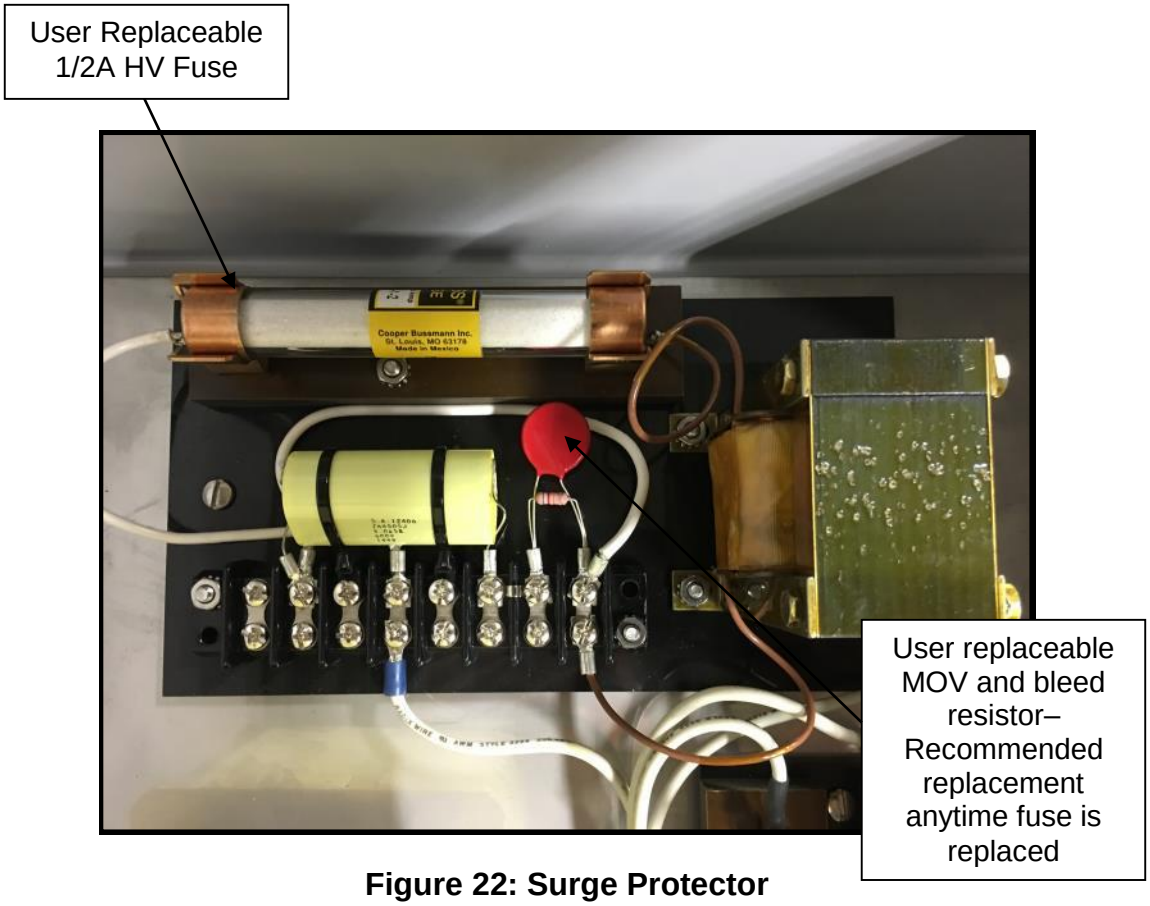
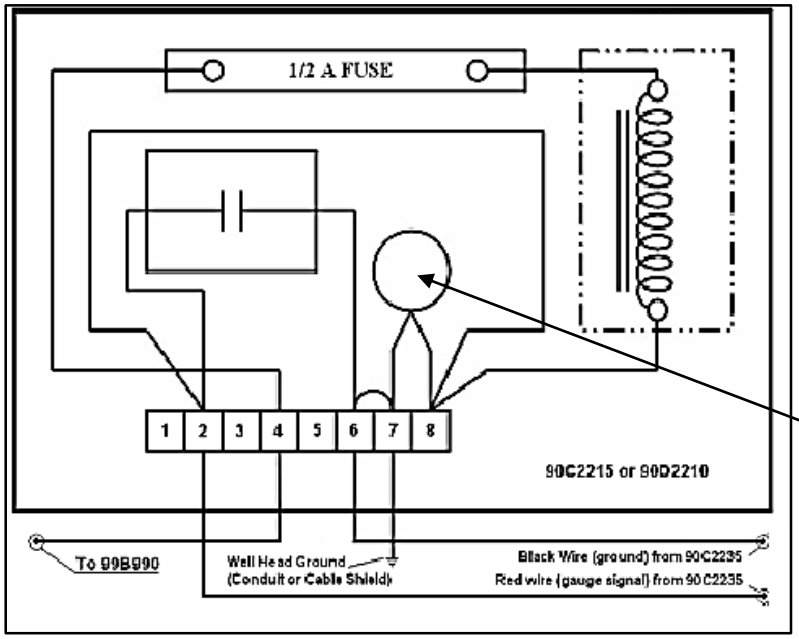


Figure 22: Surge Protector



Late model Surge Panel Protectors have a bleed resistor installed across the MOV (pin7 to pin 8) to dissipate static line charges.

Figure 23: Surge Protect Schematic and Connection

Surge Protector/Fuse Block Connections 1 – 8 (*FIGURE 23*)

1. No Connection
2. Gauge signal wire to SPS-1500 or Scout-3000
3. No Connection
4. To three-phase choke Y-point
5. No Connection
6. Gauge ground to SPS-1500 or Scout-3000
7. Dedicated wellhead ground
8. No Connection

Assembly Connections

1. Once the tubing is installed and the cable is terminated at the junction box, check the sensor with the SCOUT at the junction box. This will ensure that everything is good downhole and the rig crew can proceed with their rig down.
2. Record the parameter readings on the ESP Sensor Checklist.
3. Mount the Surface Choke and Surge Protector (Suppressor) inside the transformer cabinet.
4. Reference *FIGURE 22* & *FIGURE 23* to see the electrical connections.

Surface Choke Tips

1. Make sure that the Surface Choke wires that are connected to the transformer are braided.
2. If longer cable is needed from the Transformer to the Surface Choke, make sure that it is rated for the Transformer voltage.
3. Each wire from the surface choke connects to one phase of the transformer.

Surface Choke and Surge Protector Panel Assembly

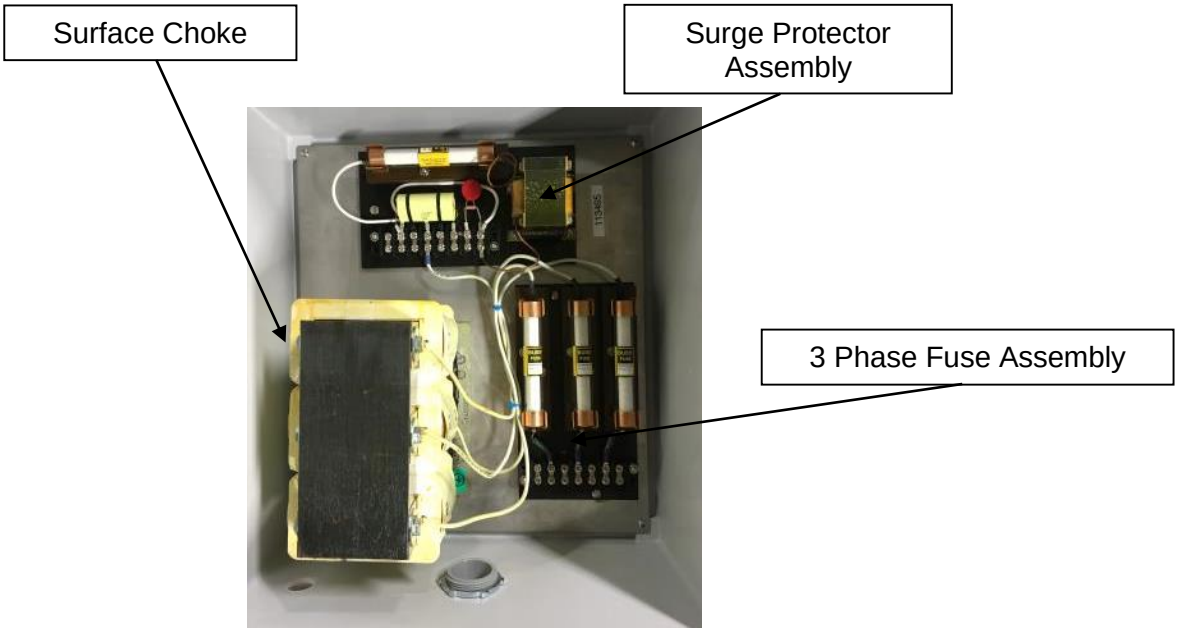


Figure 24: Surface Choke and Surge Protector Assembly 90B2175

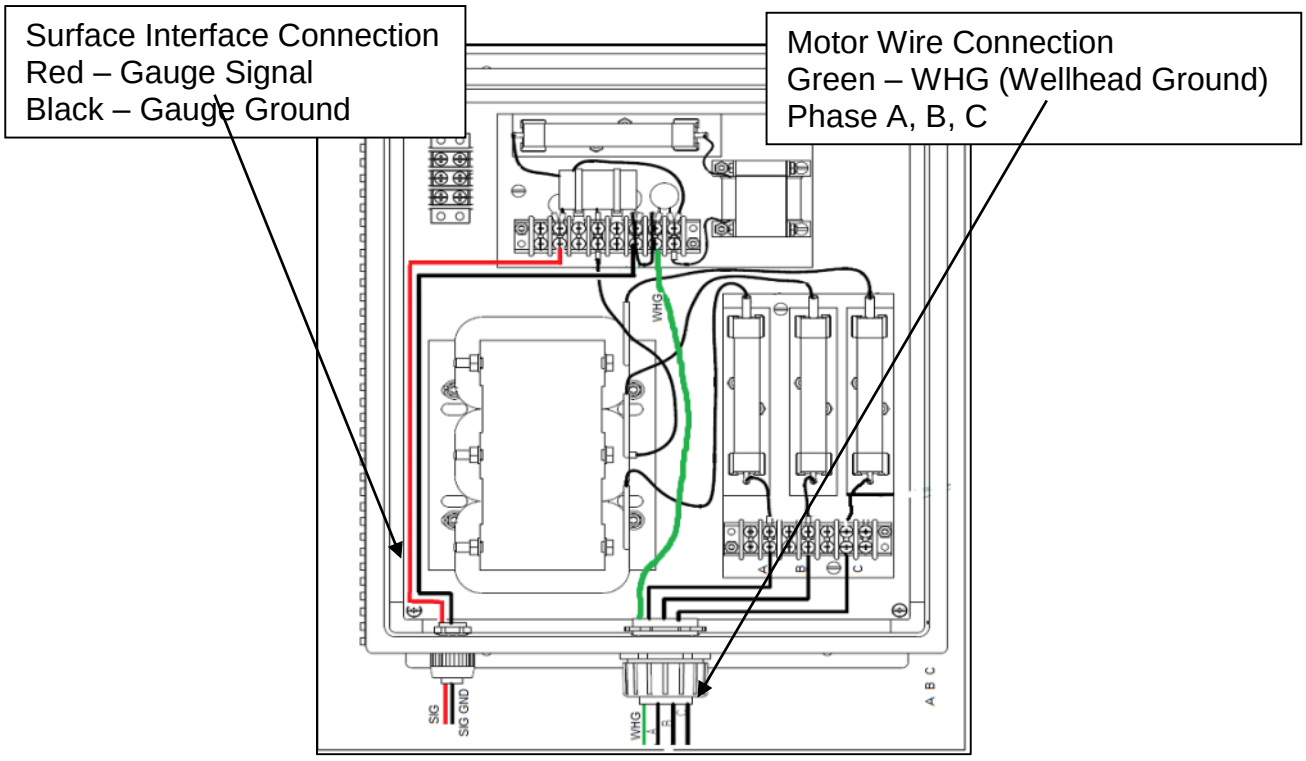


Figure 25: Surge Protector and Surface Choke Wiring Diagram

APPENDIX 1

TROUBLESHOOTING

Sensor to Surface Communication Troubleshooting

The definitive method for troubleshooting installation problems is to separate the downhole equipment from the surface equipment, including the junction box and surface cable.

Troubleshooting Steps

It is recommended to use a known functioning portable SCOUT unit for this exercise.

1. Record display screen information or error messages.
2. Insure all power going downhole is shutdown. **FAILURE TO DO THIS COULD RESULT IN INJURY, DEATH AND DAMAGE TO EQUIPMENT.**
3. Shut down power at the surface display so that no voltage is applied to the Surge Suppressor/Choke assembly.
4. Check to insure there is no voltage present at the Surge Suppressor/Choke assembly. Visually inspect for damage/discoloration of components and wiring. Then conduct individual resistance checks of the fuses, MOV and Surface Choke.
    a. All components should be isolated from the rest of the circuit while checking; this will prevent a false reading
    b. MOV should read infinite in both directions when checked with a multi-meter.
    c. Fuses should check less than 2 ohms except for the fuse in the Scout-3000, which will read approximately 12 ohms.
    d. Surface Choke should read approximately 260 ohms phase to phase and 130 ohms phase to neutral wire.
5. Allow for backspin of fluid before performing the following test. Depending on the type of wellhead penetration used, separate the downhole cable from the surface cable at the wellhead. If the downhole cable continues to the surface junction box (i.e. no cable termination at the wellhead) the test may be performed there. Disconnect the surface cable going from the junction box to the transformer in this case.
6. Perform phase to phase resistance checks of the cable and record the values.
7. Attach the positive lead of the portable surface display to one of the three phases and the negative lead to a good clean wellhead ground.
8. Power the portable surface display on and allow the system to boot up and to go through the analyzing process. If the system does not complete the analyzing steps, record the errors shown and compare it to the Scout-3000 Error Chart shown in the Scout-3000 manual (Sercel-GRC PN: 006-0191-00).
9. If errors are being seen, one corrective measure to try is to change the Line Voltage value, to both a lower and higher value by putting the SCOUT in Manual Mode. This is shown in the section “SCOUT-3000 Operation Settings”

APPENDIX 2

SCOUT and SPS Error Codes and Corrective Actions

The Surface Interface may experience communication problems due to noisy environments, grounding problems, or installation issues. The LCD on the SPS-1500 will display error codes depending on the failure it is detecting. Below is a list of common error codes and possible solutions to assist with troubleshooting the SPS-1500. To change the settings recommended you will need to use Sercel DataWorks software.

Note: During normal start-up communications with the tool you will see error messages such as “High Amp”, “Low Amp”, “DC-DC Bad”, “DC-DC Chk”, “Analyze 1” through “Analyze 16” as well as other normal messages that are all part of acquiring the tool. After the SPS analyzes the line current from the tool you will see the message “SPS Power OFF” a couple of times. Then the SPS will show 2 or 3 phase Sync cycles and then begin to read gauge header data. This is all part of normal operations of the SPS-1500. There is only a concern when an error message is repeated multiple times and communications is not established with the gauge after five minutes.

Note: The Troubleshooting Steps represent individual actions in the sequence they should be tried. If the first one doesn’t work, try the next one.

Table 2: Surface Interface Troubleshooting

Error	Possible Cause	Troubleshooting Step
DC-DC Bad or DC-DC Chk - *(Voltage measured by SPS is not matching what is sourced by SPS.)*	• Bad Ground Connection • Low Resistance from Gauge Signal to Ground • Excessive Gauge signal line current • Faulty SPS	• Check Downhole readings (Phase-Phase & Phase-Ground (Reverse Polarity Megger)) • Try alternate SPS power supply • Use voltmeter to confirm voltage MAX Voltage is over 45VDC.
Baud Fast – *(Gauge Data is changing at a Rate higher than expected)*	• Set voltage is too high • Motor noise affecting gauge current modulation	• Disable Auto Baud and raise Max Tool Baud to 8-10 • Reboot or cycle power to restart analyzing stage • Disable Auto Volt/ Auto Analyze with DataWorks. Set voltage to ~60VDC.
Low Amps – *(Gauge current is lower than expected)*	• Disconnected from tool • High resistance connection at motor WYE point to gauge • Blown Signal fuse • Low amp setting set to high	• Check Downhole readings (Phase-Phase & Phase-Ground (Reverse Polarity Megger)) • Check all connection(s) • Check Signal fuse • Check Setting of Low amp with DataWorks (15VDC Nominal) • Check Setting of High amp with DataWorks (25VDC Nominal)

High Amps – *(Gauge current is higher than expected)*	• Poor Wellhead grounding • Excessive Gauge Signal Line Current or injection of noise from motor at wye point.	• Connect to the SPS with “DataWorks” software to manually set the following current settings for the gauge: • - Check Setting of Low amp (15mA normally for SPS-1500 and 2-8mA normally for SPS-1501) • - Check Setting of High amp (25mA normally for SPS-1500 and 22-26mA normally for SPS-1501) • Verify Downhole readings (Phase to Phase, Phase-Ground (Reverse Polarity Megger)) • Replace the SPS-1500/SPS-1501
Analyzing – (SPS is adjusting output voltage to analyze gauge signal)	• **Normal Operation message** unless message is continuous or repeating over 5 minutes.	• If message is continuous or repeats over 5 minutes: ○ Check all wire connections ○ Check Phase to Phase and Phase-Ground connection (Reverse Polarity Megger) (Applies to SPS-1500 only) ○ Check Signal fuse ○ Adjust Set voltage (Approx. 60+/- for 1500 and Approx. 40+/- for the SPS-1501). This can be done using “DataWorks” software.
No Tool – (No Tool indicates there is no gauge current)	• Blown SPS Fuse • Blown Surge Protector Fuse/MOV • Bad SPS to Gauge Signal wire connection • No-Tool Current setting incorrect in SPS	• Read the DC current drawn by the gauge with an ammeter in series and DC mode. DC current is normally 15-30mA. • Check all fuses and surface connections. • If connections and equipment okay error may indicate possible downhole connection is open. • Using “DataWorks”, verify “No Tool Amp” value is set to 5.3mA (default value).
Line Noisy – (SPS is unable to measure current modulation from gauge)	• Motor WYE phase imbalance voltage is high	• Check all fuses and surface connections. • If connections and equipment okay error may indicate possible downhole problem. • Check line voltage at wye point on surge protector for motor noise injection.
No Signal – (SPS measures gauge current but no modulation current)	• Possible SPS/gauge firmware corruption • Possible SPS/gauge component failure • No-Tool Current setting incorrect in SPS	• Use DC Ammeter to measure DC current from SPS to gauge. Gauge current is normally modulated from approximately 15mA to 25mA. If not modulated, check SPS and connections.
OKAY	• **Normal Operation**, no errors	• SPS is communicating with the gauge

Note: Many communication problems with the Surface Interface can be solved with proper grounding techniques. A good ground must be established from the production tubing at wellhead back to the ground point at the surface package for proper operation.

APPENDIX 3

ESP Monitoring System Field Checklist

Initals	CALIBRATION BENCH CHECK	Pi	Pd	Ti	mT	Vx	Vy	Vz	W/C	Lv	LC	WYE	CUSTOMER	
	ESP SENSOR READING	0.1-40 psi	0.1-40 psi	Amb ±5°F	Amb ±5°F	0-1.5 g	0-1.5 g	0-1.5 g	255	20-80V	0-25mA	20-80V		
	SPY PRO SENSOR READING	5-25 psi	5-25 psi	Amb ±5°F	Amb ±5°F	0-1.5 g	0-1.5 g	0-1.5 g	4095	20-80V	0-25mA	20-80V	WELL OPERATOR	
	GAUGE MODEL	SN												
	3 PHASE SURFACE CHOKE	CONTINUITY BETWEEN 3 PHASES AND Y-POINT											WELL NAME	
		LINE 1-Y		LINE 2 -Y			LINE 3 - Y							
	TECHNICIAN	SIGNATURE			DATE								FIELD	
	SUPERVISOR	SIGNATURE			DATE									
													TVD	
													GAUGE DEPTH	
													SENSOR TYPE	
Initals	CK 1 - SCOUT TO MOTOR	Pi	Pd	Ti	mT	Vx	Vy	Vz	W/C	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CK 2 -SPOOL (MOTOR AT SURF)	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CK 3 - 10 STANDS IN HOLE	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CK 4 - 20 STANDS IN HOLE	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CK 5 - 30 STANDS IN HOLE	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CK 6 - 40 STANDS IN HOLE	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CH 7 - 60 STANDS IN HOLE	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CK 8 - 90 STANDS IN HOLE	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CK 9 - 100 STANDS IN HOLE	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME
	ESP SENSOR READING													
Initals	CK 10 - 120 STANDS IN HOLE	Pi	Pd	Ti	mT	Vx	Vy	Vz	CL	Lv	LC	WYE	DATE	TIME

I have witnessed the Field Service Representative, _____,
make all sensor checks and the ESP system is running to my satisfaction.

Client representative_____

APPENDIX 4

Surface Read Out Device Specifications

SPS-1500

The SPS-1500 includes a 2-Line Character LCD readout for display of real-time downhole data. A USB interface is also supplied for Modbus via USB monitoring of the downhole gauge. 24VDC is required to power the SPS-1500.
See ***APPENDIX 6*** **SPS-1500 Synchronization and Startup** for the complete SPS-1500 startup sequence.

Figure 26: SPS-1500

SPS-1500 Specifications:

- Small footprint DIN rail mount enclosure
- Enclosure size: 3-1/2” x 3-1/2” x 2-1/2”
- 2-Line LCD display with scrolling update of downhole sensor data
- 2 Multi-color displays for immediate communication and downhole tool status
- Single ESP gauge interface with field replaceable fuse.

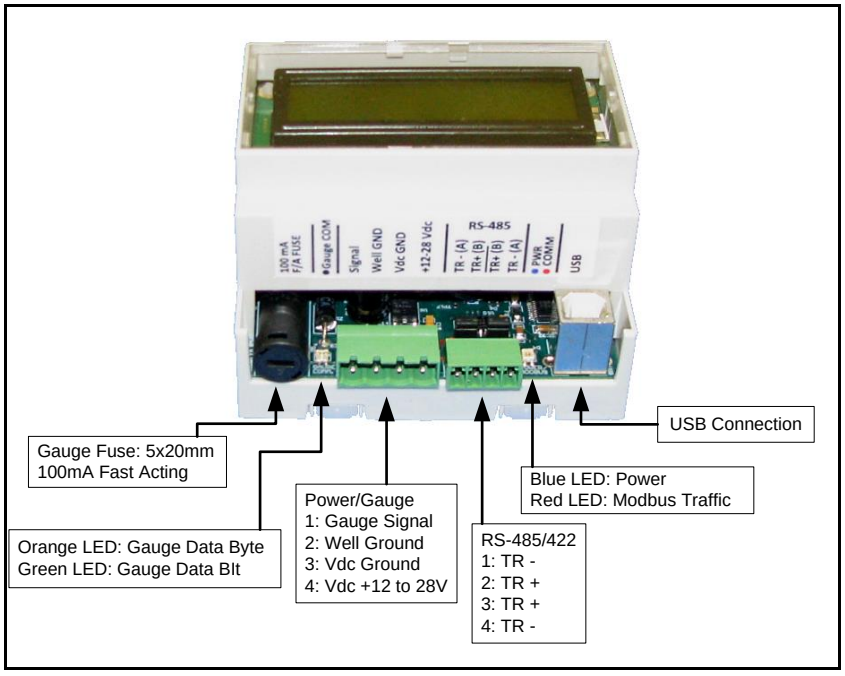


Figure 27: SPS-1500 Connections

Scout-3000

The SPS-3000 provides increased user interface with a graphical backlit color touch screen interface. All data may be viewed in addition to viewing graphical pressure and temperature trending data. Real-time graphical trending data may be viewed for periods of hours to 42 days.

Figure 28: Scout-3000

Scout-3000 Specifications

- NEMA 4X Enclosure with clear latching cover
- Single ESP gauge fused interface
- Removable 8G USB Memory Storage of well data
- Front Panel USB connection for PC monitoring and configuration
- Power Requirement:110-220 VAC or 12-24VDC
- Configurable via Touch Screen display
- Graphic Data trending display of Pressure and Temperature
- Operating Temperature: -10ºC to +70ºC

Data Pro

The Data Pro is a high-performance universal configurable surface readout. The Data Pro can operate as a simple independent RTU and/or support internal SPS-1500 or FIC-1500 gauge interfaces. The main features are data logging, real-time graphing, historical graphing, Modbus communication, and gauge configuration. The Data Pro can be powered by either an AC or DC power supply and is enclosed in an NEMA-4X rated non-conductive, rust-proof enclosure with a transparent window and side latches.

Figure 29: Data Pro Surface Interface Unit

Operating Temperature Range	**-20ºC to +60ºC**
DC Operating Voltage	**+12VDC (2.4A) to +24VDC (1.5A)** **Capable of handling 3A of inrush current on startup**
AC Operating Voltage	**100VAC Min (400mA) to 240VAC Max (200mA)** **50Hz – 60Hz** **NOTE: Primary current over protection must be supplied by user to limit current to 1A.**
Display	**7-inch Color LCD, resolution 840 x 480**
User Interface	**Touch-Screen LCD**
Enclosure Dimensions	**12” x 10” x 5”**
Enclosure Rating	**NEMA-4X**
Analog Inputs	**3 x 0-15VDC or 0-64mA 15-bit resolution**
Analog Outputs	**2 x 4-20mA 12-bit resolution**
Alarm/Relay Outputs	**2 x DPST dry contacts** **5A @ 250 VAC** **5A @ 30 VDC**
Modbus Ports	**1 x RS-485 (Non-Isolated)** **2 x RS-232 (Non-Isolated)** **1 x RS-485 or RS-232 (Isolated)**
USB Ports	**1**
Ethernet Ports	**2 (Modbus TCP/IP or SFTP)**
Storage Capacity	**5 GB Internal**

APPENDIX 5

ESP Sensors - Pass/Fail Criteria

All values must be taken at ambient conditions and the sensor allowed to stabilize if moved from a hot to cold or cold to hot environment for a period of one hour to confirm test validity.

Spy Pro			
No.	**Parameter**	**Minimum**	**Maximum**
1	Intake Pressure	5 psi	25 psi
2	*Discharge Pressure	5 psi	25 psi
3	Intake Temperature	Ambient Temp - 5°F	Ambient Temp + 5°F
4	Motor Temperature	Ambient Temp - 5°F	Ambient Temp + 5°F
5	**Vibration X	0 g	1.5 g
6	**Vibration Y	0 g	1.5 g
7	Vibration Z	0 g	1.5g
8	Water Cut	2500KΩ	4095KΩ
9	Line Voltage	20 V	80 V
11	Leakage Current	0 mA	25 mA
12	Wye Voltage	20 V	80 V

*Spy Pro 9 and 11 only
**While rotating the gauge, Vibration X and Y should vary from 0 g to 1.5 g.

ESP-2500 / 3500			
No.	**Parameter**	**Minimum**	**Maximum**
1	Intake Pressure	0.1 psi	40 psi
2	*Discharge Pressure	0.1 psi	40 psi
3	Intake Temperature	Ambient Temp - 5°F	Ambient Temp + 5°F
4	Motor Temperature	Ambient Temp - 5°F	Ambient Temp + 5°F
5	**Vibration X	0 g	1.5 g
6	**Vibration Y	0 g	1.5 g
7	Water Cut	250	260
8	Line Voltage	20 V	80 V
10	Leakage Current	0 mA	25 mA

*ESP-3500 only
**While rotating the gauge, Vibration X and Y should vary from 0 g to 1.5 g.

All values must be taken at ambient conditions and the sensor allowed to stabilize if moved from a hot to cold or cold to hot environment for a period of one hour to confirm test validity.

ESP-1500			
No.	**Parameter**	**Minimum**	**Maximum**
1	Intake Pressure	0.1 psi	40 psi
2	Discharge Pressure	NA	NA
3	Intake Temperature	Ambient Temp - 5°F	Ambient Temp + 5°F
4	Motor Temperature	Ambient Temp - 5°F	Ambient Temp + 5°F
5	*Vibration X	0 g	1.5 g
6	*Vibration Y	0 g	1.5 g
7	Water Cut	250	260
8	Line Voltage	20V	80V
10	Leakage Current	0 mA	25 mA

*While rotating the gauge, Vibration X and Y should vary from 0 g to 1.5 g.

ESP Sensors – Simpson Test Pass/Fail Criteria

All values in the table below are based on ambient conditions (70F, 14.7psia) using a Simpson 260 9V and Simpson 260 15V. The testing equipment should be checked periodically to ensure the battery for the resistance test is at full capacity. If the sensor is above or below ambient conditions for storage such as being kept outside in the winter or summer, then the sensor must be allowed to stabilize at room temperature (70F) for a period of one hour in order for the test measurement to be accurate.

Below are bench test values and are only valid when testing the sensor before it is connected to the motor.

Simpson 260	**ESP-1500**	**ESP-2500/3500**	**Spy Pro**
9V	≥150KΩ	≥150KΩ	≥1MΩ
15V	≥1.5KΩ	≥2KΩ	≥10KΩ

ESP Sensors – Megger Test Pass/Fail Criteria

All values in the table below are based on ambient conditions (70F, 14.7psia) using a FLUKE-1550C. The testing equipment should be checked periodically to ensure the battery for the resistance test is at full capacity. If the sensor is above or below ambient conditions for storage such as being kept outside in the winter or summer, then the sensor must be allowed to stabilize at room temperature (70F) for a period of one hour in order for the test measurement to be accurate.

Below are bench test values recorded for 30 second duration and are only valid when testing the sensor before it is connected to the motor.

Reverse Voltage	ESP-1500	ESP-2500/3500	Spy Pro
1000V	≥1GΩ	≥1GΩ	≥1GΩ
2500V	≥2.5GΩ	≥2.5GΩ	≥2.5GΩ
5000V	≥5GΩ	≥5GΩ	≥5GΩ

APPENDIX 6 SPS-1500 Synchronization and Startup

During the initial startup, the SPS tries to acquire the ESP gauge by performing a series of synchronization and analyzing steps. Below is typically what is displayed on the LCD screen, leaving out additional messages.

The additional messages could contain any of the following text: “Okay”, “High Amp”, “Low Amp”, and “DC to DC Bad”. These message indicate the SPS is making adjustments to best set up the gauge for communication, such as compensating for cable length or the data rate. These messages are normal.

Power On-Display:

GRC SPS-1500 Firmware Revision & Revision Date	
SPS Baudrate: 9600 Slave ID: 1	
Stat: Power Off	
Stat: SyncPhs 1	
Stat: SyncPhs 3	
Stat: Analyze 1	
Stat: Analyze 2	
Stat: Analyze 3	
Stat: Analyze 4	
Stat: Analyze 5	
Stat: Analyze 6	
Stat: Analyze 7	
Stat: Analyze 8	
Stat: Analyze 9	
Stat: Analyze 10	
Stat: Power Off Err: Analyzing	This step could occur in various places during the set up.
Stat: Analyze 11	
Stat: Analyze 12	
Stat: Analyze 13	
Stat: Analyze 14	
Stat: Analyze 15	
Stat: Analyze 16	
Stat: Power Off	
Stat: SyncPhs 3	
Stat: SyncPhs 4	
Stat: SyncPhs 5 Okay	Counts down from 15 to 0
Checking Tool…	
Checking Tool… Improved-ESP	
Stat: Checking T Okay	
Rcv Hdr 0 Okay	Counts down from 16 to 0
Sensor Serial Number ISP+/ESP+ Okay	Counts down from 26 to 0

These steps might take anywhere from 2 to 5 minutes to complete. If data is not received after 5 minutes, proceed to the troubleshooting section of this manual.

Note: During normal start-up and synchronization with the sensor you will see “Analyze 1” through “Analyze 16”. You may see messages of “High Amp”, “Low Amp”, “DC to DC Bad”, as well as other normal messages that are all part of acquiring the tool. During the Analyzing steps, you will see “SPS Power Off” “Err: Analyzing” two times and then additional sync phase packets. After the SPS-1500 analyzes the line current from the sensor, it will check for Enhanced Communication capability and begin to receive header data from the tool. This is all part of normal operation of the SPS-1500.

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Sercel - GRC CORP
13914 E. Admiral Place, Ste. B
Tulsa, Oklahoma 74116-2107/ USA
Telephone : (1) 918 834 9600
Fax : (1) 918 838 8846
E-mail : sales@sercel-grc.com

www.sercel-grc.com

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