



# **CE Compliant Mega Truck Probe**

## **Installation and Operation Manual**

**PNEG-2125CE**

Version: 2.0

Date: 10-28-21



**INTERSYSTEMS**



PNEG-2125CE



**CE Declaration of Compliance  
EC MACHINERY DIRECTIVE  
2006/42/EC**

1004 East Illinois Street, Assumption, IL, 62510, USA

+1 217 226 4429

**The GSI Group declares** that the machine, parts or equipment

**Mega Truck Probe**

Models

- MTP-CE

Meet the Essential Requirements of the Machinery Directive 2006/42/EC:

**Harmonised standards applied:**

- EN ISO 4413:2010 - Hydraulic Fluid Power - General rules and safety requirements for systems and their components.
- EN 60204:2018 - Safety of Machinery - Electrical equipment of machines.
- EN ISO 14121-1:2010 - Safety of Machinery - Risk assessment

This declaration applies only to the above machines, and does not imply conformity by any other items of equipment fitted to or connected with the above machines

The equipment above must not be put into service until the machinery into which it is to be incorporated has been declared in conformity with the provisions of all relevant Directives, nor until these components have been assembled in the manner recommended in the manufacturer's instructions.

Signed:

Name:

Date:

**All information, illustrations, photos and specifications in this manual are based on the latest information available at the time of publication. The right is reserved to make changes at any time without notice.**

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## 1. Introduction

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This manual covers the installation and operation for the Mega Truck Probe. This manual provides guidelines for installing the product. You must retain a qualified contractor to provide on-site expertise. INTERSYSTEMS IS NOT RESPONSIBLE FOR THE INSTALLATION OF THIS PRODUCT.

InterSystems reserves the right to improve its product whenever possible and practical to do so. We reserve the right to change, improve and modify products at any time without obligation to make changes, improvements and modifications on equipment sold previously.

### General Safety Statements

1. The Truck Probe is designed and manufactured with operator safety in mind. However, residual hazards remain due to the nature of material handling and specific material hazards. Use extreme caution at all times.
2. Modifications to equipment may cause extremely dangerous situations that could result in damage to the equipment as well as serious injury or death. Never modify the equipment.
3. InterSystems recommends that you contact the local power company to have a representative survey the installation to ensure wiring is compatible with their system and adequate power is supplied to the unit.

### Replacement Parts

The InterSystems, Inc. Truck Probe is a quality built piece of machinery. As with any machine, parts do wear out and fail. It is InterSystems' recommendation that a small supply of spare parts be kept on hand to cover any minor breakdowns. A separate priced Spare Parts List will be sent identifying the suggested spare parts. It is also necessary to check the certified drawings, which will list any special or custom components utilized on this equipment.

The certified drawings list the non-standard components that have been incorporated into the equipment. InterSystems, Inc. normally stocks non-fabricated parts and non-custom OEM parts. Replacement parts for any other components, including fabricated parts and custom OEM components can be supplied upon request.

For direct parts orders or requests for technical assistance to your sales representative or to:

#### **InterSystems**

1004 E. Illinois St.  
Assumption, IL 62510-0020  
Phone: 1-217-226-4421  
Fax: 1-217-226-4420

Please have available the MODEL NUMBER, SERIAL NUMBER and CUSTOMER ORDER NUMBER of the equipment in question as well as the location where the Truck Probe is INSTALLED.

## Repair Kits

The following chart lists repair kits and parts that are available from InterSystems. These kits are offered as a more economical solution by rebuilding the defective part rather than replacing it. However in some cases the part may be beyond repair and replacement will be necessary.

Product Code	Description
522387	Gear Pump Seal Kit (Parker H series)
512853	Actuator Repair Kit (Parker LTR series)
512524	Valve Seal Kit (Parker)
XW4923	1-1/2" Bore Hydraulic Cylinder O-Ring Repair Kit (Columbus LD series)
XW6651	3-1/2" Bore Hydraulic Cylinder O-Ring Repair Kit (Columbus HD series)
35691	Oil Filter Cartridge
552917	IS Blue All Season Hydraulic Oil - 5 Gallon Pail
26498	Lamp 120 VAC (GE #120PSB)

### Safety Guidelines

Safety guidelines are general-to-specific safety rules that must be followed at all times. This manual is written to help you understand safe operating procedures and problems that can be encountered by the operator and other personnel when using this equipment. Read and save these instructions.

As owner or operator, you are responsible for understanding the requirements, hazards, and precautions that exist and to inform others as required. Unqualified persons must stay out of the work area at all times.

Alterations must not be made to the equipment. Alterations can produce dangerous situations resulting in **SERIOUS INJURY or DEATH**.

This equipment must be installed in accordance with the current installation codes and applicable regulations, which must be carefully followed in all cases. Authorities having jurisdiction must be consulted before installations are made.

When necessary, you must consider the installation location relative to electrical, fuel and water utilities.

Personnel operating or working around equipment must read this manual. This manual must be delivered with equipment to its owner. Failure to read this manual and its safety instructions is a misuse of the equipment.

**ST-0001-4**

## Cautionary Symbol Definitions

Cautionary symbols appear in this manual and on product decals. The symbols alert the user of potential safety hazards, prohibited activities and mandatory actions. To help you recognize this information, we use the symbols that are defined below.



This symbol indicates an imminently hazardous situation which, if not avoided, **will result in serious injury or death.**



This symbol indicates a potentially hazardous situation which, if not avoided, **can result in serious injury or death.**



This symbol indicates a potentially hazardous situation which, if not avoided, **can result in minor or moderate injury.**



This symbol is used to address practices not related to personal injury.



This symbol indicates a general hazard.



This symbol indicates a prohibited activity.



This symbol indicates a mandatory action.

ST-0005-2

### Safety Cautions

#### Use Personal Protective Equipment

- Use appropriate personal protective equipment:

**Eye Protection**



**Respiratory Protection**



**Foot Protection**



**Hearing Protection**



**Head Protection**



**Fall Protection**



**Hand Protection**



- Wear clothing appropriate to the job.
- Remove all jewelry.
- Tie long hair up and back.

ST-0004-1

#### Follow Safety Instructions

- Carefully read all safety messages in this manual and safety signs on your machine. Keep signs in good condition. Replace missing or damaged safety signs. Be sure new equipment components and repair parts include the current safety signs. Replacement safety signs are available from the manufacturer.
- Learn how to operate the machine and how to use controls properly. Do not let anyone operate without instruction.
- If you do not understand any part of this manual or need assistance, contact your dealer.



ST-0002-1



### Maintain Equipment and Work Area

- Understand service procedures before doing work. Keep area clean and dry.
- Never service equipment while it is operating. Keep hands, feet, and clothing away from moving parts.
- Keep your equipment in proper working condition. Replace worn or broken parts immediately.



ST-0003-1

### Stay Clear of Hoisted Equipment

- Always use proper lifting or hoisting equipment when assembling or disassembling equipment.
- Do not walk or stand under hoisted equipment.
- Always use sturdy and stable supports when needed for installation. Not following these safety precautions creates the risk of falling equipment, which could crush personnel and cause serious injury or death.



ST-0047-1

### Sharp Edge Hazard

- This product has sharp edges, which can cause serious injury.
- To avoid injury, handle sharp edges with caution and always use proper protective clothing and equipment.



ST-0036-2

### Install and Operate Electrical Equipment Properly

- Electrical controls must be installed by a qualified electrician and must meet the standards set by applicable local codes (National Electrical Code for the US, Canadian Electric Code, or EN60204 along with applicable European Directives for Europe).
- Lock-out power source before making adjustments, cleaning, or maintaining equipment.
- Make sure all equipment is properly grounded.



ST-0027-4

## 2. Safety

## Stay Clear of Moving Parts

- Stay clear - machine can start without warning.
- Entanglement in gate will cause serious injury.
- Keep all shields and covers in place at all times.
- Lock-out power source before making adjustments, cleaning, or maintaining equipment.



**ST-0070-1**

# Safety Sign-Off Sheet

Below is a sign-off sheet that can be used to verify that all personnel have read and understood the safety instructions. This sign-off sheet is provided for your convenience and personal record keeping.

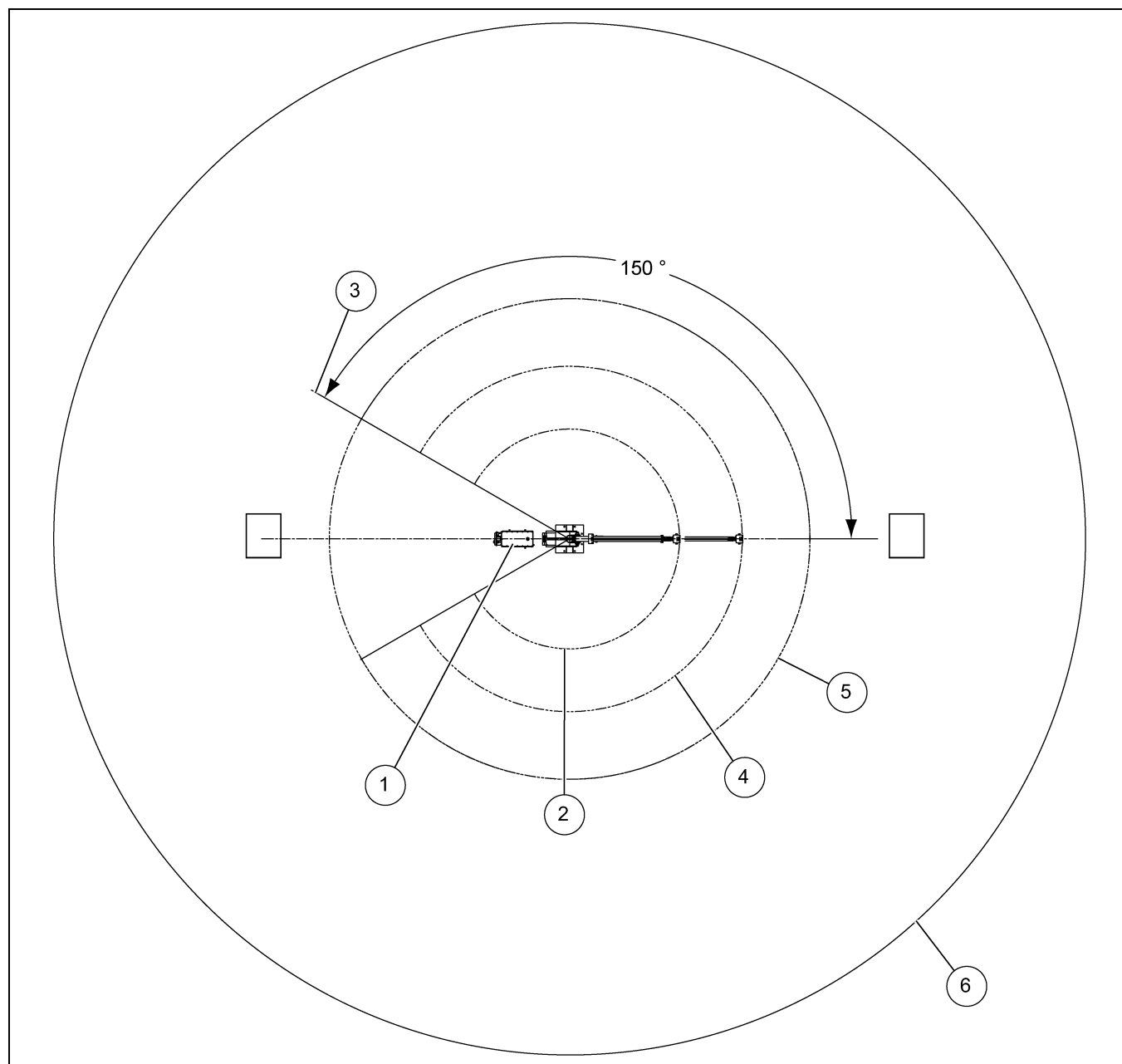
[illegible]

**ST-0007**

## Safety Installation

### Location

1. Truck probes should not be installed in close proximity to overhead electrical power lines.
  - a. Contact between the probe assembly and electrical power lines can cause fatalities.
  - b. Electrical current in conductive parts of the truck probe due to electromagnetic induction can cause electric shock.
  - c. No part of the truck probe should be any closer than 10 m horizontal distance to a overhead power line. In determining this distance, take into account the position of the probe tip or boom when fully extended. If in doubt, consult your local power company for advice.
  - d. Every conductive part of the truck probe must be directly connected to earth (ground) via a low impedance earth conductor. Do not rely on sliding or rotating contact such as pivots or hinges.
2. The operator position must be selected to afford the operator unimpeded vision of the working area, including:
  - a. Every moving part of the truck probe.
  - b. Visual contact with truck drivers.
  - c. Visibility of all other personnel working in the area.
  - d. Before operating the truck probe, the operator must be certain there is no one in the working area.
  - e. Adequate lighting so that visibility is not impaired at night or in reduced daylight.
3. A safety exclusion zone should be defined and clearly marked out warning all personnel to keep clear of moving parts of the truck probe.
4. Truck probes shall not be installed in locations where there is risk of explosion (HAZARDOUS/HAZLOC/ATEX designated location). If such installation is required an ATEX compliant version should be requested. The same condition applies to electrical controls and vacuum motors.
5. In locations where risk of oil spillage must be controlled (control of oil pollution), the truck probe should be installed within a bunded area, with a minimum 0.25 m<sup>3</sup> liquid holding capacity, such that, in the event of total loss of hydraulic fluid, all fluid can be retained and safely disposed of.
6. If risk of food/feed/material contamination from hydraulic oil is a concern, the standard truck probe should not be used. Seek advice from InterSystems/GSI on suitable “food grade” options.
7. The truck probe should be placed where it cannot be prone to damage from moving vehicles or other buildings, structures, plant and equipment. In particular care should be taken to avoid possible damage to high pressure hydraulic lines. Where necessary, suitably robust barriers should be erected to protect the truck probe.



**Figure 2A** *Mega Probe Minimum Safety Zones*

Ref #	Description
1	MTP Truck Probe
2	R3.2 m Boom Fully Retracted
3	Extent of Rotation

Ref #	Description
4	R5.0 m Boom Fully Extended
5	R7.0 m Minimum Personnel Safety Distance
6	R15.0 m Minimum Power Line Safety Distance

## Dust

As a side effect of the sampling process, dust may be liberated in the control room. Where this could result in a risk to health, a suitable designed extraction system should be installed, to safely remove any airborne dust.

## Electrical Safety

Equipment shall include:

1. Fuse protected main power supply.
  - a. The electrical supply should include earth leakage protection, e.g. Residual Current Device (RCD) or Residual Current Circuit Breaker (RCCB), to provide automatic disconnection in the event of a fault.



2. Lockable main safety disconnect.

- a. Disconnects all electrical power.

3. Lockable motor service disconnect.



- a. Adjacent to each motor (or group of motors).
  - b. Disconnects all power to the motors.

4. Emergency stops.



- a. Stops all equipment immediately when pressed.
  - b. Must remain engaged until manually disengaged.
  - c. Equipment shall not immediately re-start when the emergency stop is re-set.

5. Door safety interlocks - where doors provide access to dangerous machinery.



- a. Immediately stops and prevents re-start of all equipment when the door is open.
  - b. Equipment shall not immediately re-start when the door is closed.
  - c. Safety switches shall be SIL3 in accordance with IEC62061:2005.

6. Safety circuits should be minimum PL“c” in accordance with ISO 13849-1:2006.

7. The electrical supply must include a properly designed protective earth system (PE), with connection to all exposed conductive parts.



8. All motors shall be connected to protective earth at the terminal provided.

9. The control system shall include.

- a. Short circuit protection.



10. Equipment shall not immediately re-start following re-establishment of power.

11. All electrical design, installation and testing must be carried out by a qualified electrical engineer, in accordance with EU Directives and Standards, local laws and codes.

### Correct Use of the Truck Probe

The truck probes may be used only for sampling agricultural grain, seeds, pellets, chips, and other flowable, non-volatile, granular agricultural materials from trucks or trailers. It shall not be used for sampling any other materials including:

1. Powders
2. Fertilisers
3. Liquids
4. Gases, mists or vapours
5. Sludges or slurries
6. Manures
7. Sand
8. Stone
9. Chemicals
10. Other non-flowing materials

Use the truck probe safely and only when fit, competent and trained to do so.

1. Never use the truck sampler as a crane, hoist, winch or any other lifting equipment.
2. Never manually operate any part of the truck probe. The only correct operating position is at the control console.
3. Never operate the truck probe when anyone is in the safety exclusion zone. Truck drivers who have to uncover the load for sampling must retreat outside the exclusion zone or back to the cab of their truck.
4. Never allow anyone to manually handle or direct the truck probe.
5. Never override or bypass any safety features.
6. Never operate the truck probe with any guards removed or damaged.
7. Never operate a damaged truck probe. In particular:
  - a. Damaged hydraulic line or hoses.
  - b. Damaged electrical conductors and control equipment.
  - c. Mechanical damage which could reduce structural stability or result in falling or ejected parts.
8. Never allow a truck or trailer to move unless the sampler is completely clear of it.
9. Never attempt to take samples from hand held sacks, boxes, carts or tubs.
10. Never leave the truck probe running (hydraulic/electrical power ON) whilst unattended. Always switch OFF and lock out the power.

## Maintenance

### Dealing with a Blockage

The sampler system is designed to minimise the risk of blockage. This can be helped during installation by minimising sharp bends in the sampler line and ensuring connections in the line are smooth. In the event that the sampler does become blocked, the following procedure should be followed to clear it:

1. Lift the sampler probe out of any load that is being sampled.
2. Briefly run the sampler vacuum motor system to attempt to relieve the blockage.
3. Do not stop and start the motor excessively. This could result on motor damage.
4. If the blockage persists lower the boom to its lowest point.
5. Fully retract the boom.
6. Turn OFF the hydraulic pump.
7. Cycle sampler valves.
8. Disconnect the probe from all electrical power at the main disconnect switch and lock out to prevent any accidental starting.
9. Insert the probe stop block into the probe to prevent risk of the probe closing whilst being worked on.
10. Check the sampler probe for blockage. Tap it lightly with a soft mallet to attempt to dislodge any blockage. Take care not to damage or distort the sampler tubes.
11. Separate the sampler line at any joins.
12. Run a cable fishing line/draw tape up the sampler line to dislodge any blockage.
13. Remake all connections.
14. With all personnel clear of the truck probe, re-connect the power and attempt to run the vacuum motor.
15. If the system suffers repeated blockages, check for impediments in the sampler line.

### Hydraulic Fluid Spillage

1. Any leak or spillage of hydraulic fluid should be cleaned up immediately to reduce the risk of a hazardous, slippery surface and local water pollution.
2. Leaks should be detected and repaired immediately.
3. Apply absorbent material over any spillage; remove once fluid has been absorbed; wash surface with suitable detergent.

### Hydraulic System

Extreme care needs to be taken when working on or near high pressure hydraulics. High pressure fluid and cause serious injury and death. Only carry out work on the system if you are competent, fit and trained to do so.

1. Wherever possible, work on the system only when it is isolated from all power and de-pressurised.
2. Always wear hand, eye, body and face protection.
3. When first commissioning the system, or following replacement of a component, air may need to be bled from the system.
4. Even when powered OFF, the hydraulic system may retain stored pressure. When working on or around the probe, follow this procedure:
  - a. Lower the boom to its lowest point.
  - b. Fully retract the boom.
  - c. Shut off the hydraulic pump.
  - d. Keep the operators control powered.
  - e. Cycle the sampler valves.
  - f. Shut off and lock the main power disconnect.
  - g. Insert the probe stop block into the probe to prevent any unintended movement.
  - h. Keep the key in your possession only.



The safety decals on your equipment are safety indicators which must be carefully read and understood by all personnel involved in the installation, operation, service and maintenance of the equipment. To replace a damaged or missing decal, contact us to receive a free replacement.

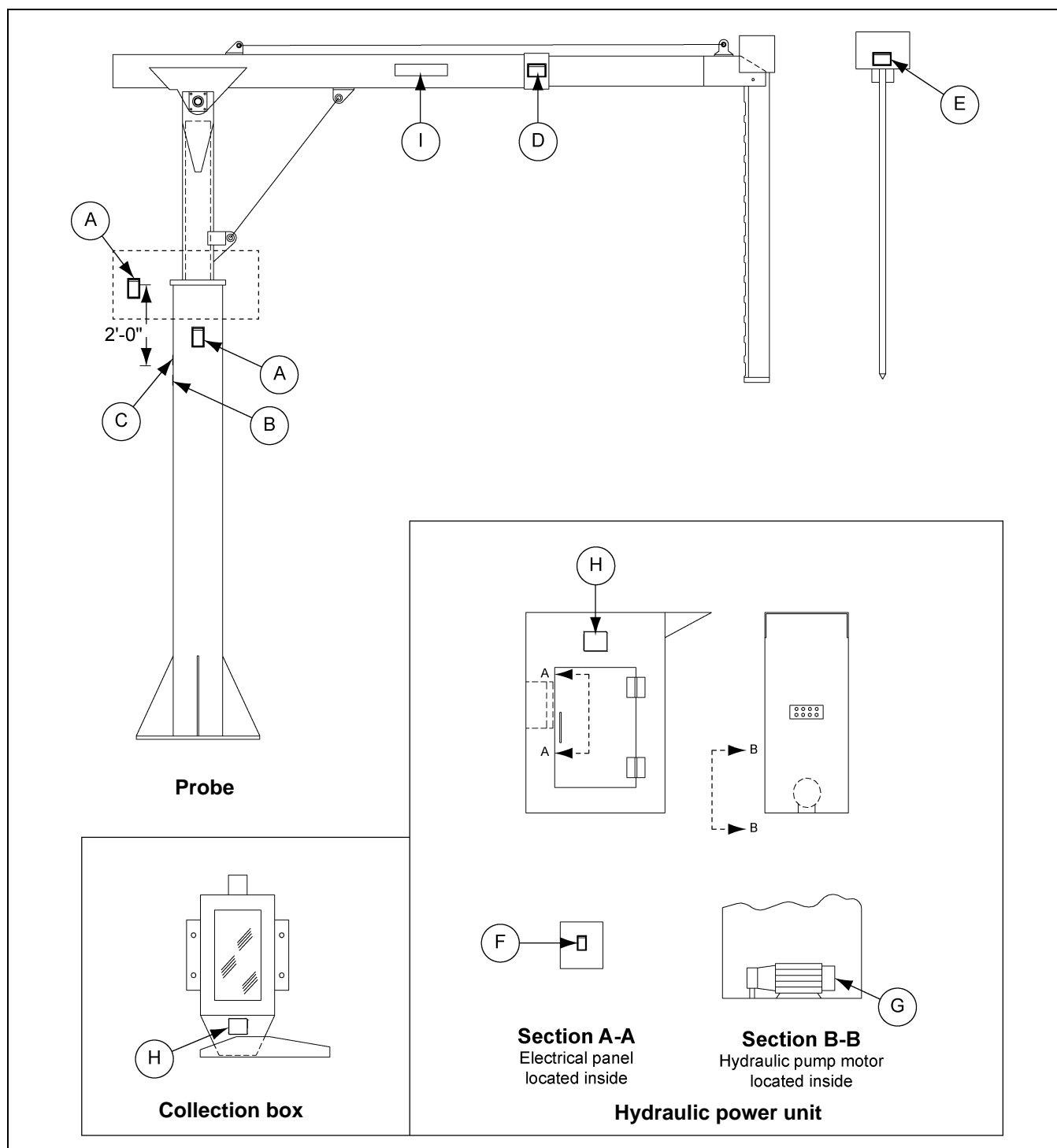
#### InterSystems

1004 E. Illinois St.

Assumption, IL 62510-0020

Phone: 1-217-226-4421

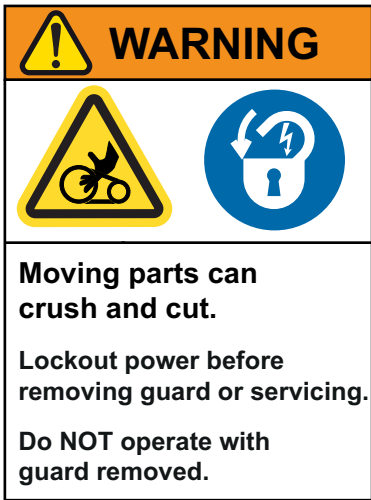

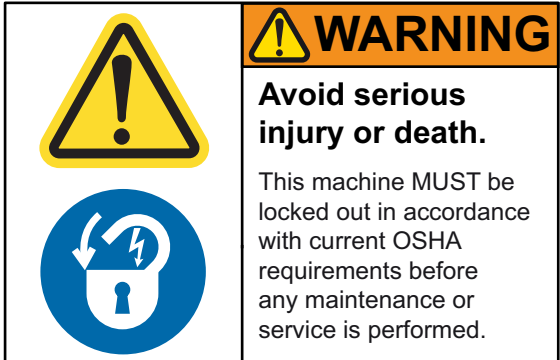
Fax: 1-217-226-4420



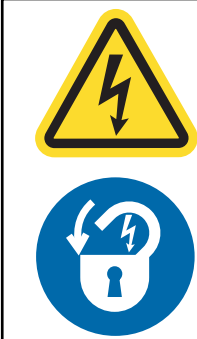



**Figure 3A MTP Truck Probe Safety Decals Locations**



### 3. Decals

**NOTE:** These signs must never be removed, tampered with, painted over, or obscured in anyway. If labels are damaged or became unreadable, replacement labels are available from InterSystems.

Ref #	Decal #	Decals	Description
A	EMC 24 J3	 <p>©Clarion clarionsafety.com Reorder No. EMC 24 J3</p>	Exposed Belt/Chain
B	EMC 403 34	 <p>©Clarion clarionsafety.com Reorder No. EMC 403 34</p>	Stay Clear
C	EMC 402 34	 <p>© Clarion Clarionsafety.com Reorder No. EMC 402 34</p>	Lock Out Machine

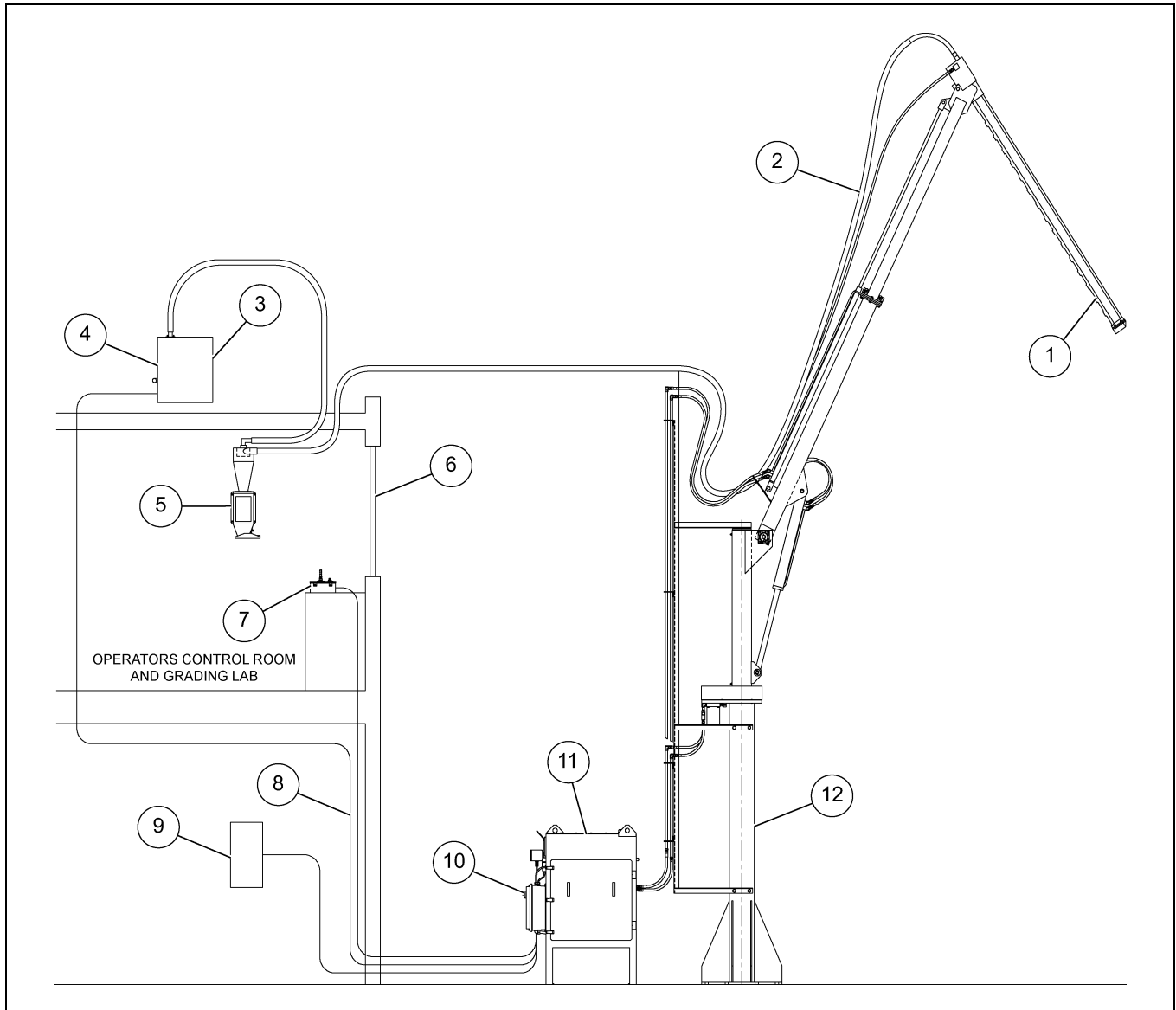
Ref #	Decal #	Decals	Description
D	EMC 30 J3	 <p><b>! WARNING</b></p> <p>Moving parts can cut and crush.</p> <p>Lockout energy source before inspection or service.</p> <p><small>© Clarion    Clarionsafety.com    Reorder No. EMC 25 J3</small></p>	Moving Parts
E	EMC 25 J3	 <p><b>! WARNING</b></p> <p>Rotating parts can crush, cut and entangle.</p> <p>Do NOT operate with guard removed.</p> <p>Lockout power before removing guard or servicing.</p> <p><small>© Clarion    Clarionsafety.com    Reorder No. EMC 25 J3</small></p>	Rotating Parts
F	EMC 11 34	 <p><b>! DANGER</b></p> <p>Hazardous voltage will cause severe injury or death.</p> <p>Turn off power and lock out before servicing.</p> <p><small>© Clarion    Clarionsafety.com    Reorder No. EMC 11 34</small></p>	High Voltage
G	IS 573X1	 <p><b>ROTATION</b></p> <p><small>IS573X1</small></p>	Rotation

3. Decals

Ref #	Decal #	Decals	Description
H	DC-2553		InterSystems Logo
I	DC-2554		InterSystems Strip

## System Description

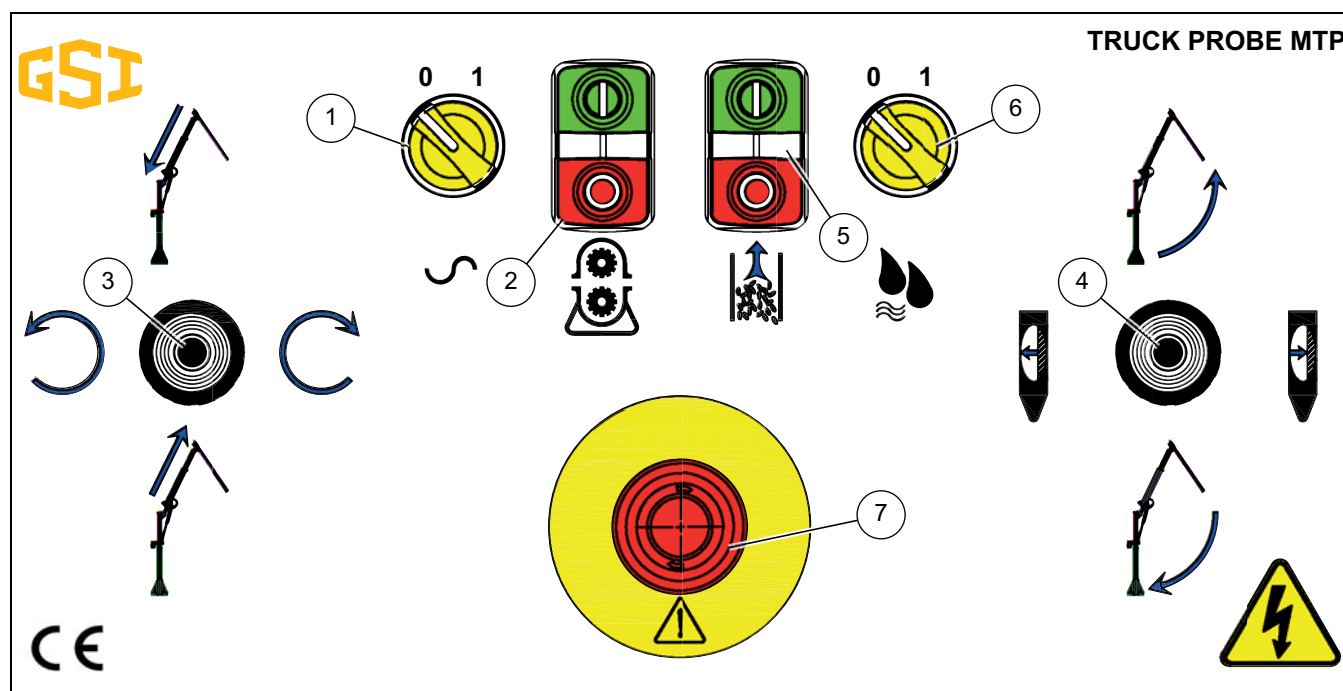
The MTP Truck Probe is designed to collect a representative sample of grain from an open top hopper truck. [Figure 4A](#) illustrates a typical MTP Truck Probe application.



**Figure 4A** Typical Installation of Mega Truck Probe System

Ref #	Description
1	2.7 m (9') Probe Tip (Compartmentalized)
2	0.038 m (1-1/2") I.D. Sample Vacuum Line
3	Dual Vacuum Motor Power Unit
4	Vacuum Exhaust
5	Sample Collection Cabinet
6	Window

Ref #	Description
7	Operators Control Panel
8	Electrical Conduits
9	Circuit Breaker Panel
10	Disconnect Panel
11	7.5 HP Hydraulic Power Unit
12	Probe Stand and Base



**Figure 4B** Operator Control Console Legend

Ref#	Description
1	Control Power ON/OFF
2	Hydraulic Pump Start/Stop
3	Boom Out/In/Left/Right Joy-Stick
4	Boom Up/Down and Sample Open/Close Joy-Stick

Ref#	Description
5	Vacuum Motor Start/stop
6	Hydraulic Oil Heater ON/OFF
7	Emergency Stop

## Sample Collection

In general, sample collection proceeds as follows.

1. Switch ON the control power (1).
2. Start the hydraulic pump (2).
3. Position the probe tip in the first sample position in the truck using the joy-stick controls (3 and 4).
4. Start the vacuum motors (5).
5. Open then close the ports on the sampling probe using joy-stick (4) to take a sample.
6. Re-position the probe and repeat the steps above until adequate samples have been taken.
7. Once the sample tubes are empty, stop the vacuum motors (5).

## Hydraulic Oil Heater (Optional)

To maintain the hydraulic oil at a working temperature, switch ON the hydraulic oil heater using switch (6). The thermostat to this heater is located on the hydraulic power unit and should be set at 32°C (90°F).

## Receiving Inspection

1. Carefully inspect the equipment for damage as soon as it is received. Also, verify that the quantity of parts or packages actually received corresponds to the quantity shown on the packing slip. Report any damage or shortage to the delivering carrier as soon as possible.
2. InterSystems responsibility for damage to the equipment ended with acceptance by the delivering carrier. Refer to the bill of lading for more detailed information.
3. Save all paperwork and documentation furnished with any of the Truck Probe components. For example, motor and reducer installation and lubrication instructions, etc.
4. A typical shipment of a standard Truck Probe, without any of the optional items has five (5) major units:
  - a. Hydraulic Power Unit
  - b. Main Stand and Boom Pivot
  - c. Probe Boom
  - d. Probe Tip
  - e. Operators Control Panel, Vacuum Power Unit, Sample Collection Cabinet, Hydraulic Hoses and Fittings Kit, Sample Vacuum Hose, Hydraulic Fluid and Fasteners and Miscellaneous Kit.

**NOTE:** *Anchoring devices and fasteners are not provided.*

## Pre-Installation Preparation

1. Before starting Truck Probe system installation, study this manual, the certified drawing(s) furnished with the system.
2. InterSystems, Inc. Truck Probes are designed to be self-supporting when securely anchored to a reinforced concrete base constructed as specified by the certified drawing(s). The Truck Probe requires no bracing but it was not designed to support other equipment. Separate support must be provided for any accessory equipment. The user or installer is advised to retain a civil or architectural engineer to plan the overall installation and more specifically, the reinforced concrete bases for the probe itself and the hydraulic power unit.
3. InterSystems, Inc. does not assume turnkey responsibility for the installation. Therefore, the factors presented hereafter for consideration are just that and only that.
  - a. Before initiating the actual installation process, determine where the probe itself, the sample cabinet, the vacuum box, the control panel and the hydraulic power unit will be situated.
  - b. As shown on the MTP general data drawing, plan to locate the control panel so that the probe operator has a clear, unobstructed view of the loads to be sampled, so that the operator's signals to drivers of the loaded vehicles will be seen and understood.
  - c. The MTP Truck Probe can be set up for single or dual lane operation. The rotation of the boom must be limited to 300° maximum rotation.
  - d. Plan the routing of the vacuum sampling hose for a minimum of bends and changes in elevation.

## 5. Installation

- e. The air exhausted from the vacuum power unit (box) may include dust or other fines from the material being sampled. Plan to exhaust the air to a roof or another location away from pedestrian traffic where the occasional discharge will not be objectionable.
- f. Plan the location of the sample collection cabinet. Most often the desired site is at the beginning of the sample grading process in the grain inspection area. If the material other than grain is being sampled, other criteria may apply.
- g. Plan the location of the concrete base for the hydraulic power unit. Preferably, it should be located within 1.2 m of the concrete probe base. If the probe is separated from the power unit by more than 1.2 m, the user or installer may have to purchase additional hydraulic hose. Maximum separation between the probe and power unit should be held to 3 m or less.
- h. Excessively long hydraulic hoses can result in pressure loss which in turn results in slow, erratic probe operation. Excessive vacuum hose length can produce low vacuum at the probe tip. The sample collection system may not function properly.
- i. It is recommended that guard posts and/or rails be placed around the probe and hydraulic power unit for protection from vehicular traffic.
- j. Review all installation plans once more. Double check to be sure that power and communications lines will not be snagged by the probe and also that no conveyors or spouting are routed through the area where the probe is to operate.

## Location

The MTP Truck Probe is typically installed near the receiving truck scale and sample lab. (See [Figure 4A on Page 21.](#)) Locate the Truck Probe and associated equipment for ease of access and maintenance. The Truck Probe operator should have an unobstructed view of the entire area of boom movement.

The Truck Probe is to be installed only as shown on the certified drawing(s). If an alternate mounting arrangement is desired, contact InterSystems, prior to installation for proper guidance. The Truck Probe is of a general design with modifications specifically for your application. It may be necessary to rework the Truck Probe in order for it to function properly if you alter the application.

## General Mounting Guidelines

The Truck Probe assembly is designed to support ONLY its own weight. As shown on the certified drawing, the Truck Probe must be installed on a special concrete foundation. The main stand base has eight (8) clearance holes for securing to the foundation. Refer to the certified drawing(s) of the Truck Probe for the dimensioned locations of these holes.



***Truck Probe cannot support any other equipment. Collapse of the whole system can cause death, serious injury and extensive damage to equipment. Properly support all electrical conduits and conveying lines.***

1. Verify that the concrete probe and power unit bases have cured to develop adequate strength.
2. Position the MTP main stand assembly on the concrete foundation as shown on the certified drawing(s). Install a washer and two (2) nuts on each of the 25.4 mm (1") diameter anchor bolts. Verify that the main stand is plumb and tighten the anchor nuts.
3. Loosen the bearing set screws on the 35 mm (1-3/8") diameter boom pivot shaft at the top of the main base assembly and pull the shaft out enough for the boom to be positioned in place. Hoist the boom assembly into position. Re-insert the boom pivot shaft, tighten the bearing set screws and re-install the washer and cotter pin.



4. Remove the up/down cylinder pivot pin from the boom assembly. Cut the shipping strap on the up/down cylinder and attach to the boom assembly. Replace the cylinder pivot pin, washers and cotter pins.
5. Remove the 19 mm (3/4") diameter nut and bolt from the end of the boom assembly. Position the probe tip assembly and re-install the 19 mm (3/4") nut and bolt. Install the 3 mm (1/8") diameter x 38 mm (1-1/2") long cotter pin, from the hardware kit, into the castle nut.
6. Position the hydraulic bulkhead pipe assembly to the main stand. Use the 19 mm (3/4") fasteners from the hardware kit.
7. Position the hydraulic power unit assembly at the base of the main stand. Hold the 1.06 m (3'-6") dimension as shown on drawing 530368.

**NOTE:** *The hydraulic power unit is shipped with 15 gallons of fluid already in the reservoir. Another 10 gallons of fluid is furnished with the probe and is to be added during initial start-up.*

8. Refer to drawing 548613, it calls out the fittings and hoses included in the hose and fitting package. Install the hoses and fittings starting at the hydraulic power unit.
9. Slip the 304.8 mm (12") radius steel elbow over the end of the tube protruding from the top of the sample probe tip. Use the U-bolt muffler clamp to secure the elbow to the tube.
10. Slide one end of the blue vacuum hose over the end of the elbow and use the worm screw clamp to secure it. Route the vacuum hose along the length of the open/close hydraulic hoses, from the probe tip actuator to the bulkhead bracket on the outer boom. Tie the vacuum hose and hydraulic hoses to each other using the wire ties. Route the vacuum hose up to the hose saddle on top of the hydraulic piping support. Leave slack in the vacuum hose similar to the hydraulic hoses. Clamp the hose to saddle using two (2) worm screw clamps.
11. Install the 25.4 mm (1") x 38 mm (1-1/2") x 38 mm (1-1/2") rotational stops. The two (2) stops must be field-welded to the 25.4 mm (1") thick top plate of the probe stand beneath the 40 tooth driven sprocket. These stops limit clockwise and counterclockwise (right and left) probe rotation. The probe rotation must be limited to 300°, this will prevent the probe from being swung around and hitting the hydraulic piping support assembly. Reduce the amount of rotation if other obstructions such as buildings, poles, etc. are near by. First lightly tack weld the stops to the plate on top of the probe stand. Then swing the probe through the entire range of travel to verify that it does not hit any obstruction. When proper stop placement is determined, firmly weld the stops in position.

**NOTE:** *When welding the stops, carefully shield the drive sprocket and other drive components from weld spatter.*

### Initial Start-Up



**Hydraulic lines under high pressure, fluid can escape with great velocity. Eye and skin injury may result. Use eye and hand protection when bleeding hydraulic lines.**

1. Ensure all personnel are clear of the safety zone around the sampler. *(See Figure 4B on Page 22.)*
2. Close the main disconnect on the power panel. *(See Figure 4B on Page 22.)*
3. Start the control power. *(See Figure 4B on Page 22.)*
4. Start the hydraulic pump and check motor rotation is as marked. DO NOT run the pump in reverse as damage will occur. *(See Figure 4B on Page 22.)*
5. Check for leaks.
6. Purge the system of air:
  - a. Stop the hydraulic pump.
  - b. Turn all flow restrictors to a low setting.
  - c. Use a suitable vessel to catch any fluid lost during the bleed process.
  - d. With the system de-pressurised and locked off, open the bleed point.
  - e. Start the system and gradually pressurise the section being bled by operating the control joy-sticks. *(See Figure 4B on Page 22.)*
  - f. Once air bubbles have stopped coming out in the fluid, stop the system, lock it off and re-close the bleed point.
  - g. Clean up any lost fluid.
7. While operating the probe, make sure that the hydraulic and vacuum hoses do not become pinched and are not pulled tight.
8. Adjust the flow control valves which determine the rotational speed (left and right) of the boom.  
Turn a valve knob counterclockwise to increase fluid flow from a motor port; turn a knob clockwise to reduce flow and slow the motor.
9. Turn the vacuum motor ON and verify proper operation.
10. Top up the hydraulic reservoir as necessary.

### Material Sample Transport Lines

The Truck Probe is supplied with 30.48 m (100') of 38 mm (1-1/2") I.D. flexible sample hose. Route the sample hose from the probe to the collection cabinet along the most direct and shortest path. Avoid tight bends and joints that may become locations that plug. Make all connections airtight and make sure all interior surfaces of joints are smooth and flush. Any ragged or raised tube ends will collect dust and debris as well as retard material flow. Escaping sample material can contaminate surrounding atmosphere and equipment.

## System Plumbing

The hydraulic power unit was pre-plumbed and tested before it left the factory. The final installation must comply with National Regulations and all other applicable local codes and regulations.

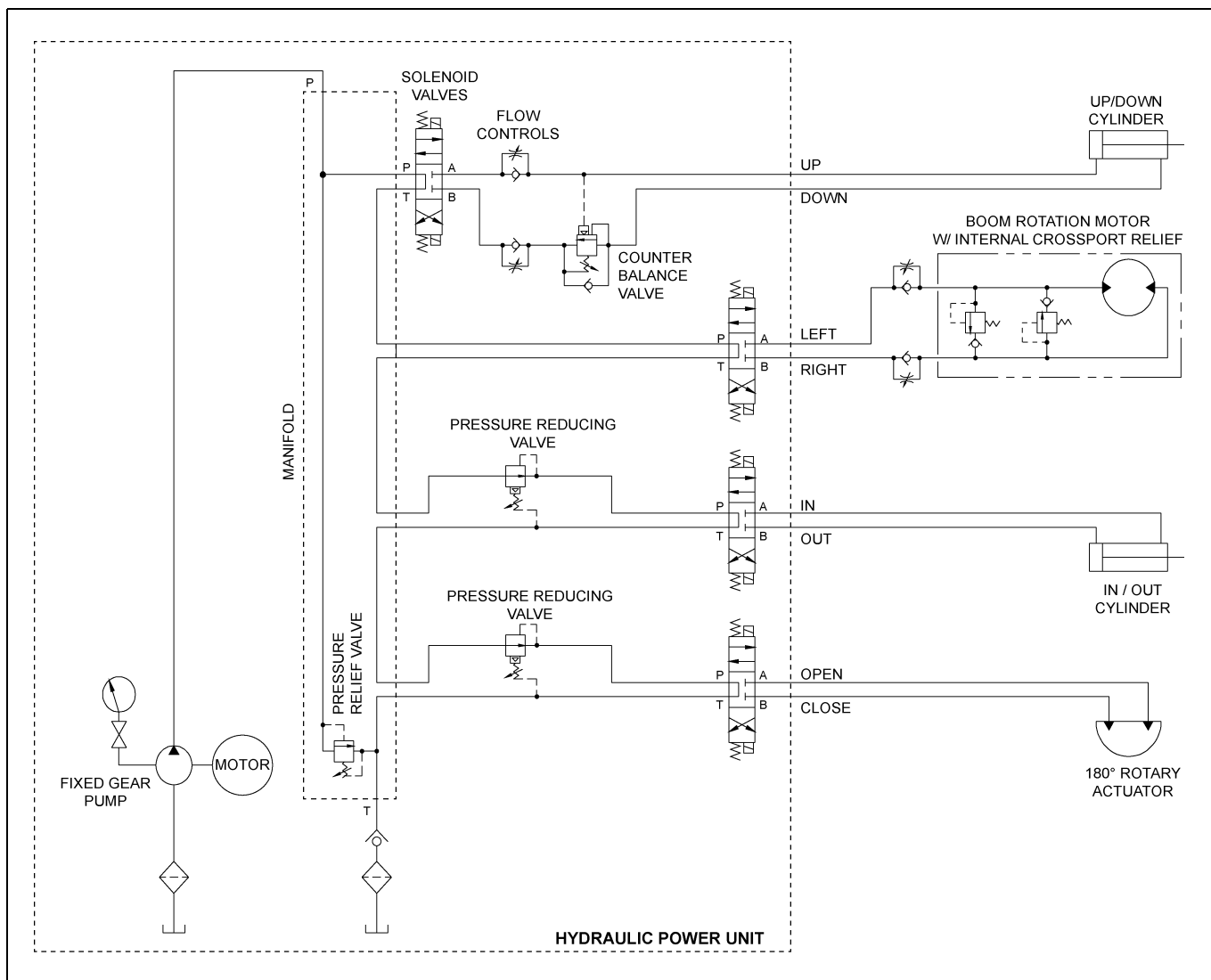
As shown on the certified drawings, the solenoid valves and manifold were mounted on the hydraulic power unit at the factory.

The Truck Probe was also provided with hoses and fittings for connecting the hydraulic power unit to all the cylinders and actuators. When connecting the hoses to the hydraulic power unit, exercise caution in preventing any contaminants from entering into the hydraulic lines.



**Hydraulic hose whip may cause minor injury. clamp hoses to prevent excessive movement.**

**NOTE:** Do not use Teflon tape or pipe sealant on “O-Ring” type and “Jic” type connections.



**Figure 5A** Hydraulic Schematic

### Positioning the Controls

The truck probe is supplied with a separate electrical control panel (10) and operators control console (7).

1. Install the power panel (10) (containing the motor starters) on, or immediately adjacent to the hydraulic power pack (11).
2. Install the operators control console (7) in the control room (6) and located so that the operator has unimpeded view of the entire operating range of the probe.

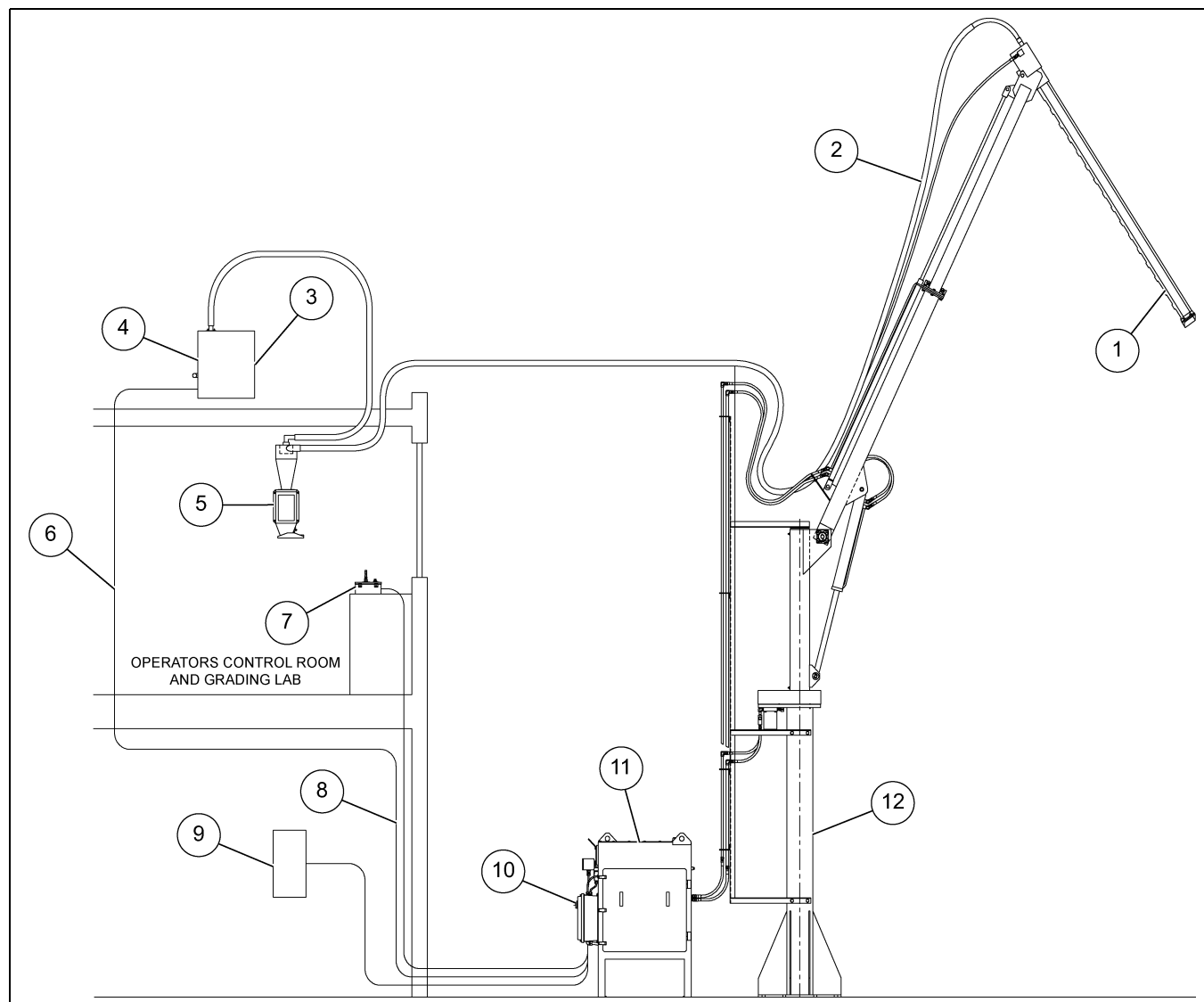


Figure 6A

Ref #	Description
1	2.7 m (9') Probe Tip (Compartmentalized)
2	0.038 m (1-1/2") I.D. Sample Vacuum Line
3	Dual Vacuum Motor Power Unit
4	Vacuum Exhaust
5	Sample Collection Cabinet
6	Control Room

Ref #	Description
7	Operators Control Console
8	Electrical Conduits
9	Circuit Breaker Panel
10	Power Panel
11	7.5 HP Hydraulic Power Unit
12	Probe Stand and Base

3. Locate a switched, fused three phase and neutral (TPN) supply in or adjacent to the control room. This shall include a protective earth (PE) connection.
4. The rating of the supply shall be adequate for all running currents of the truck probe, sampler motors, plus starting current of the hydraulic motor.
5. Refer to the rating plate on the hydraulic power pack and control panel for minimum power requirements.
6. The power supply for the operators console (7) is derived from the power panel (10).

### Interconnecting the Controls

1. The controls are interconnected via the terminals placed in each panel.
2. Refer to the connection diagrams below for terminal to terminal connections.
3. Refer to the table below for the minimum conductor sizes for making control and power connections.

**Minimum Wire Conductor Sizes**

Connection	Terminals	Minimum Conductor CSA
Switch Connections	1-18	1.5 mm <sup>2</sup> Copper
Single Phase + PE to Control Console	SL, SN and PE	2.5 mm <sup>2</sup> Copper
Vacuum Pump Power and PE	VL, VN and PE	2.5 mm <sup>2</sup> Copper
Emergency Stop	E1-A, E2-A, E1-B and E2-B	1.5 mm <sup>2</sup> Copper
Heater Power and PE	HN, HL and PE	1.5 mm <sup>2</sup> Copper
Hydraulic Motor Three Phase and PE	M1, M2, M3 and PE	2.5 mm <sup>2</sup> Copper
Solenoid Connections from Power Panel	1-8 Plus SN	1.5 mm <sup>2</sup> Copper

4. All conductors shall be protected from damage, being either run in rigid conduit, or using armoured cables.
5. Where conduit is used it shall provide a minimum ingress protection of IP 65.
6. Cable glands shall provide a minimum ingress protection of IP 65.

# Truck Probe Power Panel Power Schematic

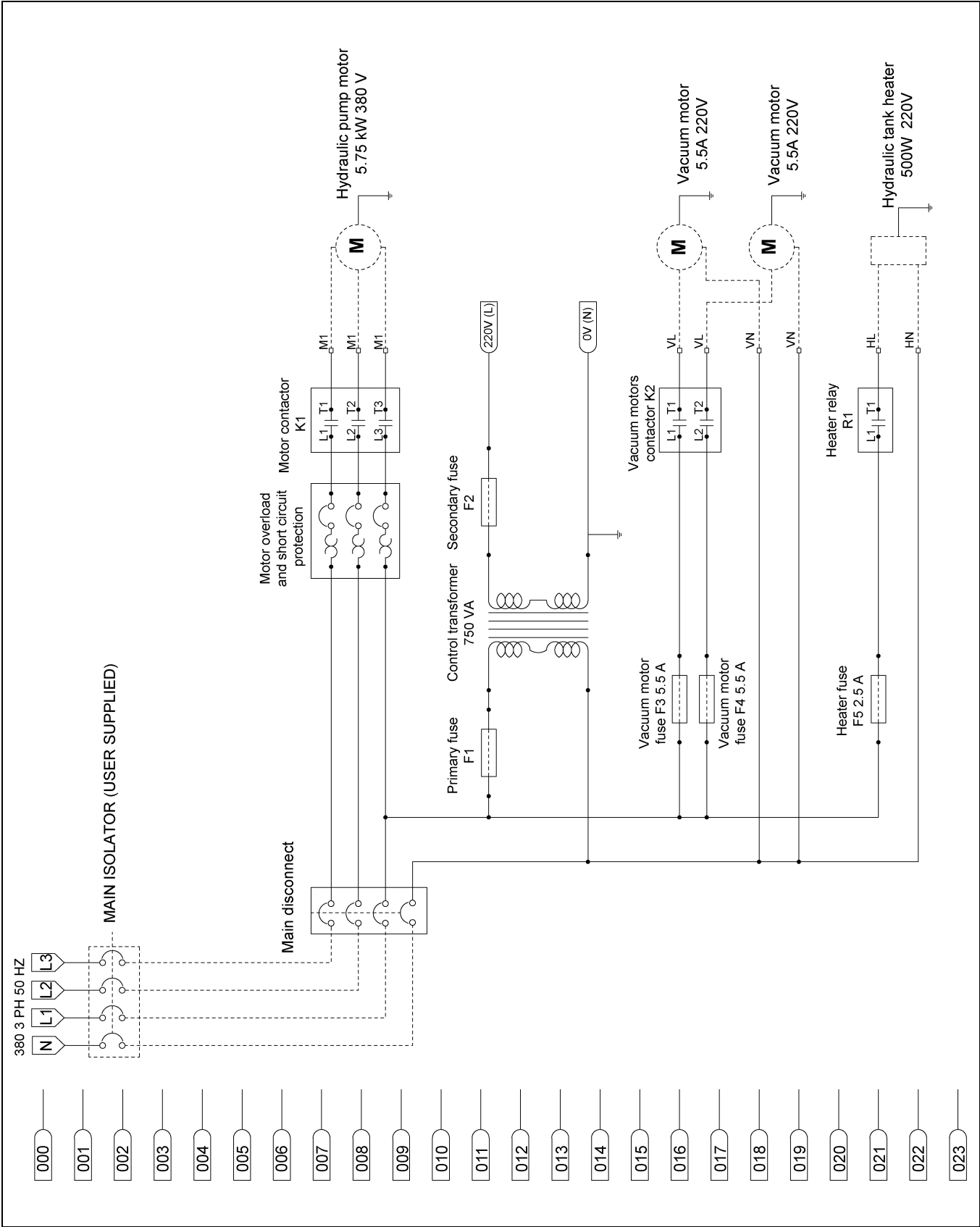


Figure 7A

## Truck Probe Power Panel Control Schematic

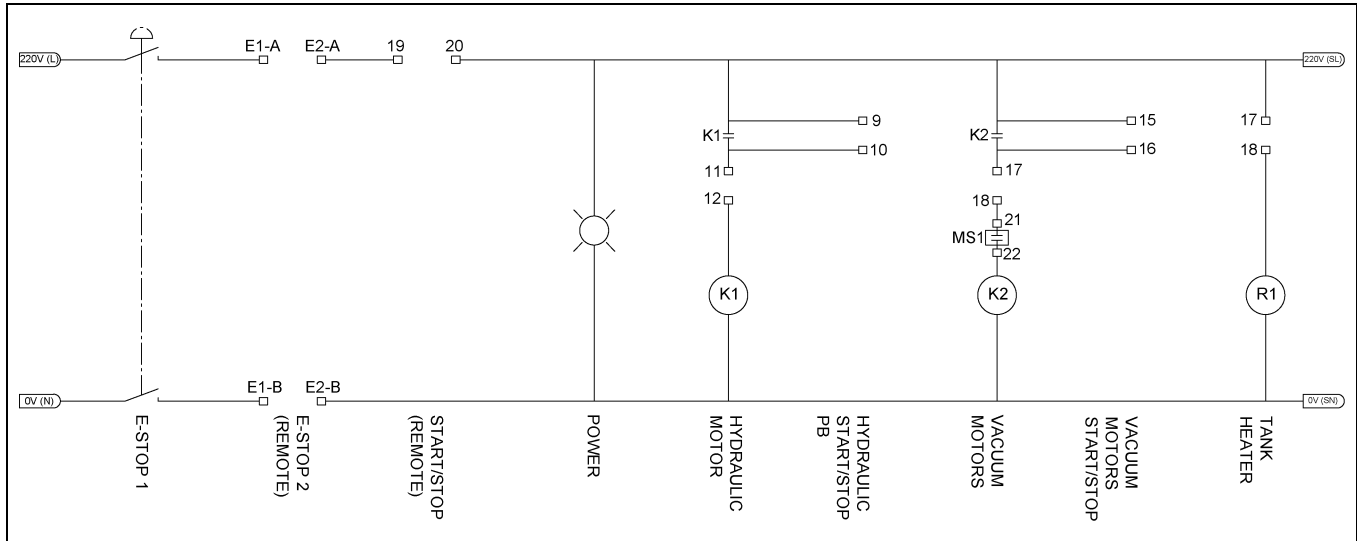


Figure 7B

## Truck Probe Power Panel Control Connections

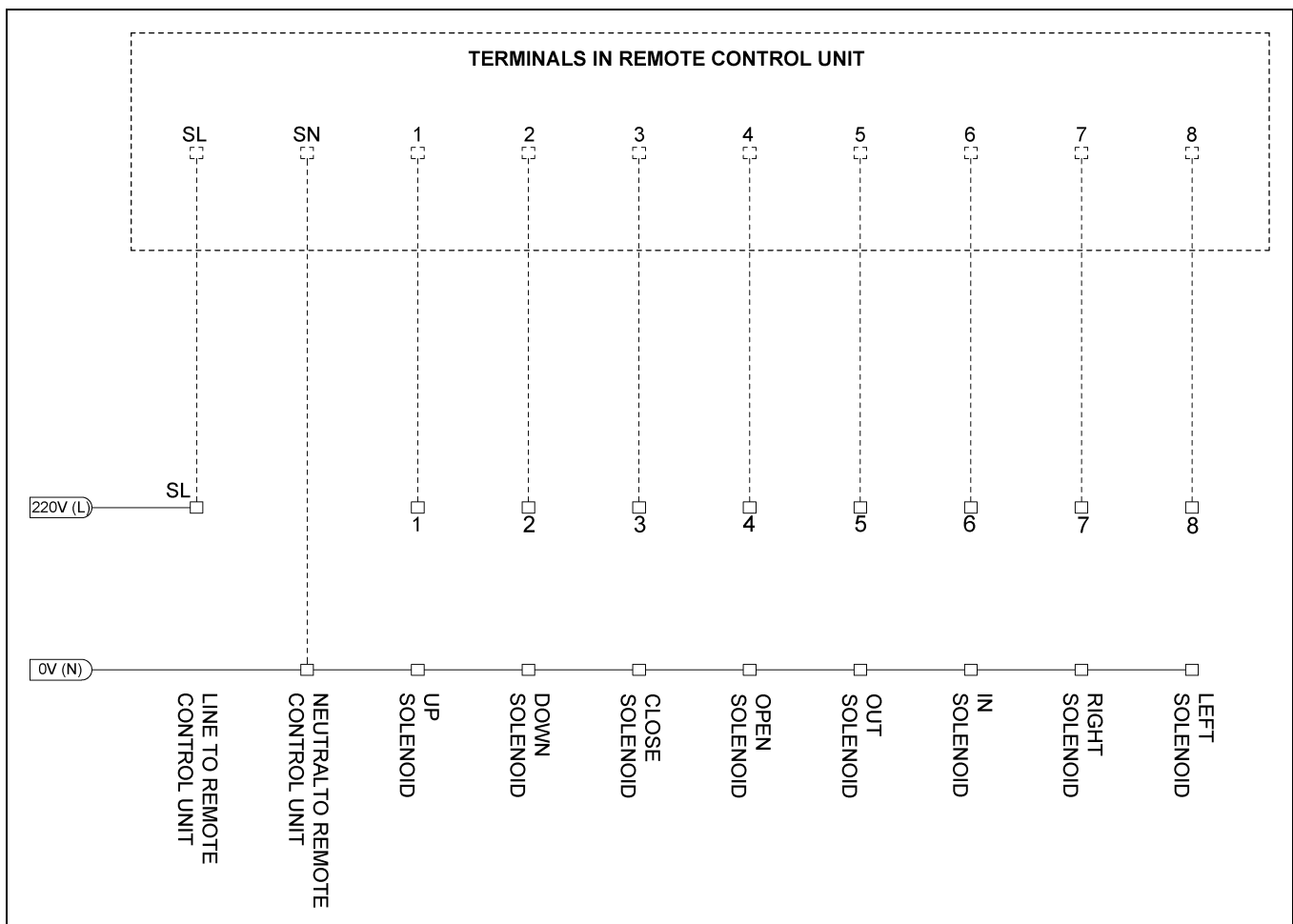


Figure 7C

### Truck Probe Operator Console to Power Panel Interconnections

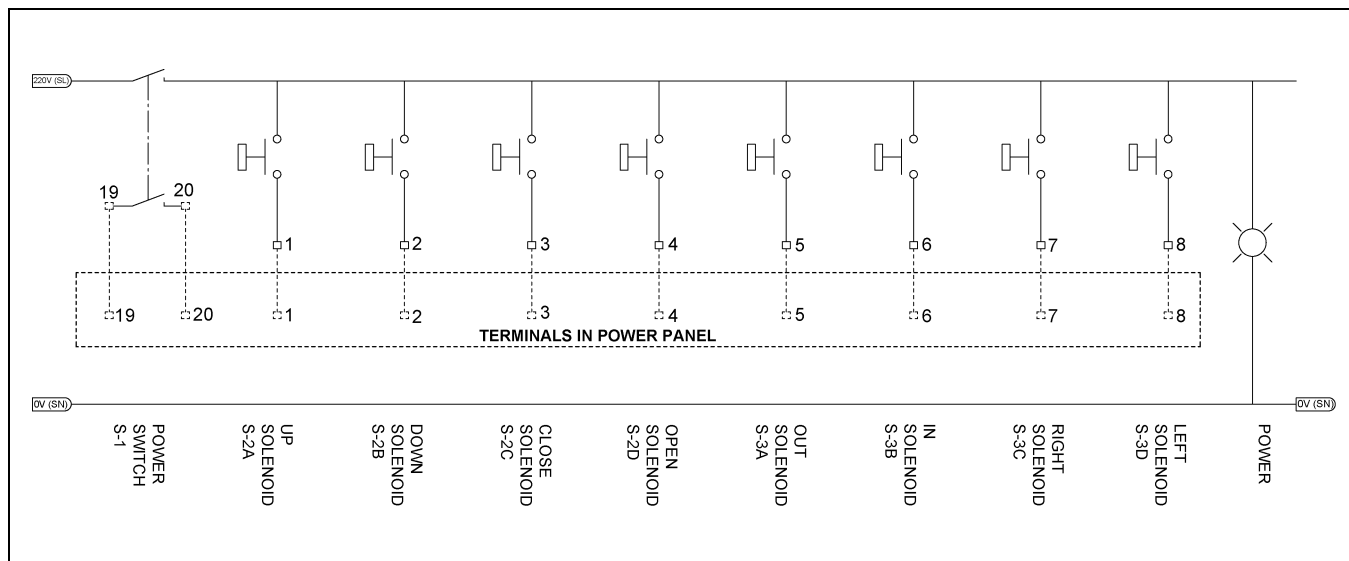


Figure 7D

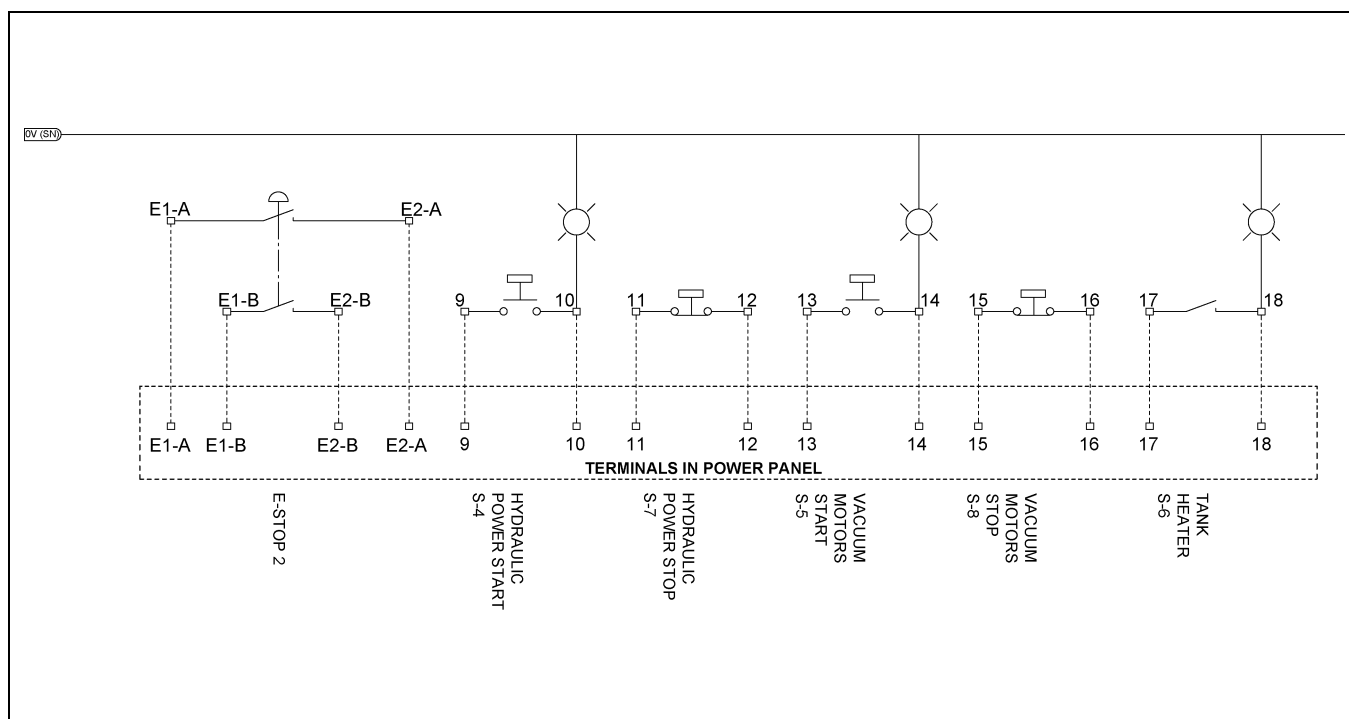


Figure 7E





***Failure to observe all safety rules, written and implied and those suggested by common sense, can result in death, serious injury and/or equipment damage. Lock out power before performing any maintenance.***

## Hydraulic Components

### Solenoid Valves V-1, V-2, V-3 and V-4

These valves are 4-way, 3-position, double-solenoid operated, spring-centered directional control valves. When both solenoids of a valve are de-energized, the valve spool is spring-centered and hydraulic fluid is routed directly into the manifold's return passage.

Each solenoid operator also has a manual operator that can be used to physically shift the valve spool. If a valve does not operate when the associated joy-stick is actuated, depressing the manual operator with a ball-point pen or a screwdriver will cause the valve to shift. If the valve shifts, it can be determined that the problem is in electrical circuit or solenoid.

The electrical connections to the solenoids are accessible by removing the cover of the terminal box on each valve. The valves are pre-wired to the disconnect panel on the outside of the hydraulic power unit.

Refer to the certified drawings for additional valve information.

#### Boom UP/DOWN Valve V-1

This solenoid-operated directional control valve alternately pressurizes the piston end and rod end of the double-acting cylinder to raise and lower the boom. When the valve's "A" solenoid is energized, the valve spool shifts, pressurizing the piston end of the cylinder, thus raising the boom. When the "B" solenoid is energized, the valve spool shifts, pressurizing the rod end of the cylinder, thus lowering the boom. Note, when neither "A" nor "B" solenoid is energized the valve is spring centered so that all ports are blocked and movement is inhibited.

#### Boom LEFT/RIGHT Valve V-2

This solenoid-operated directional control valve alternately pressurizes opposing ports of the rotational motor to swing the boom left and right. When the valve's "A" solenoid is energized, the valve spool shifts, pressurizing the port that swings the boom to the left. When the "B" solenoid is energized, the valve spool shifts, pressurizing the port that swings the boom to the right. Note, when neither "A" nor "B" solenoid is energized the valve is spring centered so that all ports are blocked and movement is inhibited.

#### Boom IN/OUT Valve V-3

This solenoid-operated directional control valve alternately pressurizes opposing ports of the rotary actuator to rotate the sample clockwise (CW) to collect samples and counterclockwise (CCW) to dump samples (when viewed from the rotary actuator end of the Truck Probe). When the valve's "A" solenoid is energized, the valve spool shifts, pressurizing the CW port of the actuator. The sample probe rotates, collecting a sample of the material from the product stream. When the "B" solenoid is energized, the valve spool shifts, pressurizing the CCW port of the actuator. The sample probe rotates, dumping the collected sample. Note, when neither "A" nor "B" solenoid is energized the valve is spring centered so that all ports are blocked and movement is inhibited.

## 8. Operation

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### Sample Ports OPEN/CLOSE Valve V-4 (Compartmentalized Probe Only)

This solenoid-operated directional control valve alternately pressurizes opposing ports of the rotary actuator to rotate the sample ports to collect and dump samples. When the valve's "A" solenoid is energized, the valve spool shifts, pressurizing the port of the actuator that opens the sample ports. When the "B" solenoid is energized, the valve spool shifts, pressurizing the port of the actuator that closes the sample ports. Note, when neither "A" nor "B" solenoid is energized the valve is spring centered so that all ports are blocked and movement is inhibited.

### Boom Left/Right Flow Control Valves V-6, V-7

A pair of in-line flow control valves mounted at the rotational motor, meters the flow of hydraulic fluid out of the rotational motor ports. Refer to the certified drawings. V-6 controls the speed of the boom swing to the left. V-7 controls the speed of the boom swing to the right. The flow controls will need to be adjusted upon initial start-up. To adjust, first loosen the small set screw on the metering screw. Turn clockwise to decrease boom swing speed and counterclockwise to increase boom swing speed. After desired speed is achieved, re-tighten the set screw to lock setting.

**NOTE:** *Avoid excessive boom swing speed, which will result in uncontrollable boom positioning and increased wear and tear on the Truck Probe.*

### Boom Up/Down Flow Control Valve V-8, V-9

A manifold mounted double flow control valve (sandwiched between the manifold and the counter balance valve V-10), controls the flow of hydraulic fluid to the up/down cylinder. Refer to the certified drawings. V-8 controls the speed the boom raises. V-9 controls the speed the boom lowers. The flow controls will need to be adjusted upon initial start-up. To adjust, first loosen the jam nut on the metering screw. Turn clockwise to decrease boom speed and counterclockwise to increase boom speed. After proper speed is achieved, re-tighten the set screws to lock setting.

**NOTE:** *Avoid excessive Truck Probe speed that will result in increased wear and tear on the Truck Probe. A good indicator of over speeding will be the loud banging of the Truck Probe when reaching its travel limits.*

### Relief Valve V-5

The relief valve has been set at the factory at 1800 PSI. No further adjustment should be necessary. Check the hydraulic pressure by first opening the gauge shut off valve. If the pump motor is running and the probe operates at all, then the gauge should register some pressure. If it does not, the gauge may be defective. It is normal for the gauge needle to vibrate slightly. Activate the DOWN solenoid. When the boom is all the way down and the DOWN solenoid is still activated the pressure gauge will read the pressure setting at which the relief valve is set.

**NOTE:** *The gauge will last longer if it is not continuously subjected to pump pressure. Close gauge shut off valve after checking and setting pressure.*

To adjust the relief valve setting simply remove the protective cap nut and loosen the lock nut on the valve stem. Use a 3 mm (1/8") hex key to turn the valve stem clockwise to increase pressure or counterclockwise to reduce pressure. Make valve adjustments in small increments and observe the gauge while doing so. If no change in pressure is noted, the relief valve may be sticking or the gauge may be defective. If the gauge and relief valve have been eliminated as the source of the problem, then the pump may be worn, particularly if the problem is low pressure.

When adjustment is complete, tighten the lock nut to maintain valve adjustment, then tightly re-thread the cap nut onto the valve stem.

## Pressure Reducing Valves V-10, V-11

These pressure reducing valves have been set at the factory. No further adjustment should be necessary. The IN/OUT valve is set at 1000 PSI. The OPEN/CLOSE valve is set at 750 PSI.

**NOTE:** *A pressure gauge will need to be installed on each of the gauge ports on the pressure reducing valves if adjustments are to be made.*

## Counter Balance Valve V-12

This counter balance valve has been set at the factory. No further adjustment should be necessary. The valve is set at 500 PSI.

**NOTE:** *A pressure gauge will need to be installed in the gauge port on the counter balance valve if adjustments are to be made.*

## Hydraulic Cylinders

These double-acting, non-cushioned rod cylinders raise or lower and extend or retract the boom. The up/down cylinder is 89 mm bore x 686 mm stroke. The in/out cylinder is 38 mm bore x 1829 mm stroke. The cylinders are attached at each end to the boom with a pivot pin. Solenoid valve V-1 controls the up/down movement. Solenoid valve V-3 controls the in/out movement.

## Rotary Actuator (Compartmentalized Probe)

The actuator is essentially a double-acting hydraulic cylinder that drives a rack and pinion unit, thus converting linear motion into rotary motion. The actuator is coupled directly to the inner tube of the compartmentalized probe. The rotary actuator opens the sampling ports to receive a sample. When the sampling ports are closed, the sample dumps into the vacuum conveying chamber of the probe. Solenoid valve V-2 controls rotary actuator motions.

## Hydraulic Pump

The hydraulic pump is a fixed displacement gear pump, that produces a flow of 1277 l/h (5.6 GPM) at 1800 RPM. The probe speed can be decreased by adding flow controls to any of the cylinders and actuators, but can not be increased. Maximum speeds for troubleshooting are as follows.

Probe Function	Approximate Time
IN	4 Seconds
OUT	7 Seconds
UP	14 Seconds
DOWN	9 Seconds



***Failure to observe all safety rules, written and implied and those suggested by common sense, can result in death, serious injury and/or equipment damage. Lock out power before performing any maintenance.***

### General Maintenance

A good maintenance program involves thorough general housekeeping, adequate periodic re-lubrication and replacement of worn or damaged components.

### Periodic Inspection

At regularly scheduled intervals, while observing all safety precautions, observe the equipment as it operates. Inspect for:

1. Loose or missing hardware.
2. Proper hydraulic oil level.
3. Noisy motors or motor bearings.
4. Structural damage.
5. Rust or corrosion.
6. Damaged wiring, including exposed conductors and connections.
7. Hydraulic leaks, damaged hydraulic lines and components, hoses that are kinked, chaffed or that are binding.
8. Excessive dirt accumulation in the hydraulic power unit, vacuum unit, boom pivot and telescoping joints.
9. Vacuum hoses that are kinked or chaffed. Vacuum leaks.
10. Make sure that all guards and warning labels are in place and legible. GENERAL SAFETY INFORMATION from [Pages 6-20](#), explains the purpose and intended location of the warning signs. Warning signs are an important part of any safety program; replace any missing signs IMMEDIATELY.

### Lubrication

#### Boom Pivoting and Sliding Joints, Monthly

Lubricate all shafts and bearings with a liberal amount of multi-purpose grease. Bearings and shafts should be re-greased monthly. All boom motions should be smooth and constant. Jerky, stick-slip operation may indicate mechanical damage to the boom, to a cylinder, or the rotation motor.

#### Boom Rotation Drive Chain and Sprockets, Every 6 Months

Because of the operating environment, the boom rotation drive chain and sprockets rapidly accumulate dust and dirt. At the recommended interval, thoroughly flush the chain with an approved solvent to rinse off all accumulated dirt. Then, while the boom is rotating, brush on a coat of lubricant. Be sure to work the lubricant into the chain pin joints.

## Hydraulic Power Unit Service

The service intervals are for average operating conditions. More severe conditions such as extreme heat or cold or nearly continuous Truck Probe operation may dictate more frequent service.

**NOTE:** Use only petroleum based fluids.

Oil Type	Viscosity, SSU @ 100 F
Exxon Mobil Univis N32 (Summer)	177
IS Blue (All Season)	73.6

### Hydraulic Oil Inspection, Daily

1. Check the reservoir fluid level with the probe operating. The level must be above the RED Low Oil Level bar on the sight gage. Replenish reservoir as necessary to maintain minimum level.
2. Check fluid temperature after the Truck Probe has operated for a time. Fluid temperature should stabilize between 43°C-57°C (110°F-135°F).

Probable causes of hydraulic fluid overheating include:

- a. Prolonged periods of continuous operation in a hot environment. A heat exchanger may have to be installed to cool the fluid. If the high temperature environment is a temporary condition, a forced draft of cooling air may be sufficient.
- b. Low hydraulic fluid level. Fluid circulates through the system so rapidly that it cannot transfer heat to the reservoir. Add fluid.
- c. Dirty power unit. A coating of hydraulic fluid and dirt prevents the power unit from shedding heat to the surrounding air. Clean the hydraulic power unit.
- d. Pump cavitation. This condition is usually signaled by a crackling or popping sound originating in the pump. It is most often caused by a clogged suction strainer resulting in the fluid vaporizing in the pump. Cavitation causes the fluid to overheat and loss of system pressure. The pump and motor will run hotter and the pump will eventually be destroyed. Identify and correct the problem as soon as possible.

### Breather Cap Cleaning, Every 3 Months

Remove the breather cap. Wash it thoroughly and blow it dry. Replace the cap.

### Hydraulic Filter Replacement, Every 3 Months

Remove and replace the filter canister. A check valve between the filter and the oil reservoir prevents excessive oil spillage during replacement. Check the hydraulic pressure as outlined in relief valve V-5 on [Page 34](#).

### Hydraulic Oil and Tank Strainer Replacement, Annually

1. Operate the probe until the fluid temperature has stabilized.
2. Shut off and lock out all power to the probe.
3. Immediately drain the reservoir of fluid. Remove the reservoir cover. It will probably have to be pried off since a bead of silicone sealant was applied at the factory to prevent fluid or vapors from leaking. Use an approved solvent to thoroughly flush any remaining fluid and dirt from the reservoir. **DO NOT** replace the cover at this time.
4. Disconnect the pressure and suction hoses at the pump to drain any remaining fluid and solvent. Then reconnect the hoses.
5. Make sure the hoses to the Truck Probe are labeled where they connect to the fittings on the end of the power unit. Disconnect the hoses to drain them of fluid. Then reconnect the hoses.
6. Replace the return line filter cartridge.
7. Temporarily remove the suction strainer. Wash it with solvent and blow it dry. Re-install the strainer or replace it if it cannot be cleaned.
8. Remove the breather cap. Wash it with solvent and blow it dry. Replace the breather.
9. Make sure the 25.4 mm (1") NPT drain plug is threaded securely in the reservoir drain. Then refill the reservoir with fifteen gallons of approved hydraulic fluid.
10. Operate the Truck Probe until no air bubbles are apparent from the return line.
11. Re-check hydraulic fluid level gauge and add additional oil if required.
12. Wipe the rim of the reservoir and the cover with a solvent-soaked rag, to provide clean, dry sealing surfaces. Apply an even bead of silicone sealant around the rim of the reservoir. Re-install the cover. Sealing the cover to the reservoir is not essential but will help to keep the exterior of the power unit clean and minimize accumulation of dirt.
13. Check the hydraulic pressure as outlined in relief valve V-5 [on Page 34](#).

### Probe Tip Inspection

This inspection is best done with the probe lowered near ground level.

1. While keeping the hands clear of the probe, have someone OPEN and CLOSE the probe tip through several cycles sequences. The inner tube should rotate smoothly and evenly within the outer tube.
2. The plastic cap on the end of the probe tip should be in good condition. A damaged cap should be replaced at once; otherwise it will leak, reducing the vacuum drawn in the probe tip.
3. With the probe tip OPEN, the inner tube should be clear and free of any obstructions.
4. The probe tip should pivot freely on the end of the boom without side play.

## General Truck Probe Troubleshooting



**Careless or accidental restoration of power can result in death or serious injury. Make certain area is clear before removing lock outs.**

Symptom	Possible Cause	Corrective Action
Truck Probe does not operate (Power light OFF).	1. Power switch OFF.	1. Turn power switch ON.
	2. Circuit breaker is open.	2. Reset breaker.
	3. Fuse(s) is blown.	3. Replace. Refer to control fuses.
	4. Faulty supply wiring.	4. Correct it. Refer to certified electrical schematic.
	5. Disconnect switch OFF.	5. Turn disconnect switch ON.
	6. Safety interlock switch activated.	6. Inspect. Contact the individual who activated.
	7. Defective power switch.	7. Replace switch.
Truck Probe does not operate (Power light ON).	1. Faulty system wiring.	1. Correct. Refer to certified electrical schematic.
	2. Starter overloads tripped.	2. Reset. Refer to pump motor starter and thermal overload.
	3. Pump motor power OFF.	3. Turn motor power ON.
	4. No or low hydraulic pressure.	4. Check pressure gauge.
	5. Defective control valve.	5. Refer to table <a href="#">below</a> .
Truck Probe sluggish (Operates too slowly).	1. Relief valve set too low.	1. Reset. Refer to relief valve V-5 <a href="#">on Page 34</a> .
	2. Cylinder seal leakage.	2. Refer to cylinder leaking <a href="#">on Page 40</a> .
	3. Hydraulic oil cold.	3. Check temperature. Inspect oil heater.
	4. Hydraulic pump worn out.	4. Replace.
	5. Teflon tape used during installation.	5. Check pressure valves. Clean or replace.

## Directional Solenoid Valve Troubleshooting

Symptom	Possible Cause	Corrective Action
Valve does not shift but full line voltage signal is present at the terminal strip inside the control.	1. No or low hydraulic pressure.	1. Check.
	2. Faulty field wiring.	2. Check for full line voltage at the solenoid.
	3. Solenoid coil burnt out.	3. Replace coil if no continuity through coil.
	4. Valve clogged or stuck.	4. Remove and clean. Or replace.

### Hydraulic Components Troubleshooting

#### Cylinder Leaking

##### 1. External Leakage

- a. Rod seal leakage can generally be traced to worn or damaged seals. Examine the piston rod for wear or damage. Replace the rod and seals if rod's surface is rough or worn out-of-round.

##### 2. Internal Leakage

- a. The lip seal piston seals are virtually leak free unless they are worn or damaged. Replace defective seals.
- b. Contaminants in the hydraulic supply can lead to scored cylinder walls, resulting in rapid seal wear. If such is the case, check to see if the filter is being replaced frequently. A different type of filter may be required; one that can remove finer particles or one that can filter out different kinds of contaminants.
- c. Possible piston cylinder leakage, apparently indicated by piston drift is not always traceable to the piston. A leak through a closed valve port can also cause piston drift.



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***INTERSYSTEMS***

**1004 E. Illinois St.  
Assumption, IL 62510-0020  
Phone: 1-217-226-4421  
Fax: 1-217-226-4420  
[www.gsiag.com](http://www.gsiag.com)**

